PHOENIX
ENVIRONMENTAL SCIENCES

Flora and fauna assessment for Lyons East Road to Gatti Road study area

Prepared for Muchea to Wubin Integrated Project Team
(Main Roads WA, Jacobs and Arup)

September 2015

Final Report

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ABBREVIATIONS

AWC – Australian Weeds Committee

BoM – Bureau of Meteorology

CR – Critically Endangered

EN – Endangered

EP Act – *Environmental Protection Act 1986*

EPA – Environmental Protection Authority

EPBC Act – *Environmental Protection and Biodiversity Act 1999*

ESA – Environmentally Sensitive Area

CAMBA – China-Australia Migratory Bird Agreement

DBH – diameter at breast height

DPaW – Department of Parks and Wildlife

DSEWPaC – Department of Sustainability, Environment, Water, Population and Communities

GNH – Great Northern Highway

GPS – Global Positioning System

IBRA – Interim Biogeographic Regionalisation of Australia

JAMBA – Japan-Australia Migratory Bird Agreement

NES – national environmental significance

NVIS – National Vegetation Information System

PDA – personal data assistant

PEC – priority ecological community

ROKAMBA – Republic of Korea on the Protection of Migratory Birds

SLK – straight line kilometre

sp. – species (singular)

spp. – species (plural)

subsp. – subspecies (singular)

TEC – threatened ecological community

VU – Vulnerable

WA – Western Australia

WC Act – *Wildlife Conservation Act 1950*

WoNS – Weeds of National Significance

EXECUTIVE SUMMARY

The Great Northern Highway (GNH) forms part of the National Land Transport Network that links the Perth Metropolitan area and Fremantle Port with the North-West of Australia, along with a link to Darwin and the Northern Territory. Main Roads Western Australia (Main Roads WA) has been undertaking a significant program of works to improve safety and efficiency of the GNH between Muchea and Wubin, north of Perth, to meet National Highway Standards.

In 2014, Main Roads WA established the Muchea to Wubin Integrated Project Team with industry partners Jacobs and Arup to conduct a comprehensive planning review of the full Muchea to Wubin link; Muchea to Wubin Upgrade Stage 2 (the Project). The Project includes a specific work package for proposed upgrades to GNH between Lyons East Road and Gatti Road.

Phoenix Environmental Sciences Pty Ltd (Phoenix) was engaged by Jacobs to undertake a flora and fauna assessment for the proposed Lyons East Road to Gatti Road work package (the study area). This report documents the flora and fauna assessment which comprised:

- a desktop review to determine potential conservation significant flora, vegetation and fauna in the study area, as well as weeds of significance
- flora and vegetation field survey including delineation and mapping of vegetation associations by quadrat sampling, mapping of vegetation condition boundaries, targeted searches for conservation significant flora and vegetation, and targeted searches for populations of declared plants
- fauna survey including a habitat assessment and habitat mapping, assessment of likelihood of occurrence within the study area for conservation significant fauna, targeted searches for conservation significant fauna, and recording of potential breeding trees, feeding and roosting sites for black cockatoos, particularly Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)
- mapping of breeding and foraging habitat for Carnaby's Black Cockatoo.

The desktop review relied on State and Commonwealth databases and available reports from previous surveys of the GNH road reserve in the vicinity of the study area. Field surveys were undertaken in October 2014, and March, May and June 2015. A total of 59 quadrats and 24 relevés were sampled. The targeted flora and fauna searches were conducted in habitats considered likely to contain or support conservation significant species, at locations of previous records and in the vicinity of these.

Descriptions of vegetation undertaken in the field were subsequently matched to regional vegetation mapping undertaken by the Department of Agriculture and Food (WA) in line with previous surveys in the vicinity of the study area. Known foraging associations/genera for black cockatoo species were cross-referenced with the vegetation type mapping from the survey to determine areas with potential feeding value to black cockatoos.

From the desktop review, four Threatened taxa under the *Wildlife Conservation Act 1950* and nine Priority Flora were identified as potentially occurring in the study area. The *Environment Protection and Biodiversity Conservation Act 1999* Protected Matters database identified 25 conservation significant flora where species or species habitat may occur within 10 km of the area.

Two declared plants were identified from the desktop review, neither of which is classified as a weed of national significance.

No Threatened Ecological Communities (TECs), Priority Ecological Communities (PECs) or Environmentally Sensitive Areas (ESAs) were identified within the study area.

From the desktop review, 15 conservation significant fauna species were identified as potentially occurring within the study area including ten Threatened species (one is also listed as Migratory), five Migratory species and one Priority species. This included 12 bird species and a reptile, a mammal and an invertebrate.

A total of 253 flora taxa representing 46 families and 110 genera were recorded in the study area during the surveys. The assemblage comprised 198 native species and 37 weeds including 67 annual and 168 perennial species. The most prominent families were Myrtaceae (33), Fabaceae (30), Chenopodiaceae (30), Poaceae (44), Asteraceae (15) and Proteaceae (13).

Specimens collected of 31 taxa could not be definitively identified to species level. A large number of Poaceae species (19) could not be definitively identified to species level as they were either too immature (seedlings) or dry and dead and lacked sufficient floristic characters. It is likely that there would be some duplication of species and consequently the actual numbers for species, weeds, natives and for the family Poaceae may be lower.

Records from the study area did not represent a range extension for any of the flora recorded.

A total of seven conservation significant flora were recorded in the study area:

- *Grevillea bracteosa* subsp. *bracteosa* (Threatened)
- *Chamelaucium* sp. Wongan Hills (Threatened)
- *Dampiera glabrescens* (Priority 1)
- *Frankenia glomerata* (Priority 3)
- *Grevillea asparagoide*s (Priority 3)
- *Grevillea pinifolia* (Priority 1)
- *Urodon capitatus* (Priority 3).

A total of 37 weed species were recorded in the study area including three declared plants, **Echium plantagineum*, **Opuntia monacantha* and **Tamarix aphylla*.

Nine vegetation types were defined locally for the study area. Broadly the vegetation types recorded represent low to mid woodlands and shrublands with *Allocasuarina campestris* thicket prominent, mixed shrublands, succulent steppe (samphire, *Tecticornia* spp.) shrublands and mosaics of these vegetation types.

None of the vegetation types recorded within the study area were considered to represent a Commonwealth or State listed TEC.

Sections of one of the woodland communities (vegetation type 352 – Medium woodland, York Gum (*Eucalyptus loxophleba*) recorded for the study area at quadrats 5.33a and 5.34 may be considered representative of the State listed PEC, Eucalypt woodlands of the Western Australian Wheatbelt.

Four of the vegetation types (8, 631, 1046 and 1048) recorded in the study area may be considered locally significant as they covered less than 1% of the study area. The areas of the vegetation recorded to be in excellent condition may be considered locally significant as they represent patches of comparatively high native species diversity in otherwise degraded vegetation, in particular for vegetation types 142, 352, 551, 1024 and 1048 as these vegetation types are classed as vulnerable.

Six of the vegetation types (142, 352, 551, 676, 1024 and 1048) may be considered to be locally significant as they represent habitat for the conservation significant flora recorded in the study area. All of the vegetation types classed as vulnerable or endangered may be considered to be regionally significant as there is less than 30% of pre-European extent remaining.

Fauna habitats recorded in the study area were described as samphire flat or samphire flat with low shrubland or woodland, shrubland (Mallee and Casuarina thickets), woodland (York Gum, Wandoo, Salmon Gum and/or Gimlet), pasture and cleared, and cleared and revegetated mosaic.

The study area was recorded to be poor quality habitat for fauna generally with largely degraded to completely degraded habitats of primarily pasture, with small pockets of remnant vegetation.

No direct observations of conservation significant fauna species were recorded during the surveys; however, evidence of four likely nesting sites for Carnaby's Black Cockatoo was recorded. Based on habitats present, known species distributions, and habitat quality and extent, up to eight conservation significant fauna species may occur in the study area. Due to the poor condition, presence of introduced species and fragmentation the fauna habitats in the study area are unlikely to provide core habitat for species of conservation significance identified in the desktop review with the exception of Carnaby's Black Cockatoo.

Potential breeding trees and breeding and foraging habitat were recorded in the study area for Carnaby's Black Cockatoo. Within the study area, 204 potential black cockatoo breeding trees were recorded during the survey, comprising predominantly *Eucalyptus camaldulensis, E. loxophleba, E. salmonophloia* and *E. salubris*. Thirteen trees were recorded that contained suitable hollows and five of these showed signs of use at the time of the survey. Based on the records, 14.7 ha of remnant vegetation within the study area has been mapped as potential breeding habitat for the species.

Feeding habitat for Carnaby's Black Cockatoo was recorded in the study area but was considered low value habitat; no quality foraging habitat was mapped within the study area. No direct evidence (residues) of feeding was observed. Potential roosting habitat for Carnaby's Black Cockatoo is present in the study area but no evidence of roosting was observed during the surveys.

1 INTRODUCTION

1.1 BACKGROUND

The Great Northern Highway (GNH) forms part of the National Land Transport Network that links the Perth Metropolitan area and Fremantle Port with the North-West of Australia, along with a link to Darwin and the Northern Territory. Main Roads Western Australia (Main Roads WA) has been undertaking a significant program of works to improve safety and efficiency of the 218 km section of GNH between Muchea and Wubin, north of Perth, to meet National Highway Standards. Stage 1 of the upgrade works were completed between 2000 and 2009 and involved upgrading 76 km of the Muchea to Wubin section of GNH.

In 2014, Main Roads WA established the Muchea to Wubin Integrated Project Team with industry partners Jacobs and Arup to conduct a comprehensive planning review of the full Muchea to Wubin link; Muchea to Wubin Upgrade Stage 2 (the Project). As part of the Project upgrades are proposed for several sections of GNH, including a specific work package between Lyons East Road and Gatti Road.

In September 2014, Phoenix Environmental Sciences Pty Ltd (Phoenix) was appointed by Muchea to Wubin Integrated Project Team (Main Roads WA, Jacobs and Arup) to undertake a flora and fauna assessment for the proposed Lyons East Road to Gatti Road work package.

1.2 PURPOSE

The purpose of this report is to document the biological survey completed for Lyons East Road to Gatti Rd study area to inform an environmental impact assessment for the proposed work package.

1.3 STUDY AREA

The Lyons East Road to Gatti Rd study area extended from straight line kilometre (SLK) 177.30, 6.5 km south of Miling at the Lyons East Road–GNH junction to SLK 207.72, 25 km south of Pithara at the Gatti Road–GNH junction (Figure 1-1). Average width of the study area was approximately 175 m and total area was approximately 654.56 ha.

1.4 SCOPE OF WORK

The scope of work comprised:

- biological desktop review of the study area
- flora and vegetation field survey entailing
    - delineation and mapping of vegetation types by quadrat sampling
    - mapping of vegetation condition
    - targeted searches for conservation significant flora and vegetation
    - targeted searches for populations of declared plants (weeds)
- fauna survey entailing
    - habitat assessment and mapping

- assessment of likelihood of occurrence within the study area for conservation significant fauna
- targeted searches for conservation significant species
- survey of potential breeding trees, roosting sites and feeding sites for black cockatoo species, particularly Carnaby's Black Cockatoo
- mapping of breeding and foraging habitat for Carnaby's Black Cockatoo.

Figure 1-1 Project location and study area

2 LEGISLATIVE CONTEXT

The protection of flora and fauna in Western Australia (WA) is principally governed by three acts:

- Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *Wildlife Conservation Act 1950* (WC Act)
- *Environmental Protection Act 1986* (EP Act).

2.1 COMMONWEALTH

Under the EPBC Act, actions that have, or are likely to have, a significant impact on a matter of national environmental significance (NES), require approval from the Australian Government Minister for the Environment. The EPBC Act provides for the listing of threatened native flora, fauna and threatened ecological communities (TECs) as matters of NES.

Conservation categories applicable to Threatened Flora and Threatened Fauna species under the EPBC Act are as follows:

- Extinct (EX)[1] – there is no reasonable doubt that the last individual has died
- Extinct in the Wild (EW) – taxa known to survive only in captivity
- Critically Endangered (CR) – taxa facing an extremely high risk of extinction in the wild in the immediate future
- Endangered (EN) – taxa facing a very high risk of extinction in the wild in the near future
- Vulnerable (VU) – taxa facing a high risk of extinction in the wild in the medium-term
- Conservation Dependent[1] – taxa whose survival depends upon ongoing conservation measures; without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened.

Ecological communities are defined as 'naturally occurring biological assemblages that occur in a particular type of habitat' (English & Blyth 1997). There are three categories under which ecological communities can be listed as TECs under the EPBC Act: Critically Endangered, Endangered and Vulnerable.

The EPBC Act is also the enabling legislation for protection of migratory species under a number of international agreements:

- Japan-Australia Migratory Bird Agreement (JAMBA)
- China-Australia Migratory Bird Agreement (CAMBA)
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn)
- Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds (ROKAMBA).

[1] Species listed as Extinct and Conservation Dependent are not matters of NES and therefore do not trigger the EPBC Act.

2.2 STATE

2.2.1 Threatened and Priority species and communities

In WA, the WC Act provides for the listing of native flora (Threatened Flora; T) and fauna (Threatened Fauna; T) species which are under identifiable threat of extinction. Threatened Flora listed under the WC Act receive statutory protection but they are also assigned to one of three categories: Critically Endangered (CR), Endangered (EN) or Vulnerable (VU), which dictates resource allocation priorities for conservation and recovery actions.

Threatened Fauna are assigned to one of four categories under the WC Act: Schedule 1 (fauna that is rare or is likely to become extinct), Schedule 2 (fauna presumed to be extinct), Schedule 3 (Migratory birds protected under an international agreement) and Schedule 4 (other specially protected fauna). Assessments for listing of both flora and fauna are based on the International Union for Conservation of Nature (IUCN) threat categories.

The Department of Parks and Wildlife (DPaW) administers the WC Act and also maintains a non-statutory list of Priority Flora and Priority Fauna species (updated each year). Priority species are still considered to be of conservation significance – that is they may be rare or threatened – but cannot be considered for listing under the WC Act until there is adequate understanding of their threat levels. Species on the Priority Flora and Fauna lists are assigned to one of five priority (P) categories, P1 (highest) – P5 (lowest), based on level of knowledge/concern.

The Minister for Environment may also list ecological communities which are at risk of becoming destroyed as 'threatened'. DPaW maintains a list of ministerial-endorsed TECs as well as a non-statutory list of Priority Ecological Communities (PECs) which are also assigned to one of five categories.

Any activities that are deemed to have a significant impact on listed flora or fauna species can trigger referral to the Environmental Protection Authority (EPA) for assessment under the EP Act. The EPA's position on TECs states that proposals that result in the direct loss of TECs are likely to require formal assessment (EPA 2006).

2.2.2 Locally or regionally significant flora and vegetation

Flora species, sub-species, varieties, hybrids and ecotypes may be significant for a variety of other reasons than being listed as Threatened or Priority Flora, including where they have keystone roles for threatened species, are representative of the range limit of a species, are locally endemic, are poorly reserved or display anomalous features that indicate a potential new discovery (EPA 2004b).

Native vegetation communities may be considered significant for a range of reasons other than a statutory listing as a TEC, including where they have restricted distributions (i.e. to one or two locations or as isolated communities, or are below threshold levels), exhibit unusually high structural and species diversity, are limited to specific landform types, are determined to be uncommon or restricted within the regional context, have a role as key habitat for threatened or priority species or provide refugial habitats (EPA 2004b). The most important factor in consideration of community significance is the degree of representation at a local and regional scale. It may be considered that representation of less than one percent of the total study area defines limited representation within the local context.

2.2.3 Clearing of native vegetation

The clearing of native vegetation in WA is not generally permitted where the biodiversity values, land conservation and water protection roles of native vegetation would be significantly affected. Any clearing of native vegetation in WA requires a permit under Part V Division 2 of the EP Act, except where an exemption applies under the act, or is prescribed by the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* (the Regulations), and the vegetation is not in an Environmentally Sensitive Area. Permit applications to clear native vegetation require assessment against the '10 Clearing Principles', as outlined in the regulations.

2.2.4 Environmentally Sensitive Areas

Under section 51B of the EP Act the Minister for Environment may declare by notice either a specified area of the State or a class of areas of the State to be Environmentally Sensitive Areas (ESAs). ESAs are declared in the *Environmental Protection (Environmentally Sensitive Areas) Notice 2005*, which was gazetted on 8 April 2005.

ESAs are generally areas where the vegetation has high conservation value. Several types of areas are declared ESAs including:

- the area covered by vegetation within 50 m of Threatened Flora, to the extent to which the vegetation is continuous with the vegetation in which the Threatened Flora is located
- the area covered by a TEC
- a defined wetland (Ramsar wetlands, conservation category wetlands and nationally important wetlands) and the area within 50 m of the wetland
- Bush Forever sites.

2.3 INTRODUCED FLORA

Introduced flora (i.e. weeds) pose threats to biodiversity and natural values by successfully out-competing native species for available nutrients, water, space and sunlight; reducing the natural diversity by smothering native plants or preventing them from growing back after clearing, fire or other disturbance; replacing the native plants that animals use for shelter, food and nesting; and altering fire regimes, often making fires hotter and more destructive (AWC 2007). Some weeds are classified as declared under the *Agriculture and Related Resources Protection Act 1976* (declared plant) or Weeds of National Significance (WoNS) and require specific control actions. Specific terms are used in WA to describe weeds (Table 2-1).

Table 2-1 Terms used to describe weeds (DEC 2012)

Term	Definition
Declared plant	A weed that has been "Declared" under the *Agriculture and Related Resources Protection Act 1976*. The Declared Plants Database lists declared plants within a particular region (shire/city) of WA and contains information on the status of a plant, its declaration, a brief description and control methods.
Environmental weed	An introduced plant that establishes in natural ecosystems and adversely modifies natural processes, resulting in decline of invaded communities (refer to the Environmental Weed Strategy, DEC 1999).
Exotic	A plant occurring in a place to which it is not native.
Invasive plant	One that is introduced and successfully reproduces resulting in the establishment of a population that spreads and threatens ecosystems, habitats or species with economic or environmental harm. Often called weeds when established they can result in harmful impacts to biodiversity, property and life. Not all introduced species are invasive if there are controls on their spread or competitiveness.
Naturalised plant	A plant that is not native to an area but has become established and can reproduce there. Not all naturalised species become weeds or have detrimental environmental or economic effects, but many do.
Weed	A plant that requires some form of action to reduce its harmful effects on the economy, the environment, human health and amenity, and can include plants from other countries or other regions in Australia or WA.

3 METHODS

3.1 DESKTOP REVIEW

Desktop review methods entailed:

- a review of existing environmental information relevant to the biological values of the study area including
    - base environmental datasets to define the physical characteristics of the study area
    - searches of relevant biological databases (Table 3-1)
    - literature reviews of available technical reports from projects adjacent to the study area, or within the area of the desktop review
- assessment and mapping of broad-scale vegetation in the study area.

Table 3-1 Databases searches conducted for the desktop review

Database	Target group/s	Search coordinates and extent
Protected Matters Search Tool (Department of the Environment 2014c)	EPBC Act Threatened Flora, TECs and Threatened Fauna	GDA94; Polyline of study area centreline (approximate) with a 10 km buffer
DPaW Threatened and Priority Flora database and WA Herbarium database (DPaW 2014b)	WC Act Threatened and Priority Flora	GDA94; Polyline of study area centreline (approximate) with a 10 km buffer
DPaW Threatened and Priority Ecological Communities database (DPaW 2014b)	TECs and PECs	GDA94; Polyline of study area centreline (approximate) with a 10 km buffer
DPaW NatureMap databases, including Western Australian Herbarium records (DPaW 2014a)	Threatened and Priority Flora, weeds and all potentially occurring fauna	GDA94; Polyline of study area centreline (approximate) with a 10 km buffer
Department of Agriculture and Food, Western Australia Organism List search for Declared Plants under the *Biosecurity and Agriculture Management Act 2007*	Declared plant species	Species recorded in the Dalwallinu (S) and Moora (S) Local Government Areas (LGA boundaries)
Department of the Environment weeds database	Weed species	National weeds lists, WoNS
Any sites of significance	Wetlands and conservation estate and ESAs	SLIP Services, Landgate: ESA (updated 22/09/2014) and Wetlands (updated 04/06/2015) location maps
DPaW Threatened Fauna database (DPaW 2014b)	Threatened and Priority Fauna	GDA94; Polyline of study area centreline (approximate) with a 10 km buffer
Birdlife Australia Birdata database (Birdlife Australia 2014)	All potential avian fauna records, including Threatened and Migratory bird species	GDA94; Polyline of study area centreline (approximate) with a 10 km buffer

Base environmental datasets were reviewed to define the physical characteristics of the study area including

- Interim Biogeographic Regionalisation of Australia (IBRA) region (DSEWPaC 2012b; Thackway & Cresswell 1995b)
- climate (BoM 2015)
- land systems – landforms and soils.

Table 3-2 Previous survey reports included in the review

Report title	SLK
Great Northern Highway: assessment of flora & vegetation (Ecologia 2004)	36–253
Preliminary environmental impact assessment (KBR 2005)	36–253
Great Northern Highway Realignment - Environmental Impact Assessment (AECOM 2012)	165–176

3.2 FIELD SURVEY

3.2.1 Flora and vegetation

Flora and vegetation was assessed for the study area over a combined three field surveys to accommodate changes to the study area.

An initial spring season flora and vegetation field survey was undertaken in October 2014 covering an approximately 40 m wide study area encompassing GNH from SLK 177.72 – SLK 207.72 (Figure 1-1). Field assessment methodology involved description of vegetation types and condition at locations in remnant and planted vegetation using quadrat, relevé and opportunistic sampling, and included searches for conservation significant and introduced flora. Pastures and completely degraded areas were not surveyed.

The second field survey was undertaken on 20–22 May 2015 and included additional areas which were not surveyed in spring 2014 but mostly within cleared pastures (Figure 1-1). In addition to the above methods, the boundaries of vegetation associations and vegetation condition classifications defined in the spring 2014 survey were ground-truthed to confirm accuracy. In the targeted searches for conservation significant flora more detailed survey effort was employed: in vegetation types that conservation significant flora were recorded during the spring 2014 survey (particularly in the vicinity of the previous records); where vegetation type 352 (potential PEC) occurs (such as within quadrats P5.33a and P5.34); and in surrounding areas outside the study area to identify other locations outside the proposed disturbance area.

The third field survey was undertaken on 16–17 June 2015 and covered an additional area within cleared pastures and patches of remnant and planted vegetation from SLK 193. 4 – SLK 195.8 (Figure 1-1). Field assessment methodology involved description of vegetation types and condition in previously undescribed vegetation and searches for conservation significant and introduced flora.

Prior to the commencement of the field surveys, all known data was loaded onto either a Personal Data Assistant (PDA) unit or a hand-held Global Positioning System (GPS, Garmin Montana 650t), including aerial photography and pre-selected vegetation quadrats. This allowed points of interest and vegetation boundaries to be directly inserted into an electronic format, ensuring all locations were accurately mapped at the time of the survey. In the latter two surveys, previously described vegetation

association and vegetation condition boundaries, and locations of previous sites were also loaded onto the devices.

Total survey effort over the three survey periods was 206 person hours.

All surveys were conducted in accordance with the EPA's Guidance Statement No. 51: *Terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia* (EPA 2004b) and Position Statement No. 3: *Terrestrial biological surveys as an element of biodiversity protection* (EPA 2002).

3.2.1.1 Quadrat and relevé selection

Quadrat and relevé sampling effort comprised 59 quadrats and 24 relevés in total. In the October 2014 survey 34 quadrats and 18 relevés were sampled, 14 quadrats and six relevés were sampled in the May 2015 survey and 11 quadrats were sampled in the June 2015 survey (Table 3-3; Figure 3-1). Quadrat sampling sites typically measured 10 m x 10 m. However, due to the nature of the study area quadrat dimensions were modified to fit the road reserve at some sites (e.g. 20 m x 5 m), though the overall quadrat area was maintained.

Table 3-3 Quadrats and relevés sampled in each survey period

Survey period	Quadrats	Relevés
October 2014	34 Site codes: P5.04, P5.05, P5.07, P5.09, P5.10, P5.12, P5.13, P5.15a, P5.16, P5.18, P5.19, P5.23, P5.25, P5.27, P5.28a, P5.31, P5.32a, P5.33a, P5.34, P5.35, P5.40, P5.42, P5.43a, P5.44, P5.45, P5.46, P5.47a, P5.49a, P5.50a, P5.G1, P5.G2, P5.G3, P5.G5 and P5.G6	18
May 2015	14 Site codes: P5.81, P5.82, P5.84a, P5.85, P5.86, P5.87-1, P5.88-1, P5.89, P5.90, P5.92, P5.93, P5.94, P5.97 and P5.99	6
June 2015	11 Site codes: P5.101, P5.102, P5.103, P5.104, P5.105, P5.106, P5.107, P5.108, P5.109, P5.110 and P5.111	-

Quadrat locations were selected to ensure that an adequate representation of the major vegetation types and flora present within the study area was sampled. This was achieved by pre-selecting locations of sampling quadrats based on apparent changes in the vegetation visible in aerial images (using supplied high quality colour aerial photography) for ground-truthing on foot, selecting additional quadrats in different vegetation types and targeting different landforms during field and relevés surveys. Vegetation in preselected quadrats that appeared similar to already described vegetation in the field within other quadrats was treated as relevés where only description of dominant vegetation was made, and additional relevés were selected during the field surveys to match vegetation described within other quadrats to facilitate mapping of vegetation type boundaries.

The following information was recorded for each quadrat (Appendix 1):

- location – the coordinates of the quadrat were recorded in GDA 94 projection utilising a Personal Data Assistant (PDA) unit or hand-held GPS.
- description of vegetation – a broad description utilising the structural formation and height classes based on National Vegetation Information System (NVIS) (2003) (Appendix 2)

- habitat – a brief description of landform and habitat
- soil – a broad description of surface soil type and rocks
- disturbance history – a brief description of any observed disturbance including an estimate of time since last fire, weed invasions, soil disturbance and animal grazing
- vegetation condition – the condition of the vegetation was recorded utilising the condition scale of (Keighery 1994) (Table 3-4)
- height and foliage cover – a visual estimate of the canopy cover of each species present was recorded as was the total vegetation cover, cover of shrubs and trees >2 m tall, cover of shrubs <2 m, total grass cover and total herb cover
- photograph – a colour photograph of the vegetation within each quadrat
- species list – the name of every species present in the quadrat; where species were located that were unknown to the botanist conducting the survey, a specimen was collected and pressed for later identification.

Table 3-4 Vegetation condition rating scale (Keighery 1994)

Vegetation condition rating	Vegetation condition	Description
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
4	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances retains basic vegetation structure or ability to regenerate it
5	Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not in a state approaching good condition without intensive management
6	Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost without native species

Figure 3-1 Survey site locations

3.2.1.2 Targeted flora searches

Targeted searches were undertaken simultaneously with the flora and vegetation survey to determine whether any of the conservation significant species identified from the database and literature review occur in the study area. The searches focused on habitats considered likely to contain or support conservation significant flora and previously recorded locations of conservation significant plants or populations within the study area. Vegetation types such as creek lines, gullies, ridges, rocky outcrops and low lying areas were also targeted as these areas typically support a higher level of diversity.

For each population of conservation significant flora recorded, the following information was documented:

- location (as points for individual plants or as polygons for populations)
- description of the floristic community in which the species was located and population size estimate
- voucher collection for lodgement at the WA Herbarium

  For each population of declared plant recorded, the following information was documented:

- location (as points for individual plants or as polygons for populations)
- population size estimate.

3.2.1.3 Vegetation mapping

Review of the previous vegetation surveys conducted for GNH between Muchea and Wubin identified various methods to delineate vegetation types. Two assessments (ENV 2007; Western Botanical 2006) utilised an approach where descriptions of vegetation undertaken in the field were subsequently matched with those of Shepherd *et al.* (2002). This approach was adopted for the current study because:

- matching the vegetation recorded to the vegetation types of Shepherd *et al.* (2002) facilitated assessment of the significance at a regional level
- the study area traverses areas that are highly impacted by multiple land uses, particularly broad scale clearing for agriculture, which have substantially altered natural community structure and values
- of the previous vegetation assessments available for review, Western Botanical (2006) and ENV (2007) were the only studies that provided description of the methods undertaken to determine vegetation types facilitating replication of the methodology.

The vegetation descriptions from quadrats and relevés from the current survey were grouped according to similarity of community structure (i.e. canopy levels) and species composition. Vegetation types were matched with the vegetation associations of Shepherd *et al.* (2002) according to the presence of the predominant species (e.g. York Gum (*Eucalyptus loxophleba*), Salmon Gum (*Eucalyptus salmonophloia*)) or combination of species and the prevalent community structure (i.e. woodland, shrubland, etc.). The vegetation boundaries were mapped utilising high quality colour aerial photography (year of capture: 2012) and from vegetation boundaries recorded on GPS during the field survey.

The vegetation classification scale used by Shepherd *et al.* (2002) was of a regional scale (WA) and therefore provided less detail than the current survey, Western Botanical (2006) and ENV (2007) assessments. The locations of some of the vegetation types mapped by Shepherd *et al.* (2002) were

supplemented to include additional types within it. For example, riparian vegetation was omitted by Shepherd *et al.* (2002).

3.2.2 Fauna and fauna habitat

A fauna assessment was conducted for the study area over five site visits, primarily to accommodate changes to the study area. Initial fauna habitat and significant black cockatoo tree assessments were undertaken concurrently with the flora and vegetation field survey on 4 November 2014 (Figure 1-1). Field work comprised recording fauna habitat attributes at each vegetation quadrat, opportunistic records of conservation significant fauna and recording the location of potential breeding trees for black cockatoos.

This was followed up with a more comprehensive Level 1 fauna survey entailing further habitat assessment, targeted searches for evidence of conservation significant fauna and complete significant black cockatoo tree survey within the entire road reserve between SLK 177.30 and SLK 207.72 on 4 – 6 March 2015 (Figure 1-1).

A third field survey was undertaken from 20–22 May 2015 concurrent with the second flora and vegetation field survey in additional areas not previously surveyed, mostly within cleared paddock. Survey methods were consistent with the March 2015 survey (Figure 1-1). An additional small area (from SLK 193. 4 – SLK 195.8) was surveyed on 16 June 2015 concurrent with third flora and vegetation survey using consistent methodology (Figure 1-1).

A subsequent site assessment was undertaken with Tony Kirkby, a recognised subject matter expert on black cockatoos, on 18–19 June 2015 to inspect the recorded habitat trees for hollows suitable for breeding and evidence of use by Carnaby's Black Cockatoo and for evidence of feeding and roosting by the species. The assessment covered all study areas.

Total survey effort over all survey periods was 144 person hours.

The survey was conducted in accordance with Position Statement No. 3: *Terrestrial biological surveys as an element of biodiversity protection* (EPA 2002) and Guidance Statement No. 56: *Terrestrial fauna surveys for environmental impact assessment in Western Australia* (EPA 2004a), representing a Level 1 assessment but with particular emphasis on conservation significant fauna. The survey of potential breeding trees, roosting sites and breeding/ foraging/ roosting habitat for black cockatoo species was also carried out with consideration for the EPBC Act referral guidelines for threatened black cockatoo species (DSEWPaC 2012a).

3.2.2.1 Habitat assessment

During the field survey, fauna habitat attributes were assessed and recorded at each flora and vegetation quadrat (Figure 3-1) including habitat type, degree of connectivity, degree of disturbance and presence of rock piles, granite and large logs and debris at ground level. Soil type was also recorded with the quadrats. Habitat suitability and likelihood of occurrence was assessed for conservation significant terrestrial fauna species identified as potentially occurring from the desktop review. Fauna habitat mapping was later undertaken based on vegetation type mapping. Vegetation types with similar fauna habitat attributes were aggregated to generate fauna habitat boundaries.

3.2.2.2 Targeted searches for conservation significant species.

Targeted searches for conservation significant fauna species identified as potentially occurring were undertaken in the study area in areas identified with potential habitat value. The searches were limited to bird observations in response to the findings of the habitat assessment.

3.2.2.3 Survey of potential breeding trees, feeding sites and roosting sites for black cockatoo species

Breeding habitat for black cockatoos is defined in the EPBC referral guidelines (DSEWPaC 2012a) as "trees of species known to support breeding (Table 3-5) within the range of the species which either have a suitable nest hollow or are of a suitable diameter at breast height (DBH) to develop a nest hollow. For most tree species, suitable DBH is 500 mm. For salmon gum and wandoo, suitable DBH is 300 mm." Breeding habitat for Carnaby's Black Cockatoo generally consists of woodland or forest; however, the species is also known to breed in former woodland or forest which is now isolated trees (DSEWPaC 2012a). Refer to Table 3-5 for known breeding trees.

The location of all potential breeding trees for Carnaby's Black Cockatoo was recorded in the study area during the field survey. Both live and dead tree species known to be suitable for nesting were inspected for presence of hollows and recorded using a GPS. Species identifications were initially conducted in the field and later checked using photos and field samples.

In the follow up site visit on 18–19 June 2015, all potential breeding trees recorded with hollows in the previous surveys were inspected by Tony Kirkby from ground level using binoculars to identify any known nesting trees, i.e. any existing trees in which breeding has been recorded or suspected. Trees with hollows suitable for current breeding by Carnaby's Black Cockatoo were inspected for evidence of use by the species, e.g. wear and chew marks around hollow entrance. Any tree containing a hollow which appeared suitable for Carnaby's Black Cockatoo was raked with a pole to flush any breeding birds which may be incubating eggs or brooding a chick[2].

Searches for food species and feeding residues were conducted at 33 areas adjacent to the tree hollow inspections and also within a 100 m transect in remnant vegetation at SLK 194.3. Inspections were also conducted for evidence of and night roost sites by Carnaby's Black Cockatoo. Night roost sites are trees or groups of trees where there are records or recent evidence of night roosting. They can be identified from presence of clipped leaves and branches and droppings under suitable trees. Roosting habitat for Carnaby's Black Cockatoo is generally in or near riparian features or natural and artificial permanent water sources. Known roosting genera include Flat-topped Yate, Salmon Gum, Wandoo, Marri, Karri, Blackbutt, Tuart, introduced eucalypts (e.g. Blue Gum) and introduced pines (DSEWPaC 2012a).

[2] This was highly unlikely at the time of the survey as most Carnaby's Black Cockatoo would have completed breeding for the 2014-2015 season (pers. comm. T. Kirkby).

Table 3-5 Known breeding trees for WA black cockatoo species (DSEWPaC 2012a)

Species[1]	DBH (mm)
Eucalyptus marginata (Jarrah)	500
Corymbia calophylla (Marri)	500
Eucalyptus salmonophloia (Salmon Gum)	300
Eucalyptus wandoo (Wandoo)	300
Eucalyptus rudis (Flooded Gum)	500
Eucalyptus loxophleba subsp. *loxophleba* (York Gum)	500
Eucalyptus accedens (Powderbark)	500
Eucalyptus camaldulensis[2]	500

[1] list excludes species for which study area is outside the known species distribution, as provided in FloraBase.
[2] not mentioned in DSEWPaC (2012a) referral guidelines; however, is known to be used for breeding (T. Kirkby pers. comm. April 2015).

3.2.2.4 Mapping of breeding and foraging habitat for Carnaby's Black Cockatoo

Mapping of potential breeding and foraging habitat within the study area was undertaken utilising field survey results and quadrat data from the flora and vegetation survey.

Foraging habitat for black cockatoos is determined from the presence of plant species that are known food sources for the respective species and evidence of feeding, such as direct observation of birds or feeding residues (chewed nuts or cones). The referral guidelines (DSEWPaC 2012a) define 'quality' habitat by black cockatoo use of the habitat (as opposed to overall quality of the vegetation).

Many plant species have been recognised to be utilised as a food resource by Carnaby's Black Cockatoo (DEC 2011; DSEWPaC 2012a) but relative 'importance' of each species varies considerably. While some plants are known staple food resources for the species (e.g. several *Banksia* species), other plants have been identified from few observations.

In order to account for this variability in mapping quality foraging habitat, a rating was applied to food plant species recorded in the study area based on regional records of foraging activity. Plant species lists from vegetation quadrats of the flora and vegetation survey were initially reviewed to identify species known to be used as food (as well as breeding and roosting) by Carnaby's Black Cockatoo. Species were then rated for importance as a food resource on a scale of 1 to 10 by Tony Kirkby where a rating of 10 is highest importance and a rating of 1 is lowest importance.

The rating took into account:

- records of foraging activity from survey work undertaken by the WA Museum in the general region
- broader knowledge of core food plants for Carnaby's Black Cockatoo
- abundance of food resource, e.g. amount of seed typically produced
- seasonality of food supply, e.g. Carnaby's Black Cockatoo takes nectar from Salmon Gum and Wandoo but only for a limited period.

Vegetation types in quadrats containing known plant species were selected and percentage cover of each plant species over the quadrat was given a rating from 1–3, where:

- 1 = 0.1–19%
- 2 = 20–49%
- 3 = >50%.

The importance rating for each plant in each quadrat was then multiplied by the cover rating and the values for all plants in each quadrat summed to derive an overall quality rating for the quadrat which was assigned to one of three categories:

- 0 = No value
- 1-19 = Habitat of low value
- > 20 = 'Quality' habitat.

Foraging habitat value for vegetation types in the study area was then extrapolated based on the quadrat values, where vegetation polygons containing a quadrat were assigned the value of the quadrat. If there was more than one quadrat within a single polygon, the highest value was applied to the polygon. Vegetation polygons without a quadrat were extrapolated from adjacent polygons. Polygons with cleared vegetation, pasture or planted vegetation types were ignored.

It is emphasised that the rating assessment was a subjective exercise and relative importance of each species will vary between locations.

To generate an area-based map of breeding habitat, potential breeding trees identified from the field surveys were displayed over vegetation types mapped in the flora and vegetation survey. Polygons of remnant vegetation types that contained potential breeding trees were defined as 'breeding habitat in vegetation types representing remnant native vegetation' All other potential breeding trees, many occurring as isolated trees within pastures were displayed as points only and labelled 'potential breeding trees in vegetation types not representing remnant native vegetation'.

3.3 TAXONOMY AND NOMENCLATURE

Species that were well known to the survey botanist were identified in the field, while unknown species were collected and assigned a unique number to facilitate tracking. All plant species collected during the field program were preserved in accordance with the requirements of the WA Herbarium.

Plant species were identified using local and regional flora keys, and comparisons with named species held at the WA Herbarium. Plant taxonomists who are considered to be an authority on a particular plant group were consulted when necessary.

The conservation status of all recorded flora was compared against the current lists available on FloraBase (DPaW 2015a) and the EPBC Act Threatened species database provided by the Department of the Environment (Department of the Environment 2015).

Nomenclature for flora and vegetation used in this report follows that used by FloraBase (DPaW 2015a) and the WA Herbarium.

Nomenclature used for each vertebrate fauna group is as follows:

- amphibians (Tyler & Doughty 2009)
- reptiles (Wilson & Swan 2013)
- birds (Christidis & Boles 2008)
- mammals (Menkhorst & Knight 2011).

Some taxonomy and nomenclature for species records from previous surveys used in the review has been updated with the publications above for consistency.

3.4 SURVEY PERSONNEL

The personnel involved in the survey are presented below (Table 3-6).

Table 3-6 Project team

Name	Qualifications	Role/s
Mrs Karen Crews	BSc (Env. Biol.) (Hons)	Project Manager, report review
Dr Grant Wells	PhD (Botany)	Field survey management, flora taxonomy, data analyses and report writing
Dr Grace Wells	PhD (Plant Conservation)	GIS, flora taxonomy and report writing
Ms Emily Ager	BSc (Nat. Res. Mgmt.) (Hons)	Field surveys and flora taxonomy
Mr Ryan Ellis	Dip (Cons. Land Mgmt.)	Field surveys, fauna taxonomy and report writing
Ms Anna Leung	BSc (Env. Sci.) (Hons)	Field surveys, fauna taxonomy and report writing
Mr Jarrad Clark	BSc (Env. Mgt)	Field survey (black cockatoo assessment)
Mr Tony Kirkby		Field survey (black cockatoo assessment)
Mr Guillaume Bouteloup	Ad. Dip. (Cons. Land Mgmt. - France), ArcGIS	GIS, spatial analysis, cartography and technical advice on avifauna

4 EXISTING ENVIRONMENT

4.1 INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA

The Interim Biogeographic Regionalisation of Australia (IBRA) defines 'bioregions' as large land areas characterised by broad, landscape-scale natural features and environmental processes that influence the functions of entire ecosystems (Thackway & Cresswell 1995a). They categorise the large-scale geophysical patterns that occur across the Australian continent that are linked to fauna and flora assemblages and processes at the ecosystem scale (Thackway & Cresswell 1995a).

WA contains 26 IBRA bioregions and 53 subregions. The study area falls within the Avon Wheatbelt bioregion. The Avon Wheatbelt bioregion covers an area of 95,171 km^2 and is divided into two subregions; Merredin (AVW01) covering 65,242 km^2 and Katanning (AVW02) covering 29,929 km^2 (Beecham 2001b; Department of the Environment 2014b). The study area spans both subregions.

The Merredin subregion is an ancient peneplain with low relief and gently undulating landscape (Beecham 2001a). Proteaceous scrub-heaths, rich in endemic flora on residual lateritic uplands and derived sandplains with mixed *Eucalyptus* and *Allocasuarina* woodlands on Quaternary alluvials and eluvials. Lateritic uplands are dominated by yellow sandplain. Special values include Yorkrakine Rock and Durokoppin Nature Reserve with a high density of flora species that supports high species richness, local endemism of invertebrate species and provides fauna refuges.

The Katanning subregion comprises erosional surface of gently undulating rises to low hills with abrupt breakaways and continuous stream channels (Beecham 2001b). Soil formed in colluvium or within weathered rocks supports woodlands of Wandoo (*Eucalyptus wandoo*), York Gum (*Eucalyptus loxophleba* subsp*. loxophleba*) and Salmon Gum (*Eucalyptus salmonophloia*) with Jam (*Acacia acuminata*) and *Casuarina* spp. Special values include Toolibin Lake (principal breeding ground for waterbirds in SW Australia), Pingelly (Boyagin-Tutanning Reserves) with high density of rare and geographically restricted flora, Dryandra woodland and the South West Botanical Province with high flora diversity and *Eucalyptus* Woodlands with high floristic diversity and a high proportion of Threatened Flora (around 25%) (Hopper *et al.* 1990; Yates *et al.* 2000).

Both Merredin and Katanning subregions contain Critical Weight Range Mammals (native species that have been most impacted by introduced predator species; 35–5,500 g; Johnson & Isaac 2009). Two species are now extinct (the Pig-footed Bandicoot and Crescent Nailtail Wallaby) and several species are considered locally extinct including the Dibbler (*Parantechinus apicalis*).

4.2 CLIMATE AND WEATHER

The climate of the Avon Wheatbelt is described as semi-arid warm Mediterranean. In general, the study area experiences warm dry summers and cool wet winters. The nearest Bureau of Meteorology (BoM) weather station is located at Dalwallinu (Latitude: 30.28°S, Longitude: 116.67°E) approximately 38 km north of the study area. Dalwallinu weather station records the highest maximum mean monthly temperature (35.4°C) in January, the lowest maximum mean monthly temperature (16.9°C) in July and an average annual rainfall of 286.5 mm (BoM 2015) (Figure 4-1).

Daily maximum temperatures were above average at Dalwallinu in the months leading up to the spring 2014 survey and below average in March to May 2015 (Figure 4-1). Rainfall at Dalwallinu leading up to the spring 2014 survey variable with above average rainfall in September and below average rainfall in August. Well above average rainfall was experienced in February, March and April 2015 (Figure 4-1).

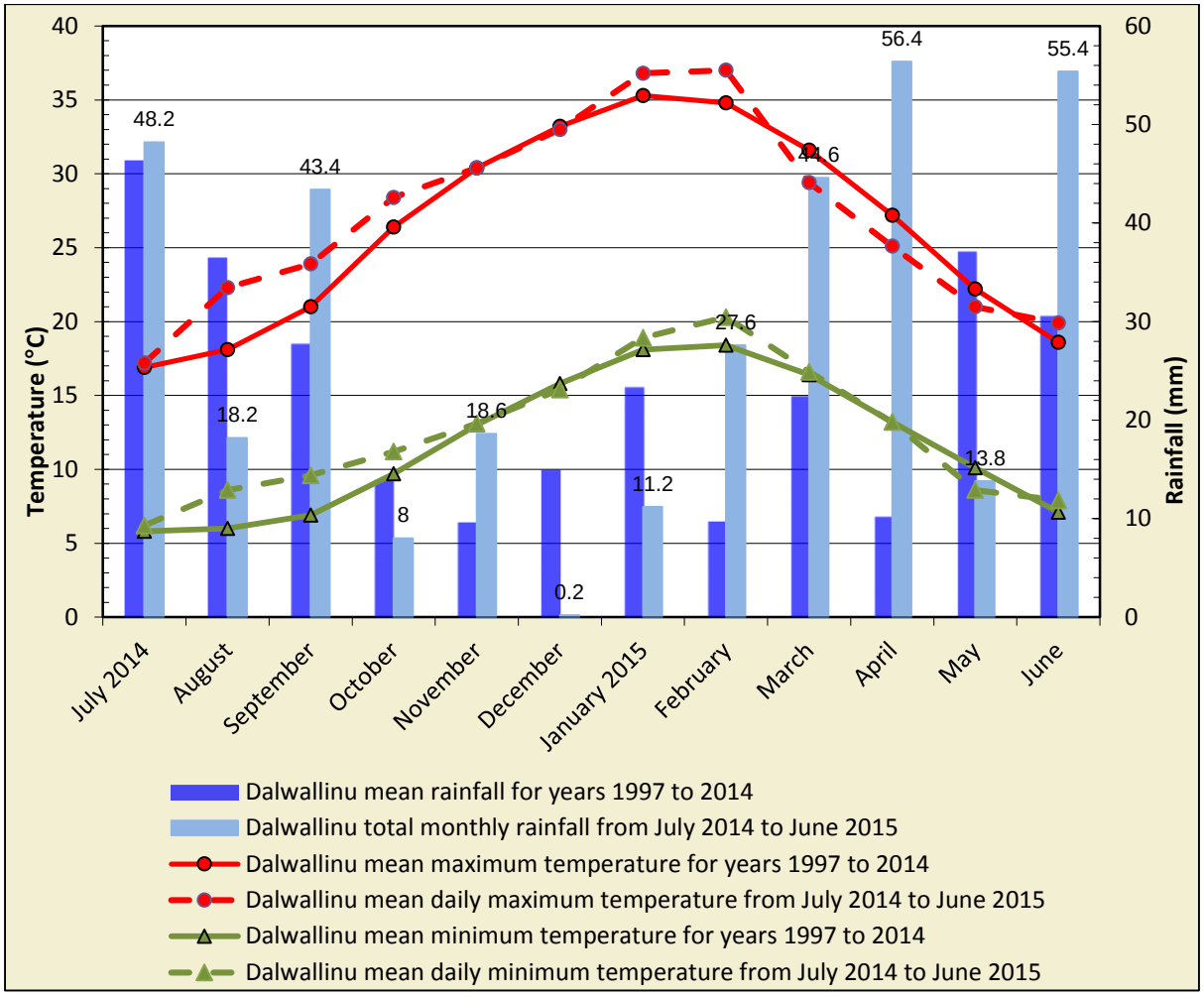

Figure 4-1 **Climate data (average monthly temperatures and rainfall records) and recent observations prior to the field survey for Dalwallinu (BoM 2015)**

4.3 LAND SYSTEMS

The Department of Agriculture and Food WA has mapped the land systems of the Merredin and Katanning subregions from aerial photography. Land systems are grouped according to a combination of landform, soils, vegetation and drainage patterns. The study area comprises two land systems (Figure 4-2):

- **Burabidge Hill System (504.82 ha; 77.1%) –** Undulating rises to low hills with rock outcrop. granite, migmatite, gneiss. Brown and red loamy and sandy earths, yellow/brown shallow loamy duplex and some stony soil. York gum-jam woodland
- **Ballidu System (127.04 ha; 19.4%) –** Gently undulating sandplain with narrow flat valleys, from weathered granite, yellow to brown sands to earths with some gravel on rises and red to brown earths to duplexes in valleys.
- **Goomalling System (22.70 ha; 3.5%) –** Poorly drained valley flats, in the northern Zone of Rejuvenated Drainage, with grey deep sandy duplex (sometimes alkaline) and saline wet soil. York Gum-Jam-Wandoo-Salmon Gum-Sheoak woodland.

Figure 4-2 Land systems of the study area

4.4 NATIVE VEGETATION EXTENT AND STATUS

The study area lies within the Avon Botanical District of the South-West Botanical Province characterised by scrub-heath on sandplain, *Acacia-Casuarina* thickets on ironstone gravels, woodlands of York gum (*Eucalyptus loxophleba)*, salmon gum (*Eucalyptus salmonophloia)* and wandoo (*Eucalyptus wandoo)* on loams, halophytes on saline soils (Beard 1990).

A vegetation type is considered under represented if there is less than 30% of its original distribution remaining. Several key criteria are applied to vegetation clearing from a biodiversity perspective, as follows (EPA 2000):

- the 'threshold level' below which species loss appears to accelerate exponentially within an ecosystem level is regarded as being at a level of 30% (of the pre-European, i.e. pre 1750 extent of the vegetation type)
- a level of 10% of the original extent is regarded as being a level representing Endangered
- clearing which would result in an increase in the threat level such that it changes the assigned remaining status classification (see below) should be avoided.

Shepherd *et al.* (2002) have assigned the status of vegetation remaining (to pre-European extent) into five classes:

- Presumed Extinct – probably no longer present in the bioregion
- Endangered[3] – <10% of pre-European extent remains
- Vulnerable[3] – 10-30% of pre-European extent exists
- Depleted[3] – >30% and up to 50% of pre-European extent exists
- Least Concern – >50% pre-European extent exists and subject to little or no degradation over a majority of this area.

Regional vegetation mapping by Shepherd *et al.* (2002) indicates the presence of four vegetation types within the study area (Figure 4-3):

- 142 'Medium woodland; York gum (*E. loxophleba*) & Salmon gum (*Eucalyptus salmonophloia*)' (26.66% remaining) – covering the vast majority of the study area
- 551 'Shrublands, *Allocasuarina campestris* thicket' (27.7% remaining)
- 631 'Succulent steppe with woodland and thicket; York gum (*Eucalyptus loxophleba*) over *Melaleuca thyoides* and samphire (*Tecticornia* spp.)' (47.84% remaining)
- 1024 'Shrublands, mallee and *Casuarina* thicket' (11.76% remaining).

Based on Shepherd *et al.* (2002), in terms of extent of vegetation remaining compared to pre-European extents, vegetation type 631 is classified as 'Depleted', vegetation types 142 and 551 are classified as 'Vulnerable and vegetation type 1024 is classified as 'Endangered'.

[3] or a combination of depletion, loss of quality, current threats and rarity gives a comparable status.

4.5 CONSERVATION RESERVES AND ESAS

The nearest conservation reserves to the study area are Damboring Nature Reserve (667 ha) located approximately 11 km south-east of the eastern end of the study area, Long Pool Nature Reserve (68 ha) located approximately 18 km west of the study area and Martinjinni Nature Reserve (254 ha) located approximately 17 km north of the study area (Figure 4-3).

No national (Australian) protected areas or ESAs were identified within a 10 km buffer of the study area.

Figure 4-3 Regional vegetation, conservation reserves and environmentally sensitive areas

5 RESULTS

5.1 SURVEY LIMITATIONS

The limitations of the 2015 survey have been considered in accordance with the potential survey limitations listed in Guidance Statement 51 (EPA 2004b) and Guidance Statement 56 (EPA 2004a) (Table 5-1).

Table 5-1 Limitations and constraints associated with the field survey

Variable	Impact on survey outcomes
Availability of contextual information	**Slight constraint.** Existing information on the vegetation and land systems of the study area has been mapped by Shepherd *et al*. (2002). Access to online floristic records and information including previous studies undertaken on or in close proximity to the study area provided adequate information on the vegetation of the study area. Few existing systematic fauna surveys were available within close proximity to the study area; however, this is not considered a major constraint due to condition of habitat present.
Access problems	**Not a constraint.** No access problems were encountered during the field survey and the majority of the study area (open paddocks excepted) was traversed by foot.
Experience levels	**Not a constraint**. The survey was undertaken by suitably qualified and experienced botanists and zoologists.
Timing, weather, season	**Slight constraint.** According to EPA Guidance Statement 51 the preferred flora survey time in the bioregion is spring. The initial survey was conducted in spring when the majority of quadrats were surveyed. Other areas were surveyed in autumn and early winter but the seasonal conditions were favourable with many individual plants flowering. Limited numbers of annual grasses indicate that further species may be recorded in the following spring. There were no constraints from a fauna survey perspective.
Disturbances	**Slight constraint**. Large sections of the study area were in degraded to completely degraded condition from multiple historical disturbances particularly clearing and weed infestation making it difficult to discern changes in vegetation type in some areas**.**
Survey intensity	**Not a constraint.** The field program was conducted over four survey events for a total of 206 flora and 144 fauna person hours. A total of 59 quadrats and 24 relevés were sampled and most patches of remnant and planted vegetation encompassed by the study were traversed by foot in search of significant flora and fauna. Targeted searches for conservation significant flora and fauna were conducted in all areas considered to have potential to provide suitable habitat. Additional flora searches were conducted outside study area in the vicinity of conservation significant flora records to determine the extent of populations. The black cockatoo breeding tree, roosting site and breeding/ foraging/ roosting habitat assessment was conducted for the entire study area.
Completeness	**Slight constraint.** The lack of annual species in the areas surveyed in May and June 2015, and the incapacity to identify some annual grasses indicate that some species that may occur in the study area have not been identified and further surveys in spring may be warranted. The fauna survey was focussed on identifying the potential for presence of conservation significant species in the study area. Systematic censusing of the fauna assemblage was not

Variable	Impact on survey outcomes
	undertaken but this is consistent with other surveys for similar linear infrastructure projects in the region.
Determination	**Not a constraint.** Determinations regarding taxonomy and conservation status of flora and fauna were made on the basis of current classifications.

5.2 DESKTOP REVIEW

5.2.1 Flora and vegetation

5.2.1.1 Conservation significant flora

The desktop and literature review identified a total of 40 conservation significant species (Table 5-2). Of these, two are listed as Vulnerable (VU), 21 as Endangered (EN) and three as Critically Endangered (CE) under the EPBC Act, and four are listed as Threatened under the WC Act (Table 5-2). A further 12 species are listed as Priority Flora by DPaW (2015b), three Priority 1, two Priority 2 and seven Priority 3 (Table 5-2).

Review of the current status of Threatened and Priority Flora species on FloraBase (DPaW 2015a) identified two changes. All conservation significant flora listed in EPBC Protected Matters database search are classified as Threatened under the WC Act, except *Centrolepis caespitosa* which is listed as Priority 4. The EPBC Protected Matters database search lists *Centrolepis caespitosa* as Endangered. The name of the Endangered species *Drakonorchis drakeoides* had changed to *Caladenia drakeoides*.

From the combined State database searches (DPaW 2014b) and literature review, two conservation significant flora were identified to occur within the study area. The species comprise one Threatened flora *Grevillea bracteosa* subsp*. bracteosa* and one Priority 1 species, *Grevillea pinifolia*. Priority 3 species, *Melaleuca sclerophylla* was previously recorded within 8 m of the survey area. Six other species were located within 1 km of the study area, including two Threatened flora (*Caladenia drakeoides* and *Gastrolobium appressum*), one Priority 1 species (*Caladenia cristata*) and three Priority 3 species (*Gastrolobium rotundifolium*, *Urodon capitatus* and *Verticordia venusta*). In addition, Priority 1 species, *Acacia trinalis*, was listed by NatureMap to occur approximately 4 km west of the survey area. Only one species, *Grevillea bracteosa* subsp*. bracteosa* was identified in the previous survey conducted within the study area (Ecologia 2004).

Table 5-2 Conservation significant flora species identified from the desktop review

Species name	Common name	Reference	EPBC Threatened species	WC Act Conservation Significant species	DPaW list	Approximate distance to study area (km)
Acacia cochlocarpa subsp. *cochlocarpa*	Spiral-fruited Wattle	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Acacia cochlocarpa subsp. *velutinosa*	Velvety Spiral Pod Wattle	Protected Matters	T (CE)			Species or species habitat may occur within 10 km of the area
Acacia lirellata subsp. *compressa*		NatureMap			P2	Within 10 km buffer
Acacia trinalis		NatureMap			P1	Within 10 km buffer
Boronia ericifolia		NatureMap			P2	Within 10 km buffer
Caladenia cristata	Crested Spider Orchid	NatureMap, DPaW 2014c			P1	Within 10 km buffer
Caladenia drakeoides		NatureMap, DPaW 2014c		T (S1)	T	Within 10 km buffer
Centrolepis caespitosa		Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Chorizema humile	Prostrate Flame Pea	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Conospermum densiflorum subsp. *unicephalatum*	One-headed Smokebush	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Daviesia dielsii	Diels' Daviesia	NatureMap, Protected Matters	T (EN)	T (S1)		Within 10 km buffer
Dasymalla axillaris	Native Foxglove	Protected Matters	T (CE)			Species or species habitat may occur within 10 km of the area
Daviesia euphorbioides	Wongan Cactus	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Drakonorchis drakeoides Current name: Caladenia drakeoides		Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Eremophila pinnatifida	Pinnate-leaf Eremophila	Protected Matters	T (EN)			Species or species habitat

Species name	Common name	Reference	EPBC Threatened species	WC Act Conservation Significant species	DPaW list	Approximate distance to study area (km)
						may occur within 10 km of the area
Eremophila scaberula	Rough Emu Bush	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Eremophila viscida	Varnish Bush	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Eucalyptus recta	Silver Mallet	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Frankenia conferta	Silky Frankenia	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Gastrolobium appressum	Scaleleaf Poison	NatureMap, DPaW 2014c, Protected Matters	T (VU)	T (S1)	T	Within 10 km buffer
Gastrolobium hamulosum	Hook-point Poison	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Gastrolobium rotundifolium	Gilbernine Poison	NatureMap, DPaW 2014c			P3	Within 10 km buffer
Grevillea asparagoides		NatureMap, DPaW 2014c			P3	Within 10 km buffer
Grevillea bracteosa subsp. *bracteosa*		NatureMap, DPaW 2014c		T (S1)	T	Within 10 km buffer
Grevillea pinifolia	Pine-leaved Grevillea	NatureMap, DPaW 2014c			P1	Within 10 km buffer
Grevillea dryandroides subsp. *dryandroides*	Phalanx Grevillea	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Grevillea dryandroides subsp. *hirsuta*	Hairy Phalanx Grevillea	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Grevillea pythara		Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Gyrostemon reticulatus	Net-veined Gyrostemon	Protected Matters	T (CE)			Species or species habitat may occur within 10 km of the area

Species name	Common name	Reference	EPBC Threatened species	WC Act Conservation Significant species	DPaW list	Approximate distance to study area (km)
Hemiandra gardneri	Red Snakebush	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Jacksonia pungens	Pungent Jacksonia	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Melaleuca sclerophylla		NatureMap, DPaW 2014c			P3	Within 10 km buffer
Podotheca uniseta		NatureMap			P3	Within 10 km buffer
Rhagodia acicularis		Protected Matters	T (VU)			Species or species habitat may occur within 10 km of the area
Rhizanthella gardneri	Underground Orchid	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Roycea pycnophylloides	Saltmat	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Stylidium periscelianthum	Pantaloon Triggerplant	NatureMap			P3	Within 10 km buffer
Urodon capitatus		NatureMap, DPaW 2014c			P3	Within 10 km buffer
Verticordia staminosa subsp. *staminosa*	Wongan Featherflower	Protected Matters	T (EN)			Species or species habitat may occur within 10 km of the area
Verticordia venusta		NatureMap, DPaW 2014c			P3	Within 10 km buffer

S1 – Schedule 1

5.2.1.2 Introduced flora

The search of the databases and review of previous flora surveys identified a total of nine weed species likely to be present in the study area of which one species, **Echium plantagineum*, a Declared plant, has previously been recorded in the road reserve (Table 5-3). None of the weeds were classified as WoNS.

Table 5-3 Weed species recorded with 1 km buffer of study area

Species	Common name	Declared plant	Reference
**Arctotheca calendula*	Cape Weed	No	NatureMap, DPaW (2015a)
**Bromus rubens*	Red Brome	No	NatureMap, DPaW (2015a)
**Chondrilla juncea*	Skeleton Weed	Yes (C2 Eradication)	NatureMap, DPaW (2015a)
**Cotula bipinnata*	Ferny Cotula	No	NatureMap, DPaW (2015a)
**Echium plantagineum*	Paterson's Curse	Yes (C3 Management)	NatureMap DPaW (2015a), AECOM (2012)
**Limonium sinuatum*	Perennial Sea Lavender	No	NatureMap, DPaW (2015a)
**Oncosiphon piluliferum*		No	NatureMap, DPaW (2015a)
**Panicum antidotale*	Giant Panic Grass	No	NatureMap, DPaW (2015a)
**Parentucellia latifolia*	Common Bartsia	No	NatureMap, DPaW (2015a)

[1]Declared plant: control measures in brackets.

5.2.1.3 Vegetation

No TECs, PECs or ESAs were recorded within a 10 km buffer of the study area.

Along the GNH between Walebing and Bindi Bindi, approximately 10-20 km south of the study area, Access Alliance (2008) identified two vegetation types as conservation significant for being under-represented in the area:

- 1023 – Medium woodland; York gum, wandoo & salmon gum, 10.9% pre-European extent remaining (Vulnerable)
- 1046 – Succulent steppe with woodland; York gum & samphire, 9.7% pre-European extent remaining (Endangered).

While the flora and vegetation survey was some distance from the study area (approximately 30 km south), Worley Parsons (2013) considered clearing of vegetation within the GNH road reserve from Batty Bog Road to Walebing to be at variance to the second clearing principle (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'* – in particular in relation to habitat for Carnaby's Black Cockatoo – and the fifth clearing principle (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*'. This philosophy could also apply to the New Norcia Bypass as the area has been extensively cleared.

AECOM (2012) identified three vegetation units (Wd1, Wd2 and Wd3) as equivalent to the PEC '*Eucalyptus* woodlands of the Western Australian Wheatbelt' within the GNH road reserve in a study area that abuts the current study area and extends south along the GNH approximately 12 km to Bindi Bindi. These three units and a further six units (Jam1, Jam2, Jam3, Jam4, Salt1 and Salt2) were

considered regionally significant as they comprise vegetation association 142 Medium woodland; York Gum and Salmon Gum (Shepherd *et al.* 2002) which has just 26.66% of pre-European extent and was therefore considered under represented and vulnerable based on Shepherd *et al.* (2002).

Figure 5-1 Threatened and Priority Ecological Communities in the vicinity of the study area

5.2.2 Fauna and fauna habitat

From the desktop review, 118 vertebrate fauna have been previously recorded in the vicinity of the study area (Table 5-4; Appendix 3). A total of 11 invertebrate species were also identified in the database searches (Table 5-4; Appendix 3). The list was strongly dominated by birds (81 species). Due to a lack of systematic surveys in the area, fauna groups, particularly amphibians, reptiles and small mammals are likely to be significantly underrepresented. Up to nine introduced species were identified; Rock Dove, Laughing Dove, Common Starling, House Mouse, Rabbit, Dog, Red Fox, Cat and Goat (Appendix 3).

Table 5-4 Summary of fauna identified in desktop review for the study area

Class	Number of species
Invertebrates	11
Fish	1
Amphibians	2
Reptiles	16
Birds	81
Mammals	7
Total	**118**

Of the fauna species identified from the desktop review, 15 are conservation significant (approximately 14%), protected by Commonwealth and/or State legislation, or listed as Priority species by DPaW (Table 5-5; Table 5-6). EPBC Act Marine species returned from the database searches have been excluded from the results as they are not relevant to the study area, considering its geographical location, and are therefore not discussed further within this report.

One species, Australian Painted Snipe identified in the desktop review is listed as both Endangered and Migratory under the EPBC Act and WC Act. Another record from the desktop review, the Western Ground Parrot (Table 5-6) is considered to be erroneous due to the lack of any confirmed historic records north of Perth and the species current restricted distribution in the far south-west of Western Australia and is not discussed further within this report.

Table 5-5 Summary of conservation significant fauna returned from database searches

Conservation category	Number of species[1]
EPBC Act Threatened species	9
EPBC Act Migratory species	5
WC Act Schedule species	14
DPaW Priority species	1

[1] Several species are listed under both EPBC Act and WC Act.

Table 5-6 Conservation significant fauna returned from database searches

Scientific name	Common name	EPBC Threatened species	EPBC Migratory	WC Act	DPaW
Invertebrates					
Idiosoma nigrum	Shield-backed Trapdoor Spider	VU		S1	
Reptiles					
Egernia stokesii badia	Western Spiny-tailed Skink	EN		S1	VU
Birds					
Leipoa ocellata	Malleefowl	VU		S1	VU
Apus pacificus	Fork-tailed Swift		•	S3	
Ardea modesta	Eastern Great Egret		•	S3	
Ardea ibis	Cattle Egret		•	S3	
Falco peregrinus	Peregrine Falcon			S4	SP
Thinornis rubricollis	Hooded Plover				P4
Rostratula australis	Australian Painted Snipe	EN	•	S1/S3	EN
Calyptorhynchus latirostris	Carnaby's Black-cockatoo	EN		S1	EN
Calyptorhynchus baudinii	Baudin's Black-cockatoo	VU		S1	EN
Cacatua pastinator pastinator	Muir's Corella	VU		S4	SP
Pezoporus flaviventrus	Western Ground Parrot	CR		S1	CR
Merops ornatus	Rainbow Bee-eater		•	S3	
Mammals					
Dasyurus geoffroii	Western Quoll	VU		S1	VU

SP – Other specially protected fauna.

5.3 FIELD SURVEY

5.3.1 Flora and vegetation

A total of 235[4] taxa representing 46 families and 110 genera were recorded in the study area (Appendix 4) and comprised 198 native species and 37 weeds. A total of 67 annual species and 168 perennial species were recorded. The most prominent families were Myrtaceae (33), Fabaceae (30), Chenopodiaceae (30), Poaceae (44), Asteraceae (15) and Proteaceae (13) (Appendix 4).

[4] A large number of Poaceae species (19 or 43%) could not be definitively identified to species level as they were either too immature (seedlings) or dry and dead and lacked sufficient floristic characters. It is likely that there would be some duplication of species and consequently the actual numbers for species, weeds and natives for the family Poaceae may be lower.

Specimens collected of 31 taxa could not be definitively identified to species level (the majority collected in the 2015 surveys):

- Asteraceae sp. – annual species, dead and dry at time of collection and lacked sufficient structures for definitive identification
- 19 Poaceae sp. specimens and *Enneapogon* sp. – either annual species, dead and dry at time of collection, or, seedlings/sterile juvenile plants that lacked sufficient structures for definitive identification
- *Acacia* sp., *Maireana* sp., *Tecticornia*? *moniliformis* and Iridaceae sp. – seedlings lacking sufficient structures for identification
- *Atriplex* sp., *Conostylis* sp., *Eucalyptus* sp., *Verticordia* sp. and *Compesperma* sp. – lacked sufficient reproductive structures for definitive identification
- *Eucalyptus* aff. *salubris* – a species planted in an area of revegetation alongside several other non-local *Eucalyptus* trees (e.g. *E. torquata*).

The specimens collected did not resemble any of the conservation significant flora identified from the desktop survey as occurring within the proximity of the study area.

5.3.1.1 Conservation significant flora

The search of the DPaW database provided a single location of the Priority 3 species *Melaleuca sclerophylla* within the study area. A thorough search conducted at this location failed to locate any plants of this species. The location occurs within a small remnant patch in a cleared paddock and it appears as though the recorded population has been removed.

A total of seven conservation significant flora were recorded for the study area (Figure 5-2). Specimens of each of the taxa were lodged with the WA Herbarium for confirmation of identity.

***Chamelaucium* sp. Wongan Hills Priority 3**
A single population of the species comprised of seven individuals was recorded in the study area (Figure 5-2).

***Dampiera glabrescens* Priority 1**
A specimen from a single plant was opportunistically collected just outside of one of the study area quadrats (Figure 5-2).

***Frankenia glomerata* Priority 3**
Two small populations (comprised of three and six individuals) were located in close proximity to one another on the edge of a salt scald within the study area (Figure 5-2).

***Grevillea asparagoides* Priority 3**
Two populations of the species were recorded in the study area with a combined total of 82 plants (Figure 5-2).

***Grevillea bracteosa* subsp. *bracteosa* Threatened**
A single plant of *Grevillea bracteosa* subsp. *bracteosa* was collected in the study area (Figure 5-2). A considerably larger population (comprised of 64 individuals) was recorded in an adjacent vegetation remnant outside of the study area.

***Grevillea pinifolia* Priority 1**
A single plant was recorded in the study area (Figure 5-2).

***Urodon capitatus* Priority 3**
A single plant was recorded in the study area (Figure 5-2).

Figure 5-2 Conservation significant flora recorded in the study area

5.3.1.2 Introduced flora

A total of 37 weed species were recorded for the study area. All of the species recorded have wide distributions in WA and there were no apparent range extensions for any species.

Weeds recorded for the study area included three declared plants, **Echium plantagineum*, **Opuntia monacantha* and **Tamarix aphylla* (Table 5-7; Figure 5-3). Two species, **Opuntia monacantha* and **Tamarix aphylla*, are listed as WoNS.

Single plants of **Opuntia monacantha* were recorded in the road reserve at two locations and two plants were recorded adjacent the Miling primary school. Several populations and a few single plants of **Tamarix aphylla* were located in the study area, notably the largest populations recorded have been intentionally planted. A single plant, two small populations (two and five plants) and one large population (50 plants) of **Echium plantagineum* were also recorded (Figure 5-3).

Table 5-7 Declared plants recorded in the study area

Species	No. locations	No. plants
**Echium plantagineum*	4	58
**Opuntia monacantha*	3	4
**Tamarix aphylla*	50	55

Figure 5-3 Declared plants recorded in the study area

5.3.1.3 Range extensions

The records from the study area did not represent a range extension for any of the flora identified.

5.3.1.4 Vegetation associations

Nine vegetation associations were defined locally for the study area (Table 5-8; Figure 5-4). This exceeds the four regional vegetation types mapped by Shepherd *et al.* (2002) within the study area (Figure 4-3). Broadly the vegetation types recorded represent low to mid woodlands and shrublands with *Allocasuarina campestris* thicket prominent, mixed shrublands, succulent steppe (samphire, *Tecticornia* spp.) shrublands and mosaics of these vegetation types.

The nine vegetation associations collectively represent 92 ha (14%) of the study area. The remainder of the study area (562 ha, 86%) was mapped as cleared, cleared and planted, pasture, pasture and cleared areas and the existing GNH (i.e. paved road and gravel shoulders).

Table 5-8 Vegetation associations recorded in the study area

Code	Vegetation Description as per Shepherd *et al.* 2002	Quadrat	Vegetation description (current survey)
8	Medium woodland; Salmon Gum & gimlet	P5.31	Mid open *Eucalyptus salmonophloia* and *E. salubris* forest over isolated mid *Dodonaea inaequifolia* shrubs over low isolated *Acacia erinacea*, *Enchylaena tomentosa* and *Maireana brevifolia* shrubs over low sparse **Ehrharta calycina*, **Avena barbata* and **Bromus diandrus* tussock grassland and low isolated *Ptilotus divaricatus*, **Raphanus raphanistrum* and **Sonchus oleraceus* forbs.
142	Medium woodland; York Gum & Salmon Gum	P5.16	Isolated tall *Eucalyptus salmonophloia* trees over a low open *E. ebbanoensis* subsp. *ebbanoensis* and *E. ewartiana* mallee forest over isolated low *Maireana brevifolia*, *Enchylaena tomentosa* and *Rhagodia* sp. Watheroo shrubs over isolated low **Ehrharta calycina* tussock grasses and low isolated *Ptilotus divaricatus* and *Sclerolaena diacantha* forbs.
		P5.32a	Mid open *Eucalyptus salmonophloia* and *E. loxophleba* forest over isolated tall *Acacia acuminata* shrubs over isolated low *Acacia colletioides*, *Atriplex semibaccata* and *Maireana brevifolia* shrubs over low isolated *Austrostipa scabra*, *A. elegantissima* and *Eriachne ovata* tussock grasses and isolated low *Sclerolaena diacantha*, *Calandrinia eremaea* and *Ptilotus divaricatus* forbs.
		P5.35	Tall open *Eucalyptus salmonophloia* forest over isolated mid *E. loxophleba* trees over isolated tall *Santalum acuminatum* shrubs over isolated mid *Eremophila drummondii* and *Rhagodia preissii* shrubs over isolated low *Acacia acuaria*, *Atriplex semibaccata* and *Maireana brevifolia* shrubs over isolated low **Avena barbata*, *Eriachne ovata* and **Bromus rubens* tussock grasses and isolated low *Ptilotus divaricatus*, *Enchylaena tomentosa* and *Sclerolaena diacantha* forbs.
		P5.111	A low open *Eucalyptus salmonophloia* and *E. loxophleba* subsp. *loxophleba* woodland over isolated mid *Acacia hemiteles* and *Melaleuca adnata* shrubs over isolated low *Acacia erinacea*, *Atriplex semibacatta* and *Melaleuca radula* shrubs over isolated low **Avena barbata*, *Austrostipa* sp. and Poaceae sp. tussock

Code	Vegetation Description as per Shepherd *et al.* 2002	Quadrat	Vegetation description (current survey)
			grasses and sparse low *Crassula exserta* and **Mesebryanthemum nodiflorum* forbland.
352	Medium woodland; York Gum	P5.13	Mid *Eucalyptus loxophleba* woodland over a tall open *Acacia aestivalis* and *Alyogyne* sp. Hutt River shrubland over isolated *Rhagodia* sp. Watheroo and *Templetonia smithiana* shrubs over isolated low *Enchylaena tomentosa* and *Maireana brevifolia* shrubs over isolated low **Avena barbata* and **Lolium rigidum* tussock grasses and isolated low *Sonchus oleraceus* forbs.
		P5.18	Low *Eucalyptus loxophleba* woodland over isolated mid *Atriplex amnicola* shrubs over isolated low *Maireana brevifolia* and *Rhagodia* sp. Watheroo shrubs over low **Avena barbata*, **Bromus rubens* and **Ehrharta calycina* tussock grassland and isolated low **Mesembryanthemum nodiflora* forbs.
		P5.19	Low *Eucalyptus loxophleba* forest over low open *Rhagodia* sp. Watheroo, *Maireana brevifolia* and *Enchylaena tomentosa* chenopod shrubland over isolated low *Austrostipa elegantissima*, **Avena barbata* and **Bromus diandrus* tussock grasses.
		P5.25	Low open *Eucalyptus loxophleba* woodland over isolated mid *Acacia daphnifolia* shrubs over isolated low *Maireana brevifolia* and *Atriplex semibaccata* shrubs over low **Avena barbata*, **Bromus diandrus* and **Ehrharta calycina* tussock grassland and low isolated **Mesembryanthemum nodiflorum*, **Limonium sinuatum* and **Sonchus oleraceus* forbs.
		P5.33a	Low *Eucalyptus loxophleba* subsp. *lissophloia* woodland over isolated low *Acacia acuaria*, *Atriplex semibaccata* and *Scaevola spinescens* shrubs over isolated low *Austrostipa elegantissima*, *Eriachne ovata* and **Avena barbata* tussock grasses and isolated low *Calandrinia eremaea* and *Sclerolaena diacantha* forbs.
		P5.34	Mid open *Eucalyptus loxophleba* and *Acacia acuminata* forest over a tall open *Allocasuarina campestris* and *Dodonaea inaequifolia* heathland over isolated low *Rhagodia* sp. Watheroo, *Rhagodia preissii* and *Eremophila lehmanniana* shrubs over low **Ehrharta longiflora*, **Brachypodium distachyon* and **Avena barbata* tussock grassland and isolated low *Hyalosperma cotula*, **Ursinia anthemoides* and *Waitzia acuminata* forbs.
		P5.47a	Mid open *Eucalyptus loxophleba* woodland tall open *Melaleuca hamata*, *Acacia acuminata*, *A. hemiteles* and *Santalum acuminatum* shrubland over isolated low *Enchylaena tomentosa* shrubs in a low open **Ehrharta longiflora*, **Avena barbata* and **Bromus diandrus* tussock grassland and low *Dianella revoluta* and **Mesembryanthemum nodiflorum* forbs.
		P5.84a	A mid *Eucalyptus loxophleba* subsp. *loxophleba* and *E. kochii* subsp. *plenissima* forest over a sparse low *Atriplex amnicola*, *A. nummularia* and *Maireana brevifolia* shrubland over a low open **Bromus rubens* tussock grassland and isolated clumps of low *Dysphania pumilio* and *Asteraceae* sp. forbs.
		P5.85	A low *Eucalyptus loxophleba* subsp. *loxophleba* forest over isolated clumps of low *Atriplex semibaccata* and *Maireana*

Code	Vegetation Description as per Shepherd *et al.* 2002	Quadrat	Vegetation description (current survey)
			brevifolia shrubs over a low open **Avena barbata*,**Lolium rigidum* and **Pentameris airoides* tussock grassland and isolated clumps of low **Arctotheca calendula* and *Erodium cygnorum* forbs.
		P5.90	A low *Eucalyptus loxophleba* subsp. *loxophleba* mallee woodland over a low open *Maireana brevifolia* and *Tecticornia pergranulata* shrubland over a closed low Poaceae spp. tussock grassland and low sparse **Mesembrynathemum nodiflorum* forbland.
		P5.44	Tall open *Eucalyptus salmonophloia* forest over isolated low *Acacia erinacea*, *Enchylaena tomentosa* and *Rhagodia* sp. Watheroo shrubs over isolated *Austrostipa elegantissima*, *Eriachne ovata* and **Ehrharta longiflora* tussock grasses with low isolated *Sclerolaena diacantha*, *Atriplex semilunaris* and **Mesembryanthemum nodiflorum* forbs.
		P5-G6	Low *Eucalyptus capillosa* subsp. *polyclada* and *E. loxophleba* woodland over isolated tall *Dodonaea inaequifolia* shrubs over mid *Melaleuca stereophloia* and *Acacia enervia* subsp. *explicata* shrubland over isolated low *Enchylaena tomentosa* and *Halgania integerrima* shrubs over a low **Ehrharta longiflora* tussock grassland and isolated low **Sonchus oleraceus* and **Mesembryanthemum nodiflora* forbs.
		P5.93	A low *Eucalyptus kochii* subsp. *plenissima* woodland over isolated low *Atriplex semibaccata*, *Maireana brevifolia* and *M. georgei* shrubs over isolated low *Austrostipa elegantissima*, Poaceae spp. and **Pentameris airoides* tussock grasses and isolated low **Mesembryanthemum nodiflorum* and **Arctotheca calendula* forbs.
		P5.106	Low open *Eucalyptus loxophleba* woodland over a low *Enchylaena tomentosa* var. *tomenotsa*, *Maireana brevifolia* and *Tecticornia* sp. shrubland over isolated low *Enneapogon* sp. and **Romulea rosea* var. *australis* tussock grasses and isolated low **Mesembryanthemum nodiflorum*, *Atriplex codonocarpa* and *Podolepis capillaris* forbs.
551	Shrublands; *Allocasuarina campestris* thicket	P5.42	Tall open *Allocasuarina campestris*, *Melaleuca hamata* and *Stylobasium australe* heathland over mid open *Baeckea crispiflora* var. *tenuior*, *Acacia aculeiformis* and *Ricinocarpos muricatus* heathland over isolated low **Ehrharta longiflora* and *Enteropogon ramosus* tussock grasses and isolated low *Spartothamnella teucriiflora*, *Dianella revoluta* and *Trachymene glabra* forbs.
		P5.43a	Tall *Allocasuarina campestris*, *Ricinocarpos muricatus* and *Santalum acuminatum* heathland over a mid-open *Grevillea paniculata* and *Acacia isoneura* heathland over isolated low **Ehrharta longiflora*, **Avena barbata* and *Eragrostis curvula* tussock grasses with isolated low *Waitzia acuminata*, **Ursinia anthemoides* and *Trachymene cyanopetala* forbs.
		P5.49a	Tall open *Allocasuarina acutivalvis*, *A. campestris* and *Hakea longifolia* heathland over isolated mid *Grevillea petrophiloides*

Code	Vegetation Description as per Shepherd *et al.* 2002	Quadrat	Vegetation description (current survey)
			and *Alyxia buxifolia* shrubs over isolated low *Gastrolobium calycinum* shrubs over isolated low *Austrostipa elegantissima* tussock grasses and *Waitzia acuminata* forbs.
		P5.92	A mid *Allocasuarina campestris* and *Grevillea paniculata* mallee shrubland over isolated clumps of low *Acacia neurophylla* shrubs over isolated clumps of low *Austrostipa elegantissima* and **Pentameris airoides* tussock grasses and isolated low *Borya sphaerocephala* forbs.
		P5.97	A mid *Melaleuca hamata* and *Allocasuarina campestris* shrubland over a low open *Acacia* sp., *Grevillea paniculata* and *Verticordia* sp. shrubland over isolated clumps of low *Austrostipa elegantissima*, **Petameris airoides* and *Avena barbata* tussock grasses and a low open *Borya sphaerocephala* and **Ursinia anthemoides* forbland.
		P5.107	Isolated tall *Acacia acuminata*, *Allocasuarina campestris* and *Dodonaea inaequifolia* shrubs over isolated low *Acacia aculeiformis*, *Grevillea paniculata* and *Stypandra glauca* shrubs over isolated low *Austrostipa elegantissima*, **Avena barbata* and Poaceae sp. tussock grasses and isolated low *Borya spaerocephala*, *Podolepis canescens* and *Waitzia acuminata* var. *acuminata* forbs.
		P5.108	Isolated mid A*llocasuarina campestris* and *Melaleuca hamata* shrubs over sparse low mixed shrubland over isolated low Poacea spp. tussock grasses and low open *Borya sphaerocephala* forbland.
		P5.109	A tall sparse *Allocasuarina campestris*, *Hakea scoparia* subsp. *scoparia* and *Petrophile shuttleworthiana* shrubland over a sparse mid *Melaleuca cordata*, *Petrohile* sp. and *Calothamnus gilesii* shrubland over isolated low *Acacia aculeiformis*, *Astroloma serratifolium* and *Stenanthemum pomaderroides* shrubs over isolated low**Avena barbata* and **Pentameris airoides* subsp. *airoides* tussock grasses and isolated low *Waitzia acuminata* var. *acuminata* forbs.
		P5.110	Tall open *Allocasuarina campestris* and *Calothamnus gilesii* shrubland over isolated mid *Acacia* sp. shrubs over isolated low *Acacia aculeiformis*, *Stypandra glauca* and *Calytrix* sp. shrubs over isolated low *Aristida contorta* and Poaceae sp. tussock grasses and isolated low *Borya sphaerocephala*, *Podolepis canescens* and *Waitzia acuminata* var. *acuminata* forbs.
631	Succulent steppe with woodland and thicket; York Gum over *Melaleuca thyoides* & samphire	P5.5	Low open *Eucalyptus aequioperta* woodland over isolated mid *Melaleuca stereophloia* shrubs over a low open *Tecticornia indica* subsp. *bidens*, *T. lepidosperma* and *Rhagodia* sp. Watheroo chenopod shrubland over isolated low *Austrostipa elegantissima*, **Lolium rigidum* and **Avena barbata* tussock grasses and low open *Pogonolepis muelleriana*, **Mesembryanthemum nodiflorum* and *Sonchus oleraceus* forbland.

Code	Vegetation Description as per Shepherd *et al.* 2002	Quadrat	Vegetation description (current survey)
676	Succulent steppe; samphire	P5.4	Isolated low *Tecticornia halocnemoides* and *T. indica* subsp. *bidens* samphire shrubs over low **Hordeum hystrix, Eragrostis curvula* and **Cynodon dactylon* tussock grassland and isolated low **Cotula bipinnata*, **Sonchus oleraceus* and **Raphanus raphanistrum* forbs
		P5.10	Low open *Tecticornia indica* subsp. *bidens* and *T. lepidosperma* samphire shrubland over low **Lolium rigidum* and **Avena barbata* tussock grassland and isolated low **Mesembryanthemum nodiflorum* forbs.
		P5.15A	Low sparse *Tecticornia halocnemoides*, *T. lepidosperma* and *T. indica* subsp. *bidens* samphire shrubland over low open **Avena barbata*, **Bromus diandrus* and **Ehrharta calycina* tussock grassland and isolated low **Mesembryanthemum nodiflorum* and **Sonchus oleraceus* forbs.
		P5.45	Low *Tecticornia? moniliformis* samphire shrubland with isolated low *Maireana brevifolia* and *Enchylaena tomentosa* shrubs over isolated low **Lolium rigidum* tussock grasses and low isolated **Mesembryanthemum nodiflorum*, *Atriplex codonocarpa* and **Limonium lobatum* forbs.
		P5.46	Low closed *Tecticornia*? *moniliformis* samphire shrubland over low isolated **Lolium rigidum*, **Avena barbata* and **Bromus diandrus* tussock grasses and isolated low *Calandrinia eremaea* forbs.
		P5.50a	Isolated mid *Melaleuca lateriflora* shrubs over a low *Tecticornia undulata*, *Tecticornia*? *moniliformis* and *Enchylaena tomentosa* shrubland over isolated low **Lolium rigidum*, **Bromus diandra* and **Ehrharta longiflora* tussock grasses and sparse**Mesembryanthemum nodiflorum* and *Atriplex codonocarpa* forbland.
		P5.81	Low *Tecticornia indica* subsp. *bidens* and *T. lepidosperma* shrubland over isolated clumps of **Hordeum leporinum*, **Ehrharta calycina* and *Enteropogon ramosus low* tussock grasses over isolated low **Mesembryanthemum nodiflorum,* **Arctotheca calendula* and *Maireana trichoptera* forbs.
		P5.83	Low *Tecticornia indica* subsp. *bidens* and *T. pergranulata* shrubland over isolated low Poaceae sp. tussock grasses and isolated low **Mesembryanthemum nodiflorum* forbs.
		P5.89	A low *Frankenia pauciflora* and *Tecticornia pergranulata* shrubland over isolated low **Mesembryanthemum nodiflorum* forbs.
1024	Shrublands; mallee & casuarina thicket	P5.27	Isolated low *Eucalyptus capillosa* subsp. *polyclada* trees over tall open *Acacia neurophylla*, *Allocasuarina campestris* and *Alyogyne hakeifolia* shrubland over isolated mid *Stylobasium australe* shrubs over isolated low **Avena barbata*, *Austrostipa elegantissima* and **Briza maxima* tussock grasses and *Borya sphaerocephala*, *Waitzia acuminata* and *Podolepis lessonii* forbs.
		P5.28A	Tall open *Acacia neurophylla* and *Allocasuarina campestris* shrubland over isolated mid *Grevillea paniculata* shrubs over isolated low *Enchylaena tomentosa* shrubs over isolated *Austrostipa elegantissima*, **Pentameris airoides* subsp. *airoides*

Code	Vegetation Description as per Shepherd *et al.* 2002	Quadrat	Vegetation description (current survey)
			and **Avena barbata* tussock grasses and isolated low *Borya sphaerocephala*, *Dianella revoluta* and *Waitzia acuminata* forbs.
		P5.40	Isolated low *Eucalyptus loxophleba* trees over tall *Acacia acuminata*, *Melaleuca hamata* and *Dodonaea inaequifolia* shrubland over mid sparse *Allocasuarina campestris* and *Alyogyne hakeifolia* shrubland over isolated low *Eremophila lehmanniana* and *Rhagodia* sp. Watheroo shrubs over isolated low *Austrostipa elegantissima*, *Avena barbata* and **Bromus diandrus* tussock grasses and isolated low **Ursinia* anthemoides, *Waitzia acuminata* and *Hyalosperma cotula* forbs.
		P5-G1	Tall open *Acacia eremaea* and *Hakea scoparia* subsp. *scoparia* shrubland over a mid-open *Allocasuarina campestris*, *Gastrolobium calycinum* and *Calothamnus gilesii* shrubland over isolated low mixed shrubs over isolated **Ehrharta longiflora* tussock grasses.
		P5-G2	Tall open *Grevillea armigera* and *Callitris arenaria* heathland over isolated mid *Verticordia monadelpha* and *Hakea erecta* shrubs over isolated low *Maireana brevifolia* shrubs over isolated low **Avena barbata* and *Ehrharta longiflora* tussock grasses, isolated low **Sonchus oleraceus* and *Enchylaena tomentosa* forbs and isolated *Muehlenbeckia adpressa* vines.
		P5-G3	Tall open *Melaleuca hamata* and *Acacia acuminata* shrubland over isolated mid open *Acacia enervia* subsp. *explicata*, *Maireana brevifolia* and *Grevillea paniculata* shrubland in a low **Bromus diandrus*, **Ehrharta longiflora*, *Avena barbata* and **Lolium rigidum* tussock grassland with isolated tall *Lepidosperma longitudinal* sedges over isolated low mixed forbs.
		P5-G5	Tall open *Grevillea armigera* and *Melaleuca cordata* heathland over isolated low *Solanum lasiophyllum* shrubs over isolated low **Bromus diandrus*, **Avena barbata*, *Eragrostis curvula* and *Lolium rigidum* tussock grasses and isolated *Muehlenbeckia adpressa* vines.
		P5.94	A low *Eucalyptus loxophleba* subsp. *loxophleba* and *Acacia acuminata* woodland over a mid-open *Allocasuarina campestris*, *Dodonaea inaequifolia* and *Acacia daphnifolia* shrubland over isolated low *Calytrix depressa*, *Glischrocaryon flavescens* and *Acacia acuaria* shrubs over isolated clumps of low *Austrostipa elegantissima*, **Briza maxima* and **Pentameris airoides* tussock grasses and a low open *Borya spaerocephala* forbland.
		P5.101	Isolated mid *Eucalyptus loxophleba* trees over isolated tall *Acacia acuminata* shrubs over a low sparse *Allocasuarina campestris*, *Grevillea paniculata* and *Acacia* sp. shrubland over isolated clumps of low *Monachather paradoxus* tussock grasses and low open *Borya spaerocephala* forbland.
		P5.102	Isolated low *Eucalyptus loxophleba* subsp. *loxophleba* trees over isolated tall *Acacia assimilis* subsp. *assimilis* and *Melaleuca hamata* shrubs over a mixed *Allocasuarina campestris, Hakea recurva* and *Grevillea paniculata* shrubland over isolated low *Austrostipa elegantissima* and *Monachather paradoxus* tussock

Code	Vegetation Description as per Shepherd *et al.* 2002	Quadrat	Vegetation description (current survey)
			grasses and isolated low *Botrya spaerocephala*, *Dianella revoluta* and *Cheilanthes sieberi* subsp. *sieberi* forbs.
		P5.103	A low open *Eucalyptus loxophleba* woodland over a low open *Maireana brevifolia*, *M. georgei* and *Rhagodia drummondii* shrubland over low sparse *Austrostipa elegantissima and* Poaceae sp. tussock grassland and low sparse **Mesembtranthemum nodiflorum* and *Podolepis capillaris* forbland.
		P5.104	A tall open *Acacia jennerae* shrubland over a sparse mid *Acacia aculeiformis and Dodonaea inaequifolia* shrubland over a low *Maireana georgei* and *Scaevola spinescens* open shrubland over a low *Dianella revoluta*, **Mesembryanthemum nodiflorum* and *Waitzia acuminata* var. *acuminata* forbland.
		P5.105	Isolated tall *Allocasuarina campestris* shrubs over a sparse mid *Dodonaea inaequifolia*, *Grevillea paniculata* and *Santalum acuminatum* shrubland over isolated low **Romulea rosea* var. *australis* tussock grasses and low sparse *Bory spaerocephala*, *Podolepis canescens* and *Erodium cygnorum* forbland.
1046	Succulent steppe with woodland; York gum and samphire	P5.99	A low *Eucalyptus loxophleba* subsp. *loxophleba* woodland over a low *Enchylaena tomentosa*, *Tecticornia lepidosperma* and *Tecticornia pergranulata* shrubland over isolated clumps of low **Lolium rigidum* tussock grasses and low open **Mesembryanthemum nodiflorum* forbland.
1048	Mosaic: Shrublands; melaleuca patchy scrub / Succulent steppe; samphire	P5.7	Tall *Hakea preissii* and *Melaleuca stereophloia* shrubland over isolated mid *Melaleuca acuminata* shrubs over low open *Rhagodia* sp. Watheroo, *Tecticornia indica* subsp. *bidens* and *Maireana brevifolia* chenopod shrubland over low *Lolium rigidum*, **Avena barbata* and **Ehrharta calycina* tussock grassland and isolated low **Mesembryanthemum nodiflorum* and *Pogonolepis muelleriana* forbs and isolated *Comesperma integerrima* vines.
		P5.9	Tall *Hakea preissii* shrubland over low open *Rhagodia* sp. Watheroo and *Tecticornia indica* subsp. *bidens and T. lepidosperma* chenopod shrubland over isolated low *Austrostipa elegantissima*, **Avena barbata* and **Lolium rigidum* tussock grasses and low sparse *Pogonolepis muelleriana* and *Eriochiton sclerolaenoides* forbs and isolated *Comesperma integerrima* vines.
		P5.82	Low isolated *Eucalyptus dolichera* mallee trees over a sparse tall *Hakea preissii*, *Melaleuca stereophloia* and *M. adnata* shrubland over a low open *Rhagodia drummondii*, *Tecticornia indica* subsp. *bidens* and *T. lepidosperma* shrubland over isolated clumps of low **Romulea rosea* and Poaceae spp. tussock grasses and isolated clumps of low **Mesembryanthemum nodiflorum*, *Podolpeis capillaris* and *Crassula colorata* forbs.

Figure 5-4a-b Vegetation associations in the study area

5.3.1.5 Vegetation condition

The condition of vegetation across the study area ranged from completely degraded to excellent (Figure 5-5; Table 5-9). Several areas within the samphire communities were in excellent condition. Excellent areas were also recorded for the woodlands and shrublands (total vegetation in excellent condition is 2.7%). Virtually all of the vegetation types recorded had areas designated as degraded or completely degraded (Figure 5-5).

There were areas within the study area that were recorded as cleared and planted. The condition of these areas was considered completely degraded to degraded as it was evident that in the past they had been completely cleared or virtually completely cleared with the subsequent loss of natural values. Similarly sections of the study area encompassed by urban areas/ townships were regarded as completely degraded.

Table 5-9 Proportion of vegetation in study area by condition rating

Condition	Area (ha)	Percentage of study area
Completely Degraded (includes existing GNH – paved road and gravel shoulders and cleared paddocks)	562.07	85.9
Degraded	30.54	4.7
Good	18.61	2.8
Very Good	25.27	3.9
Excellent	17.62	2.7

5.3.1.6 Threatened and priority ecological communities

None of the vegetation types recorded within the study area were considered to represent a Commonwealth or State listed TEC.

Sections of one of the woodland communities (vegetation type 352 – Medium woodland, York Gum (*Eucalyptus loxophleba*) recorded for the study area at quadrats 5.33a and 5.34 may be considered representative of the State listed PEC, Eucalypt woodlands of the Western Australian Wheatbelt. The PEC is also currently under review for listing as a Commonwealth TEC, with a determination due to be made in late 2015. This PEC is a Priority 3(iii) community (i.e. *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)* and is described as:

"Eucalypt-dominated woodlands in the Western Australian Wheatbelt region as defined by the IBRA Avon Wheatbelt 1 and 2 and Western Mallee subregions with the specific exceptions of: woodlands and forests dominated by Jarrah (*E. marginata*) or Marri (*Corymbia calophylla*) where they occur without York Gum present; and non-woodland communities dominated by eucalypts, specifically those dominated by eucalypts with a mallee growth form. Community is defined primarily by its structure as a woodland. The presence in the canopy layer of eucalypt trees - most commonly Salmon Gum (*Eucalyptus salmonophloia*), York Gum (*Eucalyptus loxophleba*), red morrel (*Eucalyptus longicornis*) or gimlet (*Eucalyptus salubris*) defines the Wheatbelt woodlands. Several of the other emergent eucalypt species which may be present as a defining species (e.g. Kondinin blackbutt (*E. kondinensis*), *E. myriadena*, salt river gum (*E. sargentii*), silver mallet (*E. ornata*) and mallet (*E. singularis*) are found only in the Western Australian Wheatbelt" (DPaW 2013b).

Figure 5-5a-b Vegetation condition in the study area

5.3.1.7 Local and regional significance of vegetation

Four of the vegetation types (8, 631, 1046, and 1048) recorded in the study area may be considered locally significant as they covered less than 1% of the study area (Table 5-10).

Table 5-10 Extent and percentage representation of each vegetation type recorded in study area

Vegetation type	Area (ha)*	Proportionate representation in study area of 654.56 ha (%)
8	3.36	0.5
142	7.02	1.1
352	14.98	2.3
551	9.68	1.5
631	0.62	0.1
676	32.04	4.9
1024	20.02	3.1
1046	0.83	0.1
1048	3.49	0.5
Cleared	22.40	3.4
Cleared and Planted	68.51	10.5
Pasture	9.23	1.4
Pasture and Cleared	424.36	64.9
Total	**654.1**	**100**

* Total area of vegetation associations includes the existing GNH (i.e. paved road and gravel shoulders).

The areas of the vegetation recorded to be in excellent condition may be considered locally significant as they represent patches of comparatively high native species diversity in otherwise degraded vegetation. This particularly applies for the excellent patches of vegetation types 142, 352, 551, 1024 and 1048 as these vegetation types are classed as vulnerable.

The following vegetation types may be considered to be locally significant as they represent habitat for the conservation significant flora recorded in the study area:

- 142 Medium woodland; York Gum and Salmon Gum
- 352 Medium woodland; York Gum
- 551 Shrublands; *Allocasuarina campestris* thicket
- 676 Succulent steppe; samphire
- 1024 Shrublands; mallee & casuarina thicket
- 1048 Mosaic: Shrublands; melaleuca patchy scrub / Succulent steppe; samphire.

All of the vegetation types classed as vulnerable or endangered (Table 5-10) may be considered to be regionally significant as there is less than 30% of pre-European extent remaining.

Table 5-11 Description of vegetation in the study area

Code	Vegetation description as per Shepherd *et al.* (2002)	Pre-European extent (ha)	Current extent (ha)	% remaining	Vegetation status
8	Medium woodland; Salmon Gum & gimlet	694,638.13	346,576.30	49.89	Depleted
142	Medium woodland; York Gum & Salmon Gum	787,948.49	210,069.21	26.66	Vulnerable
352	Medium woodland; York Gum	724,272.97	143,677.92	19.84	Vulnerable
551	Shrublands; *Allocasuarina campestris* thicket	302,423.08	83,761.81	27.70	Vulnerable
631	Succulent steppe with woodland and thicket; York Gum over *Melaleuca thyoides* & samphire	106,852.97	51,116.94	47.84	Depleted
676	Succulent steppe; samphire	2,063,413.94	1,963,874.72	95.18	Least concern
1024	Shrublands; mallee & casuarina thicket	742,950.55	87,341.95	11.76	Vulnerable
1046	Succulent steppe with woodland; York gum and samphire	861.78	83.71	9.71	Endangered
1048	Mosaic: Shrublands; melaleuca patchy scrub/ Succulent steppe; samphire	13,814.89	5,581.61	40.40	Depleted

5.3.2 Fauna and fauna habitat

5.3.2.1 Fauna habitats

Five fauna habitats were present in the study area (Figure 5-6):

- Pasture and cleared – 452.16 ha (69.08% of the study area)
- Cleared and revegetated mosaic – 69.94 ha (10.69%)
- Samphire flat or samphire flat with low shrubland or woodland – 37.39 ha (5.71%)
- Shrubland (Mallee and Casuarina thickets) – 30.27 ha (4.62%)
- Woodland (York Gum, Wandoo, Salmon Gum and/or Gimlet) – 25.94 ha (3.96%).

The remainder of the study area (38.86 ha, 5.94%) consists of existing infrastructure, primarily roads.

The study area is of low value for fauna as it generally comprises of cleared areas or largely degraded to completely degraded habitats of primarily pasture with pockets of remnant vegetation.

Remnant native vegetation within the study area is sparse covering less than 15%. The samphire flats, shrubland and woodland habitats are represented by isolated small remnants, within and adjacent to the road reserve (Figure 5-6). The condition of these habitats is poor in most areas, with lack of understory, degraded condition of vegetation and presence of introduced species. Due to their poor condition and fragmented nature they are considered unlikely to support species of conservation significance in the long term.

Samphire flat or samphire flat with low shrubland or woodland habitat occurs in a few small areas within the study area, often in association with low lying areas (Figure 5-6). This habitat often extends beyond the boundary of the study area into paddocks.

Shrubland habitat consisting of a mixture of Mallee and Casuarina thickets with varying understory density is sparsely scattered in isolated pockets within the study area. Where present this habitat is often open and lacking suitable vegetation cover with large areas of sparse vegetation and exposed substrates. Shrubland habitat ranged from narrow corridors less than 2 m wide along the road reserve to areas up to 150 m wide forming larger remnant blocks of vegetation adjacent to the road (Figure 5-6).

Woodland comprising various eucalypts (mapped as York Gum, Wandoo, Salmon Gum and/or Gimlet woodland) was also recorded within the study area. Along the road reserve the woodland habitat was highly fragmented, often narrow (<5-10 m positioned between the road and pasture) and with sparse understorey often dominated by pastoral grasses of low little value to fauna. Woodland habitat ranged from narrow corridors less than 2 m wide along the road reserve to areas up to 150 m wide forming larger remnant blocks of vegetation adjacent to the road, often in association with shrubland habitat (Figure 5-6).

Potential breeding habitat for Carnaby's Black Cockatoo was identified within the study area, particularly in woodland habitat (section 5.3.2.3).

5.3.2.2 Conservation significant fauna

No direct observations of conservation significant fauna species were recorded in the study area. Based on habitats present, known species distributions, and habitat quality and extent, up to eight conservation significant fauna species may occur in the study area (Table 5-12).

Figure 5-6a-b Fauna habitats in the study area

Table 5-12 Conservation significant species likelihood of occurrence assessment for study area

Species	Distribution and habitat preferences	Likelihood of occurrence
Invertebrates		
Idiosoma nigrum (Shield-backed Trapdoor Spider)	Northern Avon Wheatbelt, Yalgoo, Geraldton Sandplain, Murchison. *Acacia* (mulga) and *Eucalyptus* woodlands on heavy clay or granitic soils, often in or near southern-exposed drainage lines (Main 2003) (Minister for the Environment 2013).	Possible; may occur in shrubland and woodland habitat present within the study area; however, these habitats are often heavily degraded
Reptiles		
Egernia stokesii badia (Western Spiny-tailed Skink)	A large skink distinguishable by its short stocky body and spined tail. Found in semi-arid habitats across the mid-west region of W.A. It is generally associated with areas providing rocky outcrops or hollowed timber (Wilson & Swan 2013).	Unlikely; woodland habitat within the study area heavily degraded and often lacking hollowed logs or branches. Granite outcrops present within study area also degraded and lacking suitable exfoliation or crevices for the species.
Birds		
Leipoa ocellata (Malleefowl)	Found across the southern half of the Australian continent. In WA, mostly occurs south of a line from Shark Bay to the Nullarbor Plain. Typically found in mallee woodlands but also in *Eucalyptus* woodlands and shrublands (Benshemesh *et al.* 2008; Parsons 2008; Parsons *et al.* 2008).	Unlikely; woodland and shrubland habitat within the study area fragmented and heavily degraded, often lacking understorey
Apus pacificus (Fork-tailed Swift)	Widespread migratory species that overwinters in Australia; found across most of WA. Mostly found over inland plains, and also above foothills, in coastal areas and over settlements. Occurs in a wide range of dry or open habitats, including riparian woodlands, tea-tree swamps, low scrub, heathland, saltmarsh, grassland and spinifex sandplains, open farmland and inland and coastal sand-dunes (DSEWPaC 2011).	Possible; may frequent the area on occasion, particularly over woodland habitat, unlikely to land or nest within the study area
Ardea modesta (Eastern Great Egret)	Highly mobile species found throughout most of the western fringes of the State in coastal areas and towards the semi-arid interior. Occurs in inland rivers, lakes and shallow freshwater or saltwater wetlands and inundated samphire (Johnstone & Storr 1998).	Possible; may occur occasionally within samphire habitat, particularly following rainfall

Species	Distribution and habitat preferences	Likelihood of occurrence
Ardea ibis (Cattle Egret)	In WA, found in the Kimberley and the Southwest. Found in wetlands, grasslands, pastures/paddocks (low lying with high grass), tidal mudflats (Pizzey & Knight 2012).	Possible; may occur occasionally within samphire habitat, particularly following rainfall
Falco peregrinus (Peregrine Falcon)	The Peregrine Falcon is a widespread species found across Australia, and has a large foraging range. In Western Australia, it can be rare or scarce to moderately common. The Peregrine Falcon's preferred habitat includes cliffs and wooded watercourses. Nesting occurs mainly on cliff ledges, granite outcrops, quarries and in trees with old raven or Wedge-tailed Eagle nests (Johnstone & Storr 1998).	Possible; may forage occasionally across most habitats and may occasionally nest in in areas where suitable nesting trees are present in the study area, particularly woodland habitat
Thinornis rubricollis (Hooded Plover)	The West Australian population is primarily found on the coast from Jurien to the east of Esperance, and a part of the population nests inland (Elson & Singor 2008). Nesting pairs of Hooded Plovers can be found on the shore of inland salt lakes, inlets and coastal sandy beaches.	Unlikely; no suitable habitat present in study area
Rostratula australis (Australian Painted Snipe)	Sparse and erratic over coastal WA. Inhabits well-vegetated shallows and margins of wetlands, dams, wet pastures, marshy areas, tea tree scrub (Pizzey & Knight 2012).	Unlikely; no suitable habitat present in study area
Calyptorhynchus latirostris (Carnaby's Black Cockatoo)	Endemic to south-western Australia, south of a line from Geraldton to Esperance. The species is found in woodlands and heathlands where it essentially feeds on banksias, eucalyptus, hakeas and grevilleas but also introduced pines (Garnett & Crowley 2000) (Weerheim 2008). Carnaby's Black Cockatoos have undergone a significant decline across their distribution range. The high proportion of introduced pine trees (*Pinus* sp.) in the diet of the species is an additional threat considering most of the trees have been planted for commercial logging and will be cleared in the future (Cale 2003). The species does however feed on a wide variety of tree and shrub species (DEC 2011).	Likely; within the known range of the species, suitable habitat trees and food species present within the study area, evidence of utilisation of hollows

Species	Distribution and habitat preferences	Likelihood of occurrence
Calyptorhynchus baudinii (Baudin's Black Cockatoo)	Endemic to a 2,000 km^2 area in south-west WA, bounded by the 750 mm isohyet (Department of the Environment 2014a). Mostly feed on Marri and large fruits with diet changes over the year, depending on the food availability. The species nests in large hollows of mature Jarrah and Marri trees. The high proportion of introduced pine trees (*Pinus* sp.) in the diet of the species is an additional threat considering most of the trees have been planted for commercial logging and will be cleared in the future (Cale 2003). The species does however feed on a wide variety of tree and shrub species (DEC 2011).	Unlikely; NatureMap record from New Norcia but outside modelled distribution; unlikely to roost or breed in study area; may occur primarily in woodland habitats of the study area
Cacatua pastinator pastinator (Muir's Corella)	This subspecies is only found in the extreme south-west of WA, in woodlands (WAM & DEC 2008). They exclusively feed on seeds and grains.	Possible; may occur occasionally within the study area, particularly woodland habitat. Nesting may occur within the study area where suitable hollows present
Merops ornatus (Rainbow Bee-eater)	Migratory species (moving between Australia and Asia) occurring across Australia, with complex seasonal movements depending on location and rainfall. Found in lightly wooded, preferably sandy country, near water and creeklines supporting sandy banks in which burrows can be created (Johnstone & Storr 1998).	Possible; may occasionally occur within the study area, particularly woodland habitat
Mammals		
Dasyurus geoffroii (Western Quoll, Chuditch)	Prior to European settlement the species occupied approximately 70% of continental Australia (Smith *et al.* 2004; Van Dyck & Strahan 2008). Massive decline in range has occurred, currently occurs in only 5% of its former range. Mostly found in woodland, heath and mallee habitats.	Unlikely; long history of agricultural usage in the area has resulted in large scale clearing for pasture with any remnant vegetation being largely degraded and fragmented

5.3.2.3 Black cockatoo habitat

Within the study area, 204 potential breeding trees representing breeding habitat for Carnaby's Black Cockatoo were recorded during the survey, comprising *Eucalyptus camaldulensis, E. loxophleba*, *E. salmonophloia* and *E. salubris* (Figure 5-7; Appendix 6).

A total of 38 trees were observed with confirmed hollows within the study area; however, several others may have contained hollows which were not visible from the ground. Of the 38 potential breeding trees with hollows, 13 of the trees were confirmed by Tony Kirkby as having hollows suitable for current breeding by Carnaby's Black Cockatoo and five of these showed signed of use by the species (Figure 5-7):

- HT0124 (451135E, 6629638N) – *Eucalyptus salmonophloia*, contained a hollow of suitable size, possibly occupied by Galahs observed in tree, no evidence of Carnaby's Black Cockatoo observed
- HT0125 (451215E, 6629655N) – *Eucalyptus salmonophloia*, contained a hollow possibly suitable, no evidence of Carnaby's Black Cockatoo observed
- HT0132 (449576E, 6629650N) – *Eucalyptus salmonophloia*, contained a hollow of suitable size, evidence of Carnaby's Black Cockatoo recorded, well-worn and chewed entrance to hollow
- HT0136 (444819E, 6629618N) – *Eucalyptus salmonophloia*, contained a hollow of suitable size, evidence of Carnaby's Black Cockatoo recorded, wear and chewings at entrance to hollow
- HT0167 (443973E, 6629598N) – *Eucalyptus salubris*, contained a hollow of suitable size, no evidence of Carnaby's Black Cockatoo observed
- HT0175 (437636E, 6624157N) – *Eucalyptus salmonophloia*, contained a hollow of suitable size, no evidence of Carnaby's Black Cockatoo observed
- HT0181 (437861E, 6624587N) – *Eucalyptus salmonophloia*, contained a hollow of suitable size but occupied by Long-billed Corella, no evidence of Carnaby's Black Cockatoo observed
- HT0182 (437887E, 6624651N) – *Eucalyptus salmonophloia*, contained a hollow of suitable size, no evidence of Carnaby's Black Cockatoo observed
- HT0183 (437925E, 6624725N) – *Eucalyptus salmonophloia*, contained three hollows with suitable entrance, no evidence of Carnaby's Black Cockatoo observed
- HT0378 (445560E, 6629607N) – *Eucalyptus salmonophloia*, contained a hollow of suitable size, evidence of Carnaby's Black Cockatoo recorded, wear and chewings at entrance to hollow
- HT0474 (445835E, 6629614N) – *Eucalyptus salmonophloia*, contained a hollow occupied by Long-billed Corella which also looks suitable for Carnaby's Black Cockatoo, no evidence of Carnaby's Black Cockatoo observed
- HT4867 (437874E, 6624594N) – *Eucalyptus salmonophloia*, contained a hollow of suitable size, evidence of Carnaby's Black Cockatoo recorded, two chewed and well-worn hollows
- HT4948 (449471E, 6629669N) – *Eucalyptus salmonophloia*, contained a hollow of suitable size, evidence of Carnaby's Black Cockatoo observed, well chewed at entrance to hollow.

Based on analysis of remnant native vegetation polygons that contained potential breeding trees (section 3.2.2.4), 14.7 ha of breeding habitat within remnant native vegetation is present within the study area. Approximately 38.7% of the potential breeding trees were present within these mapped areas. The remainder were located within cleared pastures and revegetated areas.

Known food species for Carnaby's Black Cockatoo were recorded in 23 of the 59 sampled vegetation quadrats (Table 5-13). No direct evidence (residues) of feeding by Carnaby's Black Cockatoo was observed in the study area (pers. comm. T. Kirkby, March 2015). Foraging habitat was assessed in the field as being of low value generally due to little understorey remaining and limited food species. This finding was supported by the spatial analysis of foraging habitat (section 3.2.2.4) which identified 114.5 ha of low value foraging habitat and no quality foraging habitat within the study area.

No evidence of roosting by Carnaby's Black Cockatoo was recorded in the study area; however, tree species that Carnaby's Black Cockatoo is known to roost in were recorded.

Figure 5-7 Potential breeding trees recorded in the study area

Table 5-13 Important plant species for Carnaby's Black Cockatoo recorded in the vegetation quadrats for the study area

	Species (% coverage)									
	Callitris arenaria	***Eucalyptus camaldulensis***	***Eucalyptus salmonophloia***	***Eucalyptus salubris***	***Grevillea armigera***	***Grevillea paniculata***	***Grevillea paradoxa***	***Grevillea petrophiloides***	***Hakea preissii***	***Hakea scoparia* subsp. *scoparia***
Food plant	●	●	●		●	●	●	●	●	
Nesting		●	●	●						
Roosting		●								
Quadrat										
P5.04										
P5.05										
P5.07									✓ 15%	
P5.09									✓ 30%	
P5.10										
P5.12		✓ 20%								
P5.13										
P5.15a										
P5.16			✓ 5%							
P5.18										
P5.19										
P5.23										
P5.25										
P5.27										
P5.28a										
P5.31			✓ 30%	✓ 15%						
P5.32a			✓ 20%							
P5.33a										
P5.34										
P5.35			✓ 50%							
P5.40										
P5.42										
P5.43a						✓ 2%				
P5.44			✓ 50%							
P5.45										
P5.46										
P5.47a										
P5.49a								✓ 3%		

	Species (% coverage)									
	Callitris arenaria	***Eucalyptus camaldulensis***	***Eucalyptus salmonophloia***	***Eucalyptus salubris***	***Grevillea armigera***	***Grevillea paniculata***	***Grevillea paradoxa***	***Grevillea petrophiloides***	***Hakea preissii***	***Hakea scoparia* subsp. *scoparia***
P5.50a										
P5.81										
P5.82									✓ 5%	
P5.84a										
P5.85										
P5.86				✓ 10%						
P5.87										
P5.88										
P5.89										
P5.90										
P5.92						✓ 1%				
P5.93										
P5.94										
P5.97						✓ 0.1%				
P5.99										
P5.101						✓ 2%				
P5.102						✓ 2%				
P5.103										
P5.104										
P5.105						✓ 5%				
P5.106										
P5.107						✓ 2%				
P5.108						✓ 2%				
P5.109										
P5.110										
P5.111										
P5-G1										✓ 15%
P5-G2	✓ 10%				✓ 40%					
P5-G3						✓ 3%				
P5-G5					✓ 50%					
P5-G6										

6 DISCUSSION

The survey undertaken in the Lyons East Road to Gatti Road study area identified the presence of a total of seven conservation significant species comprised of:

- a single plant/population of the Threatened (State listed) taxon *Grevillea bracteosa* subsp. *bracteosa* (vegetation type 551)
- single plants of three Priority Flora (*Dampiera glabrescens* Priority 1, *Grevillea pinifolia* Priority 1, *Urodon capitatus* Priority 3)
- a single population comprised of six individuals of *Chamelaucium* sp. Wongan Hills (Priority 3)
- two populations of *Frankenia glomerata* (Priority 3) with a total of nine individuals
- two populations of *Grevillea asparagoides* (Priority 3) with a total of 82 plants.

The remnant vegetation within the study area occurs within an area that has been extensively cleared, with 85.9% (562.1 ha) of the 654 ha study area comprising cleared and planted areas, pasture and the extant road reserve. The condition of the remnant vegetation in the remaining areas ranged from degraded to excellent with 49.2 ha (7.5%) showing clear evidence of significant disturbance (degraded to good condition) and typically very low native biological diversity. Pockets of the vegetation were in very good (25.3 ha, 3.9%) and excellent (17.6 ha, 2.7%) condition.

Of the nine vegetation types defined (8, 142, 352, 551, 631, 676, 1024, 1046, 1048) in the study area, it was initially considered that the woodland communities (8, 142, 352) resembled the PEC: Eucalypt woodlands of the Western Australian Wheatbelt which is also currently under review for listing as Commonwealth TEC. After a review of the DPaW description for the PEC (Appendix 5), it was concluded that only two quadrats (5.34, 5.33a) defined as vegetation type 352 – Medium woodland, York Gum (*Eucalyptus loxophleba*) may be representative of the PEC community because the species composition and tree cover recorded in the two quadrats match those described for the PEC and vegetation condition at these locations was very good and excellent, respectively. This would also apply for the TEC listing of the community under the EPBC Act if the listing is approved.

The other quadrats in the study area defined as woodland communities are unlikely to represent the PEC either because cover for the tree canopy (i.e. forest cover >30%) was incongruent with the structural criteria for the PEC (woodland with canopy cover between 10% and 30%) or because condition of the vegetation was recorded as degraded to good and as such it was considered that historic disturbance may have resulted in the lower tree cover and these communities represent disturbed low forests rather than the PEC.

Five of the nine vegetation types defined for the study area may be considered to have regional conservation significance as they represent endangered or vulnerable communities with less than 30% of pre-European extent remaining when compared with DPaW 2013 statistics (DPaW 2013a):

- total area of vegetation type 142 within the study area is 7.02 ha which represents 0.003% of the total area of vegetation type 142 remaining (210,069.21 ha)
- total area of vegetation type 352 within the study area is 14.98 ha which represents 0.010% of the total area of vegetation type 352 remaining (143,677.92 ha)
- total area of vegetation type 551 within the study area is 9.68 ha which represents 0.012% of the total area of vegetation type 551 remaining (83,761.81 ha)
- total area of vegetation type 1024 within the study area is 20.02 ha which represents 0.023% of the total area of vegetation type 1024 remaining (87,341.95 ha)

- total area of vegetation type 1046 within the study area is 0.83 ha which represents 0.990% of the total area of vegetation type 1046 remaining (83.71 ha).

Proportion of the vegetation types within the study area relative to total extent remaining of each vegetation type (Shepherd *et al.* 2002) is very small. In addition, the assessment of regional significance of the vegetation needs to take into account the disturbed condition of the majority of the vegetation and fragmented nature of the woodlands in the study area.

Areas of six of the vegetation types recorded in the study area (142, 352, 551, 676, 1024, and 1046) may be considered locally significant as they represent habitat for Threatened Flora (551) or Priority Flora species and/ or represent areas of comparatively high native diversity in otherwise largely disturbed vegetation. This is particularly so for excellent patches of vegetation type 1024 as it is vulnerable with just 11.76% of pre-European extent remaining.

A total of 37 weed species were recorded in the study area with at least one weed species recorded in each quadrat survey and relevé. Alien grasses were the most common weeds with **Avena barbata*, **Ehrharta* spp., **Lolium rigidum, *Bromus diandrus* and **Pentameris airoides* subsp. *airoides* widespread as were three herbs **Mesembryanthemum nodiflorum*, **Sonchus oleraceus* and **Ursinia anthemoides.* Three of the weed species are declared plants **Echium plantagineum* (annual), **Opuntia monacantha* and **Tamarix aphylla*. **Opuntia monacantha* is also a WoNS. The declared plants will require management to alleviate potential harmful impact of the plant, reduce numbers and distribution, and prevent spread of the species.

As all vegetation in the study area represents remnants in an area that has been extensively cleared, clearing of vegetation in the study area is likely to be considered at variance to clearing principle E:

- Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been significantly cleared.

In addition, vegetation recorded to be in very good to excellent condition typically comprised a greater level of biological diversity than the surrounding more disturbed remnants and as such clearing of this vegetation may be at variance to clearing principle A:

- Native vegetation should not be cleared if it comprises a high level of biological diversity.

It should be noted that removal of any plants of a Threatened species requires approval from DPaW.

The majority of the study area, containing pasture, cleared and planted areas or existing road infrastructure (85.3%), is of little to no value for fauna both in terms of habitat value and as ecological corridors. Remnant native vegetation consisting of three habitat types (samphire flats, shrubland and woodland habitat) within the study area is sparse covering less than less than 15% of the study area collectively. Each of these fauna habitats cover less than 6% of the study area and their condition is mostly poor, often due to the lack of understory and degraded condition of vegetation present.

No direct observations of conservation significant fauna species were recorded in the study area. Based on habitats present and known species distributions, up to eight conservation significant fauna species may occur in the samphire flats, shrubland and/or woodland habitats of the study area (Table 5-12); however, due to the poor condition, presence of introduced species and fragmentation of these remnants they are unlikely to provide core habitat for species of conservation significance identified in the desktop review with the exception of Carnaby's Black Cockatoo.

Within the study area, 204 potential breeding trees representing breeding habitat for Carnaby's Black Cockatoo were recorded during the survey comprising *Eucalyptus camaldulensis*, *E. loxophleba*, *E. salmonophloia* and *E. salubris*. Based on the records, 14.7 ha of remnant vegetation within the study area has been mapped as potential breeding habitat for the species. Approximately 38.7% of the potential breeding trees were present within these mapped areas; the remainder were located within

cleared pastures and revegetated areas. Potential breeding habitat is defined by the presence of known breeding tree species with suitable DBH (DSEWPaC 2012a). DSEWPaC (2012a) also recognises that in such habitat, “trees of all ages and size are potentially important for maintaining breeding in the long term through maintaining the integrity of the habitat and allowing for recruitment of trees to provide future nest hollows”, as well as the importance of maintaining long-term supply of trees particularly in woodland stands that are known to support cockatoo breeding.

The study area contains five likely nesting sites for Carnaby’s Black Cockatoo and an additional eight trees with hollows suitable for current breeding by the species.

No evidence of roosting by Carnaby’s Black Cockatoo was recorded in the study area; however, tree species that Carnaby’s Black Cockatoo is known to roost in were recorded within the study area. Inspections for roost (and nest) sites were not conducted within vicinity of the study area and therefore it cannot be ruled out that a roost site occurs within 6 km of the study area or that a known nesting site occurs within 6-12 km of the study area.

No evidence of foraging activity by Carnaby’s Black Cockatoo in the study area was observed but foraging plant species were recorded. The study area contains approximately 114.5 ha of low value foraging habitat; no vegetation within the study area was considered quality habitat.

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Appendix 1 Quadrat data

Appendix 2 Vegetation structural classes (NVIS)

Height Classes

Height	Growth form					
Height class	Height range (m)	Tree, vine (Mid & Upper), palm (single-stemmed)	Shrub, heath shrub, chenopod shrub, ferns, Samphire shrub, cycad, tree-fern, Grass-tree, palm (multi-stemmed)	Tree mallee, Mallee Shrub	Tussock grass, hummock grass, other grass, sedge, rush, forbs, vine (Ground)	Bryophyte, lichen, seagrass, aquatic
8	>30	tall	N/A	N/A	N/A	N/A
7	10-30	mid	N/A	tall	N/A	N/A
6	<10	low	N/A	mid	N/A	N/A
5	<3	N/A	N/A	low	N/A	N/A
4	>2	N/A	tall	N/A	tall	N/A
3	1-2	N/A	mid	N/A	tall	N/A
2	0.5-1	N/A	low	N/A	mid	tall
1	<0.5	N/A	low	N/A	low	low

Structural Formation Classes

Growth form	Height ranges (m)	Structural formation classes					
Foliage cover % (cover #)		70-100% (5)	30-70% (4)	10-30% (3)	<10% (2)	0-5% (1)	≈0% (N)
tree, palm	<10,10-30, >30	closed forest	open forest	woodland	open woodland	isolated trees	isolated clumps of trees
tree mallee	<3, <10, 10-30	closed mallee forest	open mallee forest	mallee woodland	open mallee woodland	isolated mallee trees	isolated clumps of mallee trees
shrub, cycad, grass-tree, tree-fern	<1,1-2,>2	closed shrubland	shrubland	open shrubland	sparse shrubland	isolated shrubs	isolated clumps of shrubs
mallee shrub	<3, <10, 10-30	closed mallee shrubland	mallee shrubland	open mallee shrubland	sparse mallee shrubland	isolated mallee shrubs	isolated clumps of mallee shrubs
heath shrub	<1,1-2,>2	closed heathland	heathland	open heathland	sparse heathland	isolated heath shrubs	isolated clumps of heath shrubs

Growth form	Height ranges (m)	Structural formation classes					
chenopod shrub	<1,1-2,>2	closed chenopod shrubland	chenopod shrubland	open chenopod shrubland	sparse chenopod shrubland	isolated chenopod shrubs	isolated clumps of chenopod shrubs
samphire shrub	<0.5,>0.5	closed samphire shrubland	samphire shrubland	open samphire shrubland	sparse samphire shrubland	isolated samphire shrubs	isolated clumps of samphire shrubs
hummock grass	<2,>2	closed hummock grassland	hummock grassland	open hummock grassland	sparse hummock grassland	isolated hummock grasses	isolated clumps of hummock grasses
tussock grass	<0.5,>0.5	closed tussock grassland	tussock grassland	open tussock grassland	sparse tussock grassland	isolated tussock grasses	isolated clumps of tussock grasses
other grass	<0.5,>0.5	closed grassland	grassland	open grassland	sparse grassland	isolated grasses	isolated clumps of grasses
sedge	<0.5,>0.5	closed sedgeland	sedgeland	open sedgeland	sparse sedgeland	isolated sedges	isolated clumps of sedges
rush	<0.5,>0.5	closed rushland	rushland	open rushland	sparse rushland	isolated rushes	isolated clumps of rushes
forb	<0.5,>0.5	closed forbland	forbland	open forbland	sparse forbland	isolated forbs	isolated clumps of forbs
fern	<1,1-2,>2	closed fernland	fernland	open fernland	sparse fernland	isolated ferns	isolated clumps of ferns
bryophyte	<0.5	closed bryophytelan d	bryophytelan d	open bryophytela nd	sparse bryophytelan d	isolated bryophytes	isolated clumps of bryophytes
lichen	<0.5	closed lichenland	lichenland	open lichenland	sparse lichenland	isolated lichens	isolated clumps of lichens
vine	<10,10-30, >30	closed vineland	vineland	open vineland	sparse vineland	isolated vines	isolated clumps of vines
aquatic	0-0.5,<1	closed aquatic bed	aquatic bed	open aquatic bed	sparse aquatics	isolated aquatics	isolated clumps of aquatics
seagrass	0-0.5,<1	closed seagrass bed	seagrass bed	open seagrass bed	sparse seagrass bed	isolated seagrasses	isolated clumps of seagrasses

Appendix 3 Fauna species identified in the desktop review

Scientific name	Common name	EPBC Threatened species	EPBC Migratory	WC Act	DPaW	Introduced	NatureMap	EPBC Act Protected Matters Database	BirdData	DPaW Threatened Species Database
Invertebrates										
Missulena occatoria							●			
Araneus eburneiventris							●			
Austracantha minax							●			
Backobourkia collina							●			
Eilica albopunctata							●			
Idiosoma nigrum	Shield-backed Trapdoor Spider	VU		S1			●	●		●
Artoriopsis expolita							●			
Oxyopes gracilipes							●			
Simaetha knowlesi							●			
Latrodectus hasseltii							●			
Urodacus novaehollandiae							●			
Fish										
Galaxias occidentalis	Western Minnow						●			
Frogs										
Heleioporus albopunctatus	Western Spotted Frog						●			
Pseudophryne guentheri	Crawling Toadlet						●			
Reptiles										
Ctenophorus reticulatus	Western Netted Dragon						●			
Underwoodisaurus milii	Southern Barking Gecko						●			

Scientific name	Common name	EPBC Threatened species	EPBC Migratory	WC Act	DPaW	Introduced	NatureMap	EPBC Act Protected Matters Database	BirdData	DPaW Threatened Species Database
Gehyra variegata	Variegated Tree Dtella						●			
Delma fraseri	Fraser's Delma						●			
Pygopus lepidopodus	Common Scaly-foot						●			
Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink						●			
Ctenotus pantherinus pantherinus							●			
Egernia stokesii aethiops	Baudin Island Spiny-tailed Skink				VU			●		
Egernia stokesii badia	Western Spiny-tailed Skink	EN		S1	VU		●	●		●
Menetia greyii	Common Dwarf Skink						●			
Morethia obscura	Planin Red-throated Skink						●			
Tiliqua rugosa rugosa							●			
Varanus gouldii	Sand Monitor						●			
Demansia psammophis reticulata							●			
Pseudechis australis	Mulga Snake						●			
Pseudonaja mengdeni	Western Brown Snake						●			
Birds										
Leipoa ocellata	Malleefowl	VU		S1	VU			●		●
Cygnus atratus	Black Swan						●		●	
Chenonetta jubata	Australian Wood Duck						●		●	
Anas gracilis	Grey Teal						●		●	
Tachybaptus novaehollandiae	Australasian Grebe						●			
Columba livia	Rock Dove					●	●	●	●	
Streptopelia senegalensis	Laughing Dove					●		●		

Scientific name	Common name	EPBC Threatened species	EPBC Migratory	WC Act	DPaW	Introduced	NatureMap	EPBC Act Protected Matters Database	BirdData	DPaW Threatened Species Database
Phaps chalcoptera	Common Bronzewing						●		●	
Ocyphaps lophotes	Crested Pigeon						●		●	
Apus pacificus	Fork-tailed Swift		●	S3				●		
Ardea modesta	Eastern Great Egret		●	S3				●		
Ardea ibis	Cattle Egret		●	S3				●		
Elanus axillaris	Black-shouldered Kite								●	
Circus approximans	Swamp Harrier						●		●	
Aquila audax	Wedge-tailed Eagle						●		●	
Hieraaetus morphnoides	Little Eagle								●	
Falco cenchroides	Nankeen Kestrel						●		●	
Falco berigora	Brown Falcon								●	
Falco peregrinus	Peregrine Falcon			S4	SP		●		●	●
Burhinus grallarius	Bush Stone-curlew						●		●	
Himantopus himantopus	Black-winged Stilt						●		●	
Thinornis rubricollis	Hooded Plover				P4			●		
Vanellus tricolor	Banded Lapwing								●	
Rostratula australis	Australian Painted Snipe	EN	●	S1/S3	EN			●		
Chroicocephalus novaehollandiae	Silver Gull								●	
Calyptorhynchus banksii samueli	Red-tailed Black Cockatoo						●		●	
Calyptorhynchus latirostris	Carnaby's Black-cockatoo	EN		S1	EN		●	●		●
Calyptorhynchus baudinii	Baudin's Black-cockatoo	VU		S1	EN					●
Eolophus roseicapillus	Galah								●	

Scientific name	Common name	EPBC Threatened species	EPBC Migratory	WC Act	DPaW	Introduced	NatureMap	EPBC Act Protected Matters Database	BirdData	DPaW Threatened Species Database
Cacatua pastinator pastinator	Muir's Corella	VU		S4	SP		●		●	
Cacatua sanguinea	Little Corella						●		●	
Barnardius zonarius	Australian Ringneck								●	
Psephotus varius	Mulga Parrot								●	
Melopsittacus undulatus	Budgerigar								●	
Pezoporus flaviventrus	Western Ground Parrot	CR		S1	CR					●
Chalcites lucidus	Shining Bronze-cuckoo								●	
Cacomantis pallidus	Pallid Cuckoo						●		●	
Tyto javanica	Eastern Barn Owl						●			
Todiramphus sanctus	Sacred Kingfisher						●			
Merops ornatus	Rainbow Bee-eater		●	S3			●	●	●	●
Malurus leucopterus	White-winged Fairy-wren						●		●	
Malurus pulcherrimus	Blue-breasted Fairy-wren						●		●	
Smicrornis brevirostris	Weebill						●		●	
Gerygone fusca	Western Gerygone						●		●	
Acanthiza chrysorrhoa	Yellow-rumped Thornbill						●		●	
Acanthiza uropygialis	Chestnut-rumped Thornbill						●		●	
Acanthiza apicalis	Inland Thornbill						●		●	
Pardalotus punctatus	Spotted Pardalote						●		●	
Pardalotus striatus	Striated Pardalote						●		●	
Lichenostomus virescens	Singing Honeyeater								●	
Lichenostomus leucotis	White-eared Honeyeater						●		●	

Scientific name	Common name	EPBC Threatened species	EPBC Migratory	WC Act	DPaW	Introduced	NatureMap	EPBC Act Protected Matters Database	BirdData	DPaW Threatened Species Database
Manorina flavigula	Yellow-throated Miner						●		●	
Acanthagenys rufogularis	Spiny-cheeked Honeyeater						●		●	
Anthochaera carunculata	Red Wattlebird						●		●	
Epthianura albifrons	White-fronted Chat						●		●	
Glyciphila melanops	Tawny-crowned Honeyeater						●			
Lichmera indistincta	Brown Honeyeater						●		●	
Melithreptus brevirostris	Brown-headed Honeyeater						●		●	
Pomatostomus superciliosus	White-browed Babbler						●		●	
Coracina novaehollandiae	Black-faced Cuckoo-shrike						●		●	
Pachycephala rufiventris	Rufous Whistler						●		●	
Colluricincla harmonica	Grey Shrike-thrush						●		●	
Artamus personatus	Masked Woodswallow								●	
Artamus cinereus	Black-faced Woodswallow						●		●	
Cracticus torquatus	Grey Butcherbird						●		●	
Cracticus nigrogularis	Pied Butcherbird						●		●	
Cracticus tibicen	Australian Magpie						●		●	
Rhipidura albiscapa	Grey Fantail								●	
Rhipidura leucophrys	Willie Wagtail						●		●	
Corvus coronoides	Australian Raven						●		●	
Grallina cyanoleuca	Magpie-lark						●		●	
Petroica goodenovii	Red-capped Robin						●		●	
Drymodes brunneopygia	Southern Scrub-robin						●		●	

Scientific name	Common name	EPBC Threatened species	EPBC Migratory	WC Act	DPaW	Introduced	NatureMap	EPBC Act Protected Matters Database	BirdData	DPaW Threatened Species Database
Cincloramphus mathewsi	Rufous Songlark						●		●	
Cincloramphus cruralis	Brown Songlark						●		●	
Zosterops lateralis	Silvereye						●		●	
Hirundo neoxena	Welcome Swallow						●		●	
Petrochelidon nigricans	Tree Martin								●	
Sturnus vulgaris	Common Starling					●		●		
Taeniopygia guttata	Zebra Finch						●		●	
Anthus novaeseelandiae	Australasian Pipit								●	
Mammals										
Dasyurus geoffroii	Western Quoll	VU		S1	VU			●		
Mus musculus	House Mouse					●	●	●		
Oryctolagus cuniculus	Rabbit					●		●		
Canis lupus familiaris	Dog					●		●		
Vulpes vulpes	Red Fox					●		●		
Felis catus	Cat					●		●		
Capra hircus	Goat					●		●		

Appendix 4 Flora species inventory for the Lyons East Road to Gatti Road study area

FAMILY	SPECIES
Aizoaceae	*Gunniopsis quadrifida*
	**Mesembryanthemum nodiflorum*
Amaranthaceae	*Ptilotus divaricatus*
	Ptilotus polystachyus
	Ptilotus spathulatus
Apocynaceae	*Alyxia buxifolia*
	Rhyncharrhena linearis
Araliaceae	*Trachymene cyanopetala*
Asparagaceae	*Thysanotus manglesianus*
Asteraceae	**Arctotheca calendula*
	Blennospora drummondii
	**Cotula coronopifolia*
	Asteraceae sp.
	Hyalosperma cotula
	**Hypochaeris glabra*
	Podolepis canescens
	Podolepis capillaris
	Podolepis lessonii
	Pogonolepis muelleriana
	Sonchus hydrophilus
	**Sonchus oleraceus*
	**Ursinia anthemoides*
	Waitzia acuminata
	Waitzia acuminata var. *acuminata*
Boraginaceae	**Echium plantagineum*
	Halgania integerrima
Boryaceae	*Borya sphaerocephala*
Brassicaceae	**Raphanus raphanistrum*
	**Sisymbrium orientale*
Cactaceae	**Opuntia monacantha*
Casuarinaceae	*Allocasuarina acutivalvis*
	Allocasuarina campestris
	Casuarina obesa
Chenopodiaceae	*Atriplex amnicola*
	Atriplex bunburyana
	Atriplex codonocarpa
	Atriplex hymenotheca
	Atriplex nummularia
	Atriplex semibaccata
	Atriplex semilunaris
	Atriplex sp.
	Dissocarpus paradoxus

	Dysphania pumilio
	Enchylaena tomentosa
	Enchylaena tomentosa var. *tomentosa*
	Eriochiton sclerolaenoides
	Maireana brevifolia
	Maireana georgei
	Maireana sp.
	Maireana trichoptera
	Rhagodia drummondii
	Rhagodia preissii
	Rhagodia sp. Watheroo (R.J. Cranfield & P.J. Spencer 8183)
	Salsola australis
	Sclerolaena diacantha
	Tecticornia halocnemoides
	Tecticornia indica subsp. *bidens*
	Tecticornia lepidosperma
	Tecticornia? moniliformis
	Tecticornia pergranulata
	Tecticornia undulata
Crassulaceae	*Crassula colorata*
	Crassula colorata var. *acuminata*
Cucurbitaceae	**Citrullus lanatus*
Cupressaceae	*Callitris arenaria*
Cyperaceae	*Gahnia drummondii*
	Lepidosperma costale
	Lepidosperma longitudinale
Dilleniaceae	*Hibbertia drummondii*
Droseraceae	*Drosera macrophylla* subsp. *macrophylla*
	Drosera menziesii subsp. *penicillaris*
	Drosera subhirtella
Euphorbiaceae	*Euphorbia drummondii*
	Ricinocarpos muricatus
Fabaceae	*Acacia acuaria*
	Acacia aculeiformis
	Acacia acuminata
	Acacia aestivalis
	Acacia assimilis
	Acacia assimilis subsp. *assimilis*
	Acacia blakelyi
	Acacia colletioides
	Acacia daphnifolia
	Acacia daviesioides
	Acacia enervia subsp. *explicata*
	Acacia eremaea
	Acacia erinacea

	Acacia hemiteles
	Acacia isoneura
	Acacia jennerae
	Acacia neurophylla
	Acacia resinimarginea
	Acacia sibina
	Acacia sp.
	Daviesia benthamii subsp. *benthamii*
	Gastrolobium calycinum
	Jacksonia fasciculata
	Jacksonia foliosa
	Jacksonia rhadinoclada
	**Lupinus angustifolius*
	**Medicago minima*
	Mirbelia microphylla
	Templetonia smithiana
	Urodon capitatus (P3)
Frankeniaceae	*Frankenia glomerata* (P3)
	Frankenia pauciflora
Geraniaceae	**Erodium botrys*
	Erodium cygnorum
Goodeniaceae	*Dampiera glabrescens* (P1)
	Dampiera lavandulacea
	Goodenia helmsii
	Scaevola spinescens
Haemodoraceae	*Conostylis* sp.
Haloragaceae	*Glischrocaryon flavescens*
Hemerocallidaceae	*Dianella revoluta*
	Stypandra glauca
Iridaceae	**Freesia alba x leichtlinii*
	Iridaceae sp.
	**Romulea rosea* var. *australis*
Lamiaceae	*Cyanostegia angustifolia*
	Dasymalla terminalis
Lauraceae	*Cassytha capillaris*
	Cassytha nodiflora
Malvaceae	*Alyogyne hakeifolia*
	Alyogyne sp. Hutt River (B.J. Lepschi & T.R. Lally 2310)
	Alyogyne sp. Port Gregory (K.F. Kenneally 2382)
	**Malva parviflora*
Myrtaceae	*Baeckea crispiflora* var. *tenuior*
	Calothamnus gilesii
	Calytrix depressa
	Chamelaucium sp. Wongan Hills (B.H. Smith 1140) (P3)
	Eucalyptus aequioperta

	Eucalyptus aff. *salubris*
	Eucalyptus armillata
	Eucalyptus camaldulensis
	Eucalyptus capillosa subsp. *polyclada*
	Eucalyptus dolichocera
	Eucalyptus ebbanoensis subsp. *ebbanoensis*
	Eucalyptus ewartiana
	Eucalyptus kochii subsp. *plenissima*
	Eucalyptus leptopoda
	Eucalyptus loxophleba
	Eucalyptus loxophleba subsp. *lissophloia*
	Eucalyptus loxophleba subsp. *loxophleba*
	Eucalyptus salmonophloia
	Eucalyptus salubris
	Eucalyptus sp.
	Eucalyptus tenera
	Eucalyptus torquata
	Melaleuca acuminata
	Melaleuca adnata
	Melaleuca calyptroides
	Melaleuca cordata
	Melaleuca hamata
	Melaleuca lateriflora
	Melaleuca radula
	Melaleuca stereophloia
	Verticordia chrysantha
	Verticordia monadelpha
	Verticordia sp.
Oxalidaceae	**Oxalis pes-caprae*
Plumbaginaceae	**Limonium lobatum*
Poaceae	*Aristida contorta*
	Aristida holathera
	Austrostipa elegantissima
	Austrostipa scabra
	Austrostipa variabilis
	**Avena barbata*
	**Brachypodium distachyon*
	**Briza maxima*
	**Bromus diandrus*
	**Bromus hordeaceus*
	**Bromus rubens*
	**Cynodon dactylon*
	**Ehrharta calycina*
	**Ehrharta longiflora*
	Enneapogon sp.

	Enteropogon ramosus
	**Eragrostis curvula*
	Eriachne ovata
	Poaceae sp.1
	Poaceae sp.2
	Poaceae sp.3
	Poaceae sp.4
	Poaceae sp.5
	Poaceae sp.6
	Poaceae sp.7
	Poaceae sp.8
	Poaceae sp.9
	Poaceae sp.10
	Poaceae sp.11
	Poaceae sp.12
	Poaceae sp.13
	Poaceae sp.14
	Poaceae sp.15
	Poaceae sp.16
	Poaceae sp.17
	Poaceae sp.18
	Poaceae sp.19
	**Hordeum hystrix*
	**Hordeum leporinum*
	**Lolium rigidum*
	Monachather paradoxus
	**Pentameris airoides*
	**Pentameris airoides subsp. airoides*
	**Triticum aestivum*
Polygalaceae	*Comesperma integerrimum*
	Comesperma sp.
Polygonaceae	*Muehlenbeckia adpressa*
Portulacaceae	*Calandrinia eremaea*
Proteaceae	*Banksia densa* var. *densa*
	Grevillea armigera
	Grevillea asparagoides (P3)
	Grevillea bracteosa subsp. *bracteosa* (T)
	Grevillea paniculata
	Grevillea paradoxa
	Grevillea petrophiloides
	Grevillea pinifolia (P1)
	Hakea erecta
	Hakea preissii
	Hakea recurva
	Hakea scoparia subsp. *scoparia*

	Petrophile shuttleworthiana
Pteridaceae	*Cheilanthes sieberi* subsp. *sieberi*
Rhamnaceae	*Stenanthemum pomaderroides*
Santalaceae	*Santalum acuminatum*
Sapindaceae	*Dodonaea bursariifolia*
	Dodonaea inaequifolia
Scrophulariaceae	*Eremophila drummondii*
	Eremophila lehmanniana
	Eremophila serrulata
Solanaceae	*Solanum lasiophyllum*
	**Solanum nigrum*
Surianaceae	*Stylobasium australe*
Tamaricaceae	**Tamarix aphylla*

Appendix 5 DPaW advice regarding PEC Eucalypt woodlands of the Western Australian Wheatbelt

Uploaded separately to Dropbox

Appendix 6 Carnaby's Black Cockatoo potential breeding tree records

Name	Date	Latitude	Longitude	Tree species	DBH (mm)	Hollows present	Suitable for Carnaby's	Evidence of use by Carnaby's	Description
HT0130	24/10/2014	-30.4643	116.4742	*Eucalyptus salmonophloia*	535	No	No	No	
HT0131	24/10/2014	-30.4643	116.4736	*Eucalyptus salmonophloia*	670	No	No	No	
HT0135	24/10/2014	-30.4644	116.4246	*Eucalyptus salmonophloia*	500	No	No	No	
HT0139	24/10/2014	-30.4644	116.4308	*Eucalyptus salmonophloia*	500	No	No	No	
HT0140	24/10/2014	-30.4645	116.4353	*Eucalyptus camaldulensis*	650	No	No	No	
HT0141	24/10/2014	-30.4643	116.4440	*Eucalyptus salmonophloia*	1000	No	No	No	
HT0142	24/10/2014	-30.4645	116.4445	*Eucalyptus salmonophloia*	740	No	No	No	
HT0143	24/10/2014	-30.4645	116.4458	*Eucalyptus salmonophloia*	530	No	No	No	
HT0146	24/10/2014	-30.4644	116.4475	*Eucalyptus salmonophloia*	550	No	No	No	
HT0161	30/10/2014	-30.4679	116.3808	*Eucalyptus loxophleba*	650	No	No	No	
HT0162	30/10/2014	-30.4666	116.3819	*Eucalyptus loxophleba*	500	No	No	No	
HT0163	30/10/2014	-30.4645	116.4087	*Eucalyptus salmonophloia*	420	No	No	No	
HT0164	30/10/2014	-30.4643	116.4093	*Eucalyptus salmonophloia*	475	No	No	No	
HT0165	1/11/2014	-30.4642	116.4108	*Eucalyptus salmonophloia*	450	No	No	No	
HT0169	30/10/2014	-30.4645	116.4193	*Eucalyptus salmonophloia*	470	No	No	No	
HT0173	30/10/2014	-30.5152	116.3490	*Eucalyptus loxophleba*	750	No	No	No	
HT0174	30/10/2014	-30.5153	116.3490	*Eucalyptus loxophleba*	560	No	No	No	
HT0176	30/10/2014	-30.5115	116.3511	*Eucalyptus salmonophloia*	560	No	No	No	
HT0178	30/10/2014	-30.5110	116.3513	*Eucalyptus salmonophloia*	620	No	No	No	
HT0180	30/10/2014	-30.5097	116.3522	*Eucalyptus salmonophloia*	530	No	No	No	
HT0191	30/10/2014	-30.5029	116.3561	*Eucalyptus salmonophloia*	450	No	No	No	
HT0192	30/10/2014	-30.5027	116.3562	*Eucalyptus salmonophloia*	440	No	No	No	
HT0193	30/10/2014	-30.5024	116.3563	*Eucalyptus salmonophloia*	470	No	No	No	
HT0203	30/10/2014	-30.4982	116.3585	*Eucalyptus loxophleba*	530	No	No	No	

Name	Date	Latitude	Longitude	Tree species	DBH (mm)	Hollows present	Suitable for Carnaby's	Evidence of use by Carnaby's	Description
HT0356	5/02/2015	-30.4643	116.4094	*Eucalyptus salmonophloia*	500	No	No	No	
HT0357	5/02/2015	-30.4643	116.4910	*Eucalyptus salmonophloia*	650	No	No	No	
HT0358	5/02/2015	-30.4643	116.4125	*Eucalyptus salmonophloia*	570	No	No	No	
HT0359	5/02/2015	-30.4643	116.4127	*Eucalyptus salmonophloia*	700	No	No	No	
HT0360	5/02/2015	-30.4643	116.4131	*Eucalyptus salmonophloia*	590	No	No	No	
HT0361	5/02/2015	-30.4643	116.4132	*Eucalyptus salmonophloia*	610	No	No	No	
HT0362	5/02/2015	-30.4643	116.4134	*Eucalyptus salmonophloia*	830	No	No	No	
HT0363	5/02/2015	-30.4643	116.4145	*Eucalyptus salmonophloia*	700	No	No	No	
HT0364	5/02/2015	-30.4645	116.4146	*Eucalyptus salmonophloia*	650	No	No	No	
HT0365	5/02/2015	-30.4642	116.4151	*Eucalyptus salmonophloia*	600	No	No	No	Just over fence on property.
HT0366	5/02/2015	-30.4643	116.4158	*Eucalyptus salmonophloia*	500	No	No	No	
HT0367	5/02/2015	-30.4643	116.4165	*Eucalyptus salmonophloia*	500	No	No	No	
HT0368	5/02/2015	-30.4643	116.4169	*Eucalyptus salmonophloia*	500	No	No	No	
HT0369	5/02/2015	-30.4643	116.4170	*Eucalyptus salmonophloia*	600	No	No	No	
HT0370	5/02/2015	-30.4643	116.4173	*Eucalyptus salmonophloia*	500	No	No	No	
HT0371	5/02/2015	-30.4643	116.4174	*Eucalyptus salmonophloia*	750	No	No	No	
HT0372	5/02/2015	-30.4643	116.4228	*Eucalyptus salmonophloia*	500	No	No	No	
HT0373	5/02/2015	-30.4643	116.4229	*Eucalyptus salmonophloia*	600	No	No	No	
HT0374	5/02/2015	-30.4643	116.4315	*Eucalyptus salmonophloia*	600	No	No	No	
HT0375	5/02/2015	-30.4645	116.4309	*Eucalyptus salmonophloia*	550	No	No	No	
HT0376	5/02/2015	-30.4645	116.4313	*Eucalyptus salmonophloia*	560	No	No	No	
HT0377	5/02/2015	-30.4645	116.4321	*Eucalyptus salmonophloia*	500	No	No	No	
HT0379	5/02/2015	-30.4643	116.4330	*Eucalyptus salmonophloia*	700	No	No	No	
HT0380	5/02/2015	-30.4643	116.4357	*Eucalyptus salmonophloia*	550	No	No	No	
HT0381	5/02/2015	-30.4643	116.4358	*Eucalyptus salmonophloia*	550	No	No	No	

Name	Date	Latitude	Longitude	Tree species	DBH (mm)	Hollows present	Suitable for Carnaby's	Evidence of use by Carnaby's	Description
HT0383	5/02/2015	-30.4645	116.4476	*Eucalyptus salmonophloia*	650	No	No	No	
HT0384	5/02/2015	-30.4645	116.4479	*Eucalyptus camaldulensis*	550	No	No	No	
HT0385	5/02/2015	-30.4644	116.4481	*Eucalyptus camaldulensis*	550	No	No	No	
HT0386	5/02/2015	-30.4645	116.4484	*Eucalyptus salmonophloia*	550	No	No	No	
HT0387	5/02/2015	-30.4644	116.4997	*Eucalyptus salmonophloia*	700	No	No	No	
HT0450	4/02/2015	-30.4644	116.4088	*Eucalyptus salmonophloia*	560	No	No	No	
HT0451	4/02/2015	-30.4644	116.4087	*Eucalyptus salmonophloia*	500	No	No	No	
HT0452	4/02/2015	-30.4644	116.4088	*Eucalyptus salmonophloia*	500	No	No	No	
HT0453	4/02/2015	-30.4645	116.4127	*Eucalyptus salmonophloia*	760	No	No	No	
HT0454	4/02/2015	-30.4644	116.4137	*Eucalyptus salmonophloia*	720	No	No	No	
HT0455	4/02/2015	-30.4644	116.4137	*Eucalyptus salmonophloia*	660	No	No	No	
HT0456	4/02/2015	-30.4644	116.4139	*Eucalyptus salmonophloia*	500	No	No	No	
HT0457	4/02/2015	-30.4645	116.4140	*Eucalyptus salmonophloia*	500	No	No	No	
HT0458	4/02/2015	-30.4644	116.4141	*Eucalyptus salmonophloia*	500	No	No	No	
HT0459	4/02/2015	-30.4644	116.4166	*Eucalyptus salmonophloia*	620	No	No	No	
HT0460	4/02/2015	-30.4644	116.4166	*Eucalyptus salmonophloia*	660	No	No	No	
HT0461	4/02/2015	-30.4644	116.4179	*Eucalyptus salmonophloia*	500	No	No	No	
HT0462	5/02/2015	-30.4643	116.4181	*Eucalyptus loxophleba*	740	No	No	No	
HT0463	5/02/2015	-30.4643	116.4198	*Eucalyptus loxophleba*	660	No	No	No	
HT0464	5/02/2015	-30.4643	116.4231	*Eucalyptus salmonophloia*	500	No	No	No	
HT0465	5/02/2015	-30.4643	116.4232	*Eucalyptus salmonophloia*	660	No	No	No	
HT0466	5/02/2015	-30.4644	116.4255	*Eucalyptus salmonophloia*	680	No	No	No	
HT0467	5/02/2015	-30.4643	116.4309	*Eucalyptus salmonophloia*	520	No	No	No	
HT0468	5/02/2015	-30.4643	116.4309	*Eucalyptus salmonophloia*	660	No	No	No	
HT0469	5/02/2015	-30.4643	116.4316	*Eucalyptus salmonophloia*	760	No	No	No	

Name	Date	Latitude	Longitude	Tree species	DBH (mm)	Hollows present	Suitable for Carnaby's	Evidence of use by Carnaby's	Description
HT0470	5/02/2015	-30.4643	116.4321	*Eucalyptus salmonophloia*	640	No	No	No	
HT0471	5/02/2015	-30.4643	116.4323	*Eucalyptus salmonophloia*	520	No	No	No	
HT0472	5/02/2015	-30.4643	116.4325	*Eucalyptus salmonophloia*	780	No	No	No	
HT0473	5/02/2015	-30.4643	116.4325	*Eucalyptus salmonophloia*	680	No	No	No	
HT0475	5/02/2015	-30.4645	116.4354	*Eucalyptus salmonophloia*	620	No	No	No	
HT0477	5/02/2015	-30.4643	116.4997	*Eucalyptus salmonophloia*	840	No	No	No	
HT2961	5/02/2015	-30.4645	116.4459	*Eucalyptus salmonophloia*	660	No	No	No	
HT2962	5/02/2015	-30.4645	116.4460	*Eucalyptus camaldulensis*	540	No	No	No	
HT4861	22/05/2015	-30.5393	116.3391	*Eucalyptus loxophleba*	500	No	No	No	
HT4862	22/05/2015	-30.5269	116.3432	*Eucalyptus sp.*	500	No	No	No	Unknown species, photo taken.
HT4863	22/05/2015	-30.5231	116.3459	*Eucalyptus salmonophloia*	840	No	No	No	
HT4864	22/05/2015	-30.5232	116.3459	*Eucalyptus salmonophloia*	820	No	No	No	
HT4865	22/05/2015	-30.5217	116.3459	*Eucalyptus salmonophloia*	640	No	No	No	
HT4868	22/05/2015	-30.5089	116.3527	*Eucalyptus salmonophloia*	460	No	No	No	
HT4869	22/05/2015	-30.5090	116.3527	*Eucalyptus salmonophloia*	380	No	No	No	
HT4870	22/05/2015	-30.5089	116.3527	*Eucalyptus salmonophloia*	340	No	No	No	
HT4871	22/05/2015	-30.5088	116.3529	*Eucalyptus salmonophloia*	560	No	No	No	
HT4872	22/05/2015	-30.5088	116.3529	*Eucalyptus salmonophloia*	500	No	No	No	
HT4873	22/05/2015	-30.5085	116.3530	*Eucalyptus salmonophloia*	380	No	No	No	
HT4874	22/05/2015	-30.5085	116.3530	*Eucalyptus salmonophloia*	340	No	No	No	
HT4875	22/05/2015	-30.5084	116.3530	*Eucalyptus salmonophloia*	400	No	No	No	
HT4876	22/05/2015	-30.5085	116.3530	*Eucalyptus salmonophloia*	360	No	No	No	
HT4877	22/05/2015	-30.5041	116.3556	*Eucalyptus salmonophloia*	680	No	No	No	
HT4878	22/05/2015	-30.5021	116.3565	*Eucalyptus camaldulensis*	500	No	No	No	
HT4879	22/05/2015	-30.5015	116.3569	*Eucalyptus camaldulensis*	500	No	No	No	

Name	Date	Latitude	Longitude	Tree species	DBH (mm)	Hollows present	Suitable for Carnaby's	Evidence of use by Carnaby's	Description
HT4880	22/05/2015	-30.5012	116.3570	*Eucalyptus camaldulensis*	500	No	No	No	
HT4881	22/05/2015	-30.5011	116.3571	*Eucalyptus camaldulensis*	500	No	No	No	
HT4882	22/05/2015	-30.5009	116.3572	*Eucalyptus camaldulensis*	600	No	No	No	
HT4883	22/05/2015	-30.5008	116.3573	*Eucalyptus camaldulensis*	520	No	No	No	
HT4884	22/05/2015	-30.5000	116.3588	*Eucalyptus loxophleba*	540	No	No	No	
HT4885	22/05/2015	-30.5003	116.3595	*Eucalyptus loxophleba*	520	No	No	No	
HT4886	22/05/2015	-30.4945	116.3608	*Eucalyptus salmonophloia*	600	No	No	No	
HT4887	22/05/2015	-30.4945	116.3608	*Eucalyptus salmonophloia*	340	No	No	No	
HT4888	22/05/2015	-30.4944	116.3609	*Eucalyptus salmonophloia*	440	No	No	No	
HT4889	22/05/2015	-30.4941	116.3610	*Eucalyptus salmonophloia*	640	No	No	No	
HT4890	22/05/2015	-30.4941	116.3611	*Eucalyptus loxophleba*	500	No	No	No	
HT4891	22/05/2015	-30.4958	116.3654	*Eucalyptus salmonophloia*	440	No	No	No	
HT4892	22/05/2015	-30.4967	116.3673	*Eucalyptus loxophleba*	560	No	No	No	
HT4893	22/05/2015	-30.4960	116.3665	*Eucalyptus loxophleba*	580	No	No	No	
HT4894	22/05/2015	-30.4896	116.3689	*Eucalyptus salmonophloia*	600	No	No	No	
HT4895	22/05/2015	-30.4872	116.3687	*Eucalyptus camaldulensis*	760	No	No	No	
HT4896	22/05/2015	-30.4871	116.3685	*Eucalyptus camaldulensis*	700	No	No	No	
HT4897	22/05/2015	-30.4867	116.3677	*Eucalyptus camaldulensis*	600	No	No	No	
HT4898	22/05/2015	-30.4868	116.3676	*Eucalyptus camaldulensis*	680	No	No	No	
HT4899	22/05/2015	-30.4678	116.3844	*Eucalyptus loxophleba*	500	No	No	No	
HT4900	22/05/2015	-30.4644	116.3931	*Eucalyptus loxophleba*	540	No	No	No	
HT4901	22/05/2015	-30.4650	116.4392	*Eucalyptus loxophleba*	500	No	No	No	
HT4902	22/05/2015	-30.4687	116.4530	*Eucalyptus loxophleba*	580	No	No	No	
HT4903	22/05/2015	-30.4701	116.4585	*Eucalyptus salmonophloia*	740	No	No	No	
HT4904	22/05/2015	-30.4700	116.4586	*Eucalyptus salmonophloia*	640	No	No	No	

Name	Date	Latitude	Longitude	Tree species	DBH (mm)	Hollows present	Suitable for Carnaby's	Evidence of use by Carnaby's	Description
HT4905	22/05/2015	-30.4704	116.4586	*Eucalyptus loxophleba*	640	No	No	No	
HT4906	22/05/2015	-30.4702	116.4602	*Eucalyptus salmonophloia*	600	No	No	No	
HT4907	22/05/2015	-30.4651	116.4867	*Eucalyptus salmonophloia*	720	No	No	No	
HT4908	22/05/2015	-30.4643	116.4932	*Eucalyptus loxophleba*	600	No	No	No	
HT4909	22/05/2015	-30.4642	116.5689	*Eucalyptus camaldulensis*	500	No	No	No	
HT4910	22/05/2015	-30.5230	116.3456	*Eucalyptus salmonophloia*	1000	No	No	No	
HT4912	22/05/2015	-30.5085	116.3530	*Eucalyptus salmonophloia*	370	No	No	No	
HT4913	22/05/2015	-30.5086	116.3530	*Eucalyptus salmonophloia*	400	No	No	No	
HT4914	22/05/2015	-30.5085	116.3530	*Eucalyptus salmonophloia*	330	No	No	No	
HT4915	22/05/2015	-30.5085	116.3530	*Eucalyptus salmonophloia*	300	No	No	No	
HT4916	22/05/2015	-30.5005	116.3598	*Eucalyptus loxophleba*	500	No	No	No	
HT4917	22/05/2015	-30.4940	116.3613	*Eucalyptus salmonophloia*	500	No	No	No	
HT4918	22/05/2015	-30.4941	116.3611	*Eucalyptus salmonophloia*	500	No	No	No	
HT4919	22/05/2015	-30.4653	116.4013	*Eucalyptus salmonophloia*	500	No	No	No	
HT4921	22/05/2015	-30.4645	116.3938	*Eucalyptus loxophleba*	500	No	No	No	
HT4922	22/05/2015	-30.4652	116.3937	*Eucalyptus loxophleba*	500	No	No	No	
HT4923	22/05/2015	-30.4653	116.3946	*Eucalyptus loxophleba*	500	No	No	No	
HT4924	22/05/2015	-30.4674	116.4481	*Eucalyptus salmonophloia*	1000	No	No	No	
HT4925	22/05/2015	-30.4650	116.4405	*Eucalyptus camaldulensis*	740	No	No	No	
HT4926	22/05/2015	-30.4652	116.4381	*Eucalyptus loxophleba*	500	No	No	No	
HT4927	22/05/2015	-30.4647	116.4264	*Eucalyptus loxophleba*	500	No	No	No	
HT4928	22/05/2015	-30.4655	116.4207	*Eucalyptus salmonophloia*	300	No	No	No	
HT4929	22/05/2015	-30.4653	116.4207	*Eucalyptus loxophleba*	500	No	No	No	
HT4930	22/05/2015	-30.4699	116.4582	*Eucalyptus loxophleba*	500	No	No	No	
HT4931	17/06/2015	-30.4640	116.4745	*Eucalyptus salmonophloia*	420	No	No	No	

Name	Date	Latitude	Longitude	Tree species	DBH (mm)	Hollows present	Suitable for Carnaby's	Evidence of use by Carnaby's	Description
HT4932	17/06/2015	-30.4641	116.4745	*Eucalyptus salmonophloia*	360	No	No	No	Dead.
HT4933	17/06/2015	-30.4640	116.4746	*Eucalyptus salmonophloia*	360	No	No	No	Dead.
HT4934	17/06/2015	-30.4641	116.4748	*Eucalyptus loxophleba*	560	No	No	No	
HT4935	17/06/2015	-30.4642	116.4747	*Eucalyptus salmonophloia*	560	No	No	No	
HT4936	17/06/2015	-30.4642	116.4747	*Eucalyptus salmonophloia*	620	No	No	No	
HT4937	17/06/2015	-30.4642	116.4746	*Eucalyptus salmonophloia*	660	No	No	No	
HT4938	17/06/2015	-30.4641	116.4744	*Eucalyptus salmonophloia*	660	No	No	No	
HT4939	17/06/2015	-30.4641	116.4742	*Eucalyptus salmonophloia*	400	No	No	No	
HT4940	17/06/2015	-30.4641	116.4741	*Eucalyptus salmonophloia*	380	No	No	No	
HT4941	17/06/2015	-30.4640	116.4740	*Eucalyptus salmonophloia*	460	No	No	No	
HT4943	17/06/2015	-30.4642	116.4740	*Eucalyptus salmonophloia*	460	No	No	No	
HT4944	17/06/2015	-30.4642	116.4738	*Eucalyptus salmonophloia*	560	No	No	No	
HT4945	17/06/2015	-30.4641	116.4739	*Eucalyptus salmonophloia*	560	No	No	No	
HT4946	17/06/2015	-30.4641	116.4738	*Eucalyptus salmonophloia*	300	No	No	No	
HT4947	17/06/2015	-30.4642	116.4738	*Eucalyptus salmonophloia*	580	No	No	No	
HT4949	17/06/2015	-30.4642	116.4736	*Eucalyptus salmonophloia*	640	No	No	No	
HT4950	17/06/2015	-30.4642	116.4736	*Eucalyptus salmonophloia*	800	No	No	No	
HT0123	24/10/2014	-30.4644	116.4903	*Eucalyptus salubris*	860	Yes	No	No	Hollow too small for Carnaby's Black Cockatoo.
HT0126	24/10/2014	-30.4644	116.4942	*Eucalyptus salmonophloia*	910	Yes	No	No	Hollows at 2 m and 4 m, not deep enough for Carnaby's Black Cockatoo.
HT0127	24/10/2014	-30.4642	116.4973	*Eucalyptus salmonophloia*	760	Yes	No	No	Hollow at 4 m, unlikely to be a Carnaby's Black Cockatoo breeding hollow.
HT0128	24/10/2014	-30.4643	116.4997	*Eucalyptus salmonophloia*	450	Yes	No	No	Hollow shows no signs of use at entrance and isn't deep enough for

Name	Date	Latitude	Longitude	Tree species	DBH (mm)	Hollows present	Suitable for Carnaby's	Evidence of use by Carnaby's	Description
									Carnaby's Black Cockatoo breeding hollow.
HT0133	24/10/2014	-30.4645	116.4229	*Eucalyptus salmonophloia*	550	Yes	No	No	Shows no signs of use and unlikely to be Carnaby's Black Cockatoo breeding hollow, Galahs using this tree.
HT0134	24/10/2014	-30.4645	116.4242	*Eucalyptus salmonophloia*	750	Yes	No	No	Hollow at 12 and 14 m, Galah scarred hollow.
HT0137	24/10/2014	-30.4645	116.4253	*Eucalyptus salmonophloia*	820	Yes	No	No	Hollow at 3.5 m. Hollow too low and shows no signs of use. Unlikely to be Carnaby's Cockatoo breeding hollow.
HT0138	24/10/2014	-30.4644	116.4264	*Eucalyptus loxophleba*	650	Yes	No	No	Hollows a 3.5 and 6 m. Hollow too small for Carnaby's Black Cockatoo.
HT0144	24/10/2014	-30.4645	116.4457	*Eucalyptus salmonophloia*	780	Yes	No	No	Hollow 4 m, up. Hollow too small for Carnaby's Black Cockatoo.
HT0145	24/10/2014	-30.4644	116.4472	*Eucalyptus salmonophloia*	500	Yes	No	No	Hollow at 4 m.
HT0166	30/10/2014	-30.4644	116.4125	*Eucalyptus salmonophloia*	750	Yes	No	No	Ring-necked Parrot at hollow. Too small for Carnaby's Black Cockatoo.
HT0168	30/10/2014	-30.4644	116.4184	*Eucalyptus salmonophloia*	550	Yes	No	No	Hollow at 2.5 m. Hollow too small for Carnaby's Black Cockatoo.
HT0170	30/10/2014	-30.5175	116.3477	*Eucalyptus salmonophloia*	540	Yes	No	No	Hollows at 5 m and 6 m.
HT0171	30/10/2014	-30.5171	116.3481	*Eucalyptus salmonophloia*	420	Yes	No	No	Hollow at 4 m. Three hollows probably used by Galahs. Much evidence of Galah scarring.
HT0172	30/10/2014	-30.5156	116.3488	*Eucalyptus loxophleba*	650	Yes	No	No	Hollow at 1 m.
HT0177	30/10/2014	-30.5113	116.3512	*Eucalyptus salmonophloia*	740	Yes	No	No	Hollow at 2 m. Has large hollow but not deep enough and too low to be cockatoo hollow.
HT0179	30/10/2014	-30.5097	116.3522	*Eucalyptus salmonophloia*	660	Yes	No	No	Hollow at 1.5 m and 6 m.
HT0204	30/10/2014	-30.5216	116.3455	*Eucalyptus salmonophloia*	650	Yes	No	No	Small hollow at 8 m. Hollow used by Galah.

Name	Date	Latitude	Longitude	Tree species	DBH (mm)	Hollows present	Suitable for Carnaby's	Evidence of use by Carnaby's	Description
HT0382	5/02/2015	-30.4643	116.4363	*Eucalyptus salmonophloia*	650	Yes	No	No	Hollow at 10 m. Hollow with suitable entrance but shows no signs of use. Unlikely to be a Carnaby's Black Cockatoo breeding hollow
HT0476	5/02/2015	-30.4644	116.4464	*Eucalyptus salmonophloia*	520	Yes	No	No	Hollow too small for Carnaby's Black Cockatoo.
HT4866	22/05/2015	-30.5099	116.3526	*Eucalyptus salmonophloia*	1000	Yes	No	No	Hollow at 5 m. Hollow too small for Carnaby's Black Cockatoo.
HT4911	22/05/2015	-30.5089	116.3529	*Eucalyptus salmonophloia*	800	Yes	No	No	Hollow at 3 m. Two hollows showing no signs of use. Both too low. Unlikely to be a Carnaby's Black Cockatoo breeding hollows.
HT4920	22/05/2015	-30.4655	116.4013	*Eucalyptus salmonophloia*	480	Yes	No	No	Hollow at 5 m. No signs of use. Unlikely to be a Carnaby's Black Cockatoo breeding hollow.
HT4942	17/06/2015	-30.4642	116.4741	*Eucalyptus salmonophloia*	480	Yes	No	No	Dead. Hollow at 2.5 m. Unlikely to be Carnaby's Black Cockatoo breeding hollow, no signs of use.
HT0129	24/10/2014	-30.4643	116.5003	*Eucalyptus salmonophloia*	730	Yes	No	No	Hollow at 8 m.
HT0124	24/10/2014	-30.4645	116.4910	*Eucalyptus salmonophloia*	860	Yes	Yes	No	Hollow at 5.5 m. Galahs in tree. Good top entry. Top entry hollow suitable for Carnaby's Black Cockatoo.
HT0125	24/10/2014	-30.4643	116.4918	*Eucalyptus salmonophloia*	910	Yes	Yes	No	Hollows at 2 m and 4 m. Possible Carnaby's Black Cockatoo hollow though may be too small.
HT0132	24/10/2014	-30.4643	116.4747	*Eucalyptus salmonophloia*	300	Yes	Yes	Yes	Hollow well chewed and worn. Suitable for Carnaby's Black Cockatoo.
HT0136	24/10/2014	-30.4644	116.4252	*Eucalyptus salmonophloia*	500	Yes	Yes	Yes	Hollow with chewing and wear at entrance. Suitable for Carnaby's Black Cockatoo.

Name	Date	Latitude	Longitude	Tree species	DBH (mm)	Hollows present	Suitable for Carnaby's	Evidence of use by Carnaby's	Description
HT0167	30/10/2014	-30.4645	116.4164	*Eucalyptus salubris*	1100	Yes	Yes	No	Suitable hollow for Carnaby's Black Cockatoo.
HT0175	30/10/2014	-30.5133	116.3500	*Eucalyptus salmonophloia*	670	Yes	Yes	No	Hollow at 3 m. Possible Carnaby's Black Cockatoo hollow.
HT0181	30/10/2014	-30.5094	116.3524	*Eucalyptus salmonophloia*	800	Yes	Yes	No	Hollow at 6 m. Long-billed Corella flushed from hollow which also looks suitable for Carnaby's Black Cockatoo.
HT0182	30/10/2014	-30.5088	116.3527	*Eucalyptus salmonophloia*	500	Yes	Yes	No	Suitable hollow for Carnaby's Black Cockatoo.
HT0183	30/10/2014	-30.5082	116.3531	*Eucalyptus salubris*	1000	Yes	Yes	No	Hollows at 2 m, 4 m, 6 m, 7 m and 8 m. Three hollows with suitable entrance for Carnaby's Black Cockatoo. Long-billed Corella flushed from a lower hollow.
HT0378	5/02/2015	-30.4645	116.4329	*Eucalyptus salmonophloia*	1000	Yes	Yes	Yes	Hollow at 7 m. Chewing and wear at entrance. Suitable for Carnaby's Black Cockatoo.
HT0474	5/02/2015	-30.4644	116.4358	*Eucalyptus salmonophloia*	1250	Yes	Yes	No	Hollow at 8 m. Being used by Galahs and Long-billed Corella flushed from hollow, which also looks suitable for Carnaby's Black Cockatoo.
HT4867	22/05/2015	-30.5094	116.3525	*Eucalyptus salmonophloia*	800	Yes	Yes	Yes	Hollow at 8 m. Approx 150 mm. Two chewed and worn hollows suitable for Carnaby's Black Cockatoo. Long-billed Corella's also using this tree.
HT4948	17/06/2015	-30.4641	116.4736	*Eucalyptus salmonophloia*	480	Yes	Yes	Yes	Dead. Hollow at 5 m, entrance large enough but numerous holes in trunk below hollow. Well chewed hollow suitable for Carnaby's Black Cockatoo.