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**WATER CORPORATION
BEENYUP STAGE 2 BIOLOGICAL SURVEY**

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ACRONYMS AND GLOSSARY

ARRP Act	<i>Agriculture and Related Resources Protection Act 1976</i>
BOM	Bureau of Meteorology
DAF	Department of Agriculture and Food
DEC	Department of Environment and Conservation
DEFL	The DEC's Threatened (Declared Rare) Flora Database
DSEWPC	Department of the Sustainability, Environment, Water, Populations and Communities
DRF	Declared Rare Flora
ESA	Environmentally Sensitive Area
EPA	Environmental Protection Authority
EP Act	<i>Environmental Protection Act 1986</i>
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
IBRA	Interim Biogeographic Regionalisation for Australia
NVIS	National Vegetation Information System
PEC	Priority Ecological Community
TEC	Threatened Ecological Community
WAHERB	Western Australian Herbarium
WC Act	<i>Wildlife Conservation Act 1950</i>

EXECUTIVE SUMMARY

The Water Corporation is seeking to expand the Groundwater Replenishment (GWR) trial at Beenyup Wastewater Treatment Plant (WWTP) into a 7 GL/year scheme. This future expansion is referred to as Stage 2. As part of this project the Beenyup WWTP site will need to be expanded to allow new infrastructure.

The Project Area is located in the Perth metropolitan area, approximately 14 km east of the city centre and it is located entirely in Perth subregion of the Swan Coastal Plain Bioregion.

A level 2 Flora and Vegetation Survey and a Level 1 Fauna Survey were undertaken by *ecologia* during October 2012.

The key results of the flora, vegetation and fauna assessment are as follows:

- The vegetation of the Project Area is predominantly ‘Completely Degraded’ and few areas of vegetation that support only scattered native trees and shrubs occur.
- The regional vegetation types of the Project Area are the Cottesloe Central and South; Herdsman; and Karrakatta Central and South Complexes. The Karrakatta – Central and South Complex was reported by Perth Biodiversity Project to be represented by 24% of its pre-European extent and which falls below the threshold level of 30%. Cottesloe Central and South and Herdsman (both represented by 35% of its original extent) are considered by the Perth Biodiversity Project as under the threshold because the mapping is over-estimated due to the scale used. The proposed clearing may be variance with Principle (e) due to this result.
- Seven fauna habitat types were described and mapped for the Project Area, some of which provide suitable habitat for conservation significant vertebrate fauna species. In particular, a total area of 11.1 ha (31.8% of the Project Area) is considered suitable foraging habitat, as well as isolated trees within the open grassland with scattered *Eucalyptus/Melaleuca/Acacia* shrubs and trees habitat. The 11.1 ha of Black-Cockatoo habitat exceeds the EPBC Act Referral Guidelines minimal clearing recommendation, which state that a maximum of 1 ha of clearing of this kind of habitat is acceptable. One single isolated Eucalypt tree with DBH > 500 mm identified as a potential nesting tree was recorded within the Project Area. This tree contained no visible hollows. The Referral Guidelines advise no clearing of any known nesting trees. The proposed clearing may be variance with Principle (b) due to this result.
- Two conservation significant species were recorded during the current survey. 37 Forest Red-tailed Black-Cockatoos (*Calyptorhynchus banksii naso*) (EPBC Vulnerable, WC Act Schedule 1) and a flock of 12 Carnaby’s Black Cockatoos (*Calyptorhynchus latirostris*) (EPBC Endangered, WC Act Schedule 1) were recorded in the Project Area.

Based on the assessment results, the following recommendations are suggested:

- Limit clearing of vegetation to that which is absolutely necessary for construction and safe operation of the project, particularly within Bush Forever sites 299, 303 and 407, foraging and roosting habitat for Black-Cockatoos and other areas that support scattered native tree and shrub species.
- Liaise with WAPC regarding the current status of the vegetation in this location, with regards to protections and inclusion within Bush Forever sites 299, 303 and 407.
- Consider trenchless technology that avoids the need to clear vegetation if unacceptable impacts to the vegetation as a result of proposed clearing will result.
- Prepare an appropriate Construction Environmental Management Plan to minimise and manage impacts to ecological values during construction.

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1 INTRODUCTION

1.1 PROJECT BACKGROUND

The Water Corporation is seeking to expand the Groundwater Replenishment (GWR) trial at Beenyup Wastewater Treatment Plant (WWTP) into a 7 GL/year scheme. The GWR trial is currently proceeding at Beenyup to demonstrate the technical and social feasibility of this source option. If the trial is successful, the 7 GL/year scheme will be subject to regulatory, social and political acceptance. GWR has the potential to form part of the Water Corporation's climate independent water sources to supply a percentage of Perth's future water demands.

As part of this project, the Beenyup WWTP site will need to be expanded to allow new infrastructure, such as an Advanced Water Recycling Plant (AWRP), to be constructed (referred to as Stage 1). The scope of this survey is to investigate the flora and fauna values of a possible pipeline which may be required for future expansions to the project, referred to as Stage 2.

The Stage 2 Project Area is approximately 6 km long and 40 m wide for most of its length (some portions wider), covering approximately 35 ha, although most of this is within open parkland, dominated by introduced plants, with isolated trees. A small part of the south-west of the area to be surveyed is within Whitfords Avenue Bushland (Bush Forever Site 303), the Project Area also runs along the northern edge of Woodvale Nature Reserve (Bush Forever Site 407) and along the south and western edge of Yellagonga Regional Park (Bush Forever Site 299).

1.2 LOCATION

The Project Area is located in the municipal districts of Joondalup and Wanneroo, in the Perth metropolitan area, approximately 20 km north of the City centre. The proposed pipeline extends from the WWTP (4 km from the ocean) east across to Lake Joondalup on Ocean Reef Road and runs north along the eastern edge of the lake on Scenic Drive (Figure 1.1).

384000

385000

386000

387000

6487000

6486000

6485000

6484000

6483000



Lake Joondalup

Scenic Drive

Wanneroo Road

Mitchell Freeway

Ocean Reef Road

0 0.2 0.6
Kilometres
Absolute Scale - 1:20,000

Legend

Beenyup Stage 2 Project Area



Location of Project Area

Figure:1.1
Project ID: 1481

Drawn: MC
Date: 11/12/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: MC095

1.3 LEGISLATIVE FRAMEWORK

Legislation relevant to the protection of biodiversity in Western Australia includes, but is not limited to, the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and the State *Wildlife Conservation Act 1950* (WC Act) and *Environmental Protection Act 1986* (EP Act).

The Commonwealth EPBC Act was developed to provide protection for matters of national environmental significance. It includes provisions to protect threatened species and communities and the conservation of migratory species.

The State WC Act was developed to provide for the protection of wildlife in Western Australia. Under section 14 of the Act, all flora and fauna are protected in Western Australia. In addition, the Minister has published a list of species in need of special protection because they are considered rare, likely to become extinct, or are presumed extinct. The current listing was published in Western Australian Government Gazette on 6 November 2012.

The State EP Act was developed to ensure that impacts on native flora and fauna are considered in the assessment of development proposals. While the assessment of specific proposals is not within the scope of this report, the surveys undertaken conform to the requirements of the Environmental Protection Authority's (EPA's) *Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002a), *Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004a) and *Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004).

Under the relevant legislation, certain species of flora, fauna and ecological communities are awarded protection in the interest of their conservation.

1.3.1 Threatened and Priority Flora

During April 2011, the Department of Environment and Conservation (DEC) revised the conservation codes for Western Australian flora. DEC assigns conservation codes to endemic plant species that are geographically restricted to few known populations or threatened by local processes. Allocating conservation codes to plant species assists in protecting populations and conserving species from potential threats (DEC, 2011a and 2011b).

The definitions of the categories of Threatened and Priority Flora protected at a State level under the WC Act are presented in Appendix A.

1.3.2 Introduced Flora

1.3.2.1 Declared Plants

Weeds that are, or have the potential to become, pests to agriculture can be declared formally under the *Agriculture and Related Resources Protection Act 1976* (Department of Agriculture and Food 1976) as Declared Plants. Weeds listed under this Act are listed with Standard Control Codes that outline the requirements for their control. Five priority groupings exist (P1, P2, P3, P4 or P5). More than one priority may be assigned to a weed species and different municipal districts may list different priority levels. Landholders are obliged to control Declared Plants that occur on their property and are encouraged to adhere to the standard control recommendations.

1.3.2.2 Environmental Weeds

A second and much more extensive categorisation of weeds has been developed by the DEC, formerly the Department of Conservation and Land Management (CALM) in the Environmental Weed Strategy (Department of Conservation and Land Management 1999). Species considered to adversely affect the communities they invade are evaluated based on the following criteria:

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

Weeds listed as Environmental Weeds are ranked into four categories using the above criteria and the scoring system:

- High; a species which scores yes to all three of the above criteria. A rating of high indicates a species that should be prioritised for control and/or research.
- Moderate; a species which scores yes for two of the above criteria. A rating of moderate indicates a species which should be monitored. Control or research should be directed to it if funds are available.
- Mild; a species which scores yes to one of the criteria. A mild rating indicates monitoring or control if appropriate.
- Low; a species which does not score yes for any of the criteria. A low rating indicates a low requirement for monitoring.

1.3.3 Threatened and Priority Ecological Communities

Ecological communities are naturally occurring biological assemblages located in a particular type of habitat. At a national level, Threatened Ecological Communities (TECs) are protected under the EPBC Act. TECs are listed under this Act as either 'Critically Endangered', 'Endangered' or 'Vulnerable'. A definition of these codes is provided in Appendix A.

The DEC also maintains a list of TECs endorsed by the Minister of Environment (DEC, 2010) that are classified as being either 'Presumed Totally Destroyed', 'Critically Endangered', 'Endangered' or 'Vulnerable'. Definition of these codes is also provided in Appendix A.

The DEC maintains an additional list of Priority Ecological Communities (PECs), for communities that could potentially be classified as TECs, but are not currently adequately defined or surveyed. Communities are placed in this category while consideration can be given to their declaration as a TEC. Five priority codes exist for PECs and these are defined in Appendix A.

1.3.4 Threatened, Priority and Migratory Fauna

Species of fauna are defined as threatened where their populations are under threat, require protection or are protected under an international agreement between federal governments. DEC recognises these threats of extinction and consequently applies regulations towards population and species protection. Schedule 1 Threatened fauna are further ranked by DEC according to their threat using International Union for Conservation of Nature (IUCN) Red List criteria. Threatened fauna species are protected under the WC Act and the categories are defined in Appendix A.

Priority fauna not listed as Threatened (Scheduled) under the WC Act, but that are poorly known or poorly represented in the conservation estate are regarded as priority and attention is given to their conservation by DEC. The five classifications of Priority fauna are listed in Appendix A.

Threats of extinction of fauna species are also recognised at a Commonwealth level and are categorised according to the EPBC Act, administered by DSEWPaC. Categories of threatened species are summarised in Appendix A.

Migratory species are matters of Commonwealth environmental significance under the EPBC Act. Recognised migratory species include any native species identified in an international agreement approved by the Minister and those listed under:

- the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
- the China-Australia Migratory Bird Agreement (CAMBA)
- the Japan-Australia Migratory Bird Agreement (JAMBA).

1.3.5 Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are areas that require special protection due to aspects such as landscape, wildlife of historical value (Naturenet 2010). ESAs are declared under the *Environmental Protection (Clearing of Native Vegetation) Regulation 2004*.

1.3.6 Conservation Estate

The National Reserve System (NRS) is a network of protected areas managed for conservation under international guidelines. The objective of placing areas of bushland into the Conservation Estate is to achieve and maintain a comprehensive, adequate and representative reserve system for Western Australia. Areas vested in the Conservation Estate are managed by the Conservation Commission.

1.4 SCOPE AND OBJECTIVES

The EPA's objectives with regards to the management of native flora and vegetation are to:

- Avoid adverse impacts on biological diversity comprising the different plants and animals and the ecosystems they form, at the levels of genetic, species and ecosystem diversity.
- Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.
- Protect Declared Rare Flora (DRF) consistent with the provisions of the WC Act.
- Protect other flora species of conservation significance.

The primary objective of the assessment was to provide sufficient information to the carry out an assessment of the proposed clearing against the Clearing Principles and to assist the Water Corporation in determining whether clearing can proceed under the Statewide Clearing Purpose Permit.

The scope of the assessment was as follows:

Desktop Assessment

- Carry out a desktop assessment of relevant literature, databases and spatial information to evaluate the environmental values and any potential issues, such as Endangered or Priority flora or fauna species, Bush Forever sites, Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs) that may be present in the area of proposed disturbance or its surrounds; and
- Produce maps showing any of the above (GDA 94 datum).

Flora and Vegetation

- Complete a Level 2 floristic survey, compliant with Guidance Statement 51 in terms of survey timing and sampling methodology;
- Complete the site survey, including an inventory of plants and communities; a map and photographs showing the vegetation types/communities observed; and maps and photographs showing vegetation condition;
- Record landforms/landscape features present such as floodplains, ridgelines, side slopes;
- Record drainage features present;
- Record any land management issues such as gully erosion, water logging, salinity, weed invasion, and the extent area of the problem;
- Determine the native vegetation representation (i.e. current extent of native vegetation compared with pre-European extent) of the vegetation associations/complexes and assess the significance of the proposed clearing;
- Undertake a specific targeted search for and map the location of any *Lomandra maritima* and *Lomandra hermaphrodita*, and if found make recommendations in relation to the presence of the Graceful Sun Moth;
- Identify, map and discuss the Bush Forever site vegetation and determine the significance and quality of the Bush Forever vegetation inside the clearing area;
- Document impacts on any flora that may result from the proposed works and provide recommendations to minimise impacts on native vegetation (i.e. minimise clearing, topsoil handling etc.) and endemic or protected fauna;
- Recommend any requirements that the Water Corporation must follow under the EPBC Act, the WC Act and the EP Act;
- Assess the proposed native vegetation clearing against the 10 clearing principles, with regard to the DEC's Guide to Assessment: Clearing of Native Vegetation;
- Report on the outcome of the above assessment; and
- Propose actions consistent with the offset principles if clearing is likely to be at variance to the clearing principles.

Vertebrate Fauna

- Complete a Level 1 fauna survey, compliant with Guidance Statement 56 in terms of survey timing and sampling methodology;
- Provide an inventory of fauna species and habitat/breeding trees for fauna or conservation species from within the Project Area;
- Produce a map showing the location of any conservation significant fauna sighted, or any habitat trees for conservation significant species;
- Discuss the likelihood of conservation significant fauna species presence within the area;
- Document impacts on any conservation significant fauna that may result from the proposed works and provide recommendations to minimise impacts on native vegetation (i.e. minimise clearing, topsoil handling etc.) and endemic or protected fauna; and
- Recommend any requirements that the proponent must follow under the EPBC Act, the WC Act and the EP Act.

2 SURVEY METHODOLOGY

The flora, vegetation and fauna assessment was carried out in accordance with EPA Guidance and encompassed both desktop and field assessments. The survey was conducted by two botanists and one zoologist on 17 October 2012 with a follow up visit by one botanist on 20 October 2012. The field survey effort consisted of a total of four person days.

2.1 FLORA AND VEGETATION ASSESSMENT

A flora and vegetation assessment was carried out in accordance with EPA Guidance Statement 51 (Environmental Protection Authority 2004). The assessment was scoped to be a Level 2 assessment; however, as the condition of the vegetation was not found to be “good or better”, in accordance with EPA Guidance, quadrats were not assessed. Instead, the Project Area was surveyed using a series of transects, during which opportunistic collections were made, noting the local abundance or canopy cover of all flora species observed. Species planted for landscaping purposes were not collected and recorded unless observed to be “garden escapees”; i.e. with the potential to be invasive.

Plant specimens were collected for later identification and verification by a qualified plant taxonomist. Vegetation type, life-form strata and percentage cover for each stratum were recorded using the National Vegetation Information System (NVIS) level 6 vegetation classifications (Executive Steering Committee for Australian Vegetation Information (ESCAVI) 2003), as described in Appendix B. Nomenclature and taxonomy follow the conventions currently adopted by Florabase (Western Australian Herbarium 1998-2012).

Vegetation condition was assessed throughout the Project Area using the Keighery (1994) Scale with rankings and criteria as detailed in Table 2.1.

Table 2.1 – Vegetation Condition Assessment

Vegetation Condition	Criteria
Pristine	Pristine or nearly so, no obvious sign of disturbance.
Excellent	Vegetation structure intact; disturbance affecting individual species; weeds are non-aggressive species.
Very good	Vegetation structure altered; obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires; the presence of some more aggressive weeds; dieback; logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires; the presence of some very aggressive weeds at high density; partial clearing; dieback and grazing.
Degraded or Poor	Very few values remaining.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as “parkland cleared” with the flora comprising weed or crop species with isolated native trees or shrubs.

Source: Keighery (1994)

2.2 VERTEBRATE FAUNA ASSESSMENT

Prior to the development of survey methods, a review of factors likely to influence survey design and intensity was undertaken (Table 2.2). Based on this review, it was deemed necessary for a Level 1 survey to be conducted within the Project Area, incorporating a desktop assessment and reconnaissance field survey.

Table 2.2 – Factors Likely to Influence Survey Design (EPA 2004b)

Factor	Comment
Bioregion – level of existing survey-knowledge of the region and associated ability to predict accurately	The Swan Coastal Plain bioregion has been well studied and information was readily available.
Landform special characteristics/specific fauna/specific context of the landform characteristics and their distribution and rarity in the region	The landforms associated with the Project Area are typical for the region and do not present any rare or special characteristics.
Life forms, life cycles, types of assemblages and seasonality (e.g. migration) of species likely to be present	Not applicable to a Level 1 survey of this calibre, survey was habitat assessment based.
Level of existing knowledge and results of previous regional sampling (e.g. species accumulation curves, species/area curves)	11 previous terrestrial vertebrate fauna assessments have been conducted within 60 km of the Project Area. Regional and local knowledge for the area is available.
Number of different habitats or degree of similarity between habitats within a Project Area	The survey was undertaken to determine the different habitat types present in the Project Area.
Climatic constraints (e.g. temperature or rainfall that preclude certain sampling methods)	No climatic constraints were experienced.
Sensitivity of the environment to the proposed activities	The environment associated with the Project Area appears to be common with the surrounding region with no specifically environmentally sensitive areas.
Size, shape and location of the proposed activities	The Project Area is 35 ha in size and does not affect survey design.
Scale and impact of the proposal	The scale and impact of the proposal is not known and does not influence the design of this assessment.

The survey methods adopted by *ecologia* are aligned with the EPA's Guidance Statement No. 56 (EPA 2004b), Position Statement No. 3 (EPA 2002b), *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010) and *Referral Guidelines for Three Black Cockatoo Species* (DSEWPaC 2011).

Due to the Project Area falling within the known breeding range of conservation significant species Carnaby's Black-Cockatoo, within the range of Forest Red-tailed Black-Cockatoo and proximal to the known range of Baudin's Black-Cockatoo, survey methods were aligned with those suggested in guidelines for surveying for these species (DSEWPaC 2011). As per the guidelines, all known species of breeding trees greater than 500 mm in diameter at breast height were recorded within the Project Area. All habitats within the Project Area were assessed, with the likelihood of breeding, foraging or roosting habitat determined. Recording of potential breeding trees was restricted to patches of woodland or forest only (DSEWPaC 2011). An assessment of habitat for all potential conservation significant species was also completed, to help in determining the likelihood of occurrence.

Recording of vertebrate fauna species was achieved by opportunistic sampling methods only which included direct sightings and records of evidence of activity. Bird and reptile species were recorded opportunistically.

2.2.1 Conservation Significant Fauna Assessment

After the results of the literature review, database searches and survey results were compiled, fauna species that are listed under current legislative frameworks were identified. Three conservation lists have been developed at Commonwealth (EPBC Act) and State level (WC Act and DEC priority list).

The likelihood of a conservation significant species being present within the project was determined by examining the following:

- fauna habitats known to exist within the Project Area and their condition as assessed during the survey;
- distance of previously recorded conservation significant species from the Project Area;
- frequency of occurrence of conservation significant species records in the region; and
- time passed since conservation significant species were recorded within, or nearby the Project Area.

Each conservation significant or biologically significant species potentially occurring in the Project Area, was assigned a likelihood of occurrence based on the below categories (Table 2.3). The level of available information for each species was also taken into consideration so that species are not allocated a low likelihood of occurrence because of insufficient survey information or cryptic behaviours and ecology, in accordance with the precautionary principle. Conservation significant species likely to occur in the project area are discussed in Section 4.6.

Table 2.3 – Likelihood of Occurrence Categories

RECORDED	Species recorded during current survey
HIGH	Species recorded within, or in proximity to, the Project Area within 20*years; suitable habitat occurs in the Project Area
MEDIUM	Species recorded within, or in proximity to, the Project Area more than 20 years ago. Species recorded outside Project Area, but within 50 km; suitable habitat occurs in the Project Area
LOW	Species rarely, or not recorded, within 50 km, and/or suitable habitat does not occur in the Project Area

**ecologia* chooses to incorporate regional data from the last 20 years to assess a high likelihood of occurrence of species. Species that have previously been recorded from an area within the last 20 years and where high quality, suitable habitat still persists within an area are considered by *ecologia* to still have potential for a high likelihood of occurrence, following the precautionary principle.

2.2.2 Fauna Habitat Mapping

Previous terrestrial vertebrate fauna assessment information, aerial photographs, vegetation and land system maps of the Project Area were reviewed prior to the survey to determine the potential habitat types of the Project Area.

The various fauna habitats of the Project Area were described and mapped and a targeted assessment of Black-Cockatoo habitat was carried out, focusing on significant/habitat trees suitable for nesting, breeding and foraging.

2.2.3 Fauna Taxonomy and Nomenclature

Nomenclature for mammals, reptiles and amphibians within this report is as per *Western Australian Museum Checklist of the Vertebrates of Western Australia*, birds according to Christidis and Boles (2008). References used for fauna identification are listed in Table 2.4.

Table 2.4 – References Used for Identification

Fauna Group	Reference
Mammals	Menkhorst and Knight (2011), Van Dyck and Strahan (2008)
Bats	Churchill (1998), Menkhorst and Knight (2011)
Birds	Simpson and Day (2004)
Reptiles	Cogger (2000), Wilson and Swan (2010)
Geckos	Storr <i>et al.</i> (1990), Wilson and Swan (2010)
Skinks	Storr <i>et al.</i> (1999), Wilson and Swan (2010)
Dragons	Storr <i>et al.</i> (1983), Wilson and Swan (2010)
Varanids	Storr <i>et al.</i> (1983), Wilson and Swan (2010)
Legless Lizards	Storr <i>et al.</i> (1990), Wilson and Swan (2010)
Snakes	Storr <i>et al.</i> (2002), Wilson and Swan (2010)
Amphibians	Tyler and Doughty (2009), Cogger (2000)

2.2.4 Animal Ethics and Licences

Surveying was conducted as per *ecologia's* Animal Ethics Code of Practice, which conforms to Section 5 of the *Australian code of practice for the care and use of animals for scientific purposes* (NHMRC 2004).

Fauna were identified in the field from non-invasive observation and searching. No collection of fauna material was necessary; therefore a Regulation 17 License was not requested for this survey.

3 EXISTING ENVIRONMENT

3.1 CLIMATE

The Project Area is situated in the Swan Region of Western Australia and experiences a dry Mediterranean climate with a hot dry summer from December to March and a mild winter from June to August (BOM 2012)

Within the Lower West (data from approximately 16 km southeast of the study site, weather station Perth Metro 9225), the annual mean maximum temperature ranges from 31.5°C in summer to 18.2°C in winter (BOM 2012). The climate experienced throughout the year is usually dry since high temperatures and humidity seldom occur simultaneously (Figure 3.1). The area is characterised by the presence of strong winds, with speeds at or over 70 km/h for more than half the year (BOM 2012). Average annual rainfall at Perth Metro is 739 mm, for the period of 1994 to 2012 (BOM 2012). The wettest period is from June to August, when approximately 54% of the mean annual rain falls.

Rainfall in the six months preceding the assessment carried out during October 2012 was 418 mm, 32% lower than the long-term mean for those months (BOM 2012).

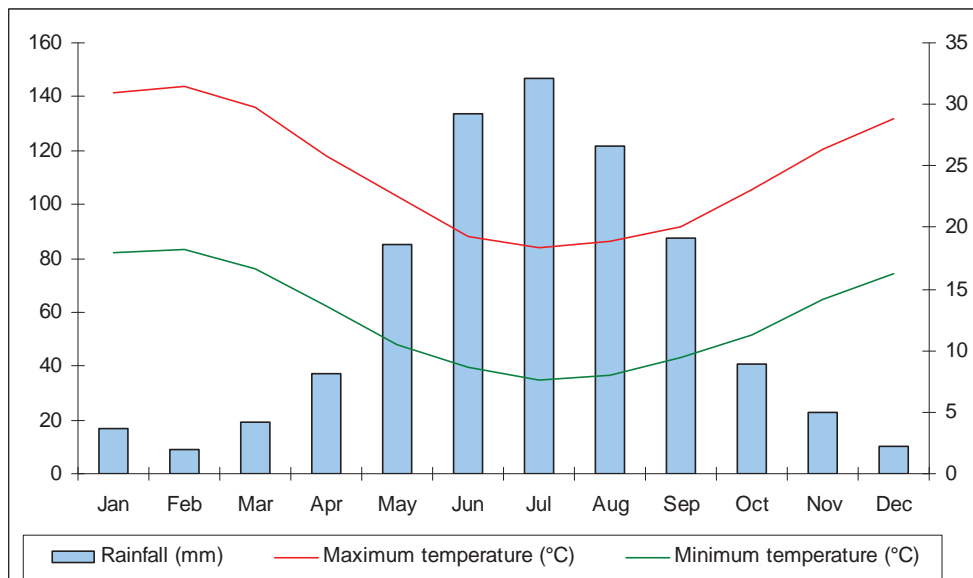


Figure 3.1 – Long-Term Climate Data in the Vicinity of the Project Area

Table 3.1 – Rainfall Data for the Project Area

Rainfall (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean from 1993 to 2012	16.5	8.9	18.9	37.0	85.0	133.8	146.8	121.4	87.5	41.0	22.7	10.3
Year 2012*	18.8	23.6	0.2	69.2	49.0	140.8	34.6	87.2	90.8	15.6		

*Data not quality controlled

3.2 BIOGEOGRAPHIC REGIONS

The Interim Biogeographic Regionalisation for Australia (IBRA, Version 6.1) classifies the Australian continent into regions (bioregions) of similar geology, landform, vegetation, fauna and climate characteristics (Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) 2010). The Project Area is located within the Swan Coastal Plain Bioregion, which has an area of 1,525,798 ha. The Swan Coastal Plain is further subdivided into two subregions: the Dandaragan Plateau and Perth. The Project Area is located entirely in the Perth subregion, which has an area of 1,142,334 ha and represents approximately 75% of the Swan Coastal Plain.

The Perth subregion is a low lying coastal plain composed of colluvial and Aeolian sands, alluvial river flats and coastal limestones (Mitchell *et al.* 2002). The main land use of the Subregion is agriculture; and the Perth Metropolitan Area encompasses about 20% of the Perth Subregion (Mitchell *et al.* 2002).

3.2.1 Regional Vegetation

The vegetation of the Swan Coastal Plain has been mapped at a regional scale by Heddle *et al.* (1980) in correlation to the major geological units of Churchward and McArthur (1980). The Beenyup Stage 2 Project Area occurs on three different complexes (Heddle *et al.* 1980):

- Cottesloe Complex – Central and South, which is comprised of a mosaic woodland of *Eucalyptus gomphocephala* (Tuart); open forest of *E. gomphocephala* (Tuart), *E. marginata* (Jarrah) and *Corymbia calophylla* (Marri); and closed heath on the limestone outcrops
- Herdsman Complex, which comprises sedgeland and fringing woodland of *Eucalyptus rudis* and *Melaleuca* spp.; and
- Karrakatta Complex – Central and South, which is comprised of predominantly open forest of *Eucalyptus gomphocephala*, *E. marginata* and *Corymbia calophylla* with *Banksia* species.

In 2010, the remnant vegetation complexes were mapped (Perth Biodiversity Project 2010), and the Project Area overlaps with portions of all three Vegetation Complexes (Figure 3.2).

The Project Area lies within Beard's (1975) South-West Botanical Province, part of a series of maps completed by Beard *et al.* from 1974 to 1981 throughout Western Australia. The vegetation mapping was subsequently reinterpreted to reflect the National Vegetation Information System (Department of Environment and Water Resources 2012) standards and revised taxonomy for some species and digitised (Shepherd *et al.* 2001). Four vegetation units are mapped within the Project Area (Figure 3.3), which are:

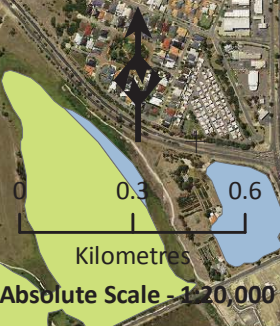
- Unit 126: Bare areas; freshwater lakes;
- Unit 998: Medium woodland; Tuart;
- Unit 6: Medium woodland; Tuart and Jarrah; and
- Unit 37: Shrublands; Teatree thicket.



Legend

- Beenyup Stage 2 Project Area
- Cottesloe Complex-Central And South
- Herdsman Complex
- Karrakatta Complex-Central And South

Remaining Vegetation Complexes (Perth Biodiversity Project 2010)



Remaining Vegetation Complexes of the Project Area

Figure: 3.2
Project ID: 1481

Drawn: MC
Date: 11/12/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994





Unique Map ID: MC101

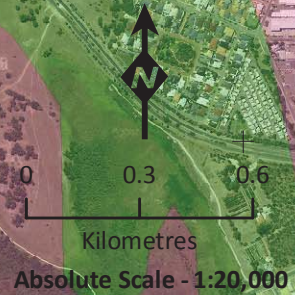


Legend

 Beenyup Stage 2 Project Area

Beard Vegetation Associations (Shepherd *et al.* 2001)

-  126: Bare areas; freshwater lakes
-  998: Medium woodland; tuart
-  6: Medium woodland; tuart & jarrah
-  37: Shrublands; teatree thicket



Vegetation Associations of the Project Area

Figure: 3.3
Project ID: 1481

Drawn: MC
Date: 11/12/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: MC100

3.3 RESULTS OF THE DESKTOP ASSESSMENT

3.3.1 Flora

A search of the DEC's Threatened Flora Database was conducted applying a buffer of 10 km around the Project Area (search reference 13-1012). Species protected by the EPBC Act 1999 and the WC Act recorded in the Perth Subregion of the Swan Coastal Plain Bioregion are listed in Table 3.2, and those recorded within 10 km of the Project Area are highlighted in blue.

Table 3.2 – Species Protected by the EPBC Act and WC Act Recorded in the Perth Subregion

EPBC Act Listing	Family	Taxon
CE	Apiaceae	<i>Brachyscias verecundus</i>
CE	Lamiaceae	<i>Dasymalla axillaris</i>
CE	Myrtaceae	<i>Darwinia foetida</i>
CE	Orchidaceae	<i>Caladenia procera</i>
CE	Proteaceae	<i>Synaphea</i> sp. Fairbridge Farm (D. Paperifus 696)
CE	Proteaceae	<i>Synaphea</i> sp. Pinjarra (R. Davis 6578)
EN	Cyperaceae	<i>Lepidosperma rostratum</i>
EN	Ericaceae	<i>Andersonia gracilis</i>
EN	Fabaceae	<i>Chorizema varium</i>
EN	Fabaceae	<i>Gastrolobium papilio</i>
EN	Fabaceae	<i>Kennedia lateritia</i>
EN	Hydatellaceae	<i>Trithuria occidentalis</i>
EN	Molluginaceae	<i>Macarthuria keigheryi</i>
EN	Myrtaceae	<i>Calytrix breviseta</i> subsp. <i>breviseta</i>
EN	Myrtaceae	<i>Darwinia acerosa</i>
EN	Myrtaceae	<i>Darwinia apiculata</i>
EN	Myrtaceae	<i>Darwinia carnea</i>
EN	Myrtaceae	<i>Darwinia whicherensis</i>
EN	Myrtaceae	<i>Eucalyptus balanites</i>
EN	Myrtaceae	<i>Verticordia densiflora</i> var. <i>pedunculata</i>
EN	Myrtaceae	<i>Verticordia</i> \square <i>longat</i> var. <i>ananeotes</i>
EN	Myrtaceae	<i>Verticordia</i> \square <i>longat</i> var. <i>pleiobotrya</i>
EN	Myrtaceae	<i>Verticordia</i> \square <i>longat</i> var. <i>vassensis</i>
EN	Orchidaceae	<i>Caladenia busseliana</i>
EN	Orchidaceae	<i>Caladenia huegelli</i>
EN	Orchidaceae	<i>Diuris purdiei</i>
EN	Orchidaceae	<i>Drakaea elastica</i>
EN	Orchidaceae	<i>Thelymitra stellata</i>
EN	Proteaceae	<i>Banksia mimica</i>
EN	Proteaceae	<i>Banksia nivea</i> subsp. <i>uliginosa</i>
EN	Proteaceae	<i>Grevillea calliantha</i>
EN	Proteaceae	<i>Grevillea christineae</i>
EN	Proteaceae	<i>Grevillea curviloba</i> subsp. <i>curviloba</i>
EN	Proteaceae	<i>Grevillea curviloba</i> subsp. <i>incurva</i>
EN	Proteaceae	<i>Grevillea humifusa</i>
EN	Proteaceae	<i>Grevillea maccutcheonii</i>
EN	Proteaceae	<i>Lambertia echinata</i> subsp. <i>occidentalis</i>
EN	Proteaceae	<i>Lambertia orbitifolia</i> subsp. Scott River Plains (L.W. Sage 684)
EN	Proteaceae	<i>Petrophile latericola</i>
EN	Proteaceae	<i>Synaphea stenoloba</i>
VU	Cyperaceae	<i>Eleocharis keigheryi</i>
VU	Cyperaceae	<i>Tetraria australiensis</i>
VU	Fabaceae	<i>Acacia anomala</i>
VU	Fabaceae	<i>Acacia aphylla</i>
VU	Fabaceae	<i>Daviesia</i> \square <i>longate</i> subsp. <i>elongata</i>
VU	Fabaceae	<i>Ptychosema pusillum</i>
VU	Haemodoraceae	<i>Anigozanthos viridis</i> subsp. <i>terraspectans</i>
VU	Myrtaceae	<i>Chamelaucium</i> sp. C Coast Plain (R.D. Royce 4872)

EPBC Act Listing	Family	Taxon
VU	Myrtaceae	<i>Eucalyptus argutifolia</i>
VU	Myrtaceae	<i>Eucalyptus crispata</i>
VU	Orchidaceae	<i>Diuris drummondii</i>
VU	Orchidaceae	<i>Diuris micrantha</i>
VU	Orchidaceae	<i>Drakaea micrantha</i>
VU	Proteaceae	<i>Banksia squarrosa</i> subsp. <i>argillacaea</i>
VU	Proteaceae	<i>Conospermum undulatum</i>
VU	Proteaceae	<i>Grevillea brachystylis</i> subsp. <i>grandis</i>
VU	Proteaceae	<i>Grevillea elongata</i>
VU	Proteaceae	<i>Hakea megalosperma</i>

Highlights indicate taxa recorded within 10 km of the Project Area

The DEC maintains a list of Priority Flora taxa, which are considered poorly known, uncommon or under threat but for which there is insufficient justification, based on known distribution and population sizes, for inclusion on the Threatened Flora schedule. One of four priority categories (Atkins 2011) as defined in Appendix A is assigned to these taxa.

A search of the DEC and the Western Australian Herbarium databases identified 23 priority flora species within the 10 km buffer (Figure 3.4 and Figure 3.5). The likelihood of their occurrence in the Project Area was assessed using the criteria in Table 3.3. The characteristics and likelihood of occurrence of the 23 priority flora are presented in Table 3.4.

Table 3.3 – Criteria used to Assess Likelihood of Occurrence of Significant Flora

Likelihood of Occurrence	Criteria
Certain	The taxon has been recorded within the Project Area.
Probable	Due to the proximity of previous records (<2 km) and the presence of suitable habitat, the taxon is considered highly likely to occur within the Project Area.
Likely	Given the presence of suitable habitat and moderate proximity (2-5 km) of previous records, the taxon is considered likely to occur within the Project Area.
Possible	The habitat specificity of the taxon is only broadly defined, or is not defined and/or there are no current records within 5 km. However there is insufficient information available to exclude the possibility of occurrence within the Project Area.
Unlikely	The habitat specificity of the taxon is well defined from previous records and the habitat is considered unlikely to be present within the Project Area.

Table 3.4 – Priority flora Recorded within a 10 km Buffer of the Project Area

Taxon	Status	Preferred habitat based on previous records	Flowering period	Likelihood of Occurrence in the Project Area
<i>Caladenia huegelii</i> (Orchidaceae)	T	Grey or brown sand, clay loam	Sep-Oct	Unlikely
<i>Dasymalla axillaris</i> (Lamiaceae)	T	Dry yellow sand	Sep-Oct	Unlikely
<i>Eucalyptus argutifolia</i> (Myrtaceae)	T	Shallow soils over limestone. Slopes or gullies of limestone ridges, outcrops	Mar-Apr	Unlikely
<i>Marianthus paralius</i> (Pittosporaceae)	T	White sand over limestones. Low coastal cliffs	Sep-Nov	Unlikely
<i>Calectasia</i> sp. Pinjar (C. Tauss 557) (Dasypogonaceae)	P1	Deep grey quartz soils. Gentle slopes, above damplands	Nov-Dec	Unlikely
<i>Dampiera triloba</i> (Goodeniaceae)	P1	Grey sand with organic matter. Loamy sand.	Aug-Dec	Possible
<i>Drosera x sidjamesii</i> (Droseraceae)	P1	Peaty sand. Along lake margins, close to winter high-water line	Jan-Mar	Unlikely
<i>Grevillea</i> sp. Ocean Reef (D. Pike Joon 4) (Proteaceae)	P1	Bare yellow-brown sand	Nov-Dec	Unlikely
<i>Leucopogon maritimus</i> (Ericaceae)	P1	On white-yellow sand. Coastal dunes	Mar-Aug	Unlikely

Taxon	Status	Preferred habitat based on previous records	Flowering period	Likelihood of Occurrence in the Project Area
<i>Acacia benthamii</i> (Fabaceae)	P2	Sand. Typically on limestone breakaways	Aug-Sep	Unlikely
<i>Austrostipa mundula</i> (Poaceae)	P2	Coastal sand or limestone.	Apr, Sep	Unlikely
<i>Fabronia hampeana</i> (Fabroniaceae)	P2	Scrubland associated with <i>Macrozamia</i>	n/a	Unlikely
<i>Lecania turicensis</i> var. <i>turicensis</i> (Bacidiaceae)	P2	Coastal rocks; limestone	n/a	Unlikely
<i>Stenanthemum sublineare</i> (Rhanmnaceae)	P2	Littered white sand. Coastal plain	Oct-Dec	Unlikely
<i>Tetraria</i> sp. Chandala (G.J. Keighery 17055) (Cyperaceae)	P2	Humic sand. Along swamps.	Jul-Aug	Unlikely
<i>Conostylis bracteata</i> (Haemodoraceae)	P3	Sand, limestone. Consolidated sand dunes	Aug-Sep	Possible
<i>Cyathochaeta teretifolia</i> (Cyperaceae)	P3	Grey sand, sandy clay. Swamps, creek edges	Nov	Unlikely
<i>Hibbertia helianthemoides</i> (Dilleniaceae)	P3	Clayey sand over sandstone or loam over quartzite. Hills and scree slopes	Jul, Sep-Oct	Unlikely
<i>Hibbertia spicata</i> subsp. <i>leptotheca</i> (Dilleniaceae)	P3	Near-coastal limestone ridges, outcrops and cliffs	Jul-Oct	Unlikely
<i>Pimelea calcicola</i> (Thymelaeaceae)	P3	Sand. Coastal limestone ridges	Sep-Nov	Unlikely
<i>Sarcozona bicarinata</i> (Aizoaceae)	P3	White sand	Aug	Unlikely
<i>Thelymitra variegata</i> (Orchidaceae)	P3	Sandy clay, sand, laterite	Jun-Sep	Possible
<i>Jacksonia sericea</i> (Fabaceae)	P4	Calcareous and sandy soils	Dec or Jan-Feb	Likely

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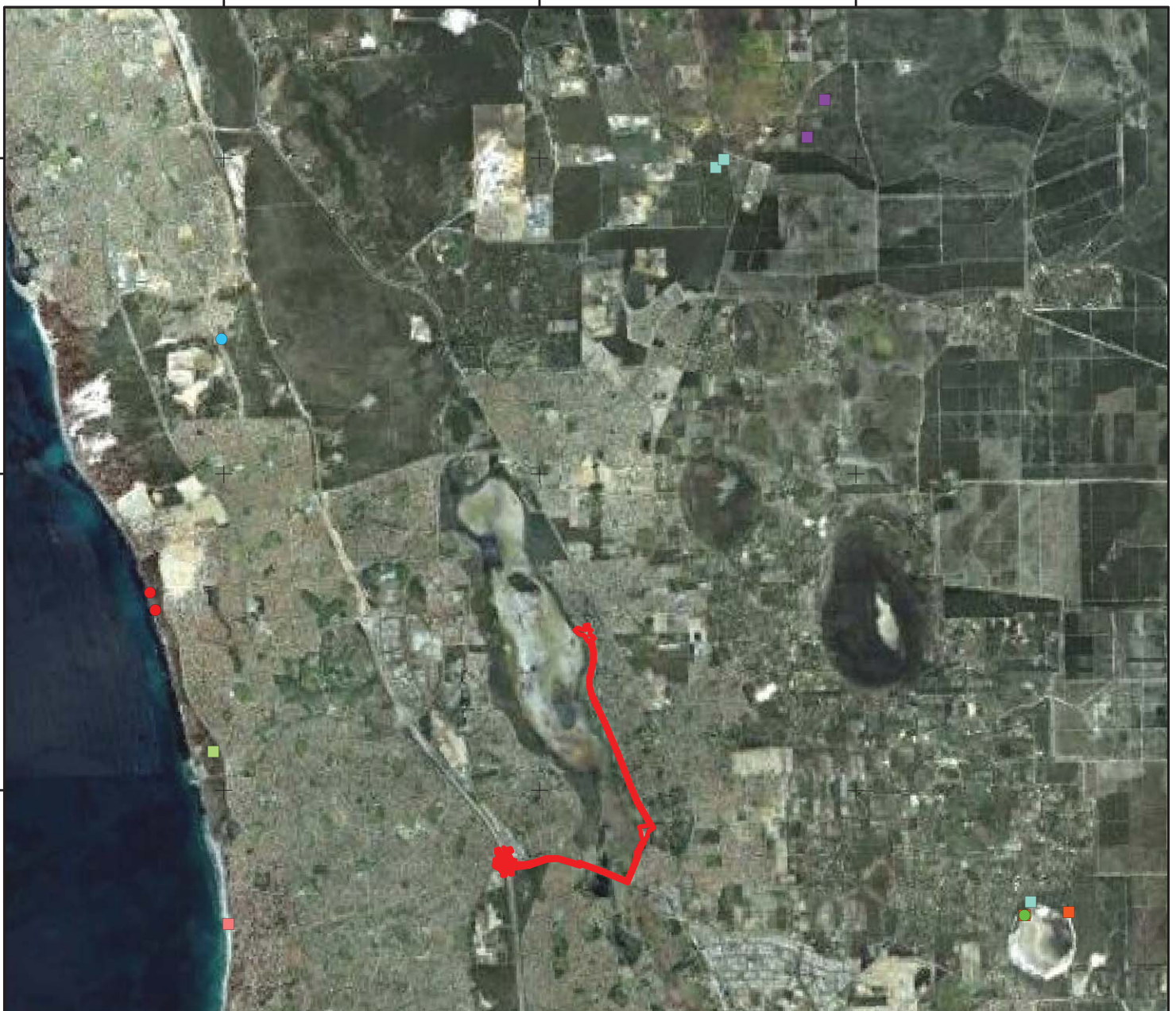
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64750000



Legend

 Beenyup Stage 2 Project Area

Priority Flora (DEC Search 13-1012)

-  *Caladenia huegelii* (T)
-  *Dasymalla axillaris* (T)
-  *Eucalyptus argutifolia* (T)
-  *Marianthus paralius* (T)
-  *Calectasia* sp. Pinjar (C. Tauss 557) (P1)
-  *Dampiera triloba* (P1)
-  *Drosera x sidjamesii* (P1)
-  *Grevillea* sp. Ocean Reef (D. Pike Joon 4) (P1)
-  *Leucopogon maritimus* (P1)



Absolute Scale - 1:95,000



**Previously Known
Priority Flora
Map A**

Figure: 3.4
Project ID: 1481

Drawn: MC
Date: 11/12/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: MC103

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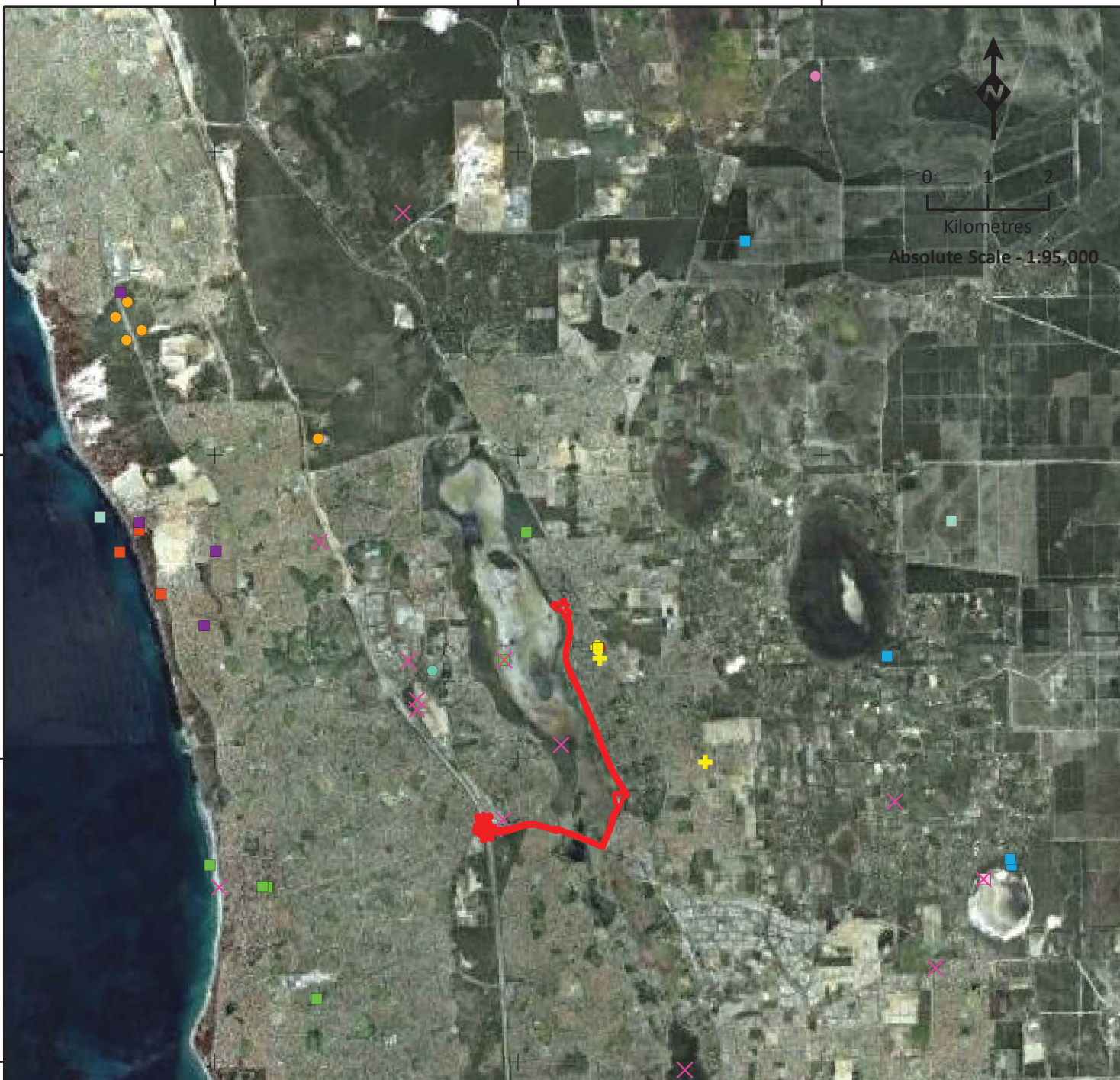
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Legend

Beenyup Stage 2 Project Area

Priority Flora (DEC Search 13-1012)

- Acacia benthamii* (P2)
- Fabronia hampeana* (P2)
- Austrostipa mundula* (P2)
- Lecania turicensis* var. *turicensis* (P2)
- Stenanthemum sublineare* (P2)
- Tetraria* sp. Chandala (G.J. Keighery 17055) (P2)
- Conostylis bracteata* (P3)
- Cyathochaeta teretifolia* (P3)
- Hibbertia helianthemoides* (P3)
- Hibbertia spicata* subsp. *leptotheca* (P3)
- Pimelea calcicola* (P3)
- Sarcozona bicarinata* (P3)
- Thelymitra variegata* (P3)
- Jacksonia sericea* (P4)



**Previously Known
Priority Flora
Map B**

Figure: 3.5
Project ID: 1481

Drawn: MC
Date: 11/12/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: MC104

3.3.2 Vegetation

A DEC search for TECs and PECs was ordered, but the results have not yet been received. *ecologia* is committed to submitting an amended version of this draft once the results are received, mapped and interpreted.

3.3.3 Fauna

Several databases were consulted in the preparation of potential fauna (and conservation significant fauna) lists (Table 3.5) for the Project Area. In addition, publications reporting on 10 terrestrial vertebrate fauna assessments conducted within 60 km of the Project Area were consulted (Table 3.6). The results of all database searches and previous surveys are presented in Appendix C. The online NatureMap database (DEC 2012) encompasses several datasets which include the Western Australian Museum, DEC threatened fauna database and DEC survey return database.

Table 3.5 – Fauna Databases Searched to Determine the Potential Terrestrial Fauna Assemblages

Database	Custodian	Search Details
NatureMap	DEC	Search co-ordinates: 31°46'15"S 115°48'10"E Distance searched (buffer): 40 km Date accessed: 11/12/2012
DEC Threatened Fauna Database	DEC	Records within 5 km of the Project Area
EPBC Act Protected Matters Search Tool	Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)	Records within 60 km of the Project Area
Birdata	BirdLife Australia	Records within 100 km of the Project Area

The desktop assessment identified a total of 381 terrestrial vertebrate fauna species with potential to occur in the Project Area. This includes 31 native and 13 introduced mammal species, 241 native and eight introduced bird species, 69 reptile species, and 12 amphibians (Appendix C).

The literature review for fauna values associated with the Project Area included a number of available assessment reports, some in relatively close proximity to the project area (Table 3.6, Appendix C). The results of these were used to contribute to the consideration of fauna species relevant to the project area.

Table 3.6 –Previous Biological Survey Reports within 60 km of the Project Area

Survey Location and Author(s)	Distance from Project Area (km)	Survey Type
<i>ecologia</i> internal database	7.5-43	Three two-phase Level 2 surveys, one single-phase Level 2 survey and one Level 1 fauna assessment
Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	8	Single-phase Level 2 vertebrate fauna assessment
Hepburn Ave Extension Fauna Assessment (<i>ecologia</i> 2000)	12.5	Level 1 fauna assessment
Fauna Survey of the Perth Airport (Tingay and Associates 1994)	27	Single-phase Level 2 vertebrate fauna assessment
Roe Highway Extension (Napier and Associates 1989)	31	Level 1 fauna assessment
Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart 1989)	50	Level 1 fauna assessment

A total of eight mammal species, 52 bird species and five reptile species of conservation significance have been identified as having the potential to occur within the Project Area (Appendix C). Of these, two mammals and eight bird species have been assessed as having a medium to high likelihood of occurrence based on consideration of habitat quality, availability, and relevance of previous records, and these are discussed in more detail in Section 5.4.

The considerably high number of potentially occurring conservation significant bird species is due to the close proximity of the Project Area to the coast (approximately 7 km), as well as the proximity of a number of lakes, commonly utilised by migratory shorebird species (e.g. Lake Joondalup, which is directly adjacent to the Project Area). Although they may occasionally overfly the Project Area, these species are considered to have a low likelihood of occurrence within the Project Area as they will not directly utilise the habitats or the site. For this reason, these 41 migratory and marine species (listed in Table 3.7 and Appendix C) have not been considered further in this assessment.

Table 3.7 – Shorebirds and Waterbirds of Conservation Significance excluded from the assessment

Species	Conservation Status		
	EPBC Act	WC Act	DEC
Australasian Bittern <i>Botaurus poiciloptilus</i>	EN	S1	EN
Australian Painted Snipe <i>Rostratula australis</i>	VU, M	S1, S3	VU
Lesser Noddy <i>Anous tenuirostris melanops</i>	VU	S1	VU
Fairy Tern <i>Sternula nereis nereis</i>	VU	S1	VU
Eastern Reef Egret <i>Egretta sacra</i>	M	S3	
Eastern Great Egret <i>Ardea modesta</i>	M	S3	
Cattle Egret <i>Ardea ibis</i>	M	S3	
Glossy Ibis <i>Plegadis falcinellus</i>	M	S3	
Pacific Golden Plover <i>Pluvialis fulva</i>	M	S3	
Grey Plover <i>Pluvialis squatarola</i>	M	S3	

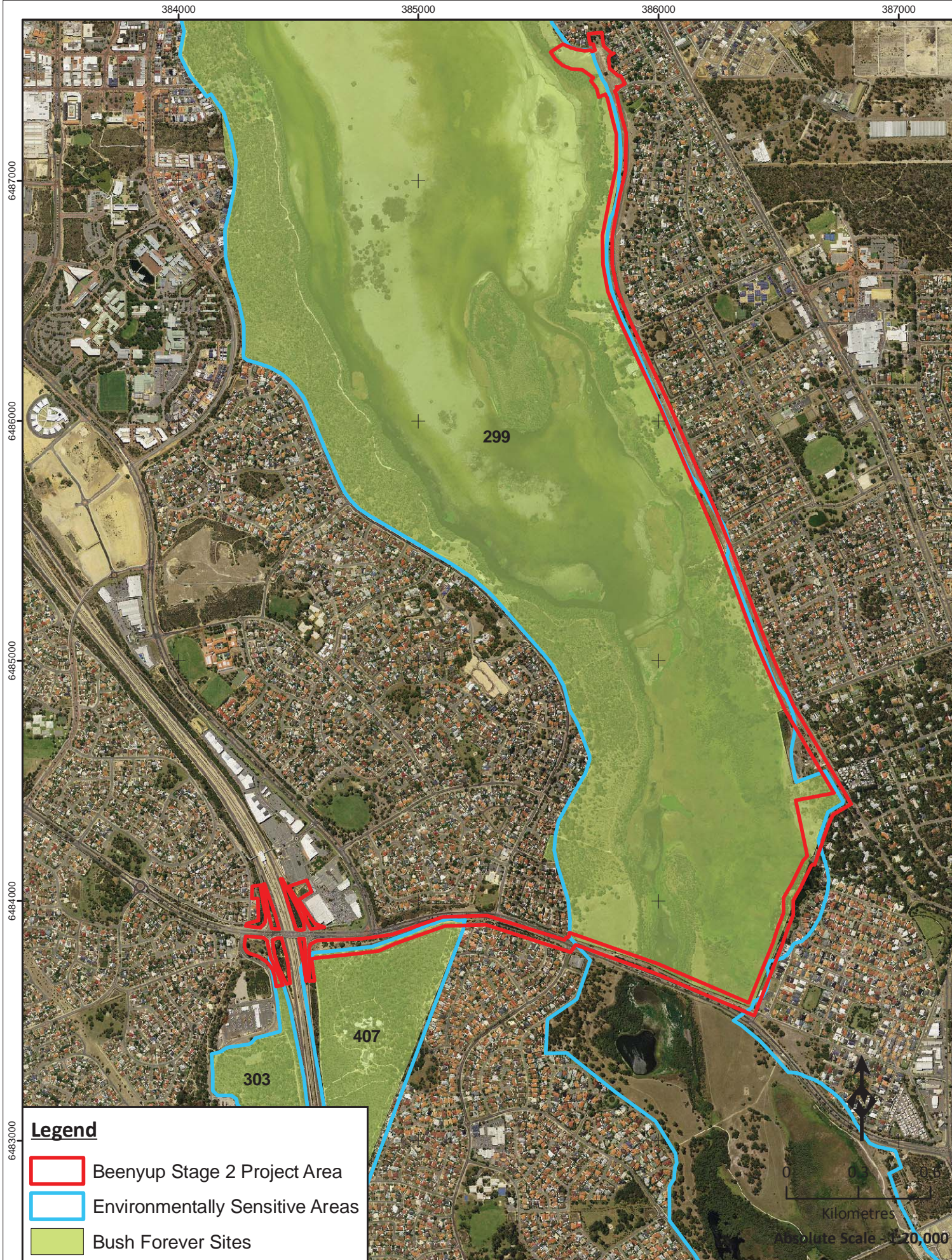
Species	Conservation Status		
	EPBC Act	WC Act	DEC
Double-banded Plover <i>Charadrius bicinctus</i>	M	S3	
Lesser Sand Plover <i>Charadrius mongolus</i>	M	S3	
Greater Sand Plover <i>Charadrius leschenaultii</i>	M	S3	
Oriental Plover <i>Charadrius veredus</i>	M	S3	
Black-tailed Godwit <i>Limosa limosa</i>	M	S3	
Bar-tailed Godwit <i>Limosa lapponica</i>	M	S3	
Little Curlew <i>Numenius minutus</i>	M	S3	
Whimbrel <i>Numenius phaeopus</i>	M	S3	
Terek Sandpiper <i>Xenus cinereus</i>	M	S3	
Common Sandpiper <i>Actitis hypoleucos</i>	M	S3	
Grey-tailed Tattler <i>Tringa brevipes</i>	M	S3	
Common Greenshank <i>Tringa nebularia</i>	M	S3	
Marsh Sandpiper <i>Tringa stagnatilis</i>	M	S3	
Wood Sandpiper <i>Tringa glareola</i>	M	S3	
Ruddy Turnstone <i>Arenaria interpres</i>	M	S3	
Great Knot <i>Calidris tenuirostris</i>	M	S3	
Red Knot <i>Calidris canutus</i>	M	S3	
Sanderling <i>Calidris alba</i>	M	S3	
Red-necked Stint <i>Calidris ruficollis</i>	M	S3	
Sharp-tailed Sandpiper <i>Calidris acuminata</i>	M	S3	
Curlew Sandpiper <i>Calidris ferruginea</i>	M	S3	
Broad-billed Sandpiper <i>Limicola falcinellus</i>	M	S3	
Ruff <i>Philomachus pugnax</i>	M	S3	
Red-necked Phalarope <i>Phalaropus lobatus</i>	M	S3	
Common Noddy <i>Anous stolidus</i>	M	S3	
Bridled Tern <i>Onychoprion anaethetus</i>	M	S3	
Caspian Tern <i>Hydroprogne caspia</i>	M	S3	
Roseate Tern <i>Sterna dougallii</i>	M	S3	

Species	Conservation Status		
	EPBC Act	WC Act	DEC
Australian Little Bittern <i>Ixobrychus minutus dubius</i>			P4
Hooded Plover <i>Thinornis rubricollis</i>			P4
Black Bittern <i>Ixobrychus flavicollis</i>			P3

3.3.4 Areas of Conservation Significance

As illustrated in Figure 3.6, 48% of the Project Area is inside an ESA. The Project Area also intersects three Bush Forever sites. Thirty percent of the project area (10.54 ha) is inside Bush Forever site 299 (Bullsbrook Nature Reserve); 4.3% (1.49 ha) is inside Bush Forever site 407 (Woodvale Nature Reserve); and 0.5% (0.18 ha) is inside Bush Forever Site 303 (Whitfords Avenue Bushland).

The results from the Communities Data branch of the DEC may increase the locations of conservation significance in the Project Area.



Legend

- Beenyup Stage 2 Project Area
- Environmentally Sensitive Areas
- Bush Forever Sites

Figure: 3.6
Project ID: 1481
Drawn: MC
Date: 11/12/2012

Coordinate System
 Name: GDA 1994 MGA Zone 50
 Projection: Transverse Mercator
 Datum: GDA 1994

Unique Map ID: MC102
 A4

**Areas of Conservation
 Significance
 of the Project Area**



4 SURVEY RESULTS

4.1 FLORA

A total of 115 flora taxa, including subspecies, varieties and hybrids, were recorded during the spring field assessment of the Project Area. Fifteen of these species could not be identified to species level due to lack of reproductive or identifiable material. The total diversity of the flora is summarised in Table 4.1. A complete list of the flora recorded in the Project Area is included as Appendix D.

Table 4.1 – Diversity of the Flora of the Project Area

Number Taxa Recorded	Number Families	Number Genera	Number Families Represented by a Single Taxon	Number Genera Represented by a Single Taxon
115	43	89	28	76

The families and genera represented by the greatest number of taxa are listed in Table 4.2.

Table 4.2 – Most Represented Families and Genera in the Project Area

Most Represented Families	Most Represented Genera
Myrtaceae (21 taxa)	<i>Eucalyptus</i> (Myrtaceae) (3 taxa)
Fabaceae (14 taxa)	<i>Corymbia</i> (Myrtaceae) (4 taxa)
Poaceae (14 taxa)	<i>Melaleuca</i> (Myrtaceae) (4 taxa)
Asteraceae (9 taxa)	<i>Avena</i> (Poaceae) (3 taxa)
Proteaceae (8 taxa)	<i>Banksia</i> (Proteaceae) (3 taxa)
Iridaceae (3 taxa)	<i>Jacksonia</i> (Fabaceae) (3 taxa)
	<i>Trifolium</i> (Fabaceae) (3 taxa)

4.1.1 Flora of Conservation Significance

None of the species recorded during the field assessment are listed as Threatened under either the EPBC Act or WC Act. No Priority Flora were recorded in the Project Area.

4.1.2 Introduced Flora

Neither weeds of National Significance, nor Declared Plants were recorded in the Project Area.

The comprehensive list of Environmental Weeds recorded in the project area includes 67 taxa (58% of total flora taxa recorded) (Table 4.3). Of these, the most frequent and dominant taxa in the Project Area were: **Arctotheca calendula*, **Avena fatua*, **Bromus diandrus*, **Cenchrus ciliaris*, **C. clandestinus*, **Cynodon dactylon*, **Ehrharta calycina*, **Eragrostis curvula*, **Sonchus oleraceus*, **Trifolium campestre* subsp. *campestre*, and **Trachyandra divaricata*. A complete list of introduced flora and their relative abundance in the Project Area is presented in Table 4.3.

Table 4.3 – Introduced Species Recorded in the Project Area

Family	Taxon	Abundance
Aizoaceae	<i>*Tetragonia decumbens</i>	occasional
Apiaceae	<i>*Anethum graveolens</i>	occasional
Apocynaceae	<i>*Nerium oleander</i> [^]	occasional
Arecaceae	<i>*Phoenix dactylifera</i> [^]	occasional
Asphodelaceae	<i>*Asphodelus fistulosus</i>	occasional
Asphodelaceae	<i>*Trachyandra divaricata</i>	abundant
Asteraceae	<i>*Arctotheca calendula</i>	abundant

Family	Taxon	Abundance
Asteraceae	* <i>Conyza bonariensis</i>	occasional
Asteraceae	* <i>Conyza sumatrensis</i>	common
Asteraceae	* <i>Cotula turbinata</i>	occasional
Asteraceae	* <i>Gazania linearis</i> [^]	occasional
Asteraceae	* <i>Hypochaeris glabra</i>	occasional
Asteraceae	* <i>Monoculus monstrosus</i> [^] .	occasional
Asteraceae	* <i>Sonchus oleraceus</i>	abundant
Brassicaceae	* <i>Brassica tournefortii</i>	common
Celastraceae	* <i>Eunymus sp.</i> [^]	occasional
Convolvulaceae	* <i>Ipomoea cairica</i> [^]	occasional
Euphorbiaceae	* <i>Euphorbia terracina</i>	occasional
Euphorbiaceae	* <i>Ricinocarpus tuberculatus</i> [^]	occasional
Fabaceae	* <i>Bauhinia sp.</i> [^]	occasional
Fabaceae	* <i>Erythrina x sykesii</i> [^]	occasional
Fabaceae	* <i>Lupinus cosentinii</i>	common
Fabaceae	* <i>Melilotus indicus</i>	occasional
Fabaceae	* <i>Robinia pseudoacacia</i>	occasional
Fabaceae	* <i>Trifolium arvense</i>	common
Fabaceae	* <i>Trifolium campestre var. campestre</i>	abundant
Fabaceae	* <i>Trifolium resupinatum</i>	occasional
Fabaceae	* <i>Vicia monantha</i>	occasional
Geraniaceae	* <i>Pelargonium capitatum</i>	common
Geraniaceae	* <i>Pelargonium x domesticum</i> [^]	occasional
Iridaceae	* <i>Gladiolus caruophyllaceus</i>	occasional
Iridaceae	* <i>Ixia paniculata</i>	occasional
Iridaceae	* <i>Watsonia sp.</i>	occasional
Lamiaceae	* <i>Lavandula angustifolia</i> [^]	occasional
Lythraceae	* <i>Punica granatum</i> [^]	occasional
Malvaceae	* <i>Malva parviflora</i> [^]	occasional
Moraceae	* <i>Morus nigra</i> [^]	occasional
Myrtaceae	* <i>Eucalyptus nicholii</i> [^]	occasional
Myrtaceae	* <i>Melaleuca quinquenervia</i>	occasional
Nyctaginaceae	* <i>Bougainvillea sp.</i> [^]	occasional
Oleaceae	* <i>Olea europaea</i> [^]	common
Onagraceae	* <i>Oenothera glazioviana</i>	occasional
Onagraceae	* <i>Oenothera sp.</i>	occasional
Orobanchaceae	* <i>Orobanche minor</i>	occasional
Oxalidaceae	* <i>Oxalis pes-caprae</i>	occasional
Pinaceae	* <i>Pinus radiata</i> [^]	occasional
Plantaginaceae	* <i>Plantago lanceolata</i> [^]	occasional
Poaceae	* <i>Aira caryophyllea</i>	common
Poaceae	* <i>Avena barbata</i>	common
Poaceae	* <i>Avena fatua</i>	abundant
Poaceae	* <i>Briza maxima</i>	common
Poaceae	* <i>Bromus diandrus</i>	abundant
Poaceae	* <i>Bromus rubens</i>	common
Poaceae	* <i>Cenchrus ciliaris</i>	abundant
Poaceae	* <i>Cenchrus clandestinus</i>	abundant
Poaceae	* <i>Cynodon dactylon</i>	abundant
Poaceae	* <i>Ehrharta calycina</i>	abundant
Poaceae	* <i>Eragrostis curvula</i>	abundant
Poaceae	* <i>Lagurus ovatus</i>	common
Poaceae	* <i>Lolium rigidum</i>	occasional
Poaceae	* <i>Phleum pratense</i>	occasional
Polygonaceae	* <i>Acetosella vulgaris</i>	occasional
Primulaceae	* <i>Lysimachia arvensis</i>	common
Solanaceae	* <i>Solanum nigrum</i>	occasional
Tropaeolaceae	* <i>Tropaeolum majus</i> [^]	occasional

Family	Taxon	Abundance
Typhaceae	* <i>Typha orientalis</i>	occasional
Ulmaceae	* <i>Ulmus parvifolia</i> [^]	occasional

[^] indicates taxa that have been planted intentionally

4.1.3 Range Extensions

Each taxa was verified with Florabase (Western Australian Herbarium 1998-2012) and the Australian Virtual Herbarium (The Council of Heads of Australasian Herbaria 2012) databases, and none of the recorded flora have been recorded outside the range of their currently known distribution.

4.2 VEGETATION

4.2.1 Vegetation Condition

The entire Project Area occurs along road verges or parklands. The vegetation condition for the entire site is either Degraded (6.96 ha, 20% of the area) or Completely Degraded (27.8 ha, 80% of the area). The mapping of the vegetation condition is presented in Figure 4.1 to Figure.

The results of the DEC search for TECs and PECs in proximity to the Project Area have not been received as yet. This information will be updated in this report when results become available.

Forty eight percent of the Project Area lies within ESA's; however these areas were not found to support high richness of native flora or vegetation and were observed to be degraded to completely degraded in vegetation structure, with a persistence of introduced species.

No signs of recent fire were observed in the Project Area.

4.2.2 Vegetation Communities

No intact native vegetation communities were recorded in the Project Area, due to the fact that all of the surveyed area had been previously cleared or has been extensively degraded. Figure 4.3 presents portions of degraded vegetation in the Project Area in the traffic islands between Ocean Reef Road and Mitchell Freeway. Parts of these are remnants of Bush Forever Sites and have been cleared and replanted with the construction of the roads. The vegetation communities have not been characterised via the collection of quadrat data due to the fact that they lack native understorey and were not found to be in "Good" condition or better. In accordance with EPA Guidance Statement 51, such vegetation is not applicable to Level 2 surveys via quadrats.



Legend

Beenyup Stage 2 Project Area

Vegetation Condition

- Degraded (*Acacia*, *Eucalyptus* and *Banksia* isolated trees and sparse shrubs over introduced grasses and herbs)
- Degraded (Open *Eucalyptus* and *Acacia* woodland over introduced species)
- Completely Degraded (Isolated *Acacia*, *Eucalyptus* and *Melaleuca* trees over introduced species)
- Completely Degraded (isolated *Melaleuca* trees over isolated native and dense introduced sedges and herbs)
- Completely Degraded (Floodplain grassland of introduced species)
- Completely Degraded (Cultivated shrubland of native species)
- Completely Degraded (Cleared for infrastructure)
- Completely Degraded (Grass parkland/road verge)



**Vegetation Condition
of Project Area
Map A**

Figure: 4.1
Project ID: 1481

Drawn: MC
Date: 14/12/12

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: MC105



Legend

Beenyup Stage 2 Project Area

Vegetation Condition

- Degraded (*Acacia*, *Eucalyptus* and *Banksia* isolated trees and sparse shrubs over introduced grasses and herbs)
- Degraded (Open *Eucalyptus* and *Acacia* woodland over introduced species)
- Completely Degraded (Isolated *Acacia*, *Eucalyptus* and *Melaleuca* trees over introduced species)
- Completely Degraded (isolated *Melaleuca* trees over isolated native and dense introduced sedges and herbs)
- Completely Degraded (Floodplain grassland of introduced species)
- Completely Degraded (Cultivated shrubland of native species)
- Completely Degraded (Cleared for infrastructure)
- Completely Degraded (Grass parkland/road verge)



**Vegetation Condition
of Project Area
Map B**

Figure: 4.2
Project ID: 1481

Drawn: MC
Date: 14/12/12

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: MC106



Legend

Beenyup Stage 2 Project Area

Vegetation Condition

- Degraded (*Acacia*, *Eucalyptus* and *Banksia* isolated trees and sparse shrubs over introduced grasses and herbs)
- Degraded (Open *Eucalyptus* and *Acacia* woodland over introduced species)
- Completely Degraded (Isolated *Acacia*, *Eucalyptus* and *Melaleuca* trees over introduced species)
- Completely Degraded (isolated *Melaleuca* trees over isolated native and dense introduced sedges and herbs)
- Completely Degraded (Floodplain grassland of introduced species)
- Completely Degraded (Cultivated shrubland of native species)
- Completely Degraded (Cleared for infrastructure)
- Completely Degraded (Grass parkland/road verge)



**Vegetation Condition
of Project Area
Map C**

Figure: 4.3
Project ID: 1481

Drawn: MC
Date: 14/12/12

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: MC107

4.3 VERTEBRATE FAUNA

During the field survey, a single introduced mammal and 19 birds were recorded within the Project Area (Table 4.4).

Table 4.4 – Vertebrate Fauna Recorded

Common Name	Scientific Name
Mammals	
*Dog	<i>Canis lupus familiaris</i>
Birds	
Australian Wood Duck	<i>Chenonetta jubata</i>
Grey Teal	<i>Anas gracilis</i>
Pacific Black Duck	<i>Anas superciliosa</i>
*Laughing Dove	<i>Streptopelia senegalensis</i>
Straw-necked Ibis	<i>Threskiornis spinicollis</i>
Black Shouldered Kite	<i>Elanus axillaris</i>
Purple Swamphen	<i>Porphyrio porphyrio</i>
Dusky Moorhen	<i>Gallinula tenebrosa</i>
Eurasian Coot	<i>Fulica atra</i>
Forest Red-tailed Black-Cockatoo	<i>Calyptorhynchus banksii naso</i>
Carnaby's Black-Cockatoo	<i>Calyptorhynchus latirostris</i>
Galah	<i>Eolophus roseicapillus</i>
Rainbow Lorikeet	<i>Trichoglossus haematodus</i>
Laughing Kookaburra	<i>Dacelo novaeguineae</i>
Red Wattlebird	<i>Anthochaera carunculata</i>
Grey Butcherbird	<i>Cracticus torquatus</i>
Australian Magpie	<i>Cracticus tibicen</i>
Australian Raven	<i>Corvus coronoides</i>
Magpie-lark	<i>Grallina cyanoleuca</i>

*Introduced species

4.4 FAUNA HABITATS

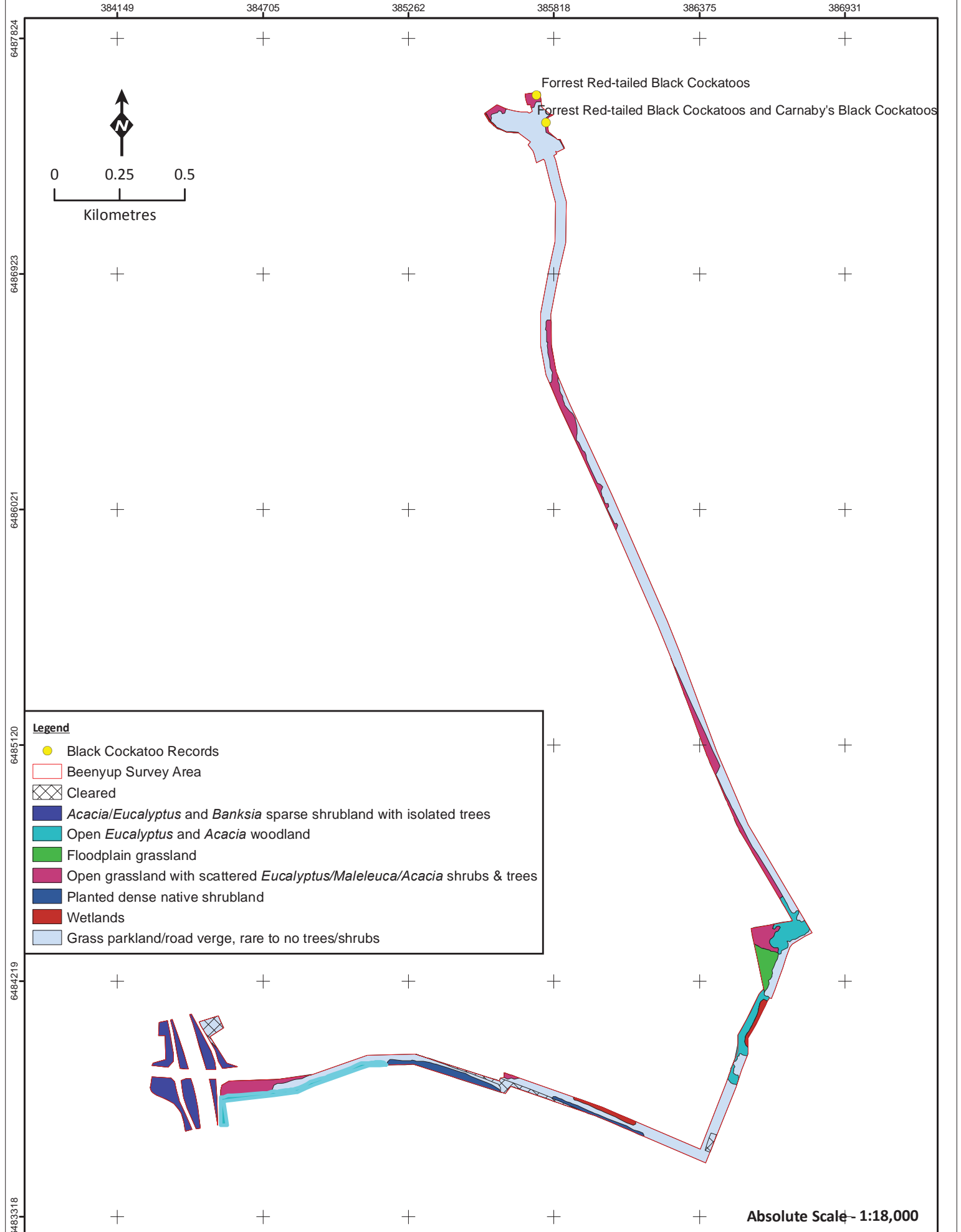
The following seven fauna habitats were identified in the Project Area:

- *Acacia/Eucalyptus* and *Banksia* sparse shrubland with isolated trees
- Open *Eucalyptus* and *Acacia* woodland
- Floodplain grassland
- Open grassland with scattered *Eucalyptus/Melaleuca/Acacia* shrubs and trees
- Planted dense native shrubland
- Wetlands
- Grass parkland/road verge, rare to no trees/shrubs.

These habitats are mapped in Figure 4.4 to Figure 4.6. Apart from the areas that have been cleared, the dominant habitat type supported by the Project Area is the “Grass parkland/road verge, rare to no trees/shrubs”, which comprises 56.5% of the total Project (Table 4.5).

Table 4.5 –Calculations of Habitat Areas and Impact Area

Habitat Type/Area	Area in hectares	% of Project Area
<i>Acacia/Eucalyptus</i> and <i>Banksia</i> sparse shrubland with isolated trees	3.7	10.6
Open <i>Eucalyptus</i> and <i>Acacia</i> woodland	3.3	9.5
Floodplain grassland	0.8	2.3
Open grassland with scattered <i>Eucalyptus/Melaleuca/Acacia</i> shrubs and trees	4.1	11.7
Planted dense native shrubland	1.3	3.8
Wetlands	0.7	2.0
Grass parkland/road verge, rare to no trees/shrubs	19.7	56.5
Cleared (roads and infrastructure)	1.3	3.7
Total	34.9	100



Legend

- Black Cockatoo Records
- Beenyup Survey Area
- Cleared
- Acacia/Eucalyptus* and *Banksia* sparse shrubland with isolated trees
- Open *Eucalyptus* and *Acacia* woodland
- Floodplain grassland
- Open grassland with scattered *Eucalyptus/Maleleuca/Acacia* shrubs & trees
- Planted dense native shrubland
- Wetlands
- Grass parkland/road verge, rare to no trees/shrubs

Absolute Scale - 1:18,000

384705 385262 385818 386375 386931

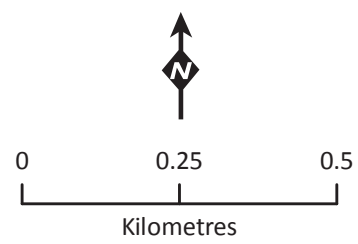
Forrest Red-tailed Black Cockatoos

Forrest Red-tailed Black Cockatoos and Carnaby's Black Cockatoos

6486923

6486021

6485120



Absolute Scale - 1:12,000

Legend

- Black Cockatoo Records
- Beenyup Survey Area
- Cleared
- Acacia/Eucalyptus* and *Banksia* sparse shrubland with isolated trees
- Open *Eucalyptus* and *Acacia* woodland
- Floodplain grassland
- Open grassland with scattered *Eucalyptus/Maleleuca/Acacia* shrubs & trees
- Planted dense native shrubland
- Wetlands
- Open Grassland, rare to no trees/shrubs



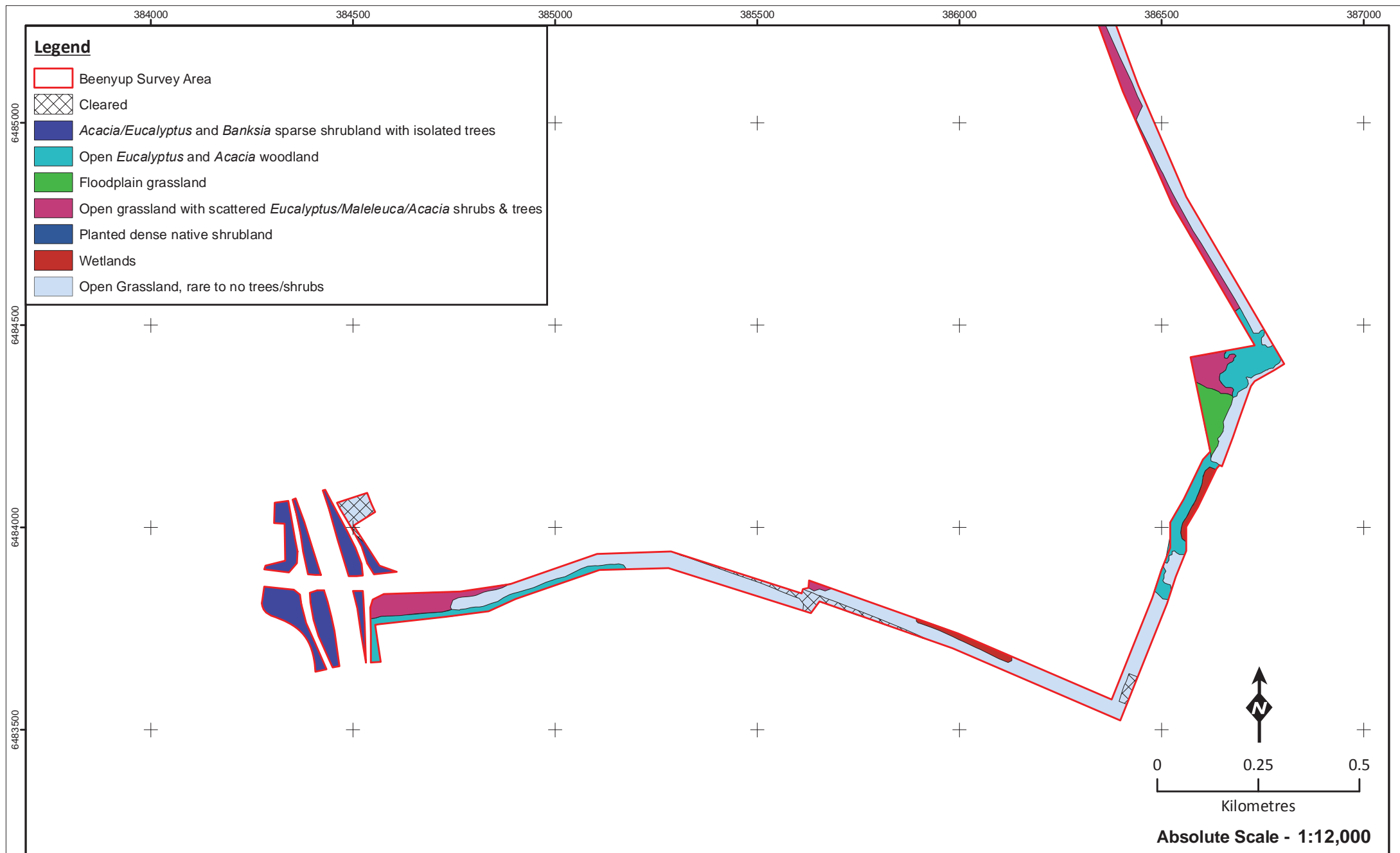
**Beenyup Stage 2
Fauna Habitats
Map A**

**Figure: 4.5
Project ID: 1481**

**Drawn: Md'A
Date: 15/11/12**

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: MXXX



4.4.1 Acacia/Eucalyptus and Banksia sparse shrubland with isolated trees

The *Acacia/Eucalyptus* and *Banksia* sparse shrubland with isolated trees habitat type occupies 3.7 ha (10.6% of the total Project Area) and occurs in the south-western extent of the Project Area. Comprising of dense mixed *Acacia/Eucalyptus* and *Banksia* shrubs, with the occasional tall *Eucalyptus*, this habitat type occurs within the traffic islands divided by the Mitchell Freeway. The substrate of this habitat type comprises soft sandy soils and loams and ground cover is sparse to bare (Figure 4.7).



Figure 4.7 – Example of *Acacia/Eucalyptus* and *Banksia* shrubland with isolated trees habitat type

4.4.2 Open Eucalyptus and Acacia woodland

The open *Eucalyptus* and *Acacia* woodland occurs in the south-eastern and south western parts of the Project Area, and includes 3.3 ha of Bush Forever site 299 and 407 (making up 9.5% of the total Project Area) and consists of medium to tall Tuart and Jarrah trees over mixed grass and weed ground cover with scattered *Xanthorrhoea* shrubs. None of the *Eucalyptus* trees within this habitat inside the Project Area have a diameter at breast height (DBH) of over 500 mm. The substrate of this habitat type ranges from medium to hard clayey soils to soft sandy loams. Ground cover consists predominantly of thick grass cover, with some scattered *Xanthorrhoea* and other small isolated shrubs (Figure 4.8).



Figure 4.8 – Example of open *Eucalyptus* and *Acacia* woodland habitat type

4.4.3 Floodplain grassland

The floodplain grassland consists of an expanse of open grassland over very soft sandy loam bordering Lake Joondalup. This habitat type is entirely within Bush Forever site 303, and includes a single large Jarrah (*Eucalyptus marginata*) tree with diameter at breast height (DBH) of 600 mm. The Floodplain grassland makes up 2.3% of the total Project Area (Figure 4.9).



Figure 4.9 – Example of Floodplain Grassland Habitat Type

4.4.4 Open grassland with scattered *Eucalyptus*/*Melaleuca*/*Acacia* shrubs and trees

The open grassland with scattered *Eucalyptus* shrubs and trees is the second-most represented habitat type of the Project Area, consisting of 11.7% of the total site. This habitat type typically occurs around residential areas and parklands and consists of open grasslands with intermittent *Melaleuca* and *Acacia* shrubs, and some medium to tall Tuart (*Eucalyptus gomphocephala*) and Jarrah (*Eucalyptus marginata*), trees (less than 500 mm DBH). The soil substrate is typically sandy loam and ground cover is composed of mainly grasses and weeds (Figure 4.10).



Figure 4.10 – Example of open grassland with scattered *Eucalyptus*/*Melaleuca*/*Acacia* shrubs and trees habitat type

4.4.5 Planted dense native shrubland

This densely planted habitat consists of low to medium mixed *Adenanthos*, *Callistemon*, *Acacia* and various Proteaceae, and comprises 1.3 ha (3.8 %) of the Project Area. This habitat type occurs along the southern side of Ocean Reef Road and separates residential properties from the road. Ground cover comprises weedy hummock grass and bare sandy to clayey loams (Figure 4.11).



Figure 4.11 – Example of planted dense shrubland habitat type

4.4.6 Wetlands

Occurring in three isolated locations in the northern and south-eastern sections of the Project Area, this habitat type occurs in locations that abut Lake Joondalup and two small wetland areas (0.8 ha in total) and comprises open *Melaleuca* woodland and an understorey of mixed grasses and weeds on soft loamy soils (Figure 4.12).



Figure 4.12 – Example of Wetlands, *Melaleuca* and mixed low shrubs

4.4.7 Grass parkland/road verge, rare to no trees/shrubs

The grass parkland habitat/road verge is associated with areas that have previously been cleared, around residential areas/public parklands and roads. This habitat type is representative of over half of the total Project Area (56.6 %) and ranges from weeded grasslands to landscaped lawn and parklands along road verges. The substrate is typically medium to soft sandy loam (Figure 4.13).



Figure 4.13 – Example of open grassland habitat type

4.5 BLACK-COCKATOO HABITAT

In conjunction with the fauna habitat assessment, recording of potential Black-Cockatoo habitat, with a focus on foraging habitat and breeding habitat/nesting trees was carried out. The habitat assessment was undertaken in accordance with the EPBC Act Referral Guidelines for three threatened Black-Cockatoo species (DSEWPaC 2012).

A single large Jarrah (*Eucalyptus marginata*) tree with diameter at breast height (DBH) of 600 mm was recorded from within the ‘floodplain grassland’ habitat type at coordinates 386631 E, 6484287 S (Figure 4.14).

The ‘open *Eucalyptus* and *Acacia* woodland’ and the ‘open grassland with scattered *Eucalyptus/Melaleuca/Acacia* shrubs and trees’ habitat types were observed to support a number of medium-sized (DBH <500mm) mixed Jarrah and Tuart trees and a single medium-large sized Pine tree that may provide suitable foraging and night roosting habitat for both Carnaby’s and Forrest Red-tailed Black Cockatoos (DSEWPaC 2012) (coordinates 385895 E, 6486359 S).

Flocks of both Carnaby’s and Forrest Red-tailed Black Cockatoos were recorded flying over the northern-most extent of the Project Area during the field survey (Figure 4.4). No hollows were recorded from any trees within the Project Area. In total, these habitat types providing potential suitable foraging and roosting trees comprise a total area of 11.1 ha (31.8%) of the Project Area.

4.6 CONSERVATION SIGNIFICANT FAUNA

During the field survey, two conservation significant species were recorded as previously mentioned; Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) (EPBC Vulnerable, WC Act Schedule 1) and Carnaby’s Black Cockatoo (*Calyptorhynchus latirostris*) (EPBC Endangered, WC Act Schedule 1). Both species were recorded in flocks of relatively high numbers, overflying the northern-most extent of the Project Area (Table 4.6). These records were both from the middle of the day (~1:30pm), suggesting likely foraging behaviour in the area.

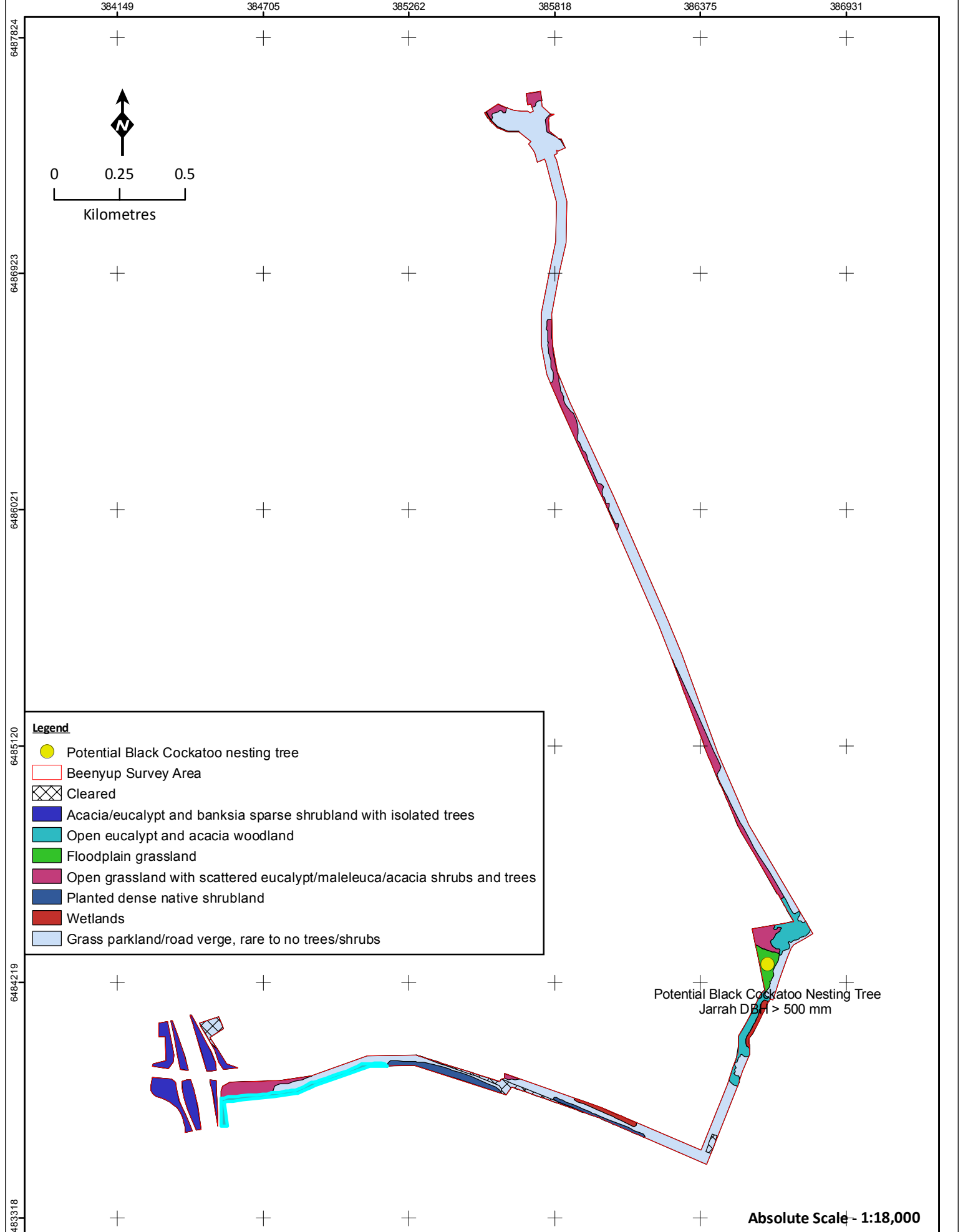
Table 4.6 – Conservation Significant Fauna Recorded during this Survey

Species	Coordinates		Comments
	Easting	Northing	
Forest Red-tailed Black Cockatoo	385752.00	6487610.00	2 individuals recorded flying over Project Area.
Forest Red-tailed Black Cockatoo	385787.00	6487504.00	35 individuals recorded flying over Project Area
Carnaby’s Black Cockatoos	385787.00	6487504.00	12 individuals recorded flying over Project Area

Zone: 50K
Datum: GDA 94

4.7 GRACEFUL SUN MOTH

The targeted Graceful Sun Moth habitat assessment involved a targeted search for the food-source plants; *Lomandra maritima* and *L. hermaphrodita*. No individuals of either species were recorded in the Project Area and the site is therefore not considered to provide habitat suitable to support the Graceful Sun Moth.



Legend

- Potential Black Cockatoo nesting tree
- Beenyup Survey Area
- Cleared
- Acacia/eucalypt and banksia sparse shrubland with isolated trees
- Open eucalypt and acacia woodland
- Floodplain grassland
- Open grassland with scattered eucalypt/maleleuca/acacia shrubs and trees
- Planted dense native shrubland
- Wetlands
- Grass parkland/road verge, rare to no trees/shrubs

Potential Black Cockatoo Nesting Tree
Jarrah DBH > 500 mm

Absolute Scale - 1:18,000

5 DISCUSSION

5.1 FLORA

The number of flora species recorded in the survey area (115 taxa), and in particular native flora (48 taxa) is very low and reflects the level of disturbance that the Project Area has been subject to. The higher representation of genera such as *Eucalyptus* (seven taxa), *Corymbia* and *Melaleuca* (four taxa each) is evidence of the remnant vegetation communities that were once supported by the Project Area. On the other hand, the high representation of the families Fabaceae, Poaceae and Asteraceae (14, 14 and nine taxa each, respectively) indicates the large number of introduced species that are now dominant in the understorey. Nine of 14 taxa of Fabaceae recorded are introduced, as well as eight of the nine taxa of Asteraceae and all of the Poaceae taxa.

Despite the fact that four species of Priority Flora were anticipated as possible or likely to occur in the Project Area, no Priority Flora were recorded. The absence of Priority Flora is most likely due to the fact that most of the Project Area has been cleared and no longer retains the attributes of the original vegetation communities.

The presence of introduced flora is widespread throughout the project area, both within areas that are completely degraded and areas that support remnant native trees and shrubs. Overall, 58% of the flora recorded during the survey are introduced species (weeds). None of the introduced species recorded are listed as Declared Plants or Weeds of National Significance.

All of the recorded taxa are within their known distribution of the species. Therefore, no range extensions have been recorded.

The timing of the survey was considered optimal, as a large proportion of the flora specimens were collected in their reproductive stage. Fifteen specimens could be identified only to genus level, however only eight of them are thought to be native species (*Apium* sp., *Hydrocotyle* sp., *Phyllostachyus* sp, *Callitris* sp., *Beaufortia* sp., *Callistemon* sp., *Corymbia* sp., and *Eucalyptus* sp.), with the remaining seven genera that only include introduced taxa.

5.2 VEGETATION

The condition of the vegetation within Project Area is poor, due to the fact that most of the surveyed area has been cleared in the past or is significantly degraded. Most of the Project Area has been cleared for the construction of roads and parkland or is completely degraded (80% of the area). The remaining 20% of the Project Area is in degraded condition. The main factors of disturbance are weeds, tracks, litter, previous clearing and edge effects.

No intact native vegetation communities were observed, rather only degraded remnants at best remain. Although degraded and lacking floristic value and structure, the remaining native vegetation in the Project Area does provide habitat for fauna.

No signs of recent fire were observed in the Project Area.

5.3 FAUNA HABITATS

Seven fauna habitat types were described and mapped for the Project Area and are listed as follows:

- *Acacia/Eucalyptus* and *Banksia* sparse shrubland with isolated trees
- Open *Eucalyptus* and *Acacia* woodland
- Floodplain grassland
- Open grassland with scattered *Eucalyptus/Melaleuca/Acacia* shrubs and trees

- Planted dense native shrubland
- Wetlands
- Grass parkland/road verge, rare to no trees/shrubs.

Additional to these seven habitat areas, areas cleared for roads and infrastructure also exist within the Project Area.

Potential suitable foraging habitat and potential roosting habitat for Black Cockatoos were recorded in the Project Area, with a total of 11.1 ha (31.8 %) determined to represent potentially suitable foraging and roosting habitat. This comprises a total of 7 ha of 'Acacia/Eucalyptus and Banksia sparse shrubland with isolated trees' and of 'open Eucalyptus and Acacia woodland' habitat types, as well as the taller Jarrah and Marri trees contained within the 4.1 ha of 'open grassland with scattered Eucalyptus/Melaleuca/Acacia shrubs and trees' habitat types. A single isolated tree with DBH > 500 mm was recorded from the 'floodplain grassland' habitat type, however no suitable hollows for nesting were present. Smaller Jarrah and Marri trees (which are recognised as suitable species for all three species of Black-Cockatoo, for foraging and roosting (DSEWPac 2012)) with DBH < 500 mm within the Project Area have the potential to develop suitable tree hollows in the future, these have not been specifically mapped however occur as isolated trees within the 'open grassland with scattered Eucalyptus/Melaleuca/Acacia shrubs and trees' habitat type, spread out across the Project Area. As the Project Area is in close proximity to Lake Joondalup, all of the larger and taller Eucalypts within the Project Area are suitable for night roosting habitat (DSEWPac 2012).

The 11.1 ha of potential Black-Cockatoo foraging and potential roosting habitat present within the Project Area exceeds the threshold limit stated in the EPBC Act referral guidelines which advise that a maximum of 1 ha of clearing of this kind of habitat is acceptable (DSEWPac 2012).

5.4 VERTEBRATE FAUNA

During the field survey, a total of 20 vertebrate fauna species were recorded either from direct sightings or from indirect observations and secondary evidence. Two species of conservation significant fauna; Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) (EPBC Vulnerable, WC Act Schedule 1) and Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*) (EPBC Endangered, WC Act Schedule 1) were recorded during the current survey flying over the Project Area (Figure 4.4).

With regards to conservation significant vertebrate fauna, a total of two mammal and eight bird species have been determined to have a medium to high likelihood of occurrence in the Project Area based on habitat suitability and the relevance and currency of previous records. These are discussed in more detail in the following section.

Table 5.1 – Conservation Significant Vertebrate Fauna Potentially Occurring in the Project Area.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence	Potential Impacts
	EPBC Act	WC Act	DEC				
Mammals							
Red-tailed Phascogale (<i>Phascogale calura</i>)	EN	S1	EN	<i>Allocasuarina</i> woodland with hollow-containing <i>Eucalyptus</i> .	Described as “species or species habitat likely to occur within area” (DSEWPac).	LOW Lack of recent records in the region.	LOW Species unlikely to occur within the Project Area.
Woylie (<i>Bettongia penicillata ogilbyi</i>)	EN	S1	EN	Range from grassland, coastal and inland. <i>Gastrolobium</i> thickets provide refuges against predators.	Described as “species or species habitat likely to occur within area” (DSEWPac).	LOW Lack of recent records in the region, suitable habitat not present	LOW Species unlikely to occur within the Project Area.
Western Quoll (<i>Dasyurus geoffroii</i>)	VU	S1	VU	Sclerophyll forest, dry woodland, heath and mallee shrubland.	Nearest record from 2010, 14 km from Project Area, within Swan Coastal Plain (DEC 2012).	LOW Recorded close by, but few recent records. Highly unlikely to occur due to isolated nature of habitats within the Project Area and lack of suitable habitat.	LOW Species unlikely to occur within the Project Area.
Brush-tailed Phascogale (<i>Phascogale tapoatafa tapoatafa</i>)	VU	S1	EN	Dry sclerophyll forest, monsoonal forest and woodland.	Three historical records within 25 km of the Project Area (DEC 2012).	LOW Lack of recent records in the region.	LOW Species unlikely to occur within the Project Area.
Quokka (<i>Setonix brachyurus</i>)	VU	S1	VU	On mainland inhabits dense, wet cover in forest or swampy flats.	Recorded from DEC threatened fauna search only. No close-by recent records.	LOW Lack of recent records in the region.	LOW Species unlikely to occur within the Project Area.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence	Potential Impacts
	EPBC Act	WC Act	DEC				
Western Brush Wallaby (<i>Macropus irma</i>)			P4	Forest and woodland with dense scrub layer, mallee, heathland. Favours open, seasonally wet flats with low grasses and scrubby thickets.	Nearest records from 14 km north of the Project Area from 2003 and south-west of Project Area from 2012 (DEC 2012). Recorded during previous surveys in the area (CALM 1993, <i>ecologia</i> internal database; Napier and Associates 1989)	MEDIUM Recorded close by (nearest record from 2012, 14km SW of Project Area), but few recent records nearby. Some potentially suitable habitat may exist within the open eucalypt and acacia woodland and acacia/eucalypt and banksia sparse shrubland habitats; however these are highly constrained habitats with no surrounding areas of suitable habitat and isolated by infrastructure.	LOW Species unlikely to occur within the Project Area due to isolated nature of the areas of potentially suitable habitat. Highly mobile species, able to move away from disturbance.
Water Rat (<i>Hydromys chrysogaster</i>)			P4	Permanent water bodies with fresh or brackish water.	Two records from 2004 and 2009 from Lake Goollelal (4km south-west of Project Area) (DEC 2012).	MEDIUM Recorded relatively recently from similar habitat close by. Suitable habitat may exist within the wetlands habitat.	LOW Species may occur within the wetlands habitat of the Project Area, but is mobile and able to move away from disturbance.
Southern Brown Bandicoot (<i>Isoodon obesulus fusciventer</i>)			P5	Sclerophyll forest, dry woodland, heath and mallee shrubland.	Nearest record 21 km north of Project Area, from 2011, numerous records 44 km south of the Project Area (DEC 2012).	LOW Suitable habitat not present within Project Area.	LOW Species unlikely to occur within the Project Area.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence	Potential Impacts
	EPBC Act	WC Act	DEC				
Birds							
Carnaby's Black-Cockatoo (<i>Calyptorhynchus latirostris</i>)	EN	S1	EN	Proteaceous scrubs and heaths, <i>Eucalyptus</i> and pine forests.	Several recent records from near Project Area (CALM 1993, ecologia internal database, DEC 2012; Tingay and Associates 1994)	RECORDED Recorded from Project Area during current survey and potential suitable foraging habitat exists within a number of habitats within the Project Area.	HIGH 7 ha of potential foraging habitat exists within the Project Area (<i>Acacia</i> / <i>Eucalyptus</i> and <i>Banksia</i> Shrubland as well as within the open eucalypt and acacia woodland, as well as isolated trees within the open grassland with scattered eucalypt habitat).
Forest Red-tailed Black-Cockatoo (<i>Calyptorhynchus banksii naso</i>)	VU	S1	VU	<i>Eucalyptus</i> forests of Marri, Jarrah, Blackbutt or Karri. Also feeds on Sheoak and Snottygobble.	Two records from within 13 km north of Project Area (NatureMap), and recorded from Byford area (<i>ecologia</i> internal database). Numerous records from within 20 km south and east of Project Area.	RECORDED Recorded from Project Area during current survey and potential suitable foraging habitat exists within a number of habitats within the Project Area.	HIGH 7 ha of potential foraging habitat exists within the Project Area (<i>Acacia/Eucalyptus</i> and <i>Banksia</i> Shrubland, within the open Eucalypt and <i>Acacia</i> woodland, as well as isolated trees within the open grassland with scattered Eucalypt habitat).
Baudin's Black-Cockatoo (<i>Calyptorhynchus baudinii</i>)	VU	S1	EN	High-rainfall areas, usually sites that are heavily forested and dominated by <i>Eucalyptus</i> species, especially Marri, Karri and Jarrah.	Three relatively recent records (2002,2008,2009) from within 10 km north and north-east of Project Area, near Lake Joondalup (Birds Australia 2010; DEC 2012).	HIGH Relatively recent nearby records and good quality foraging habitat exists within the Bush Forever habitats and the Eucalypt woodland habitats.	HIGH 7 ha of potential foraging habitat exists within the Project Area (<i>Acacia/Eucalyptus</i> and <i>Banksia</i> Shrubland, the open Eucalypt and <i>Acacia</i> woodland, as well as isolated trees within the open grassland with scattered Eucalypt habitat).

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence	Potential Impacts
	EPBC Act	WC Act	DEC				
Rainbow Bee-eater (<i>Merops ornatus</i>)	M	S3		Varied foraging habitats. Breeds in burrows constructed in sandy soils.	Several recent records nearby (CALM 1993, DEC 2012, <i>ecologia</i> internal database; Napier and Associates 1989; Tingay and Associates 1994)	HIGH Several recent records from Lake Joondalup area and nearby.	LOW Species inhabits a variety of habitats and is able to move away from disturbance.
White-bellied Sea-Eagle (<i>Haliaeetus leucogaster</i>)	M	S3		Coastal and near coastal water bodies.	One recent (2011) record from Lake Joondalup (4 km north of Project Area), 3 older records (1977, 2000) from same area (DEC 2012)	MEDIUM Species may occasionally fly over Project Area, unlikely to utilise habitats.	LOW Species is not anticipated to directly utilise the Project Area.
Fork-tailed Swift (<i>Apus pacificus</i>)	M	S3		Almost entirely aerial lifestyle. Will not land.	Three relatively recent records within 10 km north of Project Area (DEC 2012).	MEDIUM Completely aerial species which may occasionally fly over Project Area.	LOW Species is not anticipated to directly utilise the Project Area.
Eastern Osprey (<i>Pandion cristatus</i>)	M	S3		Mangroves, rivers, estuaries, inland seas, coastal islands.	Several recent and historic records from within 10 km of Project Area (Birds Australia 2010; DEC 2012)	MEDIUM Species may occasionally fly over Project Area, unlikely to utilise habitats.	LOW Species is not anticipated to directly utilise the Project Area.
Peregrine Falcon (<i>Falco peregrinus</i>)		S4		Cliffs, ranges and wooded watercourses	Several recent and historic records from within 10 km of Project Area (Birds Australia 2010; DEC 2012)	MEDIUM Species may occasionally fly over Project Area, unlikely to utilise habitats.	LOW Species is not anticipated to directly utilise the Project Area.
Australian Bustard (<i>Ardeotis australis</i>)			P4	Open grasslands, chenopod flats and low heathland.	One historic record and two recent records from within 35 km of Project Area (DEC 2012).	LOW No recent nearby records.	LOW Unlikely to occur in Project Area.
Bush Stone-curlew (<i>Burhinus grallarius</i>)			P4	Woodlands, dry and open grasslands, croplands.	Two records from 1998, one 5 km south of Project Area, two others from near Perth.	LOW No recent, nearby records.	LOW Unlikely to occur in Project Area.
Crested Shrike-tit (<i>Falcunculus frontatus sp. Leucogaster</i>)			P4	<i>Eucalyptus</i> forests and woodlands, forested gullies and along rivers in drier areas.	One historic record within 30 km from Project Area, no recent records (DEC 2012).	LOW No recent nearby records, no suitable habitat.	LOW Unlikely to occur in Project Area.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence	Potential Impacts
	EPBC Act	WC Act	DEC				
Reptiles							
Western Swamp Tortoise <i>(Pseudemydura umbrina)</i>	CR	S1	CR	Lives and feeds in ephemeral winter swamps and spends the other 6-9 months of the year in refuges in leaf litter, under fallen branches or in holes in the ground, in contact with the soil.	Described as “species or species habitat likely to occur within area” (DSEWPaC), no recent nearby records (DEC 2012).	LOW No recent nearby records.	LOW Unlikely to occur in Project Area.
Skink <i>(Ctenotus gemmula)</i>			P3	White sandplains of the Swan Coastal Plain, mainly in semiarid and subhumid zones	No recent nearby records (DEC 2012).	LOW No recent nearby records, no suitable habitat.	LOW Unlikely to occur in Project Area.
Darling Range Heath Ctenotus <i>(Ctenotus delli)</i>			P4	Jarraah and Marri woodlands over shrubby understorey on lateritic, sandy and clay soil	Species is restricted to Darling Range. No recent records close by (DEC 2012).	LOW No recent nearby records, no suitable habitat.	LOW Unlikely to occur in Project Area.
Lined Skink <i>(Lerista lineata)</i>			P3	White sands of the Swan Coastal Plain.	Species occurs south of the Swan River. No recent nearby records (DEC 2012). Recorded from one previous survey 40 km south of the Project Area (<i>ecologia</i> internal database)	LOW No recent nearby records, no suitable habitat.	LOW Unlikely to occur in Project Area.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence	Potential Impacts
	EPBC Act	WC Act	DEC				
Western Carpet Python (<i>Morelia spilota imbricata</i>)		S4	P4	Semi-arid coastal and inland habitats, in <i>Banksia</i> and <i>Eucalyptus</i> woodlands, grasslands. Needs tree hollows or rock crevices for shelter.	Several historic records from 25 km of Project Area, no recent records (DEC 2012)	MEDIUM Recorded close by, but few recent records. Some potentially suitable habitat may exist within the open Eucalypt and <i>Acacia</i> woodland and <i>Acacia</i> /Eucalypt and <i>Banksia</i> sparse shrubland habitats; however these are highly constrained habitats with no surrounding areas of suitable habitat and isolated by infrastructure	LOW Species unlikely to occur within the Project Area due to isolated nature of the areas of potentially suitable habitat. Mobile species, able to move away from disturbance.
Black-striped Snake (<i>Neelaps calonotos</i>)			P3	Sandplain on the Swan Coastal Plain.	Several historic records from 25 km of Project Area, no recent records (DEC 2012)	LOW Recorded close by, but few recent records. Some suitable habitat may exist within the <i>Acacia</i> /Eucalypt and <i>Banksia</i> sparse shrubland habitat	LOW Species unlikely to occur within the Project Area due to isolated nature of the areas of potentially suitable habitat. Mobile species, able to move away from disturbance.
Southern Death Adder (<i>Acanthophis antarcticus</i>)			P3	Wet sclerophyll forests, woodland, grasslands, Chenopod dominated shrublands, and coastal heathlands	Species occurs along Darling Range, no records close by (DEC 2012).	LOW No recent nearby records, no suitable habitat.	LOW Unlikely to occur in Project Area.
Insects							
Graceful Sun Moth (<i>Synemon gratiosa</i>)	EN		P4	<i>Banksia</i> woodland/Woolly bush on deep sands and hermland, heathland and shrubland. Breeds on <i>Lomandra hermaphrodita</i> and <i>L. maritima</i> .	Recorded from numerous locations within 2-10km of the Project Area (DEC 2012).	MEDIUM Previously recorded close by but no food source or breeding plants were recorded.	LOW No food or breeding plant recorded

5.4.1 Mammals

5.4.1.1 Western Brush Wallaby (*Macropus irma*)

Conservation Status: DEC Priority 4.

Distribution and Habitat: The Western Brush Wallaby is restricted to south-western Australia, from north of Kalbarri through to Cape Arid. Its preferred habitat is open forest or woodland, with low grasses and open shrubby thickets.

Ecology: Little is known of the Western Brush Wallaby's food preferences, but it appears to be able to manage without free water. Activity is greatest during the early morning and late afternoon, and the wallabies rest in the shade during the middle of the day.

Likelihood of Occurrence: Medium. Three Western Brush Wallaby records exist within 15 km of the Project Area (NatureMap, two undated records, one from 2002 and a recent record from bushland south-west of the Project Area). Some potentially suitable habitat may exist within the open *Eucalyptus* and *Acacia* woodland and *Acacia/Eucalyptus* and *Banksia* sparse shrubland habitats; however these are highly constrained habitats with no surrounding areas of suitable habitat and isolated by infrastructure.

Potential Impacts: Low. Western Brush Wallabies are highly mobile and able to disperse away from impact.

5.4.1.2 Water-rat (*Hydromys chrysogaster*)

Conservation Status: DEC Priority 4.

Distribution and Habitat: Water-rats are widespread across Australia, New Guinea and adjacent islands. Within Australia Water Rats are distributed around much of the periphery of Australia and can occur anywhere in the vicinity of permanent waterbodies with fresh or brackish water (Olsen 2008). The only areas in which they do not occur are the arid central and western zones.

Ecology: Water-rats hunt on land, amongst the vegetation along the shoreline, and dive around submerged roots and logs. They feed on large aquatic insects, fish, crustaceans, frogs, lizards, water birds, small mammals, fresh carrion and plant material (Olsen 2008). This species is most active around sunset, but may forage during the day (van Dyck and Strahan 2008).

Likelihood of Occurrence: Medium. Two nearby records from 2004 and 2009 from Lake Goollelal (4 km south-west of Project Area, and two records from 2011, 17 km east near Ellenbrook (DEC 2012). Suitable habitat may exist within the Project Area in the wetlands habitat type and at Lake Joondalup, which is directly adjacent to the Project Area.

Potential Impacts: Low. Water Rats are mobile and able to disperse away from impact. Suitable nearby habitat exists outside of the Project Area.

5.4.2 Birds

5.4.2.1 Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*)

Conservation Status: EPBC Act Endangered, WC Act Schedule 1 (Endangered).

Distribution and Habitat: Carnaby's Black-Cockatoo, also known as the Short-billed Black-Cockatoo, is a large, black cockatoo with white tail panels, white cheek patches and a short bill (Threatened Species Network). It is endemic to the south-west of Western Australia, ranging from the lower Murchison River in the north, throughout the south west corner, and east to Cape Arid.

Ecology: Carnaby's Black-Cockatoos are usually seen in pairs, triples or small flocks. In the non-breeding season, they occur in large flocks of up to 10,000 birds that wander in search of food, particularly in *Banksia* woodland and pine plantations on the northern Swan Coastal Plain (Johnstone *et al.* 2007). They breed mainly in the Wheatbelt, in large hollows usually high in *Eucalyptus* trees, and then move west following breeding to feed in coastal and near-coastal areas from late December to July (Morcombe 2000; Shah 2006). They forage mainly in shrubland or kwongan heath, Eucalypt woodland and pine plantations, feeding on the seeds, nuts and flowers of a large variety of Proteaceous species such as *Banksia*, *Dryandra*, *Grevillea* and *Hakea*, as well as *Eucalyptus*, *Pinus* and *Allocasuarina* (Johnstone and Storr 1998; Shah 2006). Breeding trees are known to consist of any patch of woodland or forest which contains live or dead trees of Salmon Gum, Wandoo, Tuart, Jarrah, Flooded Gum, York Gum, Karri or Marri (DSEWPaC 2011). Suitable tree hollows are required for nesting.

The life history of this cockatoo makes it extremely vulnerable to threats resulting from human activities and introduced competitors because pairs bond for life, require large tree hollows for breeding and only produce one chick per year (Shah 2006). The number of Carnaby's Black-Cockatoos remaining in the wild is estimated at 8,000-10,000 individuals (Burnham *et al.* 2010), with an estimated total population decline of over 50% in the past 45 years (Shah 2006).

Factors contributing to their decline include:

- Habitat fragmentation and clearing of semi-arid sandplains, particularly in the northern and eastern areas of the Wheatbelt. Most habitats suitable for breeding and feeding in the Wheatbelt have been cleared entirely.
- Clearing of heathland surrounding breeding sites has reduced the survival rate of fledglings by decreasing the available food sources for the young (Cale 2003; Saunders 1986).
- Poaching of eggs and young by collectors and animal dealers; breeding hollows become unsuitable for future breeding attempts through damage of hollows and trees when young and eggs are taken (Cale 2003).
- The introduction and spread of invasive species such as the Galah (*Eolophus roseicapillus*) on the Swan Coastal Plain, corellas (*Cacatua sanguinea* and *C. tenuirostris*), and feral bee (*Apis mellifera*). These species compete with and exclude Carnaby's Black-Cockatoos from traditional nest hollows (Saunders 1979; Shah 2006).

Likelihood of Occurrence: Recorded. A flock of twelve Carnaby's Black-Cockatoos were recorded overflying Project Area during the field survey, and several other records exist from the Lake Joondalup area and surrounds (Birds Australia 2010; DEC 2012).

DSEWPaC states that "breeding [is] likely to occur within [the] area", in the results of the protected matters database search.

No specific breeding location records in close proximity to the Project Area have been identified from this study.

The Great Cocky Count project noted several potential roost sites within 10 km of the Project Area, in a range of tree species including pine (highest frequency of records of roosting), *Eucalyptus* (Jarrah, Marri and Tuart) (Burnham *et al.* 2010).

Potential Impacts: High. The EPBC Act referral guidelines (DSEWPaC 2012) determine a high risk of significant impacts as clearing of any part of breeding habitat, or clearing of more than 1 ha of quality foraging habitat.

Potential suitable foraging habitat was identified within the three habitat types; the 'Acacia/Eucalyptus and *Banksia* sparse shrubland with isolated trees' (3.7 ha), the 'open *Eucalyptus* and *Acacia* woodland'

(3.3 ha) and isolated trees within the ‘open grassland with scattered *Eucalyptus/Melaleuca/Acacia* shrubs and trees’ (4.4 ha total).

Carnaby’s Black-Cockatoos have been recorded frequently within, and in close proximity to the Project Area (Figure 5.1) (DEC 2012).

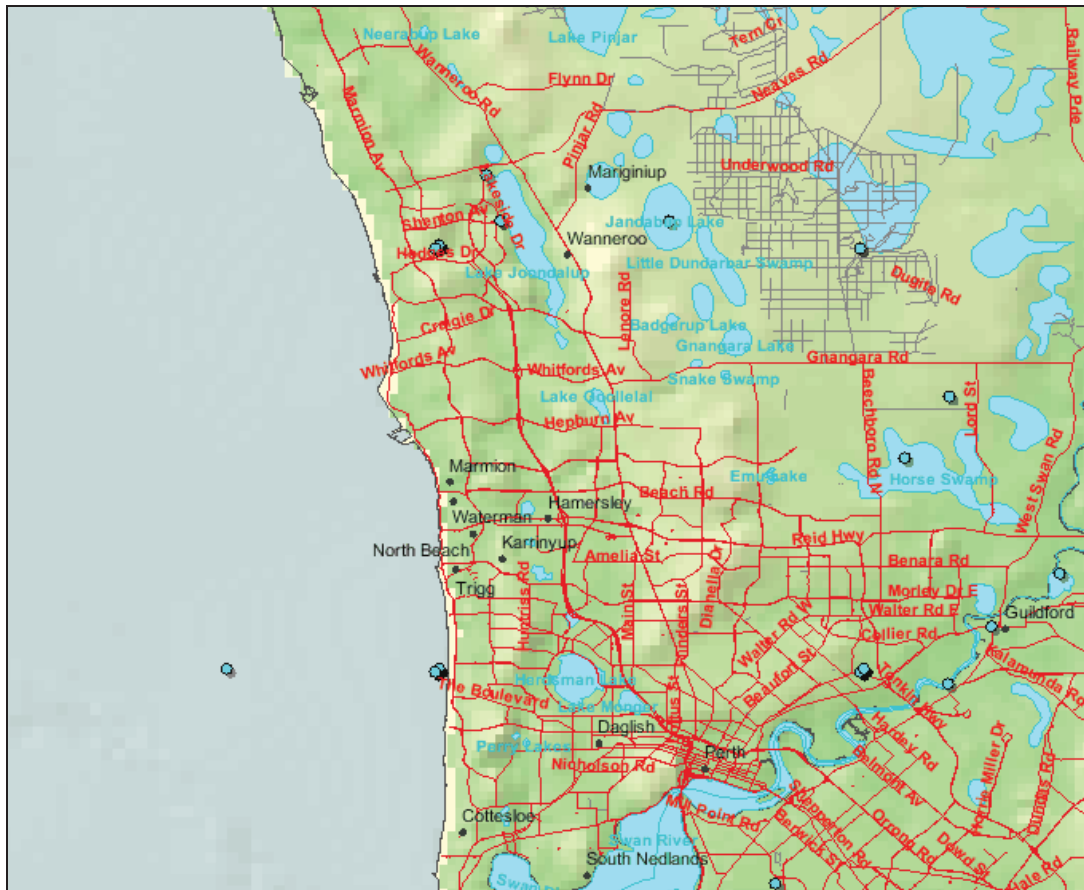


Figure 5.1 – Distribution of Carnaby’s Black Cockatoo (*Calyptorhynchus latirostris*) records from surrounding region (DEC 2012)

5.4.2.2 Baudin’s Black-Cockatoo (*Calyptorhynchus baudinii*)

Conservation Status: EPBC Act Vulnerable, WC Act Schedule 1 (Endangered).

Distribution and Habitat: Baudin’s Black-Cockatoo is also known as the Long-billed Black-Cockatoo (Higgins 1999). It is a large, black cockatoo with white tail panels, white ear patches and a bill with a long, fine tip to the upper mandible. In appearance it is very similar to Carnaby’s Black-Cockatoo, and was only recognised as separate species in 1974 (Saunders 1974). The species is endemic to the south-west of Western Australia, where it is found in or near forested areas. Being a forest specialist, its range follows the distribution of its main food species; Marri (*Corymbia calophylla*, a species of *Eucalyptus* native to the Jarrah and Karri forest).

Destruction of habitat due to logging and clearing for agriculture has reduced this species’ range by 25% while it has reduced in density over a further 25% (Garnett and Crowley 2000). Baudin’s Black Cockatoo only breeds in densely forested areas in the Southern Jarrah Forest bioregion (JF2) (Higgins 1999; McKenzie et al. 2003; Saunders 1974), with the northern-most breeding events recorded near Serpentine, 40 km south of Perth (Johnstone and Kirkby 2008).

Ecology: After breeding, birds congregate in large flocks that move north-east, searching for food (Johnstone and Storr 1998; Saunders 1974). During this time, foraging flocks may enter commercial

orchards where they feed on the seeds and juice of apples and pears (Chapman 2007; Chapman and Massam 2005; Saunders 1974; Saunders et al. 1985). Because of this habit, many birds are shot illegally by orchardists, and this process is considered the principal threat to the species (CALM 2006; Chapman 2007). On average, breeding pairs only produce one chick per two years; hence, it is unlikely that sufficient chicks are produced each year to offset the high adult mortality from shooting (Chapman 2007; Johnstone and Storr 1998).

Likelihood of Occurrence: High. This species has been recorded within close proximity to the Project Area (Figure 5.2) (DEC 2012). The Project Area is outside the typical breeding range for this species (DSEWPac 2011); therefore, habitat usage of the site would be restricted to potential foraging and roosting habitat. No known roost sites within the vicinity of the Project Area have been identified.

Potential Impacts: High. The EPBC Act referral guidelines (DSEWPac 2012) determine a high risk of significant impacts as clearing of any part of breeding habitat, or clearing of more than 1 ha of quality foraging habitat.

Potential suitable foraging habitat was identified within the three habitat types; the 'Acacia/Eucalyptus and Banksia sparse shrubland with isolated trees (3.7 ha), the 'open Eucalyptus and Acacia woodland' (3.3 ha) and 'isolated trees within the open grassland with scattered Eucalyptus/Melaleuca/Acacia shrubs and trees' (4.4 ha total).

The foraging habitat for Baudin's Black-Cockatoo is also suitable as roosting habitat for the species, with 11.4 ha of combined suitable habitat type providing potential roosting habitat within the Project Area. No roost sites are known in close proximity to the Project Area. Due to the Project Area being outside this species breeding range (DSEWPac 2011), no breeding habitat exists within the Project Area.

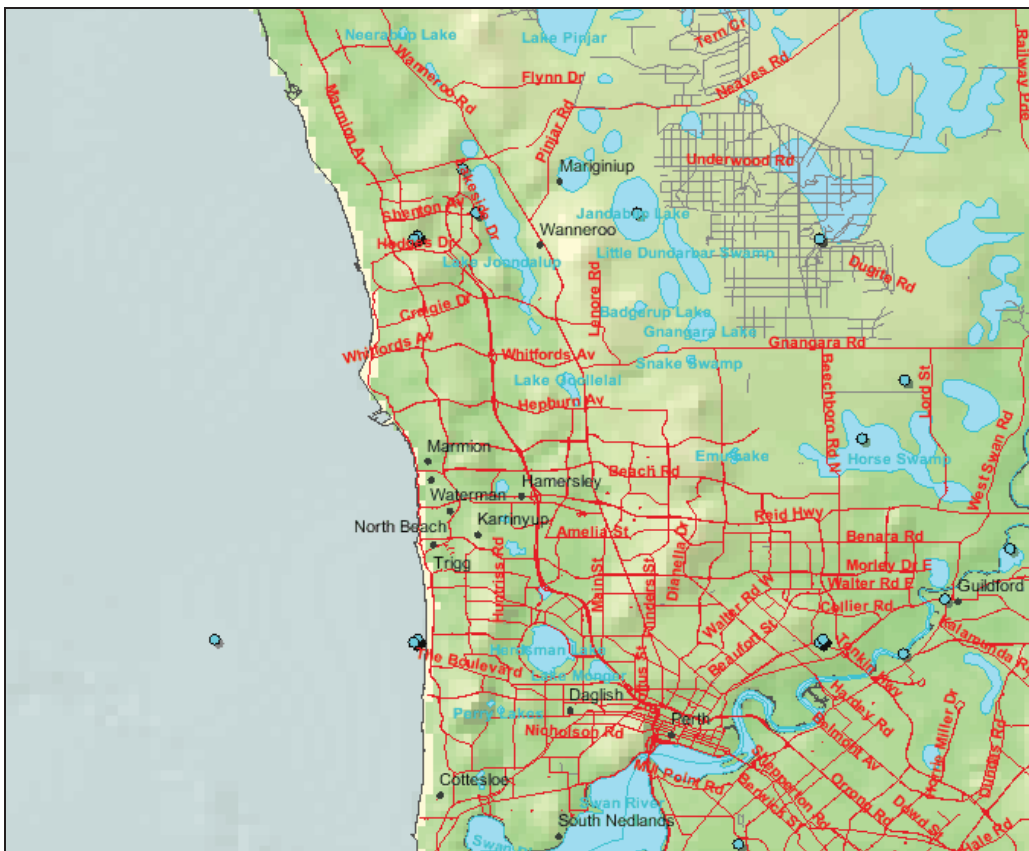


Figure 5.2 –Distribution of Baudin's Black Cockatoo (*Calyptorhynchus baudinii*) records from surrounding region (DEC 2012)

5.4.2.3 Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*)

Conservation Status: EPBC Act Vulnerable, WC Act Schedule 1 (Vulnerable).

Distribution and Habitat: The Forest Red-tailed Black-Cockatoo inhabits the dense Jarrah (*Eucalyptus marginata*), Karri (*E. diversicolor*) and Marri (*Corymbia calophylla*) forests receiving more than 600 mm average rainfall annually (Saunders and Ingram 1995; Saunders et al. 1985). Although most records are in Jarrah-Marri forests, the Forest Red-tailed Black-Cockatoo has been observed in a range of other forest and woodland types, including Blackbutt (*E. patens*), Wandoo (*E. wandoo*), Tuart (*E. gomphocephala*), Albany Blackbutt, Yate (*E. cornuta*), and Flooded Gum (*E. rudis*) (Abbott 1998).

Habitats in which the Forest Red-tailed Black-Cockatoo occurs often have an understorey of *Banksia*, Snottygobble (*Persoonia longifolia*) and Sheoak (*Allocasuarina fraseriana*), with scattered Blackbutt and Wandoo (Johnstone and Kirkby 1999). The Forest Red-tailed Black-Cockatoo occurs within the same habitat as Baudin's Black-Cockatoo (*Calyptorhynchus baudinii*), and as with Baudin's Black-Cockatoo, it nests in large hollows of Marri, Jarrah and Karri (Johnstone and Kirkby 1999). The subspecies has also been sighted nesting in Wandoo and Bullich (*E. megacarpa*).

Ecology: The life span of Forest Red-tailed Black-Cockatoo is predicted to be 25-50 years. The cockatoos are thought to begin breeding when they are 4-6 years old, fledging only one chick at a time (Johnstone and Storr 1998). It is probable that less than 10% of the population of Forest Red-tailed Black-Cockatoos are capable of breeding in any one year and birds may only breed every 2-3 years, with low breeding success (Johnstone and Kirkby 2006).

Like all black cockatoos, the Forest Red-tailed is monogamous and pairs probably form a lifetime bond (Higgins 1999; Smith and Saunders 1986). The breeding period spans from September to April, with eggs typically laid in October/November (Johnstone 1997; Johnstone and Storr 1998), or March/April in years with good autumn rains. Nests are made in large tree hollows in Marri, Jarrah, Wandoo and Bullich trees that are at least 500–600 mm in diameter at breast height and may be more than 130 years old (Johnstone and Storr 1998; Whitford 2002; Whitford and Williams 2002). Trees of less than 500 mm in diameter are considered to have the potential to develop hollows and are also important breeding resources for the species.

Around 90% of the subspecies' diet is made up of the seeds from Marri and Jarrah fruits (Johnstone and Kirkby 1999). Other species used for feeding include Blackbutt, Forest Sheoak, Snottygobble and the non-endemic native, Spotted Gum (*Eucalyptus maculata*) and Cape Lilac (Johnstone and Kirkby 1999; Johnstone and Storr 1998). Due to the slow and patchy flowering and seeding of Marri trees, Forest Red-tailed Black-Cockatoo require foraging habitat to consist of a mosaic of tree species and age classes.

Flocks of up to 50 individuals (Abbott 1998) spend the night roosting in trees and leave at sunrise, splitting into smaller family groups, of around 10 birds, and moving into adjacent forest. After a short period of preening and basking in the sunlight they feed for 10–12 hours before moving off to creeks or dams to drink and on dark, they return to their roosts (Johnstone and Kirkby 1999).

Key threats to the Forest Red-tailed Black-Cockatoo are habitat loss, nest hollow shortage and competition for available nest hollows from other species, and injury or death from the European Honeybee (*Apis mellifera*), illegal shooting and fire (CALM 2006). Climate change is an additional threat that is likely to exacerbate other threats as a result of changes to biodiversity and ecosystem function (Chambers *et al.* 2005).

Likelihood of Occurrence: Recorded. 37 Forest Red-tailed Black-Cockatoos were recorded overflying the Project Area during the current survey, on two separate observations (one single pair and a large flock of 35 individuals). Forest Red-tailed Black Cockatoos have previously been recorded to the south and east of the Project Area, indicating that they are likely to utilise the Project Area. Habitat requirements are similar to Baudin's Black-Cockatoo, with potential usage of the Project Area likely to

be restricted to foraging and potentially roosting. No known breeding or roosting sites in proximity to the Project Area are currently known.

Potential Impacts: High. As with Baudin’s Black-Cockatoo, potential suitable foraging habitat was identified within the three habitat types; the ‘*Acacia/Eucalyptus* and *Banksia* sparse shrubland with isolated trees (3.7 ha), the ‘open Eucalypt and *Acacia* woodland’ (3.3 ha) and isolated trees within the ‘open grassland with scattered *Eucalyptus/Melaleuca/Acacia* shrubs and trees’ (4.4 ha total). Forest Red-tailed Black Cockatoos are also less commonly recorded utilising Pine plantations for foraging. Much of the suitable foraging habitat for Forest Red-tailed Black Cockatoo is also potentially suitable as roosting habitat, with a total of 11.4 ha of combined suitable habitat type providing roosting habitat within the Project Area. No roost sites are known in close proximity to the Project Area which occurs just within the northern-most known distribution of this species (DSEWPac 2011)

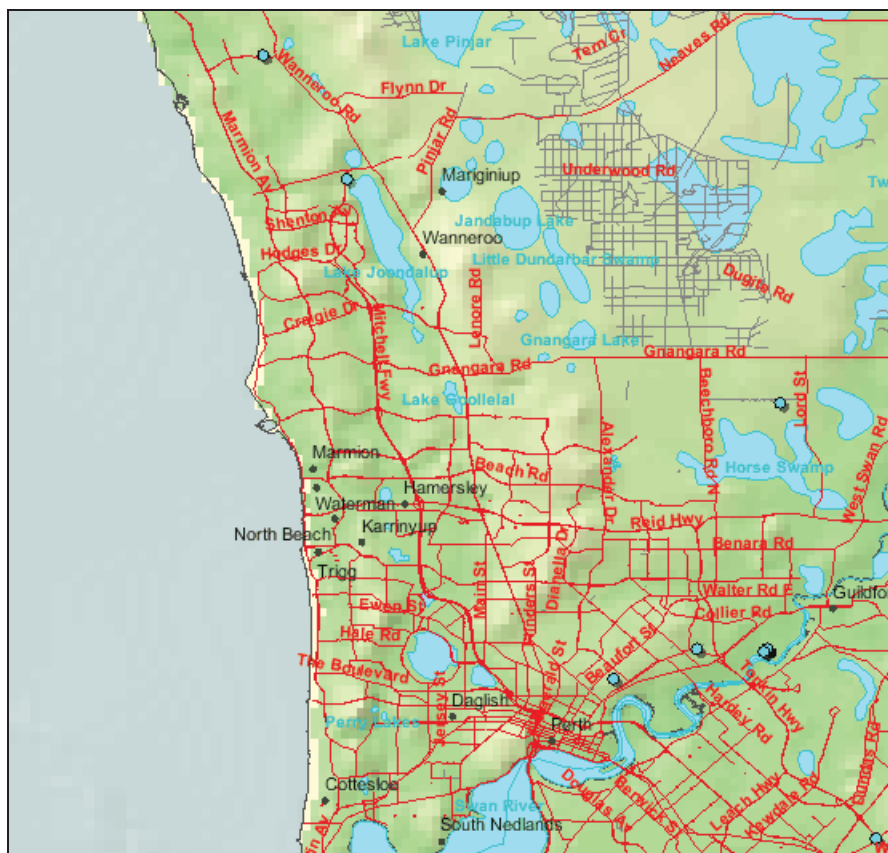


Figure 5.3 –Distribution of Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) records from surrounding region (DEC 2012)

5.4.2.4 Rainbow Bee-eater (*Merops ornatus*)

Conservation Status: EPBC Act Migratory

Distribution and Habitat: The Rainbow Bee-eater is scarce to common throughout much of Western Australia, except for the arid interior, preferring lightly wooded, preferably sandy, country near water (Johnstone and Storr 1998).

Ecology: In Western Australia the Rainbow Bee-eater can occur as a resident, breeding visitor, post-nuptial nomad, passage migrant or winter visitor. It nests in burrows usually dug at a slight angle on flat ground, sandy banks or cuttings, and often at the margins of roads or tracks (Simpson and Day 2004).

Eggs are laid at the end of the metre long tunnel from August to January (Boland 2004). Bee-eaters are most susceptible to predation.

Likelihood of Occurrence: High. Several previous records have been made throughout the region (DEC 2012).

Potential Impacts: Low. The Rainbow Bee-eater inhabits a variety of habitats which occur outside the Project Area. Due to the relatively small size of the proposed clearing, the impact on this species is anticipated to be low.

5.4.2.5 White-bellied Sea-Eagle (*Haliaeetus leucogaster*)

Conservation Status: EPBC Act Migratory, WC Act Schedule 3.

Distribution and Habitat: The White-bellied Sea-Eagle is considered moderately common in the Houtman Abrolhos Islands off Geraldton and in addition to Australia, the species is found in New Guinea, Indonesia, China, south-east Asia and India. White-bellied Sea-eagles occur in coastal and near coastal areas across Australia inhabiting most types of habitats except closed forest.

Ecology: The White-bellied Sea-Eagle feeds mainly on aquatic animals such as fish, turtles and sea snakes, but it takes birds and mammals as well. It breeds almost wholly on islands, building a large stick nest, which is used for many seasons in succession (Johnstone and Storr 1998; RPS 2008). The breeding season ranges from May to September in the north, and in winter and spring in Australia's south (Morcombe 2000).

Likelihood of Occurrence: Medium. The White-bellied Sea-Eagle has previously been recorded from the Lake Joondalup area and thus is likely to possibly overfly the Project Area in search for suitable foraging habitats near Lake Joondalup and along the coast. The White-bellied Sea-Eagle is unlikely to utilise the habitats within the Project Area.

Potential Impacts: Low. The White-bellied Sea-Eagle is likely to occasionally overfly the area in the search of these water bodies, but is not anticipated to land or utilise the Project Area directly.

5.4.2.6 Fork-tailed Swift (*Apus pacificus*)

Conservation Status: EPBC Act Migratory, WC Act Schedule 3.

Distribution and Habitat: The Fork-tailed Swift is a small, insectivorous species with a white throat and rump, and a deeply forked tail (Morcombe 2000). It is distributed from central Siberia and throughout Asia, breeding in north-east and mid-east Asia, and wintering in Australia and south New Guinea. It is a relatively common trans-equatorial migrant from October to April throughout mainland Australia (Simpson and Day 2004). In Western Australia the species begins to arrive in the Kimberley in late September, the Pilbara in November and the South-west by mid-December (Johnstone and Storr 1998). In Western Australia the Fork-tailed Swift is considered uncommon to moderately common near the north-west, west and south-east coasts, common in the Kimberley and rare or scarce elsewhere (Johnstone and Storr 1998).

Ecology: Fork-tailed swifts are nomadic in response to broad-scale weather pattern changes. They are attracted to thunderstorms where they can be seen in flocks, occasionally of up to 2,000 birds. They rarely land, living almost exclusively in the air and feeding entirely on aerial insects, especially nuptial swarms of beetles, ants, termites and native bees (Simpson and Day 2004).

Likelihood of Occurrence: Medium. Birddata states this species as present and recorded within 40 km of the Project Area, and two relatively recent records from within 7 km exist from north and north-west of the Project Area (DEC 2012). The Fork-tailed Swift is likely to occasionally overfly the Project Area, but due to its aerial lifestyle it is not expected to directly utilise the site.

Potential Impacts: Low. Due to the entirely aerial lifestyle of the Fork-tailed Swift, the impact on this species on a local or regional scale will be low.

5.4.2.7 Eastern Osprey (*Pandion cristatus*)

Conservation Status: EPBC Act Migratory.

Distribution and Habitat: The Eastern Osprey is a large (50-60 cm), highly visible and water-dependent bird of prey with a world-wide distribution (Henny 1986; Wink *et al.* 2004). It occurs around most of the Australian coastline, inhabiting coastal areas and favouring mangroves, rivers and estuaries, inshore seas as well as coastal islands (Simpson and Day 2004). The species is uncommon to rare or absent from closely settled parts of south-eastern Australia and does not occur in Victoria or Tasmania.

Ecology: The Eastern Osprey feeds mostly on fish, but also on sea snakes, seabirds, turtles, amphibians and large lizards as well as invertebrates such as crustaceans, sea snails and beetles (Henny 1986; Johnstone and Storr 1998). Breeding takes place from autumn to spring, with eggs being laid in April in the north and as late as October in the south of Australia. Eastern Osprey nests are large and usually placed at the tops of trees, prominent headlands or communication towers (Henny 1986; Simpson and Day 2004). Some nests are re-used for decades (Morcombe 2000).

Degradation and removal of habitat, and disturbance to nesting sites have been identified as threats to the Eastern Osprey's survival (Henny 1986).

Likelihood of Occurrence: Medium. The Eastern Osprey has numerous recent and historic records from within 10 km of the Project Area (Birds Australia 2010; DEC 2012). The Project Area comprises little foraging habitat but the species is likely to occasionally overfly the area.

Potential Impacts: Low. The Eastern Osprey is not likely to directly utilise the Project Area and the impact on this species is anticipated to be low.

5.4.2.8 Peregrine Falcon (*Falco peregrinus*)

Conservation Status: WC Act Schedule 4, DEC Specially Protected Fauna.

Distribution and Habitat: This nomadic or sedentary falcon is widespread in many parts of Australia and some of its continental islands, but absent from most deserts and the Nullarbor Plain. The species is considered to be moderately common in the Stirling Range, uncommon in the Kimberley, Hamersley and Darling Ranges, and rare or scarce elsewhere (Johnstone and Storr 1998). The Peregrine Falcon occurs most commonly near cliffs along coasts, rivers and ranges, and around wooded watercourses and lakes.

Ecology: Peregrine Falcons feed almost entirely on birds, especially parrots and pigeons. They nest primarily on ledges on cliffs, granite outcrops and in quarries, but may also nest in tree hollows around wetlands. Eggs are predominantly laid in September (Johnstone and Storr 1998; Olsen *et al.* 2006).

Likelihood of Occurrence: Medium. The Peregrine Falcon has numerous recent and historic records from within 10 km of the Project Area (Birds Australia 2010; DEC 2012). The Project Area comprises little foraging habitat but the species is likely to occasionally overfly the area.

Potential Impacts: Low. The Peregrine Falcon is not likely to directly utilise the Project Area, the impact on this species is anticipated to be low.

5.4.3 Reptiles

5.4.3.1 Western Carpet Python (*Morelia spilota imbricata*)

Conservation Status: WC Act Schedule 4, DEC Priority 4.

Description and Habitat: The Western Carpet Python inhabits temperate climatic areas with good winter rains and dry summers. This subspecies occurs in semi-arid coastal and inland habitats, *Banksia* woodlands, *Eucalyptus* woodlands, and grasslands of south-west Western Australia, north from Northampton, south to Albany and eastwards to Kalgoorlie. It also occurs in undisturbed remnant bushland near Perth and the Darling Ranges, Yanchep National Park and Garden Island (DEC 2007).

Ecology: Western Carpet Pythons are arboreal, terrestrial and rock-dwelling, and can shelter in burrows made by other animals, hollow tree limbs or rock crevices. Western Carpet Pythons have long periods of inactivity. At Dryandra in south-west Western Australia, the pythons remain inactive for several months during winter, where they may shelter in tree hollows for up to five months (DEC 2007).

The Western Carpet Python has declined in distribution due to the loss of bushland habitat for land development and agriculture, and changed fire regimes. Predation by introduced predators (foxes and feral cats) may have also contributed to the decline of python populations. Habitat destruction has been implicated in the decline of Western Carpet Python populations in the Esperance area (DEC 2007).

Likelihood of Occurrence: Medium. The Western Carpet Python was recorded close by, but few recent records exist. Some potentially suitable habitat may exist within the 'open *Eucalyptus* and *Acacia* woodland' and '*Acacia/Eucalyptus* and *Banksia* sparse shrubland' habitats; however these are highly constrained habitats with no surrounding areas of suitable habitat and isolated by infrastructure

Potential Impacts: Low. The species is unlikely to occur within the Project Area due to isolated nature of the areas of potentially suitable habitat. The Western Carpet Python is a relatively mobile species that is able to move away from disturbance.

5.4.4 Insect

5.4.4.1 Graceful Sun Moth (*Synemon gratiosa*)

Conservation Status: EPBC Act Endangered, DEC Priority 4.

Description and Habitat: The Graceful Sun Moth is listed as Endangered under the EPBC Act and has been recently removed (06/11/12) from the WC Act (formerly schedule 1) and is now considered a Priority 4 species (DEC).

The Graceful Sun Moth is currently only known from two general vegetation types (Bishop *et al.* 2009):

- *Banksia* woodland/Woolly bush on deep sands, in the northern suburbs of Perth on the Swan Coastal Plain. At these sites the Graceful Sun Moth breeds on *Lomandra hermaphrodita*, which often occurs in low numbers.
- Open areas of hermland, heathland and shrubland in the southern Swan Coastal Plain, close to the coast where it breeds on *Lomandra maritima*, which is often present in reasonable numbers and may even be a dominant understorey herb.

Ecology: The Graceful Sun Month has a life cycle that generally takes one to three years to complete, with adult individuals generally only living between two to ten days, with this adult phase spend mating and laying eggs. The eggs are laid at the base of the 'food-plant', and the larvae that hatch from the eggs burrow into the growing tip and down into the underground culms, roots or rhizomes. They live entirely within or alongside the underground parts of the plant, making them very difficult to observe.

The larvae look like beetle grubs; white or cream in colour, with a small dark brown head (Bishop *et al.* 2009).

The Graceful Sun Moth (*Synemon gratiosa*) is a small diurnal moth, endemic to the south-west Western Australia, and is currently only known from the Swan Coastal Plain between Quinns Rocks in Perth’s northern suburbs, to coastal areas south of Mandurah (Bishop *et al.* 2009).

The larvae of the Graceful Sun Moth are only known to feed on two species of *Lomandra* mat-rushes; *Lomandra maritima* and *Lomandra hermaphrodita*, both of which are common and have been recently and historically recorded throughout the region and within 5 km of the Project Area (DEC 2012).

Likelihood of Occurrence: Medium. The likelihood of the Graceful Sun Moth occurring in the Project area is considered moderate, based on the proximity of previous records and the provision of suitable habitat at the site and in the region. The species has been recorded both historically (1980s) and recently (2010) from numerous locations within 2–10 km of the Project Area (Figure 5.4).

No food source plants were recorded during the current survey, and neither of the above-described vegetation types were recorded from within the Project Area. *Lomandra* could possibly occur within the Project Area, however this is considered unlikely since it was not observed during the field assessment after targeted searching and this genus is neither annual nor seasonally restricted. The lack of *Lomandra* in the Project Area is likely due to the degraded nature of the site.

Potential Impacts: Low. No food-plants were recorded from inside the Project Area. The range of the species is small and it is highly unlikely that adults would visit the Project Area in search of *Lomandra* to lay their eggs.

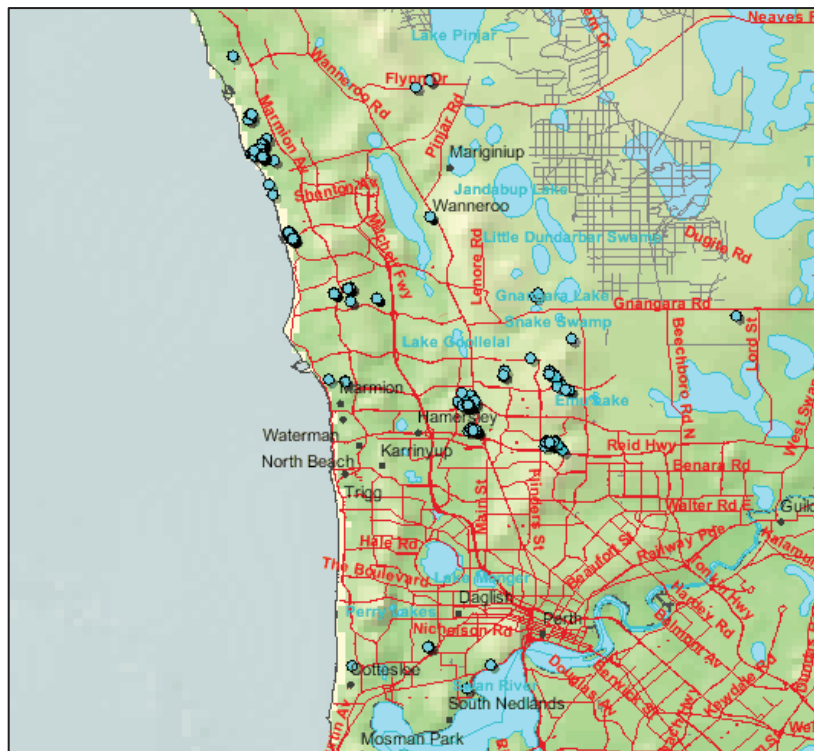


Figure 5.4 – Distribution of Graceful Sun Moth (*Synemon gratiosa*) records from surrounding region (DEC 2012)

5.5 ASSESSMENT OF THE PROJECT AGAINST THE 10 CLEARING PRINCIPLES

The impacts of the Project have been assessed against the DEC's 10 clearing principles. The results are provided in Table 5.2.

Table 5.2 – Assessment of the Proposed Clearing against the 10 Clearing Principles

Principle	Comment
1. Native vegetation should not be cleared if it comprises a high level of biological diversity.	<p>Only 115 taxa of vascular flora were recorded in the Project Area, which is 34.8 ha in size. Of the 115 taxa, only 48 were native species (67 are introduced species), therefore comprising a very low level of floral biodiversity. Only 20 species of fauna (19 of which are native) were recorded during the field assessment. Overall, the biodiversity of the Project Area, which is significantly degraded throughout is considered moderate to low due to its close proximity to Lake Joondalup, which attracts numerous birds.</p> <p>There were no species of Priority Flora recorded within the Project Area and no range extensions.</p> <p>The desktop assessment determined that four species of Priority Flora could possibly occur within the project area: <i>Acacia benthamii</i> (P2), <i>Conostylis bracteata</i> (P3), <i>Thelymitra variegata</i> (P3) and <i>Jacksonia sericea</i> (P4). <i>Jacksonia sericea</i> was determined to be "likely" to occur. The field assessment did not record any of these Priority flora species.</p> <p>The Project Area occurs within the buffer zone of an Environmentally Sensitive Area. However, the remnant vegetation that is supported by the Project Area is not considered sufficiently intact to represent true native vegetation types and is not considered equivalent to PECs.</p> <p>The results of the DEC TEC and PEC database search are yet to be received and will need to be further discussed.</p> <p>With the current available information, the proposed clearing is not at variance with this principle.</p>
2. 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.	<p>The native vegetation of the Project Area represents typically common habitat types of the Swan Coastal Plain region with some remnants of native bushland (open Eucalypt and <i>Acacia</i> woodland and <i>Acacia</i>/Eucalypt and <i>Banksia</i> sparse shrubland with isolated trees habitat types). A total of 11.4 ha of potential foraging and roosting habitat for three species of EPBC Act listed Black-Cockatoos occurs within the Project Area. Clearing of this habitat exceeds the Referral Guidelines of a maximum of 1 ha of clearing of this kind of habitat. Large numbers of the Forest Red-tailed Black-Cockatoo (EPBC Act Vulnerable, WC Act Schedule 1 (Vulnerable)) and a flock of Carnaby's Black Cockatoos were recorded flying over the Project Area during the field survey, further supporting the fact that the site provides suitable foraging and potential roosting habitat, particularly given the close proximity of the Project Area to a permanent body of water, such as Lake Joondalup, which is considered in the EPBC Act referral guidelines for Black Cockatoos as an important factors for night roosting habitat for Baudin's and Carnaby's Black Cockatoos .</p> <p>The proposed clearing is at variance with this principle.</p> <p>Avoidance recommendations – avoid clearing the recorded habitat and minimise clearing of suitable foraging habitat, with the aim of clearing less than 1 ha.</p>
3. Native vegetation should not be cleared if it includes, or is necessary for the continued existence of rare flora.	<p>Based on habitat suitability and previous records, the desktop assessment determined that the Project Area has the potential to support four species of Threatened Flora, with all of these determined to be unlikely. None of these species were recorded during the field assessment, nor were any other species of Threatened Flora. The habitats of the Project Area are mostly highly degraded and this further diminishes the likelihood of any of the potentially occurring Threatened Flora occurring.</p> <p>The proposed clearing is not at variance with this principle.</p>
4. Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of a threatened ecological community.	<p>The results of the DEC TEC and PEC database search are yet to be received and will need to be further discussed. However, the vegetation of the Project Area is all sufficiently degraded that a Level 2 assessment and the recording of quadrat data was not possible (nor appropriate in accordance with EPA Guidance). The vegetation remnants that occur are not considered intact vegetation communities and therefore not comparable to Floristic Community Types (FCTs) to determine equivalence to TEC vegetation types.</p> <p>With the current available information, the proposed clearing is not at variance with this principle.</p>

Principle	Comment
<p>5. Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.</p>	<p>One of the objectives in EPA's Position Statement No. 2 is to protect at least 30% of the pre-European extent of vegetation. The regional vegetation types of the Project Area are the Cottesloe Complex – Central and South; the Herdsman Complex and the Karrakatta Complex – Central and South. In 2010, the Perth Biodiversity Project reported that these vegetation complexes were at that time represented by 35%, 35% and 23% of their pre-European extents, respectively. Although only one of the vegetation complexes falls below the threshold level of 30%, the Perth Biodiversity Project considers the calculations to be overestimates and suggests all three complexes would, realistically fall under the 30% threshold.</p> <p>The area surrounding and including the Project Area has been extensively cleared. However, the remaining vegetation in the Project Area is either Completely Degraded or in Very Poor condition and is, therefore, not considered a significant remnant of the original vegetation communities of the area. Clearing degraded vegetation is not anticipated to have an impact on that vegetation type on a regional scale.</p> <p>The proposed may be considered to be at variance with this principle.</p>
<p>6. Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.</p>	<p>The Project Area occurs in a palusplain area and numerous wetlands occur in a chain all along the Swan Coastal Plain. One of the Vegetation Complexes (Herdsman) is typical wetland vegetation. The project area intersects only with already degraded vegetation areas and clearing of the area should not further impact the area.</p> <p>The proposed clearing may be considered to be at variance with this principle.</p> <p>Mitigation recommendation - rehabilitation of vegetation outside of the clearing area, and avoidance of remnants of native wetland vegetation, even when in degraded condition.</p>
<p>7. Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.</p>	<p>The majority of the Project Area is currently in degraded or completely degraded condition. Provided that the development includes appropriate drainage features, the site is not considered to be at risk of soil erosion and does not occur within an area of salinity risk. The Acid Sulfate Soil (ASS) risk (DEC) within the proposed corridor is "no risk" (27.7 ha) with some areas of "moderate to high" (7 ha) in proximity to Lake Joondalup Wetlands. The excavation of the trench for pipeline installation has the potential to expose these ASSs; however, the clearing proposed will not disturb them. The proposed clearing is not expected to result in appreciable land degradation.</p> <p>The proposed clearing is not considered to be at variance with this principle.</p>
<p>8. Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.</p>	<p>The proposed corridor intersects with Bush Forever sites 299, 303 and 407. In all of these intersections, the vegetation is in poor condition and supports few values that would have been representative of this vegetation type in its original form. The intersections total 12 ha, and are part of a combined Bush Forever extent of 483.79 ha between sites 299, 303 and 407.</p> <p>Bush Forever (2000) shows the section of Bush Forever site 299 as being zoned "Conservation Wetlands" The area inside the Project boundary is, however, currently open parkland with lawn and other introduced species, with occasional planted trees.</p> <p>The proposed clearing may be at variance with this principle.</p> <p>Recommendation – Liaise with WAPC regarding the current status of the vegetation in this location, with regards to protections and inclusion within Bush Forever sites 299, 303 and 407.</p> <p>Avoidance recommendation – thrust bore or other trenchless technology that avoids the need to clear vegetation may be considered if unacceptable impacts to the vegetation will result.</p>
<p>9. Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.</p>	<p>Due to the fact that the Project Area supports little remaining intact native vegetation, the clearing of that which does remain is not expected to cause any deterioration to the quality of surface water or groundwater.</p> <p>The proposed clearing is not considered to be at variance with this principle.</p>
<p>10. Native vegetation should not be cleared the clearing of the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.</p>	<p>Due to the fact that the Project Area supports little remaining intact native vegetation, the clearing of that which does remain is not expected to cause or exacerbate the incidence or intensity of flooding.</p> <p>The proposed clearing is not considered to be at variance with this principle.</p>

6 CONCLUSIONS AND RECOMMENDATIONS

The Project Area is mostly completely degraded from an ecological point of view. The key results of the flora, vegetation and fauna assessment are as follows:

- The vegetation of the Project Area is predominantly ‘Completely Degraded’ and few areas of vegetation that support only scattered native trees and shrubs occur. None of the vegetation was eligible for assessment to Level 2 detail (using quadrats) in accordance with EPA Guidance as it is too degraded and is not considered to support any intact floristic values.
- The regional vegetation types of the Project Area are the Cottesloe Central and South; Herdsman; and Karrakatta Central and South Complexes. The Karrakatta – Central and South Complex was reported by Perth Biodiversity Project to be represented by 24% of its pre-European extent and which falls below the threshold level of 30%. Although values above 30% are observed for Cottesloe Central and South and Herdsman (35% for both), the Perth Biodiversity Project considers them in the category under the threshold because the mapping is over-estimated due to the scale used. The proposed clearing may be variance with Principle (e) due to this result.
- Seven fauna habitat types were described and mapped for the Project Area, some of which provide suitable habitat for conservation significant vertebrate fauna species. In particular, a total area of 11.1 ha (31.8% of the Project Area) is considered suitable foraging habitat, as well as isolated trees within the open grassland with scattered Eucalyptus/Melaleuca/Acacia shrubs and trees habitat. The 11.1 ha of Black-Cockatoo habitat exceeds the EPBC Act Referral Guidelines minimal clearing recommendation, which state that a maximum of 1 ha of clearing of this kind of habitat is acceptable. One single isolated Eucalypt tree with DBH > 500 mm identified as a potential nesting tree was recorded within the Project Area. This tree contained no visible hollows. The Referral Guidelines advise no clearing of any known nesting trees. The proposed clearing may be variance with Principle (b) due to this result.
- Two conservation significant species were recorded during the current survey. 37 Forest Red-tailed Black-Cockatoos (*Calyptorhynchus banksii naso*) (EPBC Vulnerable, WC Act Schedule 1) and a flock of 12 Carnaby’s Black Cockatoos (*Calyptorhynchus latirostris*) (EPBC Endangered, WC Act Schedule 1) were recorded in the Project Area.

Based on the assessment results, the following recommendations are suggested:

- Limit clearing of vegetation to that which is absolutely necessary for construction and safe operation of the project, particularly within Bush Forever sites 299, 303 and 407, foraging and roosting habitat for Black-Cockatoos and other areas that support scattered native tree and shrub species.
- Liaise with WAPC regarding the current status of the vegetation in this location, with regards to protections and inclusion within Bush Forever sites 299, 303 and 407.
- Consider thrust bore or other trenchless technology that avoids the need to clear vegetation if unacceptable impacts to the vegetation as a result of proposed clearing will result.
- Prepare an appropriate Construction Environmental Management Plan that addresses matters including:
 - measures to avoid accidental over-clearing
 - site fauna management including avoidance of vehicle and machinery collisions with native vertebrate species
 - erosion, sedimentation and ASS control/management during construction.

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7 STUDY TEAM

The flora and fauna assessment described in this document was planned, coordinated, executed and reported by:

Project Staff and Qualifications		
Kellie Honczar	BSc	Principal Ecologist
Mariana Campos	PhD	Botanist
Udani Sirisena	PhD	Botanist and Taxonomist
Mimi d'Auvergne	BSc (Hons)	Zoologist

Licences – “Licence to Take Flora for Scientific Purposes”		
The vegetation and flora assessment described in this report was conducted under the authorisation of the following licences issued by the DEC:		
	Permit Type	Permit Number
Mariana Campos	Flora Licence	SL 009 995
Udani Sirisena	Flora Licence	SL 010 214

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8 REFERENCES

- Beard, J. S. 1975. The vegetation of the Pilbara region. Explanatory notes to map sheet 5 of vegetation survey of Western Australia: Pilbara. University of Western Australia Press, Perth.
- Birds Australia. 2010. Birddata: Atlas of Australian Birds Database. URL: <http://www.birddata.com.au>.
- Bishop, C., Williams, M., and Gamblin, T. 2009. Graceful Sun-Moth: Information Kit and Survey Methods. Department of Environment and Conservation.
- BOM. 2012. Bureau of Meteorology. Accessed Jan 2012. <http://www.bom.gov.au>.
- Burnham, Q., Barrett, G., Blythman, M. and Scott, R. 2010. Carnaby's Cockatoo (*Calyptorhynchus latirostris*) identification of nocturnal roost sites and the 2010 Great Cocky Count. Prepared for the Department of Environment and Conservation, Perth, Western Australia.
- Cale, B. 2003. Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*) Recovery Plan. Department of Conservation and Land Management, Wanneroo, Western Australia.
- Department of Conservation and Land Management. 1993. Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park. Unpublished report for Water Authority of Western Australia, Perth.
- Christidis, L. and Boles, W. E. 2008. Systematics and Taxonomy of Australian Birds. CSIRO Publishing, Collingwood.
- Churchill, S. 1998. Australian Bats. Reed New Holland, Sydney.
- Cogger, H. G. 2000. Reptiles and Amphibians of Australia. Reed New Holland, Sydney.
- Department of Environment and Conservation. 2007. Species Profile: Carpet Python. Department of Environment and Conservation, Perth.
- DEC. 2012. NatureMap: Mapping Western Australia's Biodiversity. Department of Environment and Conservation.
- Department of Agriculture and Food. 1976. Agriculture and Related Resources Protection Act 1976, as at Jan 2011 - Declared Plants. The Agriculture Protection Board, Department of Agriculture and Food, Western Australia.
- Department of Conservation and Land Management. 1999. Environmental Weed Strategy for Western Australia. Department of Conservation and Land Management, Government of Western Australia, Western Australia.
- Department of Environment and Water Resources. 2012. NVIS - National Vegetation Information System. Department of Environment and Water Resources, Canberra.
- Department of Sustainability, Environment, Water, Population and Communities. 2011. EPBC Act 1999 draft referral guidelines for three threatened black cockatoo species.
- Department of Sustainability, Environment, Water, Population and Communities. 2012. EPBC Act 2012 referral guidelines for three threatened black cockatoo species.
- ecologia* Environment. 2000. Hepburn Ave Extension Fauna Assessment Survey. Unpublished report for City of Swan.
- Environmental Protection Authority. 2004. Guidance for the Assessment of Environmental Factors. Guidance Statement 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. Environmental Protection Authority, Western Australia.
- Environmental Protection Authority. 2002a. Position Statement No. 3 Terrestrial Biological Surveys as an element of Biodiversity Protection. Perth.

- Environmental Protection Authority. 2002b. Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection. Environmental Protection Authority, Perth.
- Environmental Protection Authority. 2004a. Guidance for the Assessment of Environmental Factors No. 51: Terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia.
- Environmental Protection Authority. 2004b. Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia. Environmental Protection Authority, Perth.
- Environmental Protection Authority and Department of Environment and Conservation. 2010. Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment. Technical report for the Environmental Protection Authority and the Department of Environment and Conservation.
- Executive Steering Committee for Australian Vegetation Information (ESCAVI). 2003. Australian Vegetation Attribute Manual: National Vegetation Information System (NVIS), Version 6.0. Department of the Environment and Heritage, Canberra.
- Hart, Simpson and Associates. 1989. Kwinana Freeway Yangebup Road to Thomas Road Biological Survey. Unpublished report for Main Roads Department.
- Hedde, E. M., Loneragan, O. W., and Havel, J. J. 1980. Vegetation complexes of the Darling System, Western Australia. Atlas of natural resources of the Darling System, Western Australia. Department of Environment and Conservation, Perth, Western Australia.
- Higgins, P. J. 1999. Handbook of Australian, New Zealand and Antarctic Birds. Volume 4: Parrots to Dollarbird. Oxford University Press, Melbourne.
- Johnstone, R.E., Johnstone, C. and Kirkby, T. 2007. Assessment of significant habitat for Carnaby's Cockatoo *Calyptorhynchus latirostris* in the Eneabba region. Unpublished Report for Iluka Resources. Department of Conservation and Land Management.
- Johnstone, R. E. and Storr, G. M. 1998. Handbook of Western Australian Birds, Volume I - Non-Passerines (Emu to Dollarbird). Western Australian Museum, Perth.
- Keighery, B. 1994. Bushland plant survey. A guide to plant community survey for the community. Wildflower Society of Western Australia, Nedlands, Western Australia.
- Menkhorst, P. and Knight, F. 2011. *A Field Guide to the Mammals of Australia*. Oxford University Press, Melbourne.
- Mitchell, D., Williams, K., and Desmond, A. 2002. Swan Coastal Plain 2 (SWA2 - Swan Coastal Plain subregion). Department of Conservation and Land Management, Perth, Western Australia.
- Morcombe, M. 2000. Field Guide to Australian Birds. Steve Parish Publishing Pty Ltd, Archerfield, Australia.
- Napier and Associates. 1989. A Biological Survey of the Road Reserve of the Proposed Extension of the Roe Highway. Unpublished report for Main Roads Department of Western Australia.
- National Health and Medical Research Council. 2004. Australian code of practice for the care and use of animals for scientific purposes. Canberra.
- Olsen, P. D. 2008. Water Rat *Hydromys chrysogaster*. pp. 662-664 in van Dyck, S., and Strahan, R., eds. The Mammals of Australia. 3rd edition. Reed New Holland, Sydney.
- Perth Biodiversity Project. 2010. Remnant Vegetation by Vegetation Complex Dataset for Perth and Peel. Western Australian Local Government Association, Western Australia.

- Saunders, D. A. 1979. The availability of tree hollows for use as nest sites by White-tailed Black-Cockatoos. *Australian Wildlife Research* 6: 205-216.
- Saunders, D. A. 1986. Breeding-season, nesting success and nestling growth in Carnaby's Black-Cockatoo (*Calyptorhynchus funereus latirostris*), over 16 years at Coomallo Creek, and a method for assessing the viability of populations in other areas. *Australian Wildlife Research* 13(2): 261-273.
- Shah, B. 2006. Conservation of Carnaby's Black-Cockatoo on the Swan Coastal Plain, Western Australia. *Birds Australia Western Australia*, Perth.
- Shepherd, D. P., Beeston, G. R., and Hopkins, A. J. M. 2001. Native vegetation in Western Australia: Extent, type and status. Technical Report 249. Department of Agriculture, South Perth, Western Australia.
- Simpson, K. and Day, N. 2004. *Field Guide to the Birds of Australia*. Penguin Group, Camberwell.
- Storr, G. M., Smith, L. A., and Johnstone, R. E. 1983. *Lizards of Western Australia II: Dragons and Monitors*. Western Australian Museum, Perth.
- Storr, G. M., Smith, L. A., and Johnstone, R. E. 1990. *Lizards of Western Australia III: Geckos and Pygopods*. Western Australian Museum, Perth.
- Storr, G. M., Smith, L. A., and Johnstone, R. E. 1999. *Lizards of Western Australia I: Skinks*. Western Australian Museum, Perth.
- Storr, G. M., Smith, L. A., and Johnstone, R. E. 2002. *Snakes of Western Australia*. Western Australian Museum, Perth.
- The Council of Heads of Australasian Herbaria. 2012. Australia's Virtual Herbarium. Available at: <http://avh.chah.org.au>.
- Tingay and Associates Pty Ltd. 1994. Report of a Fauna Survey of the Perth Airport. Unpublished report for Federal Airports Corporation.
- Tyler, M. J. and Doughty, P. 2009. *Field Guide to Frogs of Western Australia*. Western Australian Museum, Perth.
- van Dyck, S. and Strahan, R. 2008. *The Mammals of Australia*. Reed New Holland, Sydney.
- Western Australian Herbarium. 1998-2012. FloraBase - The Western Australian Flora. Department of Environment and Conservation. Available at: <http://florabase.dec.wa.gov.au/>.
- Wilson, S. and Swan, G. 2010. *A Complete Guide to Reptiles of Australia*. New Holland Publishers, Sydney.

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**APPENDIX A CONSERVATION CODES FOR THREATENED AND
PRIORITY FLORA, FAUNA AND ECOLOGICAL
COMMUNITIES**

Table A.1 – Definition of Codes for Threatened and Priority Flora (DEC)

Code	Definition
T	Threatened Flora – (Declared Rare Flora – Extant) Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection and have been gazetted as such (Schedule 1 under the <i>Wildlife Conservation Act 1950</i>).
X	Presumed Extinct Flora (Declared Rare Flora – Extinct) Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such Schedule 2 under the <i>Wildlife Conservation Act 1950</i> .
P1	Priority One – Poorly Known Species Species that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.
P2	Priority Two – Poorly Known Species Species that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.
P3	Priority Three – Poorly Known Species Species that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.
P4	Priority Four – Rare, Near Threatened and other species in need of monitoring (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.
P5	Priority Five – Conservation Dependent species Species that are not threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Table A.2 – Definition of Codes for Commonwealth Listed Threatened Flora

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

Table A.3 – Definition of Codes for Threatened Ecological Communities

Code	Definition
PD: Presumed Totally Destroyed	An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant
CR: Critically Endangered	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future.
EN: Endangered	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future.
VU: Vulnerable	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future.

Table A.4 – Definition of Codes for Priority Ecological Communities

Code	Definition
P1: Priority One	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or Pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
P2: Priority Two	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
P3: Priority Three	<p>(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:</p> <p>(ii) Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;</p> <p>(iii) Communities made up of large, and/or widespread occurrences that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.</p> <p>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.</p>
P4: Priority Four	<p>Ecological communities that are adequately known, Rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.</p> <p>(a) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.</p> <p>(b) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.</p> <p>(c) Ecological communities that have been removed from the list of threatened communities during the past five years.</p> <p>P5: Priority Five Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.</p>
P5: Priority Five	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Table A.5 – Definition of Codes for Threatened Fauna (WC Act)

Code	Definition
T (Schedule 1)	<p>Fauna that is rare or likely to become extinct</p> <p>Taxa that have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction or otherwise in need of special protection, and have been gazetted as such.</p> <p>Further categorised as:</p> <ul style="list-style-type: none"> ○ CR Critically Endangered – considered to be facing an extremely high risk of extinction in the wild ○ EN Endangered – considered to be facing a very high risk of extinction in the wild ○ VU Vulnerable – considered to be facing a high risk of extinction in the wild.
X (Schedule 2)	<p>Presumed Extinct Fauna</p> <p>Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such.</p>
IA (Schedule 3)	<p>Birds protected under an international agreement.</p> <p>Birds that are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction are declared to be fauna that is in need of special protection.</p>
S (Schedule 4)	<p>Other specially protected fauna</p> <p>Fauna that is in need of special protection, otherwise than for the reasons mentioned [in Schedule 1 – 3].]</p>

Table A.6 – Definition of Codes for Priority Fauna (WC Act)

Code	Definition
P1	<p>Priority One</p> <p>Taxa with few, poorly known populations on threatened lands. Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.</p>
P2	<p>Priority Two</p> <p>Taxa with few, poorly known populations on conservation lands. Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.</p>
P3	<p>Priority Three</p> <p>Taxa with several, poorly known populations, some on conservation lands. Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.</p>
P4	<p>Priority Four</p> <p>Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.</p>
P5	<p>Priority Five</p> <p>Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.</p>

Table A.7 – Definition of Codes for Threatened Fauna (EPBC Act)

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

**APPENDIX B NATIONAL VEGETATION INFORMATION SYSTEM
(NVIS) VEGETATION CLASSIFICATIONS**

NVIS Structural Formation Classes Used For Vegetation Classification

Height Range (m)	Tree	Shrub	Mallee	Grass			
>30	tall	-	-	-			
10-30	mid	-	tall	-			
<10	low	-	mid	-			
<3	-	-	low	-			
>2	-	tall	-	tall			
1-2	-	mid	-	tall			
0.5-1	-	low	-	mid			
<0.5	-	low	-	low			
Growth Form	Height (m)	Structural Formation Classes					
Foliage cover % (cover #)		70-100% (5)	30-70% (4)	10-30% (3)	<10% (2)	0-5% (1)	≈0% (N)
Tree	<10,10-30, >30	closed forest	open forest	woodland	isolated clumps of trees	isolated trees	isolated clumps of trees
Tree mallee	<3, <10, 10-30	closed mallee forest	open mallee forest	mallee woodland	isolated clumps of mallee trees	isolated mallee trees	isolated clumps of mallee trees
Shrub	<1,1-2,>2	closed shrubland	shrubland	open shrubland	isolated clumps of shrubs	isolated shrubs	isolated clumps of shrubs
Mallee shrub	<3, <10, 10-30	closed mallee shrubland	mallee shrubland	open mallee shrubland	isolated clumps of mallee shrubs	isolated mallee shrubs	isolated clumps of mallee shrubs
Heath shrub	<1,1-2,>2	closed heathland	heathland	open heathland	isolated clumps of heath shrubs	isolated heath shrubs	isolated clumps of heath shrubs
Chenopod shrub	<1,1-2,>2	closed chenopod shrubland	chenopod shrubland	open chenopod shrubland	isolated clumps of chenopod shrubs	isolated chenopod shrubs	isolated clumps of chenopod shrubs
Samphire shrub	<0.5,>0.5	closed samphire shrubland	samphire shrubland	open samphire shrubland	isolated clumps of samphire shrubs	isolated samphire shrubs	isolated clumps of samphire shrubs
Hummock grass	<2,>2	closed hummock grassland	hummock grassland	open hummock grassland	isolated clumps of hummock grasses	isolated hummock grasses	isolated clumps of hummock grasses
Tussock grass	<0.5,>0.5	closed tussock grassland	tussock grassland	open tussock grassland	isolated clumps of tussock grasses	isolated tussock grasses	isolated clumps of tussock grasses
Sedge	<0.5,>0.5	closed sedgeland	sedgeland	open sedgeland	isolated clumps of sedges	isolated sedges	isolated clumps of sedges
Rush	<0.5,>0.5	closed rushland	rushland	open rushland	isolated clumps of rushes	isolated rushes	isolated clumps of rushes

Source: Department of Environment and Heritage, 2003.

**APPENDIX C REGIONAL FAUNA RECORDS AND SPECIES RECORDED
DURING THE SURVEY**

Mammals

Family and Species	Common name	Conservation Status			ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birddata	This Survey
		EPBC Act	WC Act	DEC										
TACHYGLOSSIDAE														
<i>Tachyglossus aculeatus</i>	Echidna						✓			✓				
DASYURIDAE														
<i>Antechinus flavipes leucogaster</i>	Yellow-footed Antechinus									✓				
<i>Dasyurus geoffroii</i>	Western Quoll	VU	S1	VU						✓		✓		
<i>Ningauai timealeyi</i>	Pilbara Ningauai									✓				
<i>Phascogale calura</i>	Red-tailed Phascogale	EN	S1	EN								✓		
<i>Phascogale tapoatafa tapoatafa</i>	Brush-tailed Phascogale	VU	S1	VU						✓				
<i>Planigale ingrami</i>	Long-tailed Planigale									✓				
<i>Planigale maculata</i>	Common Planigale									✓				
<i>Sminthopsis crassicaudata</i>	Fat-tailed Dunnart									✓				
<i>Sminthopsis macrourus</i>	Strip-faced Dunnart									✓				
PERAMELIDAE														
<i>Isoodon obesulus fusciventer</i>	Southern Brown Bandicoot (south-western)			P5	✓		✓	✓	✓	✓				
POTOROIDAE														
<i>Bettongia penicillata ogilbyi</i>	Woylie	EN	S1	VU						✓		✓		
<i>Bettongia lesueur graii</i>	Boodie									✓				
MACROPODIDAE														
<i>Macropus fuliginosus</i>	Western Grey Kangaroo				✓	✓				✓				

Family and Species	Common name	Conservation Status			ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birdata	This Survey
		EPBC Act	WC Act	DEC										
<i>Macropus irma</i>	Western Brush Wallaby			P4	✓	✓		✓						
<i>Setonix brachyurus</i>	Quokka	VU	S1	VU					✓		✓			
PHALANGERIDAE														
<i>Trichosurus vulpecula vulpecula</i>	Common Brushtail Possum				✓				✓					
BURRAMYIDAE														
<i>Cercartetus concinnus</i>	Western Pygmy-possum								✓					
TARSIPEDIDAE														
<i>Tarsipes rostratus</i>	Honey Possum				✓	✓			✓					
PTEROPODIDAE														
<i>Pteropus scapulatus</i>	Little Red Flying Fox								✓					
VESPERTILIONIDAE														
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat				✓				✓					
<i>Chalinolobus morio</i>	Chocolate Wattled Bat								✓					
<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat				✓				✓					
<i>Nyctophilus gouldi</i>	Gould's Long-eared Bat								✓					
<i>Vespadelus regulus</i>	Southern Forest Bat				✓				✓					
MOLOSSIDAE														
<i>Mormopterus planiceps</i>	South-western Freetail Bat				✓				✓					
<i>Tadarida australis</i>	White-striped Freetail Bat				✓	✓			✓					
MURIDAE														
<i>Hydromys chrysogaster</i>	Water-rat			P4					✓	✓				

Family and Species	Common name	Conservation Status			ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birdata	This Survey
		EPBC Act	WC Act	DEC										
<i>Pseudomys albocinereus</i>	Ash-grey Mouse								✓					
<i>Pseudomys delicatulus</i>	Delicate Mouse								✓					
<i>Pseudomys desertor</i>	Desert Mouse								✓					
<i>Rattus fuscipes</i>	Western Bush Rat								✓					
INTRODUCED MAMMALS														
* <i>Funambulus pennant</i>	Indian Palm Squirrel								✓					
* <i>Mus musculus</i>	House Mouse				✓	✓	✓		✓					
* <i>Mustela putorius</i>	European Polecat								✓					
* <i>Rattus rattus</i>	Black Rat						✓		✓					
* <i>Canis lupus familiaris</i>	Dog				✓				✓				✓	
* <i>Vulpes vulpes</i>	Red Fox				✓	✓	✓	✓	✓					
* <i>Felis catus</i>	Cat				✓	✓	✓		✓					
* <i>Oryctolagus cuniculus</i>	Rabbit				✓	✓	✓	✓	✓					
* <i>Equus caballus</i>	Horse								✓					
* <i>Camelus dromedarius</i>	Camel								✓					
* <i>Ovis aries</i>	Sheep								✓					
* <i>Sus scrofa</i>	Pig								✓					
* <i>Bos taurus</i>	Cow								✓					

Birds

Family and Species	Common name	Conservation Status			ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birddata	This Survey
		EPBC Act	WC Act	DEC										
CASUARIIDAE														
<i>Dromaius novaehollandiae</i>	Emu				✓				✓			✓		
PHASIANIDAE														
<i>Coturnix pectoralis</i>	Stubble Quail								✓			✓		
<i>Coturnix ypsilophora</i>	Brown Quail				✓				✓			✓		
* <i>Pavo cristatus</i>	Indian Peafowl											✓		
* <i>Phasianus colchicus</i>	Common Pheasant											✓		
ANATIDAE														
<i>Dendrocygna eytoni</i>	Plumed Whistling-Duck								✓			✓		
<i>Biziura lobata</i>	Musk Duck				✓		✓		✓			✓		
<i>Stictonetta naevosa</i>	Freckled Duck											✓		
<i>Cygnus atratus</i>	Black Swan				✓		✓		✓			✓		
* <i>Branta canadensis</i>	Canada Goose											✓		
<i>Tadorna tadornoides</i>	Australian Shelduck				✓		✓					✓		
<i>Chenonetta jubata</i>	Australian Wood Duck				✓		✓		✓			✓	✓	
<i>Malacorhynchus membranaceus</i>	Pink-eared Duck											✓		
<i>Anas rhynchotis</i>	Australasian Shoveler						✓		✓			✓		
<i>Anas gracilis</i>	Grey Teal				✓		✓		✓			✓	✓	

Family and Species	Common name	Conservation Status			ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birdata	This Survey
		EPBC Act	WC Act	DEC										
<i>Anas castanea</i>	Chestnut Teal								✓			✓		
<i>Anas platyrhynchos</i>	Mallard								✓			✓		
<i>Anas superciliosa</i>	Pacific Black Duck				✓		✓	✓	✓			✓	✓	
<i>Aythya australis</i>	Hardhead								✓			✓		
<i>Oxyura australis</i>	Blue-billed Duck				✓							✓		
PODICIPEDIDAE														
<i>Tachybaptus novaehollandiae</i>	Australasian Grebe						✓						✓	
<i>Tachybaptus ruficollis</i>	Little Grebe												✓	
<i>Poliiocephalus poliocephalus</i>	Hoary-headed Grebe				✓								✓	
<i>Podiceps cristatus</i>	Great Crested Grebe												✓	
COLUMBIDAE														
* <i>Columba livia</i>	Rock Dove				✓				✓				✓	
* <i>Streptopelia senegalensis</i>	Laughing Dove				✓	✓	✓	✓					✓	
* <i>Streptopelia chinensis</i>	Spotted Dove				✓			✓					✓	
<i>Phaps chalcoptera</i>	Common Bronzewing				✓	✓	✓						✓	
<i>Phaps elegans</i>	Brush Bronzewing												✓	
<i>Ocyphaps lophotes</i>	Crested Pigeon				✓		✓						✓	
<i>Geopelia cuneata</i>	Diamond Dove								✓					
<i>Geopelia striata</i>	Peaceful Dove								✓					

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PODARGIDAE														
<i>Podargus strigoides</i>	Tawny Frogmouth				✓								✓	
EUROSTOPODIDAE														
<i>Eurostopodus argus</i>	Spotted Nightjar								✓					
AEGOTHELIDAE														
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar								✓					
APODIDAE														
<i>Apus pacificus</i>	Fork-tailed Swift	M	S3						✓	✓	✓	✓		
PHALACROCORACIDAE														
<i>Microcarbo melanoleucos</i>	Little Pied Cormorant				✓		✓						✓	
<i>Phalacrocorax carbo</i>	Great Cormorant				✓		✓						✓	
<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant				✓		✓						✓	
<i>Phalacrocorax varius</i>	Pied Cormorant				✓								✓	
<i>Phalacrocorax fuscescens</i>	Black-faced Cormorant												✓	
PELECANIDAE														
<i>Pelecanus conspicillatus</i>	Australian Pelican				✓		✓						✓	
ARDEIDAE														
<i>Botaurus poiciloptilus</i>	Australasian Bittern	EN	S1	EN					✓	✓	✓			
<i>Ixobrychus dubius</i>	Australian Little Bittern			P4									✓	

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<i>Ixobrychus flavicollis</i>	Black Bittern			P3						✓				
<i>Ardea pacifica</i>	White-necked Heron						✓		✓			✓		
<i>Ardea modesta</i>	Eastern Great Egret	M	S3		✓		✓		✓	✓	✓	✓		
<i>Ardea ibis</i>	Cattle Egret	M	S3						✓	✓	✓	✓		
<i>Egretta novaehollandiae</i>	White-faced Heron				✓		✓	✓	✓			✓		
<i>Egretta garzetta</i>	Little Egret											✓		
<i>Egretta sacra</i>	Eastern Reef Egret	M	S3						✓	✓		✓		
<i>Nycticorax caledonicus</i>	Nankeen Night-Heron											✓		
THRESKIORNITHIDAE														
<i>Plegadis falcinellus</i>	Glossy Ibis	M	S3							✓		✓		
<i>Threskiornis molucca</i>	Australian White Ibis				✓		✓					✓		
<i>Threskiornis spinicollis</i>	Straw-necked Ibis				✓		✓					✓	✓	
<i>Platalea regia</i>	Royal Spoonbill											✓		
<i>Platalea flavipes</i>	Yellow-billed Spoonbill						✓					✓		
ACCIPITRIDAE														
<i>Pandion cristatus</i>	Eastern Osprey	M										✓		
<i>Elanus axillaris</i>	Black-shouldered Kite				✓		✓	✓	✓			✓	✓	
<i>Lophoictinia isura</i>	Square-tailed Kite											✓		
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	M	S3							✓	✓	✓		
<i>Haliastur sphenurus</i>	Whistling Kite				✓							✓		

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<i>Accipiter fasciatus</i>	Brown Goshawk				✓		✓	✓		✓			✓	
<i>Accipiter cirrocephalus</i>	Collared Sparrowhawk				✓	✓	✓			✓			✓	
<i>Circus assimilis</i>	Spotted Harrier												✓	
<i>Circus approximans</i>	Swamp Harrier				✓					✓			✓	
<i>Aquila audax</i>	Wedge-tailed Eagle						✓			✓			✓	
<i>Hieraaetus morphnoides</i>	Little Eagle					✓	✓			✓			✓	
FALCONIDAE														
<i>Falco berigora</i>	Brown Falcon				✓		✓			✓			✓	
<i>Falco longipennis</i>	Australian Hobby									✓			✓	
<i>Falco subniger</i>	Black Falcon									✓				
<i>Falco peregrinus</i>	Peregrine Falcon		S4							✓	✓		✓	
RALLIDAE														
<i>Porphyrio porphyrio</i>	Purple Swamphen				✓		✓						✓	✓
<i>Gallirallus philippensis</i>	Buff-banded Rail									✓			✓	
<i>Porzana pusilla</i>	Baillon's Crake												✓	
<i>Porzana fluminea</i>	Australian Spotted Crake				✓								✓	
<i>Porzana tabuensis</i>	Spotless Crake												✓	
<i>Tribonyx ventralis</i>	Black-tailed Native-hen									✓			✓	
<i>Gallinula tenebrosa</i>	Dusky Moorhen				✓		✓			✓			✓	✓
<i>Fulica atra</i>	Eurasian Coot				✓		✓			✓			✓	✓

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OTIDIDAE														
<i>Ardeotis australis</i>	Australian Bustard			P4						✓				
BURHINIDAE														
<i>Burhinus grallarius</i>	Bush Stone-curlew			P4						✓				
HAEMATOPODIDAE														
<i>Haematopus longirostris</i>	Australian Pied Oystercatcher												✓	
<i>Haematopus fuliginosus</i>	Sooty Oystercatcher												✓	
RECURVIROSTRIDAE														
<i>Himantopus himantopus</i>	Black-winged Stilt				✓		✓						✓	
<i>Recurvirostra novaehollandiae</i>	Red-necked Avocet												✓	
<i>Cladorhynchus leucocephalus</i>	Banded Stilt						✓			✓			✓	
CHARADRIIDAE														
<i>Pluvialis fulva</i>	Pacific Golden Plover	M	S3									✓		
<i>Pluvialis squatarola</i>	Grey Plover	M	S3									✓		
<i>Charadrius dubius</i>	Little Ringed Plover									✓			✓	
<i>Charadrius ruficapillus</i>	Red-capped Plover									✓			✓	
<i>Charadrius bicinctus</i>	Double-banded Plover	M										✓		
<i>Charadrius mongolus</i>	Lesser Sand Plover	M	S1	EN						✓		✓	✓	
<i>Charadrius leschenaultii</i>	Greater Sand Plover	M	S1	VU						✓		✓	✓	

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<i>Charadrius veredus</i>	Oriental Plover	M	S3						✓					
<i>Elsyornis melanops</i>	Black-fronted Dotterel				✓		✓	✓	✓			✓		
<i>Thinornis rubricollis</i>	Hooded Plover			P4					✓			✓		
<i>Erythrogonys cinctus</i>	Red-kneed Dotterel								✓			✓		
<i>Vanellus tricolor</i>	Banded Lapwing											✓		
ROSTRATULIDAE														
<i>Rostratula australis</i>	Australian Painted Snipe	VU, M	S1, S3	VU								✓	✓	
SCOLOPACIDAE														
<i>Limosa limosa</i>	Black-tailed Godwit	M	S3									✓	✓	
<i>Limosa lapponica</i>	Bar-tailed Godwit	M	S1	VU								✓	✓	
<i>Numenius minutus</i>	Little Curlew	M	S3									✓	✓	
<i>Numenius phaeopus</i>	Whimbrel	M	S3									✓	✓	
<i>Xenus cinereus</i>	Terek Sandpiper	M	S3									✓	✓	
<i>Actitis hypoleucos</i>	Common Sandpiper	M	S3						✓	✓	✓	✓	✓	
<i>Tringa brevipes</i>	Grey-tailed Tattler	M	S3								✓	✓	✓	
<i>Tringa nebularia</i>	Common Greenshank	M	S3							✓	✓	✓	✓	
<i>Tringa stagnatilis</i>	Marsh Sandpiper	M	S3								✓	✓	✓	
<i>Tringa glareola</i>	Wood Sandpiper	M	S3							✓	✓	✓	✓	
<i>Arenaria interpres</i>	Ruddy Turnstone	M	S3						✓		✓	✓	✓	
<i>Calidris tenuirostris</i>	Great Knot	M	S1	VU					✓		✓	✓	✓	

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<i>Calidris canutus</i>	Red Knot	M	S1	VU						✓		✓		
<i>Calidris alba</i>	Sanderling	M	S3							✓		✓	✓	
<i>Calidris ruficollis</i>	Red-necked Stint	M	S3							✓	✓	✓	✓	
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	M	S3							✓			✓	
<i>Calidris ferruginea</i>	Curlew Sandpiper	M	S1	VU						✓	✓	✓	✓	
<i>Limicola falcinellus</i>	Broad-billed Sandpiper	M	S3									✓		
<i>Philomachus pugnax</i>	Ruff	M	S3										✓	
<i>Phalaropus lobatus</i>	Red-necked Phalarope	M	S3										✓	
TURNICIDAE														
<i>Turnix maculosus</i>	Red-backed Button-quail												✓	
<i>Turnix varius</i>	Painted Button-quail				✓									
<i>Turnix velox</i>	Little Button-quail												✓	
LARIDAE														
<i>Anous stolidus</i>	Common Noddy	M	S3							✓			✓	
<i>Anous tenuirostris melanops</i>	Lesser Noddy	VU	S1	VU						✓		✓		
<i>Onychoprion anaethetus</i>	Bridled Tern	M	S3									✓	✓	
<i>Onychoprion fuscata</i>	Sooty Tern												✓	
<i>Sternula nereis nereis</i>	Fairy Tern	VU	S1	VU								✓	✓	
<i>Gelochelidon nilotica</i>	Gull-billed Tern												✓	
<i>Hydroprogne caspia</i>	Caspian Tern	M	S3		✓							✓	✓	

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<i>Chlidonias hybrida</i>	Whiskered Tern												✓	
<i>Sterna dougallii</i>	Roseate Tern	M	S3										✓	
<i>Sterna paradisaea</i>	Arctic Tern												✓	
<i>Thalasseus bergii</i>	Crested Tern												✓	
<i>Larus dominicanus</i>	Kelp Gull												✓	
<i>Chroicocephalus novaehollandiae</i>	Silver Gull				✓								✓	
CACATUIDAE														
<i>Calyptorhynchus banksii</i>	Red-tailed Black-Cockatoo									✓			✓	
<i>Calyptorhynchus banksii naso</i>	Forest Red-tailed Black-Cockatoo	VU	S1	VU						✓		✓		✓
<i>Calyptorhynchus latirostris</i>	Carnaby's Black-Cockatoo	EN	S1	EN	✓	✓	✓			✓	✓	✓	✓	✓
<i>Calyptorhynchus baudinii</i>	Baudin's Black-Cockatoo	VU	S1	EN						✓	✓	✓	✓	
<i>Eolophus roseicapillus</i>	Galah				✓	✓	✓	✓	✓	✓			✓	✓
<i>Cacatua tenuirostris</i>	Long-billed Corella									✓			✓	
<i>Cacatua pastinator</i>	Western Corella				✓					✓			✓	
<i>Cacatua sanguinea</i>	Little Corella				✓					✓			✓	
<i>Cacatua galerita</i>	Sulphur-crested Cockatoo									✓			✓	
<i>Nymphicus hollandicus</i>	Cockatiel				✓								✓	
<i>Trichoglossus haematodus</i>	Rainbow Lorikeet				✓								✓	✓

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<i>Glossopsitta porphyrocephala</i>	Purple-crowned Lorikeet												✓	
<i>Aprosmictus erythropterus</i>	Red-winged Parrot								✓					
<i>Polytelis anthopeplus</i>	Regent Parrot												✓	
<i>Platycercus icterotis</i>	Western Rosella												✓	
<i>Barnardius zonarius</i>	Australian Ringneck				✓	✓	✓	✓					✓	
<i>Purpureicephalus spurius</i>	Red-capped Parrot				✓	✓	✓	✓					✓	
<i>Neophema elegans</i>	Elegant Parrot					✓	✓						✓	
<i>Neophema petrophila</i>	Rock Parrot												✓	
CUCULIDAE														
<i>Chalcites basalis</i>	Horsfield's Bronze-Cuckoo				✓					✓			✓	
<i>Chalcites lucidus</i>	Shining Bronze-Cuckoo					✓	✓	✓		✓			✓	
<i>Cacomantis pallidus</i>	Pallid Cuckoo				✓		✓			✓			✓	
<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo					✓	✓	✓		✓			✓	
STRIGIDAE														
<i>Ninox connivens</i>	Barking Owl												✓	
<i>Ninox novaeseelandiae</i>	Southern Boobook				✓	✓							✓	
TYTONIDAE														
<i>Tyto javanica</i>	Eastern Barn Owl				✓								✓	
HALCYONIDAE														

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<i>*Dacelo novaeguineae</i>	Laughing Kookaburra				✓	✓	✓	✓	✓				✓	✓
<i>Todiramphus sanctus</i>	Sacred Kingfisher				✓	✓	✓	✓					✓	
MEROPIDAE														
<i>Merops ornatus</i>	Rainbow Bee-eater	M	S3		✓	✓	✓	✓		✓	✓		✓	
CORACIIDAE														
<i>Eurystomus orientalis</i>	Dollarbird								✓					
CLIMACTERIDAE														
<i>Climacteris rufa</i>	Rufous Treecreeper								✓				✓	
PTILONORHYNCHIDAE														
<i>Ptilonorhynchus violaceus</i>	Satin Bowerbird												✓	
<i>Ptilonorhynchus muculatus</i>	Spotted Bowerbird												✓	
MALURIDAE														
<i>Malurus splendens</i>	Splendid Fairy-wren				✓	✓	✓						✓	
<i>Malurus leucopterus</i>	White-winged Fairy-wren				✓								✓	
<i>Malurus lamberti</i>	Variogated Fairy-wren												✓	
<i>Malurus pulcherrimus</i>	Blue-breasted Fairy-wren												✓	
<i>Malurus elegans</i>	Red-winged Fairy-wren												✓	
<i>Stipiturus malachurus</i>	Southern Emu-wren												✓	
ACANTHIZIDAE														

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<i>Sericornis frontalis</i>	White-browed Scrubwren				✓	✓							✓	
<i>Calamanthus campestris</i>	Rufous Fieldwren												✓	
<i>Smicronis brevirostris</i>	Weebill				✓	✓	✓						✓	
<i>Gerygone fusca</i>	Western Gerygone				✓	✓	✓	✓	✓	✓			✓	
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill				✓	✓	✓	✓	✓	✓	✓		✓	
<i>Acanthiza uropygialis</i>	Chestnut-rumped Thornbill								✓	✓				
<i>Acanthiza inornata</i>	Western Thornbill				✓	✓			✓	✓			✓	
<i>Acanthiza apicalis</i>	Inland Thornbill				✓	✓	✓		✓	✓			✓	
PARDALOTIDAE														
<i>Pardalotus punctatus</i>	Spotted Pardalote				✓	✓	✓						✓	
<i>Pardalotus striatus</i>	Striated Pardalote				✓	✓	✓	✓					✓	
MELIPHAGIDAE														
<i>Acanthorhynchus superciliosus</i>	Western Spinebill				✓	✓	✓		✓	✓			✓	
<i>Lichenostomus virescens</i>	Singing Honeyeater				✓	✓	✓	✓					✓	
<i>Lichenostomus leucotis</i>	White-eared Honeyeater												✓	
<i>Lichenostomus ornatus</i>	Yellow-plumed Honeyeater												✓	
<i>Purnella albifrons</i>	White-fronted Honeyeater												✓	

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<i>Manorina flavigula</i>	Yellow-throated Miner				✓								✓	
<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater				✓				✓	✓			✓	
<i>Anthochaera lunulata</i>	Western Wattlebird				✓		✓		✓				✓	
<i>Anthochaera chrysoptera</i>	Little Wattlebird					✓								
<i>Anthochaera carunculata</i>	Red Wattlebird				✓	✓	✓	✓	✓				✓	✓
<i>Conopophila rufogularis</i>	Rufous-throated Honeyeater								✓					
<i>Epthianura tricolor</i>	Crimson Chat								✓				✓	
<i>Epthianura albifrons</i>	White-fronted Chat						✓		✓				✓	
<i>Glyciphila melanops</i>	Tawny-crowned Honeyeater				✓		✓						✓	
<i>Lichmera indistincta</i>	Brown Honeyeater				✓	✓	✓	✓					✓	
<i>Phylidonyris novaehollandiae</i>	New Holland Honeyeater				✓	✓	✓	✓					✓	
<i>Phylidonyris niger</i>	White-cheeked Honeyeater				✓		✓						✓	
<i>Melithreptus lunatus</i>	White-naped Honeyeater												✓	
NEOSITTIDAE														
<i>Daphoenositta chrysoptera</i>	Varied Sittella				✓	✓	✓	✓		✓			✓	
CAMPEPHAGIDAE														
<i>Coracina maxima</i>	Ground Cuckoo-shrike								✓					

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		EPBC Act	WC Act	DEC										
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike				✓	✓	✓	✓	✓			✓		
<i>Lalage sueurii</i>	White-winged Triller						✓					✓		
PACHYCEPHALIDAE														
<i>Falcunculus frontatus sp. Leucogaster</i>	Crested Shrike-tit			P4					✓					
<i>Pachycephala pectoralis</i>	Golden Whistler					✓						✓		
<i>Pachycephala rufiventris</i>	Rufous Whistler				✓	✓	✓	✓				✓		
<i>Colluricincla harmonica</i>	Grey Shrike-thrush				✓	✓	✓	✓	✓			✓		
<i>Oreoica gutturalis</i>	Crested Bellbird											✓		
ARTAMIDAE														
<i>Artamus leucorhynchus</i>	White-breasted Woodswallow								✓					
<i>Artamus personatus</i>	Masked Woodswallow								✓			✓		
<i>Artamus cinereus</i>	Black-faced Woodswallow				✓		✓	✓	✓			✓		
<i>Artamus cyanopterus</i>	Dusky Woodswallow						✓		✓			✓		
<i>Cracticus torquatus</i>	Grey Butcherbird				✓	✓	✓	✓	✓			✓	✓	
<i>Cracticus nigrogularis</i>	Pied Butcherbird								✓			✓		
<i>Cracticus tibicen</i>	Australian Magpie				✓	✓	✓	✓	✓			✓	✓	
<i>Strepera versicolor</i>	Grey Currawong											✓		

Family and Species	Common name	Conservation Status			ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birdata	This Survey
		EPBC Act	WC Act	DEC										
DICRURIDAE														
<i>Dicrurus bracteatus</i>	Spangled Drongo								✓					
RHIPIDURIDAE														
<i>Rhipidura albiscapa</i>	Grey Fantail				✓	✓	✓	✓				✓		
<i>Rhipidura leucophrys</i>	Willie Wagtail				✓		✓	✓				✓		
CORVIDAE														
<i>Corvus coronoides</i>	Australian Raven				✓	✓	✓	✓	✓			✓	✓	
<i>Corvus bennetti</i>	Little Crow								✓			✓		
<i>Corvus orru</i>	Torresian Crow								✓					
MONARCHIDAE														
<i>Myiagra inquieta</i>	Restless Flycatcher											✓		
<i>Grallina cyanoleuca</i>	Magpie-lark				✓		✓	✓				✓	✓	
PETROICIDAE														
<i>Microeca fascinans</i>	Jacky Winter											✓		
<i>Petroica boodang</i>	Scarlet Robin				✓	✓		✓				✓		
<i>Petroica goodenovii</i>	Red-capped Robin						✓					✓		
<i>Melanodryas cucullata</i>	Hooded Robin				✓							✓		
<i>Eopsaltria griseogularis</i>	Western Yellow Robin								✓			✓		
<i>Eopsaltria georgiana</i>	White-breasted Robin					✓			✓			✓		

Family and Species	Common name	Conservation Status			ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birddata	This Survey
		EPBC Act	WC Act	DEC										
ACROCEPHALIDAE														
<i>Acrocephalus australis</i>	Australian Reed-Warbler						✓			✓			✓	
MEGALURIDAE														
<i>Megalurus gramineus</i>	Little Grassbird												✓	
<i>Cincloramphus mathewsi</i>	Rufous Songlark								✓				✓	
<i>Cincloramphus cruralis</i>	Brown Songlark								✓				✓	
TIMALIIDAE														
<i>Zosterops lateralis</i>	Silvereye				✓	✓	✓	✓	✓				✓	
HIRUNDINIDAE														
<i>Cheramoeca leucosterna</i>	White-backed Swallow								✓				✓	
<i>Hirundo neoxena</i>	Welcome Swallow				✓	✓	✓	✓					✓	
<i>Petrochelidon ariel</i>	Fairy Martin						✓						✓	
<i>Petrochelidon nigricans</i>	Tree Martin				✓		✓	✓					✓	
NECTARINIIDAE														
<i>Dicaeum hirundinaceum</i>	Mistletoebird				✓		✓	✓	✓				✓	
ESTRILDIDAE														
<i>Stagonopleura oculata</i>	Red-eared Firetail												✓	
<i>Lonchura castaneothorax</i>	Chestnut-breasted Mannikin												✓	

Family and Species	Common name	Conservation Status			ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birddata	This Survey
		EPBC Act	WC Act	DEC										
MOTACILLIDAE														
<i>Anthus Australis</i>	Australian Pipit								✓					
<i>Anthus novaeseelandiae</i>	Australasian Pipit				✓		✓	✓					✓	
FRINGILLIDAE														
* <i>Carduelis carduelis</i>	Goldfinch								✓				✓	

Reptiles

Family and Species	Common name	EPBC Act	WC Act	DEC	ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birdata	This Survey
CHELUIDAE														
<i>Chelodina oblonga</i>	Oblong Turtle						✓			✓				
<i>Pseudemydura umbrinas</i>	Western Swamp Tortoise	CR	S1	CR								✓		
AGAMIDAE														
<i>Ctenophorus adelaidensis</i>	Western Heath Dragon				✓					✓				
<i>Ctenophorus caudicinctus</i>	Ring-tailed Dragon									✓				
<i>Ctenophorus ornatus</i>	Ornate Crevice Dragon									✓				
<i>Diporiphora valens</i>										✓				
<i>Pogona minor</i>	Dwarf Bearded Dragon				✓	✓	✓				✓			
DIPLODACTYLIDAE														
<i>Crenadactylus ocellatus</i>	Clawless Gecko				✓					✓				
<i>Diplodactylus calcicolus</i>														
<i>Diplodactylus granariensis</i>										✓				
<i>Diplodactylus polyophthalmus</i>										✓				
<i>Diplodactylus pulcher</i>										✓				
<i>Diplodactylus savagei</i>										✓				
<i>Oedura marmorata</i>	Marbled Velvet Gecko				✓									

Family and Species	Common name	EPBC Act	WC Act	DEC	ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birdata	This Survey
<i>Strophurus spinigerus</i>					✓									
CARPHODACTYLIDAE														
<i>Nephrurus milii</i>	Barking Gecko									✓				
GEKKONIDAE														
<i>Christinus marmoratus</i>	Marbled Gecko				✓					✓				
<i>Gehyra variegata</i>										✓				
PYGOPODIDAE														
<i>Aprasia pulchella</i>										✓				
<i>Aprasia repens</i>					✓	✓				✓				
<i>Delma concinna</i>										✓				
<i>Delma fraseri</i>					✓	✓	✓			✓				
<i>Delma grayii</i>										✓				
<i>Delma pax</i>										✓				
<i>Lialis burtonis</i>					✓	✓								
<i>Pletholax gracilis</i>	Keeled Legless Lizard													
<i>Pygopus lepidopodus</i>	Common Scaly Foot				✓									
SCINCIDAE														
<i>Acritoscincus trilineatus</i>					✓		✓			✓				

Family and Species	Common name	EPBC Act	WC Act	DEC	ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birdata	This Survey
<i>Carlia munda</i>										✓				
<i>Cryptoblepharus buchananii</i>										✓				
<i>Cryptoblepharus plagiocephalus</i>					✓	✓	✓	✓	✓	✓				
<i>Ctenotus australis</i>	Western limestone ctenotus						✓			✓				
<i>Ctenotus delli</i>	Darling Range Heath Ctenotus			P4						✓				
<i>Ctenotus fallens</i>					✓	✓				✓				
<i>Ctenotus gemmula</i>				P3						✓				
<i>Ctenotus impar</i>							✓			✓				
<i>Ctenotus labillardieri</i>										✓				
<i>Ctenotus saxatilis</i>										✓				
<i>Cyclodomorphus celatus</i>										✓				
<i>Egernia kingii</i>	King's Skink				✓					✓				
<i>Egernia napoleonis</i>					✓	✓				✓				
<i>Hemiergis peronii</i>					✓				✓					
<i>Hemiergis quadrilineata</i>					✓	✓	✓							
<i>Lerista elegans</i>					✓	✓	✓	✓						
<i>Lerista lineata</i>	Lined Skink			P3	✓									

Family and Species	Common name	EPBC Act	WC Act	DEC	ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birdata	This Survey
<i>Lerista macropisthopus</i>					✓									
<i>Lerista praepedita</i>					✓	✓								
<i>Lissolepis luctuosa</i>	Western Swamp Skink									✓				
<i>Menetia greyii</i>					✓	✓	✓	✓	✓					
<i>Morethia lineocellata</i>					✓									
<i>Morethia obscura</i>					✓	✓								
<i>Tiliqua rugosa</i>	Bobtail				✓	✓	✓	✓	✓					
VARANIDAE														
<i>Varanus gouldii</i>	Sand Monitor						✓		✓					
<i>Varanus tristis tristis</i>	Racehorse Monitor				✓	✓	✓							
TYPHLOPIDAE														
<i>Ramphotyphlops australis</i>					✓									
BOIDAE														
<i>Antaresia stimsoni</i>	Stimson's Python									✓				
<i>Morelia spilota imbricata</i>	Western Carpet Python		S4	P4							✓			
ELAPIDAE														
<i>Acanthophis antarcticus</i>	Southern Death Adder			P3						✓				
<i>Brachyurops fasciolatus</i>										✓				

Family and Species	Common name	EPBC Act	WC Act	DEC	ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birdata	This Survey
<i>Brachyuropsis semifasciatus</i>										✓				
<i>Demansia psammophis</i>	Yellow-faced Whipsnake									✓				
<i>Echiopsis curta</i>	Bardick				✓					✓				
<i>Elapognathus coronatus</i>	Crowned Snake						✓			✓				
<i>Neelaps bimaculatus</i>	Black-naped Snake				✓									
<i>Neelaps calonotos</i>	Black-striped Snake			P3							✓			
<i>Notechis scutatus</i>	Tiger Snake								✓					
<i>Parasuta gouldii</i>					✓				✓					
<i>Pseudonaja affinis</i>	Dugite				✓	✓	✓							
<i>Simoselaps bertholdi</i>	Jan's Banded Snake				✓									

Amphibians

Family and Species	Common name	Conservation Status			ecologia internal database	Fauna Studies in Water Supply Reserve 34537, Adjacent to Neerabup National Park (CALM 1993)	Fauna Survey of the Perth Airport (Tingay & Associates 1994)	Roe Highway Extension (Napier & Associates 1989)	Kwinana Freeway Yangebup Road to Thomas Road Biological Survey (Hart, Simpson & Associates 1989)	NatureMap	DEC Rare Fauna	DSWEPaC Protected Matters Search	Birdata	This Survey
		EPBC Act	WC Act	DEC										
HYLIDAE					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<i>Litoria adelaidensis</i>	Slender Tree Frog					✓								
<i>Litoria coplandi</i>	Rock Frog				✓									
<i>Litoria moorei</i>	Motorbike Frog				✓									
LIMNODYNASTIDAE														
<i>Heleioporus eyrei</i>	Moaning Frog				✓	✓	✓							
<i>Limnodynastes dorsalis</i>	Western Banjo Frog				✓	✓		✓						
MYOBATRACHIDAE														
<i>Crinia georgiana</i>	Quacking Frog								✓					
<i>Crinia glauerti</i>	Clicking Frog						✓		✓					
<i>Crinia insignifera</i>	Squelching Froglet				✓		✓		✓					
<i>Crinia pseudinsignifera</i>	Bleating Froglet								✓					
<i>Geocrinia leai</i>	Ticking Frog								✓					
<i>Myobatrachus gouldii</i>	Turtle Frog				✓									
<i>Pseudophryne guentheri</i>	Crawling Toadlet				✓		✓							

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APPENDIX D FLORA SPECIES LIST RECORDED IN THE PROJECT AREA

Family	Taxon	Status
Aizoaceae	<i>Tetragonia decumbens</i>	Introduced
Apiaceae	<i>Anethum graveolens</i>	Introduced
	<i>Apium</i> sp.	
Apocynaceae	<i>Nerium oleander</i>	Introduced
Araliaceae	<i>Hydrocotyle</i> sp.	
Arecaceae	Arecaceae INDET	
	<i>Phoenix dactylifera</i>	Introduced
Asphodelaceae	<i>Asphodelus fistulosus</i>	Introduced
	<i>Trachyandra divaricata</i>	Introduced
Asteraceae	<i>Arctotheca calendula</i>	Introduced
	<i>Conyza bonariensis</i>	Introduced
	<i>Conyza sumatrensis</i>	Introduced
	<i>Cotula turbinata</i>	Introduced
	<i>Gazania linearis</i>	Introduced
	<i>Hypochaeris glabra</i>	Introduced
	<i>Monoculus monstrosus</i>	Introduced
	<i>Olearia axillaris</i>	
	<i>Sonchus oleraceus</i>	Introduced
Brassicaceae	<i>Brassica tournefortii</i>	Introduced
Casuarinaceae	<i>Allocasuarina fraseriana</i>	
Celastraceae	<i>Eunymus</i> sp.	Introduced
Convolvulaceae	<i>Ipomoea cairica</i>	Introduced
Cupressaceae	<i>Callitris</i> sp.	
Cyperaceae	<i>Isolepis congrua</i>	
	<i>Lepidosperma longitudinale</i>	
Dilleniaceae	<i>Hibbertia hypericoides</i>	
Euphorbiaceae	<i>Euphorbia terracina</i>	Introduced
	<i>Ricinocarpus tuberculatus</i>	Introduced
Fabaceae	<i>Acacia saligna</i>	
	<i>Avena barbata</i>	Introduced
	<i>Bauhinia</i> sp.	Introduced
	<i>Erythrina x sykesii</i>	Introduced
	<i>Hardenbergia comptoniana</i>	
	<i>Jacksonia furcellata</i>	
	<i>Lupinus cosentinii</i>	Introduced
	<i>Melilotus indicus</i>	Introduced
	<i>Robinia pseudoacacia</i>	Introduced
	<i>Trifolium arvense</i>	Introduced
	<i>Trifolium campestre</i> var. <i>campestre</i>	Introduced
	<i>Trifolium resupinatum</i>	Introduced
	<i>Vicia monantha</i>	Introduced
	<i>Viminaria juncea</i>	
Geraniaceae	<i>Pelargonium capitatum</i>	Introduced
	<i>Pelargonium x domesticum</i>	Introduced
Haemodoraceae	<i>Conostylis candicans</i>	
Iridaceae	<i>Gladiolus caruophyllaceus</i>	Introduced
	<i>Ixia paniculata</i>	Introduced
	<i>Watsonia</i> sp.	Introduced
Lamiaceae	<i>Lavandula angustifolia</i>	Introduced
Lythraceae	<i>Punica granatum</i>	Introduced
Malvaceae	<i>Alyogyne hakeifolia</i>	
	<i>Malva parviflora</i>	Introduced
Meliaceae	<i>Melia azedarach</i>	
Moraceae	<i>Ficus</i> sp.	
	<i>Morus nigra</i>	Introduced
Myrtaceae	<i>Agonis flexuosa</i>	
	<i>Beaufortia</i> sp.	

Family	Taxon	Status
	<i>Callistemon</i> sp.	
	<i>Chamelaucium uncinatum</i>	
	<i>Corymbia ?umbonata</i>	
	<i>Corymbia calophylla</i>	
	<i>Corymbia ficifolia</i>	
	<i>Corymbia</i> sp.	
	<i>Eucalyptus marginata</i>	
	<i>Eucalyptus nicholii</i>	Introduced
	<i>Eucalyptus polyanthemos</i>	
	<i>Eucalyptus rudis</i>	
	<i>Eucalyptus</i> sp.	
	<i>Eucalyptus todtiana</i>	
	<i>Eucalyptus utilis</i>	
	<i>Hypocalymma angustifolium</i>	
	<i>Jacksonia furcellata</i>	
	<i>Melaleuca nesophila</i>	
	<i>Melaleuca quinquenervia</i>	Introduced
	<i>Melaleuca raphiophylla</i>	
	<i>Melaleuca trichophylla</i>	
Nyctaginaceae	<i>Bougainvillea</i> sp.	Introduced
Oleaceae	<i>Olea europaea</i>	Introduced
Onagraceae	<i>Oenothera glazioviana</i>	Introduced
	<i>Oenothera</i> sp.	Introduced
Orobanchaceae	<i>Orobanche minor</i>	Introduced
Oxalidaceae	<i>Oxalis pes-caprae</i>	Introduced
Pinaceae	<i>Pinus radiata</i>	Introduced
Plantaginaceae	<i>Plantago lanceolata</i>	Introduced
Poaceae	<i>Aira caryophyllea</i>	Introduced
	<i>Avena barbata</i>	Introduced
	<i>Avena fatua</i>	Introduced
	<i>Briza maxima</i>	Introduced
	<i>Bromus diandrus</i>	Introduced
	<i>Bromus rubens</i>	Introduced
	<i>Cenchrus ciliaris</i>	Introduced
	<i>Cenchrus clandestinus</i>	Introduced
	<i>Cynodon dactylon</i>	Introduced
	<i>Ehrharta calycina</i>	Introduced
	<i>Eragrostis curvula</i>	Introduced
	<i>Lagurus ovatus</i>	Introduced
	<i>Lolium rigidum</i>	Introduced
	<i>Phleum pratense</i>	Introduced
Polygonaceae	<i>Acetosella vulgaris</i>	Introduced
Primulaceae	<i>Lysimachia arvensis</i>	Introduced
Proteaceae	<i>Adenanthos cygnorum</i> subsp. <i>cygnorum</i>	
	<i>Banksia attenuata</i>	
	<i>Banksia ilicifolia</i>	
	<i>Banksia menziesii</i>	
	<i>Grevillea vestita</i> subsp. <i>vestita</i>	
	<i>Hakea costata</i>	
	<i>Hakea trifurcata</i>	
	<i>Jacksonia furcellata</i>	
Scrophulariaceae	<i>Eremophila glabra</i>	
Solanaceae	<i>Solanum nigrum</i>	Introduced
Tropaeolaceae	<i>Tropaeolum majus</i>	Introduced
Typhaceae	<i>Typha orientalis</i>	Introduced
Ulmaceae	<i>Ulmus parvifolia</i>	Introduced
Xanthorrhoeaceae	<i>Xanthorrhoea preissii</i>	
Zamiaceae	<i>Macrozamia fraseri</i>	

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Perth Groundwater
Replenishment Scheme
Stage 2

Level 2 Flora and Fauna Assessment

Prepared for:
Water Corporation

October 2016

● people ● planet ● professional

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1663 AB	C CLIENT FINAL				1 Electronic (CD)	

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Executive Summary

360 Environmental Pty Ltd (360 Environmental) was commissioned by the Water Corporation (WA) in May 2016 to undertake a flora and vegetation assessment, fauna survey and Black Cockatoo habitat assessment for relevant sections of the proposed recharge main pipeline route (including alternative alignment options) as part of the Perth Groundwater Replenishment Scheme (GWRS). As a result of the preliminary flora assessment, 360 Environmental was commissioned to undertake a spring Level 2 flora and vegetation survey and targeted flora survey. The proposed pipeline alignment runs from the current Waste Water Treatment Plant (WWTP) to two proposed water recharge sites located north-east of Lake Joondalup in the City of Wanneroo (Survey Area), Perth, Western Australia.

A total of 149 taxa (including species, subspecies, varieties and forms) from 99 genera and 44 families were recorded in the Survey Area, of these 38 were introduced species.

No Threatened species pursuant to the *Environment Protection and Biodiversity Act 1999* (EPBC Act) and/or gazetted as Declared Rare Flora (DRF) pursuant to the *Wildlife Conservation Act 1950* (WC Act) were recorded during the survey. One Priority species *Conostylis bracteata* (Priority 3) was recorded during the survey.

Vegetation condition ranged from Very Good to Completely Degraded with the majority of the Survey Area considered to be in a Completely Degraded (41.56 ha) condition. Historical vegetation clearing, weeds, road infrastructure, parks and residential development within and adjacent to the survey area were the most frequently observed impacts on native vegetation. Of the 38 introduced species recorded, one species, **Moraea flaccida*, is listed as Declared under the *Biosecurity and Agriculture Management Act 2007* (BAM Act). None of the species are listed as Weeds of National Significance (WONS).

The Department of Parks and Wildlife (DPaW) Geomorphic Wetlands Dataset identifies two Conservation Category Wetlands (CCW) occurring in the Survey Area. The alignment transects the wetland with the unique identification number (UFI) 7954 (Joondalup Lake) just north of Ocean Reef Road and wetland with UFI 8169 on the southern side of Ocean Reef Road.

The Survey Area encroaches into four Bush Forever Site, Site 299 – Yellagonga Regional Park, Wanneroo/Woodvale/Kingsley, at several locations. Site 303 – Whitfords Avenue Bushland, Craigie/Padbury, Site 383 – Neerabup National Park, Lake Nowergup Nature Reserve and adjacent Bushland, Neerabup and Site 407 – Woodvale Nature Reserve, Woodvale.

A search of the DPaW database and EPBC Protected Matters Search Tool (PMST) for Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs) identified one State listed TEC and two PECs as occurring within five (5) kilometres of

the Survey Area. These communities listed under the EPBC Act were not recorded in the Survey Area.

The intact vegetation in the Survey Area is found to be most similar to FCT SCP28 - Spearwood *Banksia attenuata* or *Banksia attenuata* – Eucalyptus woodlands;

Vegetation association CcEmBA, has been determined to have the highest affiliation with FCT SCP28, which has recently been listed as a sub-community of 'Banksia woodlands of the Swan Coastal Plain'. Banksia woodlands of the Swan Coastal Plain has been recently listed as Endangered under the EPBC Act.

Several sections of the Survey Area are within an Environmentally Sensitive Area (ESA). The reasoning for the ESAs is likely to be the Conservation Category Wetlands (CCWs) and the Bush Forever sites. ESAs are declared to prevent degradation of important environmental values such as T/DRF, TECs or significant wetlands. Exemptions contained in the *Environmental Protection (Clearing of Native vegetation) Regulations 2004* for low impact land clearing do not apply in ESAs and a native vegetation clearing permit is required.

The fauna field assessment was undertaken on 17th and 18th May 2016. Two species of conservation significance were recorded during the field assessment. Approximately ten Carnaby's Black Cockatoo were observed flying over the Survey Area and foraging evidence in the way of chewed Marri nuts was found in the Survey Area. The Southern Brown Bandicoot was recorded indirectly with numerous bandicoot diggings observed in the Survey Area.

During the Black Cockatoo habitat assessment, 109 potential breeding trees were recorded. These were comprised of Marri, Jarrah, Powderbark Wandoo, Tuart and Flooded Gum. These trees also provided foraging habitat for Black Cockatoos. A total of 10.8 ha of Black Cockatoo breeding and foraging habitat was recorded in the Survey Area.

In order to minimise the impact on native flora and fauna, several recommendations are provided below:

- Minimise clearing of vegetation beyond that strictly required for the proposed pipeline alignment;
- Woody debris (this includes trees felled and logs) and leaf litter formed during clearing should be retained, as they create good microhabitat for a large array of fauna, particularly reptiles; and
- If the proposed pipeline alignment changes significantly from that surveyed here, then additional surveys may be required.

Permits

This flora survey was conducted under the following licences issued by DPaW; Licence to take flora for scientific or other prescribed purposes SL011541 and Permit to take

Declared Rare Flora 44-1516 issued to Narelle Whittington. Licence to take flora for scientific or other prescribed purposes SL011882 and Permit to take Declared Rare Flora 28-1617 issued to Amy Dalton.

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1 Introduction

1.1 The Project

360 Environmental Pty Ltd (360 Environmental) was commissioned by the Water Corporation (WA) in May 2016 to undertake a preliminary flora and vegetation survey, along with a fauna survey and Black Cockatoo habitat assessment for relevant sections of the proposed Perth Groundwater Replenishment Scheme (GWRS) (Stage 2). A spring Level 2 flora and vegetation assessment was subsequently conducted on the 6th September 2016 along with a targeted flora survey on the 4 October 2016 following the preliminary flora assessment. The proposed pipeline (including alternative alignment options) runs from the current Waste Water Treatment Plant (WWTP) to two proposed water recharge sites located north-east of Lake Joondalup in the City of Wanneroo.

As a result of the preliminary flora assessment, it was identified that a follow up spring flora survey and targeted flora survey should be undertaken for species such as *Caladenia huegelii* (Grand Spider Orchid) (Endangered under the EPBC Act) and *Conostylis bracteata* (Priority 3). The focus of this survey was in areas with relatively intact native vegetation, such as the vegetation remnants in the northern section of the proposed pipeline alignment.

The proposed alignment is approximately 13 km long and runs from Beenyup Waste Water Treatment plant in the south, alongside of Lake Joondalup to Wanneroo Road approximately 26 km north of Perth, Western Australia (WA). Following the preliminary flora assessment, the proposed pipeline route was amended to minimise impacts to native vegetation. The follow up spring flora survey and targeted flora survey were completed within a revised survey area (Figure 1). The removal of vegetation may be required along a corridor between 6 m and 20 m in total width. The total area of potential clearing, including the areas likely to be temporarily disturbed during construction, is described by the Development Envelope (Figure 6, Figure 7, Figure 8).

1.1.1 Objectives

The objectives of the Level 2 flora and vegetation survey were to:

- Conduct a desktop assessment of relevant literature, databases and spatial datasets to determine the environmental values and any potential issues, such as Threatened/Rare and significant species, Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs), that may be present in the Survey Area and the surrounding areas;
- Produce a list of plant species (including weed species);
- Document and map the location of any Threatened/Declared Rare Flora (T/DRF), Priority flora and any other flora of local or taxonomic significance;

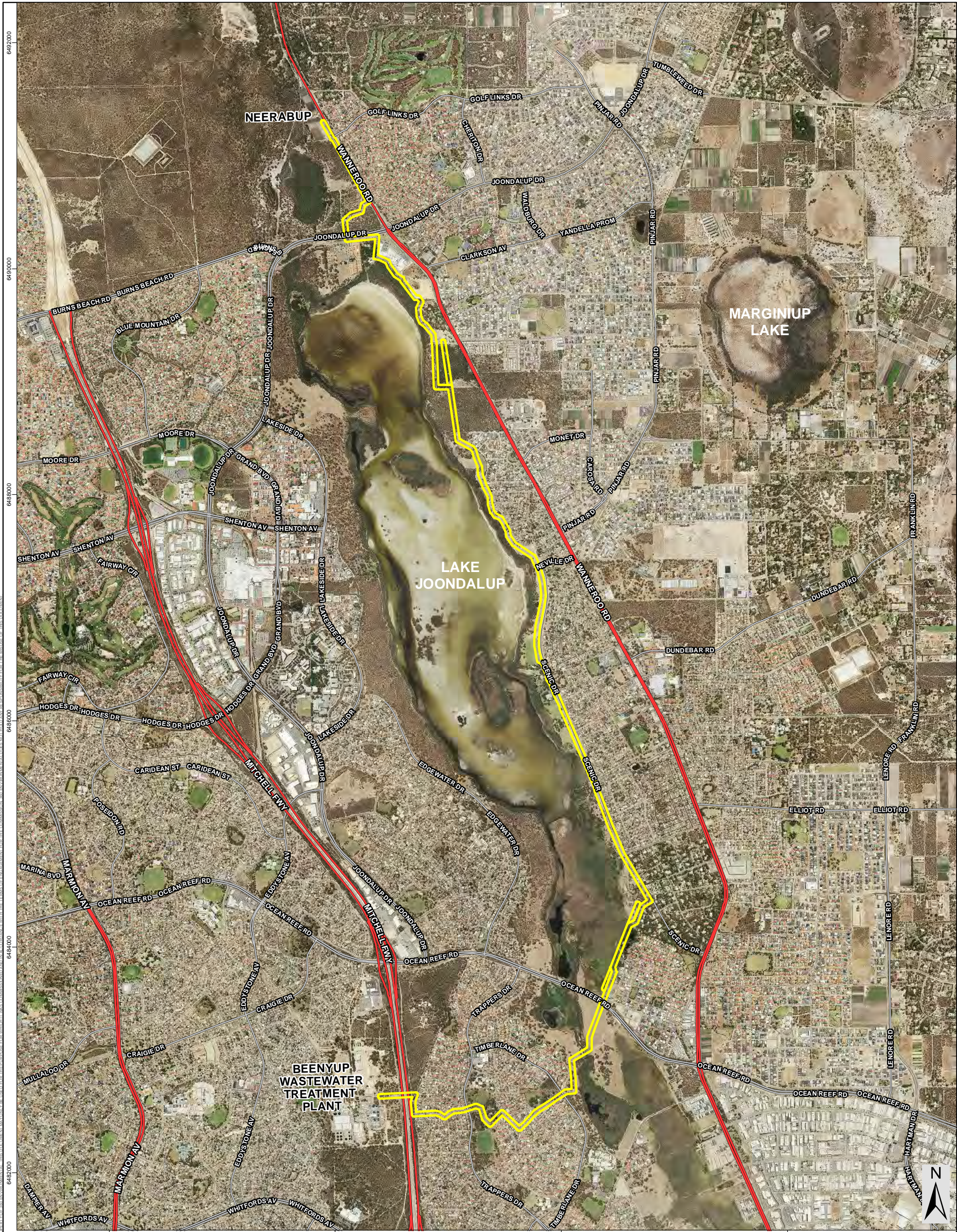
- Identify, map and discuss the significance of any TECs, PECs and any other areas of ecological importance (e.g. National Parks, wetlands and Environmentally Sensitive Areas [ESAs] etc.);
- Assess, map and photograph vegetation condition; and
- Document, describe and map the vegetation associations present.

The objectives of the fauna assessment were to:

- Conduct a desktop assessment of fauna databases and any relevant literature;
- Document and describe the vertebrate fauna habitats present;
- Identify fauna of conservation significance that may potentially occur in the Survey Area; and
- Record opportunistic fauna sightings.

The objective of the Black Cockatoo Survey was to:

- Identify and determine the type and extent of habitat (breeding, roosting and foraging) suitable for Black Cockatoos in the Survey Area with reference to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) referral guidelines for three threatened Black Cockatoo species (DSEWPaC 2011).



Legend

Survey Area (52.99 ha)

DATA SOURCES

- CADASTRAL BOUNDARY SOURCED FROM LANDGATE 2009
- LOCALITY MAP SOURCED LANDGATE 2006
- AERIAL PHOTOGRAPHY SOURCED LANDGATE FEB 2016
- (© Western Australian Land Information Authority 2015)

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people planet professional

WATER CORPORATION

CREATED JJ	CHECKED NW/RF	APPROVED MRh	REVISION 0	DATE 13/10/2016
HORIZONTAL DATUM GDA 1994 MGA Zone 50		PROJECT NO 1663		

0 150 300 600 900 1,200 1,500
 Meters
 1:30,000 @ A3

SLIP ENABLER

NOTE THAT POSITIONAL ERRORS MAY BE >5M IN SOME AREAS

Water Corporation
Groundwater Replenishment Scheme
Beenyup Stage 3 Pipeline

Level 2 Flora Survey

Figure 1
Survey Area

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1.2 Background to the Protection of Flora, Vegetation and Fauna

Western Australian (WA) flora and fauna is protected formally and informally by various legislative and non-legislative measures, which are as follows:

Legislative measures:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- *Wildlife Conservation Act 1950* (WC Act);
- *Environmental Protection Act 1986* (EP Act); and
- *Biosecurity and Agriculture Management Act 2007* (BAM Act).

Non-legislative measures:

- Western Australian Department of Parks and Wildlife (DPAW) Priority lists for flora, ecological communities and fauna;
- Weeds of National Significance (WONS); and
- Recognition of locally significant populations by the DPAW.

A short description of each is given below. Other definitions, including species conservation categories, are provided in Appendix A. Conservation categories for ecological communities are provided in Appendix B.

1.2.1 EPBC Act

The EPBC Act aims to protect Matters of National Environmental Significance (MNES). Under the EPBC Act, the Commonwealth Department of the Environment and Energy (DoEE) lists threatened species and communities in categories determined by criteria set out in the Act (www.environment.gov.au/epbc/index.html) (Appendices A and B).

Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*) is listed as Endangered under the EPBC Act. The Forest Red-tailed Black Cockatoo (FRTBC [*Calyptorhynchus banksii naso*]) and Baudin's Black Cockatoo (*Calyptorhynchus baudinii*) are classified as Vulnerable.

Projects likely to cause a significant impact on MNES are referred to the DoEE for assessment under the EPBC Act.

1.2.2 WC Act

The WA DPAW lists flora and fauna under the provisions of the WC Act as protected according to their need for protection (Appendices A & B).

Flora is given Declared Rare status when populations are geographically restricted or are threatened by local processes. In addition, under the WC Act, by Notice in the WA Government Gazette of 9 October 1987, all native flora (spermatophytes, pteridophytes,

bryophytes and thallophytes) are protected throughout the State. Fauna are classified as Schedule 1 to Schedule 7 according to their need for protection.

Under the WC Act both Carnaby's Black Cockatoo and Baudin's Black Cockatoo are listed as Endangered and the FRTBC is listed as Vulnerable.

1.2.3 EP Act

Declared Rare Flora (DRF) and TECs are given special consideration in environmental impact assessments, and have special status as Environmentally Sensitive Areas (ESAs) under the EP Act and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. Exemptions for a clearing permit do not apply in an ESA. In addition, habitat necessary for the maintenance of indigenous fauna is considered in the clearing principles and assessed during consideration of applications for a clearing permit.

1.2.4 BAM Act

Plants may be 'Declared' by the Agriculture Protection Board (APB) under the BAM Act 2007 (WA). Declared Plants are gazetted under three categories (C1-C3), which define the action required. Details of the definitions of these categories are provided in Appendix C. A declaration may apply to the whole State, to districts, individual properties or even to single paddocks. If a plant is 'Declared', landholders are obliged to control that plant on their properties (Department of Agriculture and Food Western Australia [DAFWA] 2014).

1.2.5 Weeds of National Significance

The Australian Government along with the State and Territory governments has endorsed 32 WONS. Four major criteria were used in determining WONS:

- The invasiveness of a weed species;
- A weed's impacts;
- The potential for spread of a weed; and
- Socio-economic and environmental values.

Each WONS has a national strategy and a national coordinator, responsible for implementing the strategy. WONS are regarded as the worst weeds in Australia because of their invasiveness, potential for spread, and economic and environmental impacts (Thorp & Lynch 2000).

1.2.6 DPAW Priority Lists

The DPaW lists 'Priority' flora and fauna that have not been assigned statutory protection as Declared Rare or 'Scheduled' under the WC Act, but which are under consideration for declaration as DRF or 'Scheduled' fauna. Flora and fauna assessed as Priority 1-3 are considered to be in urgent need of further survey. Priority 4 flora and

fauna require monitoring every 5-10 years and Priority 5 flora and fauna are subject to a specific conservation programme (Appendix A).

The DPaW maintains a list of PECs which identifies ecologically valuable communities that need further investigation before possible nomination for TEC status. Once listed, a community is a PEC, and when endorsed by the WA Minister of Environment becomes a TEC, and protected as an ESA under *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* (Appendix B).

1.2.7 Informal Recognition of Flora and Fauna

Certain populations or communities of flora may be of local significance or interest because of their patterns of distribution and abundance. For example, specific locations of flora may be locally significant because they are range extensions to the previously known distribution, or are newly discovered taxa (and have the potential to be of more than local significance). In addition, many species are in decline as a result of threatening processes (e.g. land clearing, grazing and changed fire regimes), and relict populations of such species assume local importance for the DPaW. It is not uncommon for the DPaW to make comment on these species of interest.

1.3 Background to Black Cockatoos

Three species of Black Cockatoo are found in south-west WA; Carnaby's Black Cockatoo, FRTBC and Baudin's Black Cockatoo. All three Black Cockatoos have suffered a substantial decline in numbers and breeding distribution in the past 50 years (Johnstone & Storr 1998a). Direct causes of population decline include the large numbers shot by orchardists (mainly associated with Baudin's Black Cockatoo), clearing and fragmentation of habitat (especially the loss of breeding hollows), the impact of hollow competitors including the Galah (*Cacatua roseicapilla*), corellas including Butler's Corella (*Cacatua pastinator butleri*), Australian Shelduck (*Tadorna tadornoides*), Australian Wood Duck (*Chenonetta jubata*), the feral European honey bee (*Apis mellifera*), and also vehicle strikes. Around 60% of the original vegetation on the Swan Coastal Plain has been cleared and up to 85% in other parts of the south-west region for agriculture (crops), meat production, dairying, farms, orchards, vineyards, pine plantations, mining, timber and wood chipping, cities and towns. At present, extensive tracts of uncleared land only remain in State forest and conservation reserves and what is left of remnant vegetation (in roadside verges etc.) is often disturbed to a varying degree (Johnstone & Kirkby 2011).

The south-west region is now a severely fragmented landscape and the further loss of foraging habitat, the lack of suitable breeding sites, climate change, and alterations in the landscape led to significant changes in forest structure. Almost every part of the Jarrah-Marri forest has been logged in the past, and most present day trees are too immature to form suitable sized hollows, and competition with exotic species, exacerbate

the future conservation of Carnaby's Black Cockatoo, FRTBC's and Baudin's Black Cockatoo (Johnstone & Kirkby 2011).

The distribution of all three Black Cockatoo species can be seen in the 2014 DoE (now DoEE) distribution maps in Appendix D. The Survey Area is within the known distribution of Carnaby's Black Cockatoo; however, it is on the northern extremity of Baudin's Cockatoo and FRTBCs distribution. Nevertheless, all three species of Black Cockatoo were returned in the three database searches and have therefore been included for consideration in this document given that these species are all highly mobile and the DoEE distribution maps are indicative only. In addition the difficulty in distinguishing Carnaby's Black Cockatoo and Baudin's Black Cockatoo, again make it advisable to include both species.

2 Biophysical Environment

2.1 Climate

The closest official Bureau of Meteorology (BoM) weather station currently operating near to the Survey Area is the Perth Weather Station (Station number 009225), approximately 26 km south of the Survey Area. The climate for Joondalup is described as warm Mediterranean (Mitchell *et al.* 2002), with mean minimum of approximately 12.8 °C and a mean maximum of 24.8°C. Average annual rainfall is 728.1 mm (Figure 2) (BoM 2016).

Perth recorded 639.9 mm of rain in the 12 months prior to the survey (September 2015 – August 2016) which is 88.2 mm below the long term average rainfall of 728.1 mm for the same period (BoM 2016). The three months prior to survey (June 2016 – August 2016), Perth recorded 372.2mm of rainfall, 5.2% below the 392.9 mm average rainfall for the same period (BoM 2016).

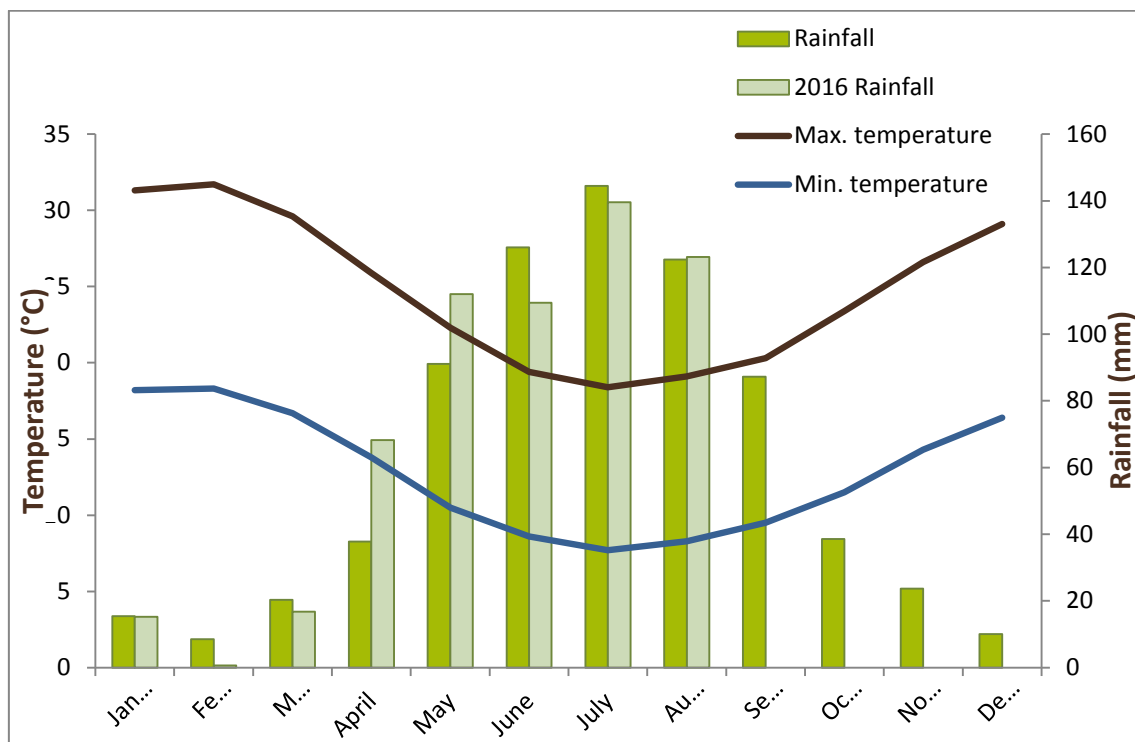


Figure 2: 2016 rainfall and mean rainfall for Perth Weather Station (009225) from 1993 to 2016 (BoM 2016).

2.2 Geology and Soils

Soil-landscape mapping of South West WA has been captured at scales ranging from 1:20 000 to 1:250 000. Soil-landscape mapping describes broad soil and landscape characteristics from regional to local scales.

The Survey Area contains the following two geological units:

- Coastal Dunes 38488: Beach sand, sand dunes, coastal dunes, beaches, and beach ridges; calcareous and siliceous, locally shelly and/or cemented (beach rock); locally reworked; and
- Lake Deposits 38492: Lacustrine or residual mud, clay, silt and sand, commonly gypsiferous and/or saline; playa, claypan, and swamp deposits; peat; peaty sand and clay; halitic and gypsiferous evaporates (GSWA 2008).

2.3 Hydrology

The Geomorphic Wetlands dataset is identified and utilised by the Environmental Protection Authority (EPA), Department of Environment Regulation (DER) and the Department of Planning as a basis for planning and decision making.

The DPaW Geomorphic Wetlands Dataset identifies two Conservation Category Wetlands (CCW) occur in the Survey Area. The alignment transects the wetland with the unique identification number UFI 7954 (Joondalup Lake) just north of Ocean Reef Road and wetland with UFI 8169 on the southern side of Ocean Reef Road (Figure 3).

There are three other geomorphic wetlands in close proximity to the Survey Area (Table 1).

Table 1: Geomorphic Wetlands in the Survey Area

MANAGEMENT CATEGORY	WETLAND UFI	DISTANCE FROM SURVEY AREA
Conservation Wetland	8159	0.20 km
Conservation Wetland	15458	0.15 km
Multiple Use Wetland	7956	1 km

2.4 Bush Forever

Bush Forever is a State Government Policy and programme that identifies 51,200 ha of regionally significant vegetation for protection, covering 26 vegetation complexes. This amounts to approximately 18% of the original vegetation on the SCP biogeographic region of the Perth metropolitan area.

Regionally significant vegetation has been identified based on criteria relating to its conservation value. Important criteria in the identification process include the achievement, where possible, of a comprehensive representation of all the ecological communities originally occurring in the region, principally through protecting a target of at least 10% of each vegetation complex in the Bush Forever project boundary (Government of WA 2000).

The Survey Area encroaches into four Bush Forever Site, Site 299 – Yellagonga Regional Park, Wanneroo/Woodvale/Kingsley, at several locations. Site 303 – Whitfords Avenue Bushland, Craigie/Padbury, Site 383 – Neerabup National Park, Lake Nowergup Nature Reserve and adjacent Bushland, Neerabup and Site 407 – Woodvale Nature Reserve, Woodvale (Figure 4).

2.5 Ecological Linkages

The Survey Area forms part of the Perth Biodiversity Project's Draft Regional Ecological linkage network presented in Figure 4. The purpose of the Regional Ecological Linkages identified by the Perth Biodiversity Project was to link protected natural areas with other areas of mapped native vegetation. Priority was given to identifying linkages through those areas having the greatest assumed protection and to those areas that maximised opportunities to form continuous corridors of native vegetation. Three linkages intersect the Survey Area, Linkages 6, 24 and 25 (Figure 4).

Ecological linkages are not legislatively protected, however, the EPA expects that in preparing plans and proposals for development, consideration will be given to both the site-specific biodiversity conservation values of patches of native vegetation, as well as the landscape function and core linkage significance of a patch in supporting the maintenance of an ecological linkage.

2.6 Environmentally Sensitive Areas

Parts of the alignment intersect land which is mapped as ESAs (Figure 4).

2.7 Broad Vegetation Types

Vegetation across the State has been mapped at different scales by various people. The Survey Area has been mapped by both Beard (1979) which was later reassessed by Shepherd *et al.* (2001). Heddle *et al.* (1980) undertook vegetation mapping for the region and therefore both these studies have been used to demonstrate the broad vegetation types in the Survey Area (Tables 2 and 3).

The Shepherd *et al.* (2001) and Heddle *et al.* (1980) studies have been used to estimate vegetation currently present in comparison to the pre-European extent of the same vegetation types. From these comparisons, it can be determined what vegetation types have been extensively cleared and therefore in need of protection. This is later discussed in Section 5.5.

Mapping of the vegetation of the Perth region of WA was completed on a broad scale (1:250,000) by Beard (1979). These vegetation units were re-assessed by Shepherd *et al.* (2001) to account for clearing in the intensive land use zone, dividing some larger vegetation units into smaller units.

There are three Beard / Shepherd vegetation units in the Survey Area. The Shepherd *et al.* (2001) vegetation types (along with the corresponding Beard [1979] type in brackets), are described below, and their representation within the Survey Area, subregion, region and State is shown in Table 2.

- 6 (e2,4Mi) – Medium woodland, Tuart and Jarrah;
- 37 (mSc) – Shrublands; teatree thicket; and
- 126 (fl) – Bare areas; fresh water lakes;

Table 2: Broad Vegetation Types within the Survey Area and its State and Regional Representation (Government of Western Australia 2014).

	PRE-EUROPEAN AREA (HA)	CURRENT EXTENT (HA) 1	REMAINING (%)	CURRENT EXTENT % IN IUCN CLASS I-IV RESERVES1
Vegetation Types (Beard 1979/ Shepherd <i>et al.</i> 2001) in the state				
6	56,343	13,411.19	23.80	13.88
37	39,296.52	24,754.49	62.99	18.78
126	23,503.38	9,564.25	40.69	37.33
Vegetation Types (Beard 1979/ Shepherd <i>et al.</i> 2001) in the Swan Coastal Bioregion				
6	56,343.00	13,411.19	23.80	13.88
37	15,617.85	5,424.54	34.73	36.85
126	3,420.06	789.60	23.09	35.51
Vegetation Types (Beard 1979/ Shepherd <i>et al.</i> 2001) in the Perth Subregion				
6	56,343.00	13,411.19	23.80	13.88
37	14,018.45	4,793.02	34.19	41.39
126	3,420.06	789.60	23.09	35.51

Mapping by Heddle *et al.* (1980) based in relation to the landform-soil units determined by Churchward and McArthur (1978) identified two vegetation complexes occurring in the Survey Area which are summarised in Table 3. The delineation of vegetation complexes is based on the concept of series of plant communities forming regularly repeating complexes associated with a particular soil unit. The Heddle *et al.* (1980) vegetation complexes that occur across the Survey Area are described below:

- Karrakatta Complex – Central and South; and
- Herdsman Complex.

Table 3: Vegetation Complexes within the Survey Area and its State and Regional Representation.

	PRE-EUROPEAN AREA (HA)	CURRENT EXTENT (HA)	REMAINING (%)	CURRENT EXTENT % SECURE TENURE RESERVES
Vegetation Complex (Heddle <i>et al.</i> 1980) in the System 6/part System 1 area (EPA 2006)				
Karrakatta Complex – Central and South	49,912	14, 729	29.5	2.5
Herdsmen Complex	8, 309	2,875	34.6	11.5
Vegetation (Heddle <i>et al.</i> 1980) in the Swan Coastal Bioregion (PBP 2013)				
Karrakatta Complex – Central and South	49786.04	11905.85	23.91	4.69
Herdsmen Complex	8309.48	2877.47	34.63	21.41

3 Methods

3.1 Background

The flora survey was consistent with a Level 2 spring survey as per the EPA requirements for environmental surveying and reporting for flora and vegetation in Western Australia, where possible and as set out in the following documents:

- EPA Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia No. 51 (EPA 2004a);
- EPA Guidance for the Level of Assessment for Proposals affecting Natural Areas within the System 6 Region and Swan Coastal Plain Portion of the System 1 region. Guidance Statement No. 10 (EPA 2006); and
- Technical Guide – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment (EPA-DPaW 2015).

The fauna survey was compliant with the EPA requirements for the environmental surveying and reporting of fauna in Western Australia where practical and relevant, and as set out in the following documents:

- Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3 (EPA 2002);
- Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia. Guidance Statement No. 56 (EPA 2004b);
- Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA-DEC 2010); and
- EPBC Act referral guidelines for three threatened black cockatoo species (DSEWPaC 2012).

3.2 Flora and Vegetation Survey Methods

3.2.1 Flora and Vegetation Database Review

The desktop study provided background information on the flora and vegetation of the Survey Area. This involved a search of the following sources:

- DPaW Threatened and Priority Flora database (DPaW 2016a);
- DPaW Threatened and Priority Ecological Communities database (DPaW 2016b); and
- DoE Protected Matters Search Tool (PMST) (DoE 2016a).

A request for a database search was submitted to the DPaW on the 29th April 2015 (5 km radial search around the Survey Area) (Appendix F) to obtain a list of Declared Rare Flora/Threatened or Priority flora, and TECs and PECs in and near the Survey Area (Figure 5). These sources were used to compile a list of expected DRF or Priority species and TECs and PECs that may occur based on the landforms in the Survey Area.

3.2.2 Flora and Vegetation Field Assessment

The preliminary flora assessment was undertaken on the 17th and 18th May 2016. The Level 2 flora and vegetation survey was undertaken on the 6th September 2016, and the targeted rare and priority flora survey was undertaken on the 4th October 2016. The Survey Area was found to be mostly cleared with isolated native trees, gardens and non-endemic species. There are pockets of intact native vegetation in several locations.

The flora survey included the assessment of eight (8) quadrats and eight (8) relevés, along with vegetation mapping notes. Quadrats are vegetation and survey plots which are accurately measured out as 10 x 10 m (or an equivalent to 100 m²) and marked at the northwest (NW) corner using a handheld Garmin GPS unit. Relevés are unbounded vegetation survey plots with information recorded including landscape features, surface soil colour and texture, bare ground, litter cover, disturbance, fire age, aspect and vegetation condition. Each dominant species at each relevé was recorded, including information on height and percentage cover.

3.2.3 Taxonomy and Nomenclature

Where field identification of plant taxa was not possible, specimens were collected systematically for later identification utilising resources of the Western Australian Herbarium (WAH).

The species list was checked against FloraBase (WAH 2016) to determine the species conservation status. Threatened and Priority Flora were verified against the EPBC Act listing of threatened species to determine Commonwealth listing.

Introduced species were checked against the DPaW Weed Prioritisation Process (WPP) (DPaW 2013), to determine their ranking in terms of environmental impact. The BAM Act Declared Plants list was consulted to determine if any are Declared Plants, and the WONS list to determine the presence of any WONS (Thorp & Lynch 2000).

3.2.4 Vegetation Mapping

The vegetation mapping units were described based on their structure and species composition, as defined by quadrat data and field observations. Vegetation was mapped in the field using handheld GPS (Garmin) units and high-resolution aerial photographs, which in the office were digitised using GIS software.

Vegetation condition was mapped in the field using handheld GPS (Garmin) units and high-resolution aerial photographs, which in the office were digitised using GIS software.

Vegetation condition was assessed based on Keighery (1994) from Bush Forever (Government of WA 2000).

3.3 Fauna Survey Methods

3.3.1 Fauna Database Review

A four (4) km DPaW threatened fauna database search and a five (5) km radial NatureMap search was undertaken from the centre of the GWRS proposed pipeline. An EPBC PMST search with a 20 m buffer on either side of the length of the proposed alignment was undertaken (Appendix G). The searches were undertaken to identify fauna species of conservation significance potentially occurring in the Survey Area (DPaW 2016c, DPaW 2016d, DoE 2016b).

Collectively, these sources were used to compile a list of species that have been previously recorded in the vicinity of the Survey Area (Appendix K). This list invariably includes some species that do not occur in the Survey Area, as some fauna have a limited or patchy distribution or a high level of habitat specificity for habitats which are not located in the Survey Area e.g. waders/shorebirds that require coastal shores for habitat. Some fauna may have become locally extinct or were erroneously identified in previous surveys. These fauna were examined and then excluded from the list as appropriate.

3.3.2 Field assessment

The field assessment was undertaken on 17th and 18th May 2016 by two Zoologists. The survey was consistent with standard protocols for the region and relevant EPA Guidance Statements and EPBC Act Survey Guidelines as outlined above in section 3.1 (where relevant and practical).

The purpose of the field assessment was to verify the accuracy of the desktop assessment and to further delineate and characterise the fauna assemblages and fauna habitat in the Survey Area.

The outcome of the field survey was to assist in the final placement of the GWRS pipeline alignment.

The positioning of the proposed GWRS alignment was selected by Water Corporation in an attempt to limit clearing of native vegetation where possible. The Survey Area was highly disturbed and consisted mostly of cleared vegetation with isolated native trees, gardens and non-endemic species (beside roads and in parks) and small pockets of intact native vegetation, particularly in the northern part of the Survey Area. Due to this, the field survey was concentrated mainly on areas of native vegetation particularly in the northern part of the Survey Area.

Given the limited stands of native vegetation in the Survey Area, and isolated trees (particularly along sections of the route near Lake Joondalup), the primary focus of the

fauna survey was a Black Cockatoo habitat assessment given their conservation status (EPBC Act listed) and distribution in Perth. Fauna habitat assessment and opportunistic observations were also undertaken during the survey.

3.3.3 Opportunistic Observation

Fauna were opportunistically observed and recorded during the assessment. The assessment included looking through leaf litter, overturning rocks, looking under decorticating bark and searches for scats, tracks, burrows and other traces of animals throughout the Survey Area (when the habitat supported such features). If conservation significant species were located, the coordinates were recorded with a GPS.

3.3.4 Taxonomy

For species identified in the desktop assessment, where there is doubt as to their true taxonomy (through subsequent name changes or taxonomic reviews), an effort was made to determine the current scientific name for each taxon. In some cases, old scientific names may be presented where correct nomenclature could not be determined due to name changes. Some taxon names may be followed by 'sp.', meaning that the species name was not given in the data source or the identification is in doubt. Where there are previously recorded taxa such as this that have the potential to be a conservation significant species, they are discussed specifically in the results and discussion section.

Taxonomy and nomenclature in this report follows the accepted listing of published terrestrial vertebrate species. The listing for amphibians and reptiles follows Cogger (2014), birds follows Christidis & Boles (2008) and mammals Van Dyck & Strahan (2008).

3.4 Black Cockatoo Survey Methods

The three species of Black Cockatoo were of interest for the Water Corporation with regards to the GWRS; as such a Black Cockatoo Assessment was an important part of the fauna survey (as discussed in section 3.3.2).

The Black Cockatoo Assessment was undertaken on 17th and 18th May 2016 and was the main focus of the field survey.

The Black Cockatoo assessment involved traversing the Survey Area by foot. Any trees meeting each of the following criteria for potential breeding were recorded and electronically logged using a hand held Global Positioning System (GPS) unit:

- Native trees (e.g. Jarrah, Tuart, Marri etc.);
- Diameter at breast height (DBH) > 500 mm (300 mm for Wandoo and Salmon Gum) regardless of the presence or absence of hollows;
- Trees were placed in the following size class categories:
 - A = 500 – 1000 mm DBH

- B = 1000 – 2000 mm DBH
- C = >2000 mm DBH

The Black Cockatoo assessment involved assessing the habitat for tree and shrub species known to be important dietary items e.g. Marri and *Banksia sp.* It also included looking for:

- Evidence of feeding (chewed cones, seed and nut material); and
- Opportunistic observations of Black Cockatoos in the Survey Area.

4 Results

4.1 Flora, Vegetation and Fauna Survey Limitations and Constraints

It is important to note the specific constraints imposed on surveys. Constraints are often difficult to predict, as is the extent to which they influence survey effort. Survey constraints of the flora and fauna survey are detailed in Table 4.

Table 4: Limitations and Constraints Associated with the Survey Area.

VARIABLE	IMPACT ON SURVEY OUTCOMES
Access	Majority of the Survey Area was accessed and traversed. Access was denied for the western side of the freeway. Particular focus was given to areas expected to be impacted that may have species of conservation significance and where there was relatively intact native vegetation present.
Experience	<p>The personnel who executed these surveys were practitioners suitably qualified in their respective fields:</p> <ul style="list-style-type: none"> ● Field Staff: Narelle Whittington (Botanist), Amy Dalton (Botanist), Dr Ron Firth and Laura Stevens (Zoologists); ● Data Interpretation and Reporting: Narelle Whittington, Laura Stevens and Amy Dalton; and ● Report Review: Dr Ron Firth.
Timing, weather, season	<p>The survey was conducted during September after three months of slightly below average rainfall (refer to section 2.1).</p> <p>The climate for Joondalup is described as warm Mediterranean (Mitchell <i>et al.</i> 2002), with a mean minimum of approximately 12.8 °C and a mean maximum of 24.8°C. Rainfall totals, on average, 728.1 mm per annum (Figure 2) (BoM 2016).</p> <p>Flora composition changes with time, particularly seasonally as a result of seasonal conditions. Therefore, botanical surveys completed at different times will have varying results.</p> <p>Fauna were opportunistically observed throughout the day, but especially in the first few hours following dawn, when</p>

VARIABLE	IMPACT ON SURVEY OUTCOMES
	birds in particular are most active.
Scope: Life forms sampled	<p>The scope of this project included the detailed surveying of flora and vegetation and searching for perennial conservation significant species or communities.</p> <p>The fauna survey was primarily a habitat assessment, many species that occur in the Survey Area would not have been observed, particularly small ground-dwelling fauna that are normally captured by methods such as trapping. All conservation significant species previously recorded in the area have been considered. Based on the habitat present, those species deemed to potentially occur in the Survey Area have been addressed in this report.</p> <p>The scope of this project also included the surveying of potential Black Cockatoo habitat.</p>
Sources of information	<p>The desktop analysis used several sources to produce a list of flora and fauna species previously recorded in the vicinity of the project area. This includes records from the EPBC Protected Matters Search Tool (DOEE) (formally DoE 2016a&b), and DPaW Threatened flora (DPaW 2016a), TECs and PECs (DPaW 2016b) NatureMap (DPaW 2016d) and NatureMap fauna search (DPaW 2016e) and DPaW Threatened Fauna Database search (DPaW 2016c) as well as field guides and other scientific literature.</p>
Completeness	<p>The majority of the Survey Area was accessible; however, access was restricted to the alignment on the western side of the freeway. All vegetation associations were sufficiently surveyed; with eight (8) quadrats, eight (8) relevés and additional vegetation mapping notes recorded.</p> <p>Four fauna habitat assessments were carried out and all trees considered to be potential breeding trees in the Survey Area were measured.</p>
Disturbances	<p>A large portion of the Survey Area has been severely altered by urbanisation and infrastructure. Only a few pockets of intact native vegetation are present. The majority of the vegetation in the Southern section of the Survey Area consists of mature native trees over weed species and garden variety species (including non-endemic trees such as Eucalypts).</p>

4.2 Flora Results

4.2.1 Database Results

The review of the database searches identified 28 conservation significant flora potentially occurring in the vicinity of the Survey Area. Of these, nine are classed as Threatened, four as Priority 1, six as Priority 2, seven as Priority 3 and two as Priority 4.

The likelihood of these 28 conservation significant flora occurring in the Survey Area is shown in Appendix H.

A search of the DPaW TEC and PEC database and EPBC PMST identified one State listed TEC as occurring within five (5) km of the Survey Area and two Priority communities (Figure 5), none of these are listed under the EPBC Act. The TEC and PEC communities are:

- FCT SCP20a – *Banksia attenuata* woodlands over species rich dense shrublands (Endangered [DPaW]);
- FCT SCP24 – Northern Spearwood shrublands and woodlands (Priority 3 [DPaW]); and
- FCT SCP25 – Southern *Eucalyptus gomphocephala* – *Agonis flexuosa* woodlands (Priority 3 [DPaW]).

Since the database search was undertaken for the initial survey, “*Banksia* woodlands of the Swan Coastal Plain” has been listed as Endangered under the EPBC Act.

4.2.2 Overview of Flora

A total of 149 taxa (including species, subspecies, varieties and forms) from 99 genera and 44 families were recorded in the Survey Area, of these 38 were introduced species. The commonly occurring families were; Asparagaceae and Fabaceae (both with 17 taxa), Myrtaceae (13 taxa), Proteaceae (11 taxa) and Proteaceae (11 taxa) and Poaceae (10 taxa). The flora inventory is provided in Appendix I and the Survey Area data sheets in Appendix J.

4.2.3 Flora of Conservation Significance

No Threatened species pursuant to the EPBC Act and/or gazetted as DRF pursuant to the WC Act were recorded during the survey. One Priority 3 species, *Conostylis bracteata*, was recorded during the survey. The locations of *Conostylis bracteata* are located in Figure 6e.

Table 5: Locations and number of Priority plants recorded during the survey.

TAXA	EASTING (GDA 94)	NORTHING (GDA 94)	NUMBER OF PLANTS
<i>Conostylis bracteata</i> (P3)	385113	6488609	1
	385093	6488842	2
	384881	6489096	4
	385006	6488842	1
	385090	6488759	1
	385102	6488772	2
	385085	6488807	5
	385082	6488821	6
	385159	6488889	1
	385154	6488956	3
	386758	6484420	8
	386730	6484408	2


Plate 1: *Conostylis bracteata*

4.2.4 Introduced Flora

A total of 38 introduced species were recorded during the survey (Table 6). One species, **Moraea flaccida*, is listed as Declared under the BAM Act. None of the species are listed as a WONS.

Table 6: Introduced Flora Recorded in the Survey Area.

TAXON	(COMMON NAME)	DECLARED BAM ACT	WONS
* <i>Asteraceae sp.</i>	Daisy family	No	No
* <i>Aira caryophylla</i>	Silvery Hairy Grass	No	No
* <i>Arctotheca calendula</i>	Cape Weed	No	No
* <i>Briza maxima</i>	Blowfly Grass	No	No
* <i>Cerastium glomeratum</i>	Mouse Ear chickweed	No	No
* <i>Conyza bonariensis</i>	Flaxleaf, fleabane	No	No
* <i>Crassula thunbergiana</i>	Crassula	No	No
* <i>Cynodon dactylon</i>	Couch	No	No
* <i>Cyperus congestus</i>	Dense flat-sedge	No	No
* <i>Cyperus tenellus</i>	Tiny Flatsedge	No	No
* <i>Ehrharta calycina</i>	Perennial Veldt Grass	No	No
* <i>Ehrharta longiflora</i>	Annual Veldt Grass	No	No
* <i>Eragrostis curvula</i>	African lovegrass	No	No
* <i>Ferraria crispus</i>	Black Flag	No	No
* <i>Freesia sp.</i>	Freesia	No	No
* <i>Ficus macrophylla</i>	Moreton bay fig	No	No
* <i>Gladiolus caryophyllaceus</i>	Wild Gladiolus	No	No
* <i>Hypochaeris glabra</i>	Smooth Catsear	No	No
* <i>Leptospermum laevigatum</i>	Coast Teatree	No	No
* <i>Lupinus sp.</i>	Lupin	No	No
* <i>Lysimachia arvensis</i>	Pimpernel	No	No
* <i>Melia azedarach</i>	Cape Lilac, White Cedar	No	No
* <i>Moraea flaccida</i>	One-leaf Cape Tulip	Yes	No
* <i>Nerium oleander</i>	Oleander	No	No
* <i>Olea europaea</i>	Olive	No	No
* <i>Oxalis pes-caprae</i>	Soursob	No	No
* <i>Pelargonium capitatum</i>	Rose Pelargonium	No	No
* <i>Pennisetum clandestinum</i>	Kikuyu	No	No
* <i>Pinus pinaster</i>	Maritime Pine, Pinaster Pine	No	No
* <i>Poa annua</i>	Winter Grass	No	No
* <i>Poaceae sp.</i>	Poaceae	No	No

TAXON	(COMMON NAME)	DECLARED BAM ACT	WONS
* <i>Polycarpon tetraphyllum</i>	Fourleaf Allseed	No	No
* <i>Ricinus communis</i>	Castor oil plant	No	No
* <i>Romulea rosea</i>	Guildford Grass	No	No
* <i>Schinus terebinthifolius</i>	Japanese pepper	No	No
* <i>Senecio sp.</i>	Ragwort	No	No
* <i>Typha orientalis</i>	Bullrush	No	No
* <i>Ursinia anthemoides</i>	Ursinia	No	No

In addition to the introduced species there are several species that, even though they are native to WA, they are not naturally occurring in the Survey Area and/or have been planted (Table 7).

Table 7: Non Endemic Native Flora Species Recorded in the Survey Area.

TAXON
<i>Agonis flexuosa</i>
<i>Callistemon sp.</i>
<i>Calothamnus quadrifidus</i>
<i>Chamelaucium uncinatum</i>
<i>Eucalyptus accedens</i>
<i>Melaleuca nesophila</i>
<i>Pteridium esculentum</i>

4.2.5 Vegetation Associations

Eight natural vegetation associations were described for the Survey Area. In addition to the associations, 15 vegetation units were also mapped, which included mature trees in isolation or over gardens and weeds. Descriptions of these are provided in Table 8 and Figures 6a – 6f.

Table 8: Vegetation Association and unit Descriptions and their Extent in the Survey Area.

VEGETATION ASSOCIATION CODE (AND SITES WHICH REPRESENT THIS ASSOCIATION)	DESCRIPTION	AREA (HA)
CcEmBa (R1, R2, R3, R4, R5, Q1, Q2, Q3,	Woodland of <i>Corymbia calophylla</i> , <i>Eucalyptus marginata</i> , <i>Banksia attenuata</i> , <i>Banksia menziesii</i> and <i>Allocasuarina fraseriana</i> over <i>Hibbertia</i>	35.06

VEGETATION ASSOCIATION CODE (AND SITES WHICH REPRESENT THIS ASSOCIATION)	DESCRIPTION	AREA (HA)
Q4, Q5, Q6, Q7, Q8)	<i>hypericoides</i> , <i>Xanthorrhoea preissii</i> , <i>Macrozamia riedlei</i> , <i>Mesomelaena pseudostygia</i> , <i>Jacksonia sternbergiana</i> , <i>Jacksonia furcellata</i> , <i>Hibbertia racemosa</i> and <i>Desmocladius flexuosus</i> .	
EmAf (R6)	Low Woodland of <i>Eucalyptus marginata</i> , <i>Allocasuarina fraseriana</i> , <i>Banksia attenuata</i> , <i>Banksia prionotes</i> over <i>Xanthorrhoea preissii</i> , <i>Macrozamia riedlei</i> , <i>Hibbertia hypericoides</i> and * <i>Ehrharta calycina</i> .	0.54
EgEt	Woodland of <i>Eucalyptus gomphocephala</i> , <i>Eucalyptus todtiana</i> , <i>Eucalyptus calophylla</i> , Non-endemic <i>Eucalyptus</i> sp. and <i>Banksia</i> over <i>Hardenbergia comptoniana</i> and introduced species.	0.29
MrPe	Low Woodland of <i>Melaleuca raphiophylla</i> over <i>Pteridium esculentum</i> , <i>Acacia saligna</i> and <i>Acacia rostellifera</i> .	1.08
EmJf	<i>Eucalyptus marginata</i> over <i>Jacksonia furcellata</i> and <i>Macrozamia riedlei</i> .	0.06
BmJf	<i>Banksia menziesii</i> over <i>Jacksonia furcellata</i> and <i>Thysanotus dichotomus</i> .	0.04
EgPe	<i>Eucalyptus gomphocephala</i> over <i>Pteridium esculentum</i> .	0.08
AfBa	Low Open Woodland of <i>Allocasuarina fraseriana</i> , <i>Banksia attenuata</i> , <i>Banksia menziesii</i> , <i>Banksia prionotes</i> over <i>Jacksonia sternbergiana</i> and <i>Hibbertia hypericoides</i>	0.007
EgLI	<i>Eucalyptus gomphocephala</i> over * <i>Leptospermum laevigatum</i>	0.07
MrLI (R7)	Low woodland of <i>Melaleuca raphiophylla</i> and <i>Eucalyptus rudis</i> over <i>Baumea articulata</i> and <i>Lepidosperma longitudinale</i> .	2.03
ErG	<i>Eucalyptus rudis</i> over garden species.	0.02
Rehab (R8)	Areas of rehabilitation/revegetation.	1.07
Mr	<i>Melaleuca raphiophylla</i> isolated trees.	0.29

VEGETATION ASSOCIATION CODE (AND SITES WHICH REPRESENT THIS ASSOCIATION)	DESCRIPTION	AREA (HA)
To	* <i>Typha orientalis</i>	1.08
Ma	* <i>Melia azedarach</i>	0.004
Eg	<i>Eucalyptus gomphocephala</i>	3.06
Cc	<i>Corymbia calophylla</i>	
Em	<i>Eucalyptus marginata</i>	
Er	<i>Eucalyptus rudis</i>	
As	<i>Acacia saligna</i>	
Ba	<i>Banksia attenuata</i>	
Af	<i>Allocasuarina fraseriana</i>	
Jf	<i>Jacksonia furcellata</i>	
Ea	<i>Eucalyptus accedens</i>	
Pp	* <i>Pinus pinaster</i>	2.78
G	*Garden/non-endemic species	1.84

4.2.6 Vegetation Condition

Vegetation condition ranged from Very Good to Completely Degraded with the majority of the Survey Area considered to be in a Completely Degraded (41.56 ha) condition (Table 9, Figures 7a-7f).

Historical vegetation clearing, weeds, road infrastructure, parks and residential development within and adjacent to the Survey Area were the most frequently observed impacts on native vegetation.

The vegetation along the length of the route is extremely fragmented and the majority of the Survey Area consists of non-endemic and weed species.

Land use in the Survey Area has caused fragmentation of the native vegetation, with much of the remaining mature native trees having been integrated with gardens and parks along with non-endemic species. In these instances the vegetation no longer has a natural structure and is mapped as Completely Degraded. The majority of the intact native vegetation with condition ratings of Good to Very Good is within the portion of the alignment that transects Bush Forever site 164 (Figure 7e). In addition to this area there are also pockets of intact native vegetation along Wanneroo road at the northern end of the Survey Area. These are considered to be in Degraded to Very Good Condition as they are weed infested and have reduced species diversity.

Table 9: Vegetation Condition and Extent in the Survey Area.

CONDITION	EXTENT (HA)
Very Good	0.27
Good	1.49
Good-Degraded	1.63
Degraded	0.19
Completely Degraded	41.56
Roads/paths/houses/paving etc.	7.53

4.2.7 Floristic Community Types

Statistical analysis (multivariate analysis) and data interpretation, as shown in Table 10 was undertaken to help determine the FCTs represented by the vegetation in the project area. This involves reviewing site data for other factors that are diagnostic for FCTs, including the presence of indicator species, soil types and landform position. The quadrat data was tested for similarity against each of Gibson *et al.* FCT's that were determined and mapped as part of a regional study to describe the vegetation types present on the Swan Coastal Plain in 1994. Results from the statistical analysis and the site information, identified one FCT as occurring in the Survey Area.

Quadrats were established only in intact vegetation in good or better condition. This, therefore, limited the locations that they could be established due to disturbance levels. As a consequence all the quadrats were ultimately positioned in what turned out to be the same vegetation community. Several tree species occurred within the largest remnant (CcEmBa) (in the northern section of the alignment) the only variation was in density of each of the species. The difficulty in determining different vegetation communities was also augmented by the fact that the understorey species were typically the same across the intact remnants regardless of the composition of the overstorey.

Table 10: Floristic Community Type Analysis

VEGETATION ASSOCIATION	GIBSON <i>ET AL.</i> QUADRAT & FCT	SIMILARITY BASED ON STATISTICAL ANALYSIS	COMMENTS	INFERRED FLORISTIC COMMUNITY TYPE
CcEmBa Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8	FCT SCP25 – Southern Eucalyptus gomphocephala – Agonis flexuosa woodlands	37.45	Even though there were scattered Occurrences of Eucalyptus gomphocephala were not in association with Agonis flexuosa and given the dominance of the other tree species it is unlikely to occur within the Survey Area.	FCT SCP28 – Spearwood <i>Banksia attenuata</i> or <i>B. attenuata</i> – Eucalyptus woodlands Based on the several tree species present and the
	FCT SCP24 - Northern Spearwood shrublands and woodlands	36.36	Based on the dominant overstorey species the quadrats are unlikely to represent FCT SCP24	occurrence of the FCT in nearby vegetation remnants
	FCT SCP21c - Low lying <i>Banksia attenuata</i> woodlands or shrublands	34.04	FCT SCP21c has not been commonly recorded in the area and based on the species present it is unlikely to occur in the Survey Area	FCT SCP28 is likely to be represented in the Survey Area

The size and condition of several vegetation remnants meant establishing quadrats in these areas was not suitable, relevés were therefore established. Statistical analysis was not undertaken for these site and therefore FCTs were referred (Table 10). Relevés were used to collect information on vegetation communities in the Survey Area where quadrats were not warranted, these included areas of vegetation outside of the alignment e.g. the fringing vegetation of Joondalup Lake.

Table 11: Inferred Floristic Community Type Analysis.

VEGETATION ASSOCIATION	COMMENTS	INFERRED FLORISTIC COMMUNITY TYPE
EmAf	Based on the dominant species present and the location it is likely to be FCT SCP28. The lack of species and size of the remnant makes it ineligible to be considered the TEC Banksia woodlands on the Swan Coastal Plain	FCT SCP28 - Spearwood <i>Banksia attenuata</i> or <i>B. attenuata</i> – <i>Eucalyptus</i> woodlands
EgEt	Based on the dominant species present and the location it is likely to be FCT SCP28. The lack of species and size of the remnant makes it ineligible to be considered the TEC Banksia woodlands on the Swan Coastal Plain	FCT SCP28 - Spearwood <i>Banksia attenuata</i> or <i>B. attenuata</i> – <i>Eucalyptus</i> woodlands
MrPe	This vegetation association was very low in native species diversity and density and therefore a FCT cannot be inferred	Not applicable
BmJf	Based on the dominant species present and the location it is likely to be FCT SCP28. The lack of species and size of the remnant makes it ineligible to be considered the TEC Banksia woodlands on the Swan Coastal Plain	FCT SCP28 - Spearwood <i>Banksia attenuata</i> or <i>B. attenuata</i> – <i>Eucalyptus</i> woodlands
EmJf	This vegetation association	Not applicable

VEGETATION ASSOCIATION	COMMENTS	INFERRED FLORISTIC COMMUNITY TYPE
	was very low in native species diversity and density and therefore a FCT cannot be inferred	
MrLi	The edges of the lake were inferred as supplementary community type S7 based on the dominant species present and position.	S7 – Northern woodlands to forests over tall sedgeland alongside permanent wetlands
AfBa	Based on the dominant species present and the location it is likely to be FCT SCP28. The lack of species and size of the remnant makes it ineligible to be considered the TEC Banksia woodlands on the Swan Coastal Plain	FCT SCP28 - Spearwood <i>Banksia attenuata</i> or <i>B. attenuata</i> – Eucalyptus woodlands

4.2.8 Threatened and Priority Ecological Communities

Vegetation association CcEmBA, has been determined to have the highest affiliation with FCT SCP28, which is listed as a sub-community of 'Banksia woodlands of the Swan Coastal Plain'. As of 2016, Banksia woodlands of the Swan Coastal Plain have been listed as Endangered under the EPBC Act. TECs and their associated buffers are regarded as ESAs. FCT SCP28 is not listed as a TEC under state legislation or as a Priority community.

4.2.9 Regional Representation

Vegetation mapping units described in the Survey Area were correlated with the Beard (1978) and Shepherd *et al.* (2001) broad vegetation types as much as possible by examining similarities in vegetation descriptions (Table 12). Differences exist with the terminology used in the descriptions as they are based on different methods of categorising and characterising vegetation types, and the different spatial scale of the analysis (i.e. region vs. local scale).

Table 12: Representation of broad Vegetation Types and corresponding Vegetation Associations.

VEGETATION TYPE AND DESCRIPTION (SHEPHERD ET AL. 2001/BEARD 1978)	CORRESPONDING VEGETATION ASSOCIATION (CURRENT SURVEY)	VEGETATION ASSOCIATION EXTENT IN SURVEY AREA (HA)
6 (e2,4Mi)	CcEmBa, AfBa, EmAf, BaBg & EmEr	4.86

4.3 Fauna Results

4.3.1 Database Searches

Database searches returned 244 vertebrate species from 75 families as potentially occurring in the vicinity of the Survey Area. Of these, nine species were amphibians from five families, 44 were reptiles from eight families, 173 were bird species from 49 families and 17 were mammals from 13 families.

A total of 38 conservation significant vertebrate species (including Priority species) from 20 families were identified during the desktop review of the database searches (Appendix K). These were comprised of one amphibian species, one reptile species, 32 bird species from 15 families, and four mammals from three families.

4.3.2 Conservation Significant Fauna

The four (4) km DPaW threatened fauna database and NatureMap database and a 20 m linear EPBC PMST search returned a number of wetland species, in particular birds (i.e. marine birds and waders), as well as the Loggerhead Turtle and Water Rat, that require specific habitats (i.e. oceans, shorelines and wetlands) not present in the Survey Area. The Grey Wagtail (*Motacilla cinerea*) also inhabits wetland areas, requiring banks and rocks in fast-running fresh water habitats (Johnstone & Storr 1998). Although the proposed GWRS pipeline alignment runs alongside Lake Joondalup, the Survey Area does not enter the lake and the proposed alignment does not directly impact the lake and the coast is approximately five (5) km from the Survey Area.

Many of these wetland, marine and coastal species in the databases may occur nearby; however, given the absence of suitable habitat in the Survey Area, all marine and wetland species are unlikely to occur in the Survey Area itself.

A number of species returned were also known to be historical records of species now extinct (e.g. Malleefowl, Western Quoll and Red-tailed Phascogale) in the local area and more broadly in the region. These species have been omitted from any further discussion.

It is important to note, that the EPBC PMST is not entirely based on point records, but also on broader information, for example bioclimatic distribution models. Whereas DPaWs NatureMap and threatened fauna database is, consequently, the results of the EPBC PMST are in some cases less accurate, particularly at a local scale. Consequently, the EPBC PMST will include species that do not occur in the search area because for example there is no habitat or they are now known to be locally extinct.

In addition, many fauna are not distributed evenly across the landscape, are more abundant in some places than others are, and consequently more detectable (Currie 2007). Furthermore, some small, common ground-dwelling reptile and mammal species tend to be habitat specific, and many bird species can occur as regular migrants, occasional visitors or vagrants. Therefore all these species have been omitted from any further discussion regarding fauna results.

With the afore mentioned marine species removed, a total of seven conservation significant species (including Priority species) from the database searches are potentially considered to either be likely, possibly or unlikely to occur in the Survey Area. These eight species comprise of one reptile, six bird and one mammal species.

Of these seven conservation significant species, two species were recorded during the field assessment, two species are considered as 'Likely' to occur, no species are considered 'Possible' and three species are considered 'Unlikely' to occur within the Survey Area (Table 13).

The Likelihood of each species is based on the following criteria:

- Recorded: Recorded during the field assessment;
- Likely: Suitable habitat is present in the Survey Area and the Survey Area is in the species' known distribution;
- Possible: Limited or no suitable habitat is present in Survey Area, but is nearby. The species has good dispersal abilities and is known from the general area; and
- Unlikely: No suitable habitat is present in Survey Area but is nearby, the species has poor dispersal abilities, but is known from the general area; or suitable habitat is present, however the Survey Area is outside of the species' known distribution.

Table 13: Conservation significant fauna potentially occurring in the Survey Area.

En = Listed as Endangered under the EBPC Act, Vu = Listed as Vulnerable under the EBPC Act, Mi = Listed as Migratory under the EBPC Act, Ma = Listed as Marine under the EBPC Act, S = Scheduled under the WC Act, and P = Listed as Priority by the DPaW.

TAXA	CONSERVATION STATUS	LIKELIHOOD
Reptiles		
Black-striped Snake (<i>Neelaps calonotos</i>)	P3	Unlikely
Birds		
Peregrine Falcon (<i>Falco peregrinus</i>)	S7	Unlikely
Forest Red-tailed Black-Cockatoo (<i>Calyptorhynchus banksii naso</i>)	Vu	Likely
Baudin's Black Cockatoo (<i>Calyptorhynchus baudinii</i>)	Vu	Likely
Carnaby's Black Cockatoo (<i>Calyptorhynchus latirostris</i>)	En	Recorded
Rainbow Bee-eater (<i>Merops ornatus</i>)	MaMi, S5	Likely
Mammals		
Southern Brown Bandicoot (<i>Isodon obesulus fusciventer</i>)	P5	Recorded

4.3.3 Field assessment Results

During the field assessment 18 species from ten families were recorded. This consisted of 16 bird species from eight families and two mammal species from two families.

4.3.3.1 Amphibians

From the database searches, nine amphibian species have been previously recorded from the following five families in the surrounding area: Cheloniidae, Chelidae, Limnodynastidae, Myobatrachidae and Hylidae (Appendix K). During the survey, no amphibians were recorded.

4.3.3.2 Reptiles

From the database searches, a total of 44 reptile species have been previously recorded from the following eight families in the surrounding area; Diplodactylidae, Pygopodidae, Gekkonidae, Scincidae, Agamidae, Varanidae, Boidae and Elapidae. No reptile species were recorded during the field assessment (Appendix K).

4.3.3.3 Birds

From the database searches, a total of 143 bird species from 49 families have been previously recorded in the surrounding area. During the field assessment 16 bird species were recorded from the following 8 families: Casuariidae, Columbidae, Psittacidae,

Acanthizidae, Meliphagidae, Dicruridae, Cracticidae, Corvidae and Motacillidae (Appendix K).

4.3.3.4 Mammals

From the database searches, a total of 17 mammal species from 13 families have been previously recorded in the surrounding area. During the field assessment two mammal species were recorded; the Western Grey Kangaroo and the Southern Brown Bandicoot (Appendix K).

4.3.4 Black Cockatoo Results

The EPBC PMST, NatureMap and DPaW searches identified all three Black Cockatoo species as occurring in the surrounding area; Carnaby's Black Cockatoo, Baudin's Black Cockatoo and FRTBC (Appendix K).

During the survey, a small group of Carnaby's Black Cockatoos were observed flying over the Survey Area. Chewed Marri nuts, with markings from Carnaby's Black Cockatoos were observed throughout the Survey Area.

4.3.4.1 Foraging Habitat

There is a total of 10.8 ha of foraging and potential breeding Black Cockatoo habitat in the Survey Area. This includes trees that are both potential breeding trees and known foraging species, as well as trees with a DBH of <500 mm (<300 mm for Wandoo) and other known Black Cockatoo dietary items.

Five species of Eucalypts recorded in the Survey Area are Marri, Jarrah, Powderbark Wandoo, Tuart and Flooded Gum and are considered Black Cockatoo foraging habitat. As well as foraging species including *Banksia attenuata*, *Banksia grandis*, *Banksia menziesii*, *Allocasuarina fraseriana*, *Acacia saligna* and *Xanthorrhoea preissii* (Figures 8 A-F). These species provide important foraging habitat for all three species of Black Cockatoo.

4.3.4.2 Potential Breeding Trees

Five species of Eucalypts, Marri, Jarrah, Powderbark Wandoo, Tuart and Flooded Gum recorded in the Survey Area are also considered Black Cockatoo potential breeding habitat. The Survey Area contains 108 potential breeding trees with a DBH of more than 500 mm (Marri (20), Jarrah (46 [14 of which were stags]) Tuart (30) and Flooded Gum (11). As well as Powderbark Wandoo (1) with a DBH more than 300 mm. The dimensions and the locations of the potential breeding trees are displayed in Appendix L and Figures 8 A-F.

A total of 38 hollows were observed in the Survey Area. Of these, four were considered to be large enough at their entrances (>120 mm) to be considered as potential breeding hollows in the future.

4.3.5 Fauna Habitat

Four fauna habitat assessments were undertaken during the survey (Appendix M) and two fauna habitats were identified in the Survey Area:

Eucalypt Remnants

This habitat has an overstorey that includes Marri, Jarrah, Powderbark Wandoo, Tuart and Flooded Gum, a midstorey that comprises species including *Acacia*, *Allocasuarina*, *Banksia*, *Hakea* and *Xanthorrhoea*, over an understorey of mixed herbs.

The large Eucalypt trees provide potential breeding habitat for Black Cockatoos, while along with the *Allocasuarina*, *Banksia*, *Hakea* and *Xanthorrhoea*, the trees and shrubs provide foraging habitat for Black Cockatoos.

This habitat has vegetation in multiple strata (canopy, midstorey and understorey), woody debris and leaf litter that provides habitat for small reptile, bird and mammal species. However, as these patches are for the most part fragmented, fauna movement between them is limited, particularly for the less mobile groups such as small reptiles and mammals.

Isolated *Eucalyptus* Trees

This habitat includes individual large Marri, Jarrah, Powderbark Wandoo, Tuart and Flooded Gum trees which provide important foraging and breeding habitat for all three Black Cockatoo species. This habitat, however, is disturbed as a result of vegetation clearing and so lacks any understorey. It therefore provides limited value to other fauna species due to a lack of vegetation structure that provides cover and different ecological niches.

5 Discussion

5.1 Flora Context

A large portion of the Survey Area is highly fragmented as due to urbanisation, clearing and roads. As a result of the historical and present land-use the quality and size of vegetation remnants varies greatly across the Survey Area. The survey resulted in 149 taxa (including species, subspecies, varieties and forms) from 99 genera and 44 families being recorded in the Survey Area, of these, 38 were introduced species. The majority of the original vegetation in the Survey Area has been cleared with only a few pockets of intact vegetation remaining. Several species present are native to WA, but do not naturally occur in the Survey Area and have been used for rehabilitation or landscaping.

5.2 Flora of Conservation Significance

No Threatened species listed under the EPBC Act or gazetted as T/DRF (Threatened) pursuant to the WC Act were recorded during the survey.

The review of the database searches identified nine T/DRF flora species potentially occurring in the vicinity of the Survey Area. Of these species, one (*Dasymalla axillaris*) does not have information available to determine whether it could occur in the Survey Area, seven are unlikely and one is possible. One species, *Caladenia huegelii*, is a perennial (tuberous) short-lived herb (orchid) that needs various conditions to flower and exhibits different flowering patterns. The survey was undertaken within the flowering period for this species, and it was concluded that it was not located within the Survey Area.

One Priority flora species was recorded during the survey. Nineteen *Conostylis bracteata* [P3] was recorded from 11 locations within the Survey Area (Figure 6e). The presence of this Priority Species does not form a statutory constraint for the Survey Area. There is no written policy on how to respond to the presence of priority flora species within proposed development sites. The presence of the species is dealt with by the DER on a case by case basis.

Of the Priority Flora identified as potentially occurring within the Survey Area during the desktop assessment, six do not have ecological information available to determine whether they could occur in the Survey Area i.e. habitat type and preference and their distribution. Nine are considered unlikely due to the absence of suitable habitat, one is considered possible (*Leucopogon* sp. Yanchep) and three are considered likely (*Conostylis bracteata* [P3] (found in Survey Area), *Lasiopetalum membranaceum* [P3] and *Jacksonia sericea* [P4]). The likelihood of these four species occurring is based on the habitat present in the Survey Area and the closest known record.

5.3 Vegetation of Conservation Significance

A search of the DPaW database and EPBC PMST for TECs and PECs identified one State listed TEC and two PECs as occurring within 5 km of the Survey Area, none of these are listed under the EPBC Act. None of these are thought to occur in the Survey Area.

Banksia woodlands of the Swan Coastal Plain ecological community has only been recently listed (16 September 2016) as an Endangered community under the EPBC Act. A key diagnostic feature is a prominent tree layer of *Banksia*, with scattered Eucalypts and other tree species often present among emerging *Banksia* canopy. To determine if the TEC is present in the Survey Area, the results of the statistical analysis were compared to the list of sub-communities which were drawn from the FCT descriptions outlined in Gibson *et al.* (1994), Government of WA (2000) and Keighery *et al.* (2008). Input into the sub-communities was obtained by DPaW.

The Statistical analysis resulted in the CcEmBa vegetation community having the most affiliation with FCT SCP28 – Spearwood *Banksia attenuata* or *Banksia attenuata* – *Eucalyptus* woodlands. Under the State legislation FCT SCP28 is currently considered well reserved and is not considered a TEC or priority community.

FCT SCP28 has been listed as a sub-community under the EPBC Act listed Banksia woodlands of the Swan Coastal Plain (DOEE 2016). For vegetation remnants to be under full national protection the community has to meet key diagnostic characteristics. In regards to the presence of FCT SCP28, the Approved Conservation Advice for the thresholds state that for vegetation in Good condition, the minimum patch size should be 2 ha and vegetation in Very Good condition should be a minimum of 1 ha. If a vegetation patch is considered Degraded or worse it is not considered favourable for national protection.

Based on this information, and the survey results, there is approximately 35.06 ha of FCT SCP28 rated as Good to Very Good condition, therefore is considered to be the federally listed Banksia woodlands of the Swan Coastal Plain.

5.4 Environmentally Sensitive Areas

Several sections of the Survey Area are within an ESA, with these ESAs likely to be the CCWs and the Bush Forever sites. ESAs are declared to prevent degradation of important environmental values such as T/DRF, TECs or significant wetlands. Exemptions contained in the Environmental Protection (Clearing of Native vegetation) Regulations 2004 for low impact land clearing do not apply in ESAs and a native vegetation clearing permit is required.

5.5 Vegetation Condition and Introduced Flora

Vegetation condition ranged from Very Good to Completely Degraded with the majority of the Survey Area considered to be in a Completely Degraded (41.56 ha) condition. Historical vegetation clearing, weeds, road infrastructure, parks and residential development in and adjacent to the survey area were the most frequently observed impacts on native vegetation.

Land use in the survey area has caused fragmentation of the native vegetation, with much of the remaining mature native trees having been integrated with gardens, parks and non-endemic species. In these instances the vegetation no longer has a natural structure and is mapped as Completely Degraded. The majority of the intact native vegetation has a condition rating of Good to Very Good and occurs in the northern portion of the Survey Area.

A total of 22 introduced species were recorded during the survey. One species, *Moraea flaccida*, is listed as Declared under the BAM Act. None of the species are listed as WONS. The Survey Area presents extensive weed infestations and is therefore a dominant feature of the Survey Area. Due to the scale of weed cover, a comprehensive weed list was not produced. Weeds that present within intact native vegetation were recorded. The majority of these weeds are common bushland and agricultural weeds (Hussey *et al.* 2007).

5.6 Regional Representation

The Perth Biodiversity Project (PBP 2013) has mapped native vegetation extent by vegetation complex on the Swan Coastal Plain. It is estimated that Karrakatta Complex – Central and South is estimated to have 23.91% native vegetation remaining based on the pre-European extent and the Herdsman Complex has 34.63% remaining.

The EPA recognises vegetation complexes that are not well represented as being significant. Vegetation complexes which have 10%-30% remaining may be considered regionally significant. Proposals that would affect a vegetation complex with 10% or less remaining are likely to be formally assessed by the EPA (EPA 2006).

These levels may be modified for 'Constrained Areas'. Such areas include the Swan Coastal Plain portion of the Perth metropolitan Region (in which the Survey Area lies), and may include urban, urban deferred and industrial zoned lands, and lands with development approvals.

The modified objectives for Constrained Areas are to:

- Retain at least 10% of the pre-clearing extent of the ecological community where >10% of the ecological community remains; or
- Retain all remaining areas of each ecological community where <10% of this ecological community remains.

The remaining extent of both of these vegetation communities is greater than the 10% threshold set by the EPA for protecting Australia's biological diversity in constrained areas.

5.7 Ecological Linkages

The Survey Area forms part of the Perth Biodiversity Project's Draft Regional Ecological linkage network. The Survey Area is part of a non-continuous linkage of bushland that connects parcels of bushland, undeveloped land and private properties. Three linkages dissect the Survey Area, Linkage 6, 24 and 25. Linkage 6 runs parallel with the alignment and crosses the Survey Area in the south. At this location there is very minimal native vegetation and its contribution to the linkage system is questionable. Linkage 25 dissects the Survey Area at its southern end point and consists mostly of housing and roads with a small portion of vegetation where it runs parallel with Bush Forever site 407 and crosses Bush Forever site 303. Linkage 24 dissects the largest remnant of intact vegetation in the Survey Area (Bush Forever Site 299). Given the width of the potential disturbance caused by the proposed works it is unlikely to have a large impact on the connectivity of the remnant.

Recognised by the EPA, DPaW and local government, the retention of native vegetation and fauna habitat within the Regional Ecological Linkages aims to reduce the loss of biodiversity and key ecological functions across the south-west. Ecological linkages are not legislatively protected, however, The EPA expects that in preparing plans and proposals for development, consideration will be given to both the site-specific biodiversity conservation values of patches of native vegetation, as well as the landscape function and core linkage significance of a patch in supporting the maintenance of an ecological linkage.

5.8 Fauna of Conservation Significance

5.8.1 Species Recorded

During the field assessment, two conservation significant species were recorded; Carnaby's Black Cockatoo, which listed as Endangered under the EPBC Act and the Southern Brown Bandicoot which is listed as Priority 5 under the DPaW Priority List.

As a Black Cockatoo Assessment forms part of this report, all three Black Cockatoo species will be discussed in detail in section 5.11.

Southern Brown Bandicoot

The Southern Brown Bandicoot is listed as Priority 5 under the DPaW Priority List. It once occurred throughout south-west WA; it now occurs from Guilderton southwards on the SCP, including the Perth Metropolitan area, in Jarrah and Karri (*Eucalyptus diversicolor*) forests and adjacent coastal vegetation complexes. The species inhabits scrubby, often swampy, vegetation with dense cover up to about 1m high. It feeds in

adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and cropland lying close to dense cover. The Southern Brown Bandicoot is patchily distributed in suitable habitat, with populations inhabiting Jarrah and Wandoo forests usually associated with watercourses. On the Swan Coastal Plain it is often associated with wetlands with dense vegetation where they feed on fruit, seeds, insects and fungi (Woinarski *et al.* 2012).

The DPaW threatened fauna database returned eight records from a four km radial search and during the survey Southern Brown Bandicoot diggings were observed in the northern section of the Survey Area (large section of bushland).

5.8.2 Species Considered Likely to Occur

Three species are considered Likely to occur in the Survey Area; Baudin's Black Cockatoo, FRTBC and the Rainbow Bee-eater. As a Black Cockatoo Assessment forms part of this report, all three Black Cockatoo species will be discussed in detail in section 5.11

Rainbow Bee-eater

The Rainbow Bee-eater is listed as Marine and Migratory under the EPBC Act and Schedule 5 under the WC Act. This species is one of the most common and widespread birds in Australia with a distribution that covers the majority of Australia (Barrett *et al.* 2003). It occurs in lightly wooded, often sandy country, preferring areas near water. It feeds on airborne insects, and nests throughout its range in WA in burrows excavated in sandy ground or banks, often at the margins of roads and tracks. In WA this species can occur as a 'resident, breeding visitor, postnuptial nomad, passage migrant and winter visitor' (Johnstone & Storr 1998b). The Survey Area contains potential foraging habitat for this species.

The DPaW threatened fauna database returned 15 records of the Rainbow Bee-eater, and due to its numbers and distribution, the Rainbow Bee-eater is considered Likely to occur in the Survey Area.

5.8.3 Species Considered as Possibly Occurring

No species are considered as Possibly Occurring in the Survey Area.

5.8.4 Species Considered as Unlikely to Occur

A total of two species of conservation significance are considered unlikely to occur in the Survey Area; the Black-striped Snake and the Peregrine Falcon.

Black-striped Snake

The Black-striped Snake is listed as Priority 3 under the DPaW Priority List. It is restricted to a narrow coastal and near-coastal strip of south-western WA, from about Lancelin to Rockingham and inland for about 90 km. It is a burrowing snake found in

coastal heaths and low shrubland, where it feeds on lizards mostly of the burrowing skink genus *Lerista*.

The DPaW results returned four historic records of the Black-striped Snake, this and a lack of heath habitat in the Survey Area make the Black-striped Snake considered Unlikely to occur.

Peregrine Falcon

The Peregrine Falcon is listed as Schedule 7 under the WC Act and is an uncommon but a wide-ranging bird across Australia. It occurs mainly along rivers and ranges as well as wooded watercourses and lakes and nests primarily on cliffs, granite outcrops and quarries. The diet of the Peregrine Falcon has been well studied and includes primarily flocking species such as European Starlings (Olsen *et.al.* 2008).

The DPaW results returned eight records of the Peregrine Falcon, however the Survey Area lacks suitable habitat and as such the Peregrine Falcon is considered Unlikely to Occur.

5.9 Black Cockatoo Assessment

Carnaby's Black Cockatoo

Carnaby's Black Cockatoo is listed as Endangered under the EPBC Act. It was returned from the EPBC PMST, NatureMap and DPaW searches and was observed during the field assessment. Carnaby's Black Cockatoo is endemic to south-west WA, and is distributed from the Murchison River to Esperance and inland to Coorow, Kellerberrin and Lake Cronin (Cale 2003). The species was once common, but the population has declined significantly in the last half century, and is now locally extinct in some areas (Johnstone and Storr 1998, Shah 2006). In the last 45 years the species has suffered a 50% reduction in its abundance (Cale 2003). This reduction is due to the clearing of core breeding habitat in the wheatbelt, the deterioration of nesting hollows, and clearing of food resources on the Swan Coastal Plain (Cale 2003). The total population of Carnaby's Black Cockatoo in 2008 was estimated at 40,000 (Johnstone & Johnstone 2008). Results from the 2015 Great Cockey Count (Birdlife 2015) however recorded 9,082 white-tailed black-cockatoos (Carnaby's and Baudin's Black Cockatoo) across the species range, which is the lowest total number recorded in the last three GCCs (2013 - 2015).

Carnaby's Black Cockatoos feed on seeds, nuts and flowers of a variety of native and exotic plants. Food plants include Banksia (including those previously included in the genus *Dryandra*), Pine trees (*Pinus* sp.), Marri, Jarrah, Grevillea, Allocasuarina, and Hakea species (Shah 2006). Marri nuts that are damaged extensively, especially on the main body of the nut, are likely to have been chewed by Carnaby's Black Cockatoo or Forest Red-tailed Black Cockatoos. The severed new growth, developing flower heads and chewed seed pods of Banksia species are also a good indicator of Black Cockatoo

feeding. Recent damage to bark is regarded as Black Cockatoo feeding activity along with the stripping of pine needles and cones (Cale 2003).

The seeds from seed pods of *Banksia* and the cones of Pine trees provide the highest energetic yield (Cooper *et al.* 2002). Carnaby's Black Cockatoo are less efficient at extracting Marri seeds than (the long-billed) Baudin's Black Cockatoo (Cooper *et al.* 2002).

Breeding has been recorded from early July to mid-December, and primarily occurs in the wheatbelt in the semi-arid and subhumid interior (Johnstone and Storr 1998).

The Survey Area is located within the known distribution of this species and the vegetation contains species, such as Marri and Jarrah which provide suitable foraging, roosting and breeding habitat. Carnaby's Black Cockatoo were recorded flying over the Survey Area during the assessment. Foraging evidence in the form of chewed Marri nuts was observed in the Survey Area.

Forest Red-tailed Black Cockatoo

The FRTBC is listed as Vulnerable under the EPBC Act and was returned from the EPBC PMST, NatureMap and DPaW searches.

The FRTBC is distributed through the humid and subhumid south-west of WA from Gingin through the Darling Ranges to the south-west from Bunbury to Albany. It occasionally occurs in the southern Swan Coastal Plain, and rarely in the Perth metropolitan area. The FRTBC occurs in pairs or small flocks, or occasionally large flocks of up to 200 birds (Johnstone & Storr 1998). The FRBC inhabits dense Jarrah, Karri and Marri forests that receive more than 600 mm average annual rainfall.

The FRTBC feeds primarily on Marri and Jarrah fruit (Johnstone & Kirkby 1999) and to a lesser extent on Blackbutt (*Eucalyptus patens*), Albany Blackbutt (*Eucalyptus staeri*), Karri, Sheoak (*Allocasuarina fraseriana*) and Snottygobble (*Persoonia longifolia*). FRTBC can obtain energy faster when feeding on Marri and Jarrah than other food sources (Cooper *et al.* 2002) and these two plant species make up 90% of the diet of the FRTBC.

The Survey Area is on the northern extremity of FRTBC distribution and the vegetation contains species, such as Marri and Jarrah which provide suitable foraging, roosting and breeding habitat.

Baudin's Black Cockatoo

Baudin's Black Cockatoo is listed as Vulnerable under the EPBC Act. It was returned from the EPBC PMST, NatureMap and DPaW searches, however it was not recorded during the field assessment. This species is distributed through the south-western humid and subhumid zones, from the northern Darling Range and adjacent far east of the SCP (south of the Swan River), south to Bunbury and across to Albany (Johnstone & Kirkby

2011). Baudin's Black Cockatoo rarely occurs near the coast north of Mandurah, and rarely occurs north of the Swan River (Johnstone & Kirkby 2008, Johnstone & Storr 1998a). Baudin's Black Cockatoo usually occur in small flocks of up to 30, or occasionally up to 50 and rarely in aggregations of up to 1200 (Johnstone & Kirkby 2008). Baudin's Black Cockatoo is distinguished from Carnaby's Black Cockatoo by its longer bill and slightly different call.

This species forages primarily in Eucalypt forest, where it feeds on Marri seeds, flowers, nectar and buds. They also feed on a wide range of seeds of Eucalypt, Banksia, Hakea and Pines (*Pinus* sp.) as well as fruiting apples and pears and beetle larvae from under the bark of trees (Johnstone & Kirkby 2008, Johnstone & Storr 1998a). Baudin's Black Cockatoo forages at all levels of the forest from the canopy to the ground, often feeding in the understorey on proteaceous trees and shrubs, especially Banksia, and in orchards both in trees and on dropped or fallen fruit on the ground.

The breeding biology of this species is poorly known. It has been recorded breeding in deep south-west, north to the Whicher Range and Lowden and also isolated records at Wungong Catchment, Serpentine (hills area) and east to Kojonup and near Albany (Johnstone & Kirkby 2008). They nest in large, mostly vertical, hollows of Karri (*E. diversicolor*), Marri, Wandoo, and Bullich (*E. megacarpa*). Baudin's Black Cockatoos display strong pair bonds are monogamous and most likely mate for life (Johnstone & Kirkby 2008). The pair remains together all year round except when the female is incubating and brooding. Both adults play a part in selecting the nest hollow, but only the female is responsible for renovation and preparing the hollow for breeding. Preparation of the hollow consists of chewing around the entrance of the hollow and down one part of the interior wall. Pairs have also been recorded prospecting for hollows in most months and also outside the breeding range (Johnstone & Kirkby 2008).

The Survey Area is on the northern extremity of FRTBC distribution and the vegetation contains species, such as Marri and Jarrah which provide suitable foraging, roosting and breeding habitat.

5.9.1 Foraging Habitat

The total area of foraging habitat present in the Survey Area is 10.8 ha. This foraging habitat consisted primarily of Marri, Jarrah and Tuart trees and to a lesser extent Powderbark Wandoo and Flooded Gum. Foraging habitat also consisted of species including *Acacia*, *Allocasuarina*, *Banksia*, *Hakea* and *Xanthorrhoea*, which are known dietary items of all three Black Cockatoo species, (Johnstone & Kirkby 2011).

Throughout the Survey Area there was evidence of Carnaby's Black Cockatoo foraging, in the form of chewed Marri nuts.

5.9.2 Breeding Habitat

Black Cockatoos breed in large hollow-bearing trees, generally within woodlands or forests (Johnstone *et al.* 2013). The size of the tree can be a useful indication of the hollow-bearing potential of the tree. Trees of suitable DBH are potentially important for maintaining breeding in the long-term, through maintaining the integrity of the habitat and allowing trees to provide future nest hollows. Maintaining the long-term supply of trees of a size to provide suitable nest hollows is particularly important in woodland stands that are known to support Black Cockatoo breeding (SEWPaC, 2012).

The Black Cockatoo habitat assessment revealed that the Survey Area contains Marri, Jarrah, Powderbark Wandoo, Tuart and Flooded Gum trees which have reached a size that are considered to be potential future hollow bearing trees, therefore potential breeding trees (>500 mm DBH [>300 mm for Wandoo]) according to the EPBC Act Black Cockatoo referral guidelines.

In total, 109 trees were recorded which met the criteria to be classed as a potential breeding trees. This suggests that these trees may develop hollows and have the potential to be use for breeding in the future. In order to be suitable for Black Cockatoos, the hollow entrances need to be greater than 120 mm diameter.

A total of 38 hollows were observed in the Survey Area. Of these, four were considered to be large enough at their entrances to be considered as potential breeding hollows in the future. These hollows could not be inspected internally, therefore we could determine if the hollows would be deep enough for nesting to occur.

There were many other Marri, Jarrah, Powderbark Wandoo, Tuart and Flooded Gum trees that have the potential to be foraging habitat, however, they were under the threshold of 500 mm (300 mm for Wandoo) to be considered as potential breeding trees.

5.10 Fauna Habitat Types

Eucalypt Remnants

This habitat mainly constitutes the area of intact bushland to the west of Wanneroo Road, opposite Ashley Road. It is a mix of Marri, Jarrah, Powderbark Wandoo Tuart and Flooded Gum with a midstorey consisting of *Acacia*, *Allocasuarina*, *Banksia*, *Hakea* and *Xanthorrhoea*. This habitat provides foraging and breeding habitat for Carnaby's Black Cockatoos, FRTBC and Baudin's Black Cockatoo.

The intact structure of this Eucalypt Remnant habitat provides cover and shelter for other fauna species. The understorey is comprised of mixed herbs and some areas have woody debris and leaf litter that provides microhabitat for some common reptile, bird and mammal species.

Isolated Eucalypt Trees

This habitat consists of large Eucalypt Trees comprised of Marri, Jarrah, Powderbark Wandoo, Tuart and Flooded Gum which provide important foraging and breeding habitat for Carnaby's Black Cockatoos, FRTBC and Baudin's Black Cockatoos.

The isolated large Eucalypts lack understory and as such this habitat is considered highly disturbed. A lack of vegetation in the mid and lower strata results in limited cover for common reptile, bird and mammal species and so provides limited value to fauna.

6 Conclusions

The flora and vegetation assessment was undertaken within the optimum time for flora surveys in the region that the Survey Area lies and the following conclusions can be drawn:

- No Threatened species were recorded within the Survey Area;
- One Priority species, *Conostylis bracteata* (Priority 3) was detected in the Survey Area;
- A total of 38 introduced species were recorded during the survey. One species, **Moraea flaccida*, is listed as Declared under the BAM Act. None of the species are listed as a WONS;
- The intact vegetation in the Survey area is found to be most similar to FCT SCP28 - Spearwood *Banksia attenuata* or *Banksia attenuata* - *Eucalyptus* woodlands;
- Vegetation association CcEmBA, has been determined to have the highest affiliation with FCT SCP 28, which is listed as a sub-community of 'Banksia woodlands of the Swan Coastal Plain. Banksia woodlands of the Swan Coastal Plain have been recently listed as Endangered TEC under the EPBC Act;
- The Survey Area encroaches into four Bush Forever Site, Site 299 – Yellagonga Regional Park, Wanneroo/Woodvale/Kingsley, at several locations. Site 303 – Whitfords Avenue Bushland, Craigie/Padbury, Site 383 – Neerabup National Park, Lake Nowergup Nature Reserve and adjacent Bushland, Neerabup and Site 407 – Woodvale Nature Reserve, Woodvale;
- The DPaW Geomorphic Wetlands Dataset identifies Two Conservation Category Wetlands (CCW) occurring in the Survey Area;
- Parts of the Survey Area are identified as an ESA. These are most likely associated with the CCW and the Bush Forever sites;
- The vegetation complexes in the survey area are: Karrakatta Complex – Central and South which is estimated to have 23.91% native vegetation remaining based on the pre-European extent and the Herdsman Complex has 34.63% remaining; and
- The remaining extent of both of these vegetation communities is greater than the 10% threshold set by the EPA for protecting Australia's biological diversity in constrained areas.

The fauna assessment was undertaken at a time considered appropriate for the species of conservation significance considered likely to be present on site. The following conclusions can be made:

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- During the desktop review of database searches, seven conservation significant species were identified;
 - Two species of conservation significance were recorded in the Survey Area:
 - Carnaby's Black Cockatoo; and
 - Southern Brown Bandicoot.
 - 10.8 ha of Black Cockatoo breeding and foraging habitat was recorded in the Survey Area;
 - 109 Black Cockatoo potential breeding trees were recorded; and
 - Two fauna habitats were identified in the Survey Area.

7 Recommendations

In order to minimise the impact on native flora and fauna, several recommendations are provided below:

- Minimise clearing of vegetation beyond that strictly required for the proposed pipeline alignment; and
- Woody debris (this includes trees felled and logs) and leaf litter formed during clearing should be retained, as they create good microhabitat for a large array of fauna, particularly reptiles.

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9 References

- Barrett, G., Silcocks, A., Barry, S., Cunningham, R., & Poulter, R. (2003). *The New Atlas of Australian Birds*. Hawthorn East, Victoria: Royal Australasian Ornithologists Union.
- Beard, J. S. (1972-80). *Vegetation Survey of Western Australia, 1:250 000 Series*. 21 titles published by Vegmap Publications.
- Bureau of Meteorology [BOM]. (2016). *Daily Weather Observations, Commonwealth of Australia*. Retrieved May, 2016, from <http://www.bom.gov.au/climate>.
- Cale, B. (2003). *Carnaby's Black-Cockatoo (Calyptorhynchus latirostris) Recovery Plan*. Perth: Department of Conservation and Land Management.
- Christidis, L., & Boles, W. E. (2008). *Systematics and Taxonomy of Australian Birds*. Victoria: CSIRO Publishing.
- Churchward, H.M & McArthur, W.M (1978). Landforms and Soils of the darling System, Western Australia in *Atlas of Natural resources, Darling System, Western Australia*. Department of Conservation and Environment, Western Australia.
- Cooper, C. E., Withers, P. C., Mawson, P. R., Bradshaw, S. D., Prince, J., & Robertson, H. (2002). *Metabolic ecology of cockatoos in the south-west of Western Australia*. *Australian Journal of Zoology* 50, 67–76.
- Cogger, H. (2013). *Reptiles and Amphibians of Australia*. CSIRO Publishing
- Commonwealth of Australia. (2014). *Weeds of National Significance*. Retrieved June, 2016, from <http://www.weeds.gov.au/weeds/lists/wons.html>
- Department of Agriculture and Food Western Australia [DAFWA]. (2016). *Declared Plants in Western Australia*.
http://www.agric.wa.gov.au/PC_93088.html?s=270181382,Topic=PC_93079
- Department of Environment and Conservation (2013). *Clearing Regulations - Environmentally Sensitive Areas (ESA) Department of Environment and Conservation*. Accessed via SLIP portal: Slip Services.
- Department of Environmental Protection [DEP] (1996). *System 6 and Part System 1 Update Programme*. Unpublished bushland plot and area records and analysis. Department of Environmental Protection, Perth, Western Australia.
- Department of Parks and Wildlife [DPaW]. (2016a). *Request for Rare Flora Information (custom search)*.
- Department of Parks and Wildlife [DPaW]. (2016b). *Threatened and Priority Ecological Communities Information (custom search)*.

Department of Parks and Wildlife [DPaW]. (2016c & e). NatureMap: Mapping Western Australia's Biodiversity. Department of Parks and Wildlife and Western Australian Museum. <http://naturemap.dec.wa.gov.au/>

Department of Parks and Wildlife [DPaW]. (2016d). Threatened and Priority Fauna Information (custom search).

Department of the Environment [DoE]. (2016a & b). *Protected Matters Search Tool*. Accessed from <http://www.environment.gov.au/epbc/pmst/index.html>.

Department of the Environment, Water, Heritage and the Arts. (2010). Survey Guidelines for Australia's Threatened Birds. EPBC Act Survey Guidelines 6.2.

Environmental Protection Authority [EPA]. (2002). Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3.

Environmental Protection Authority [EPA]. (2004a). Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia, Guidance Statement No. 51.

Environmental Protection Authority [EPA]. (2004b). Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (Guidance Statement No. 56).

Environmental Protection Authority [EPA] (2006). Level of Assessment for Proposals affecting Natural Areas within the System 6 Region and Swan Coastal Plain Portion of the System 1 region in Western Australia. Guidance Statement No. 10, EPA, Perth, Western Australia.

Environmental Protection Authority [EPA] and Department of Environment and Conservation (DEC). (2010). Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment.

Geoscience Australia, 2010, Surface Geology: Published 1: 250,000 scale geological maps Geological Survey of WA 1984 and Geoscience Australia, supplemented in parts by more recent stratigraphic classification in GSWA 1: 500,000 scale Solid Geology dataset 2008

Gibson, N., Keighery, B., Keighery, G., Burbidge, A., & Lyons, M. (1994). *A Floristic Survey of the Southern Swan Coastal Plain. Unpublished report for the Australian Heritage Commission. Western Australia: Department of Conservation and Land Management and the Western Australian Conservation Council of Western Australia.*

Government of Western Australia. (2000). Bush Forever: Volume 1: Policies, Principles and Processes. Perth: Department of Environmental Protection.

Government of Western Australia. (2015). 2013 State wide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Accessed [June 2016]. WA Department of Parks and Wildlife, Perth.

- Johnstone, R. E., & Kirkby, T. (2011). Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*), Baudin's Black Cockatoo (*Calyptorhynchus baudinii*) and the Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) on the Swan Coastal Plain (Lancelin–Dunsborough), Western Australia. Studies on distribution, status, breeding, food, movements and historical changes. Perth: Department of Planning.
- Johnstone, R. E., & Kirkby, T. (1999). Food of the forest red-tailed black cockatoo *Calyptorhynchus banksii naso* in south-west Western Australia. *Western Australian Naturalist* **22**, 167–177.
- Johnstone, R. E. & Storr, G. M. (1998a). *Handbook of Western Australian Birds*. Volume 1 - Non-Passerines (Emu to Dollarbird). Oxford University Press.
- Johnstone, R. E. & Storr, G. M. (1998b). *Handbook of Western Australian Birds*. Volume 2 - Passerines (Blue-winged Pitta to Goldfinch). Oxford University Press.
- Keighery B. J. (1994). Bushland Plant Survey. A Guide to Plant Community Survey for the Community. Wildflower Society of WA (Inc.) Nedlands, WA
- Mitchell, D., Williams, K., & Desmond, A. (2002). Swan Coastal Plan 2 (SWA2 – Perth subregion). In *A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions*. Perth: Department of Conservation and Land Management
- Perth Biodiversity Project (2013) Native vegetation on the Swan coastal Plain. Western Australian Local Government Association. Perth. Western Australia.
- Shah, B. (2006). *Conservation of Carnaby's Black Cockatoo on the Swan Coastal Plain, Western Australia*. Perth: Birds Australia.
- Shepherd, D. P., Beeston, G. R., & Hopkins, A. J. M. (2001). Native Vegetation in Western Australia (Technical Report 249). Perth: Department of Agriculture.
- Thorp, J R, & Lynch, R. (2000). The Determination of Weeds of National Significance. National Weeds Strategy Executive Committee, Launceston.
- Van Dyck, S., & Strahan, R. (2008). *The Mammals of Australia*. New South Wales: New Holland Publishers.
- Western Australian Herbarium [WAH]. (2016). Florabase - Information on the Western Australian Flora. Accessed from <http://florabase.dpaw.wa.gov.au>
- Woinarski, J.C.Z., Burbidge, A.A., & Harrison, P.L. (2014). *The action plan for Australian mammals 2012*. CSIRO Publishing.

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