



Appendix B

Perth Groundwater Replenishment Scheme Stage 2 Flora and Fauna Survey Report – 360 Environmental





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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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;

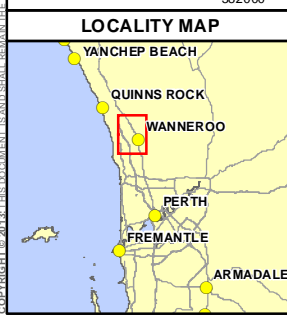
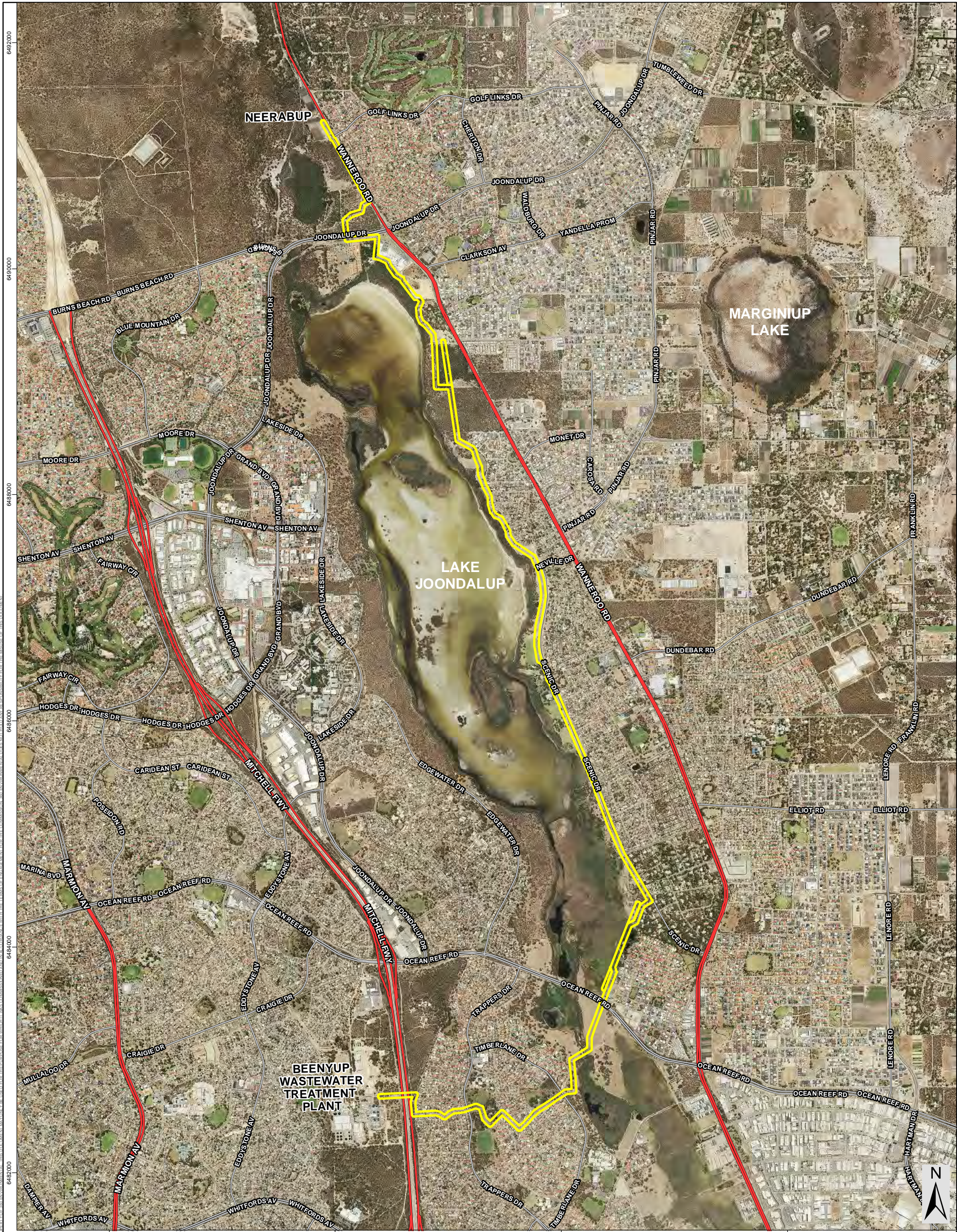
- Identify, map and discuss the significance of any TECs, PECs and any other areas of ecological importance (e.g. National Parks, wetlands and Environmentally Sensitive Areas [ESAs] etc.);
- Assess, map and photograph vegetation condition; and
- Document, describe and map the vegetation associations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

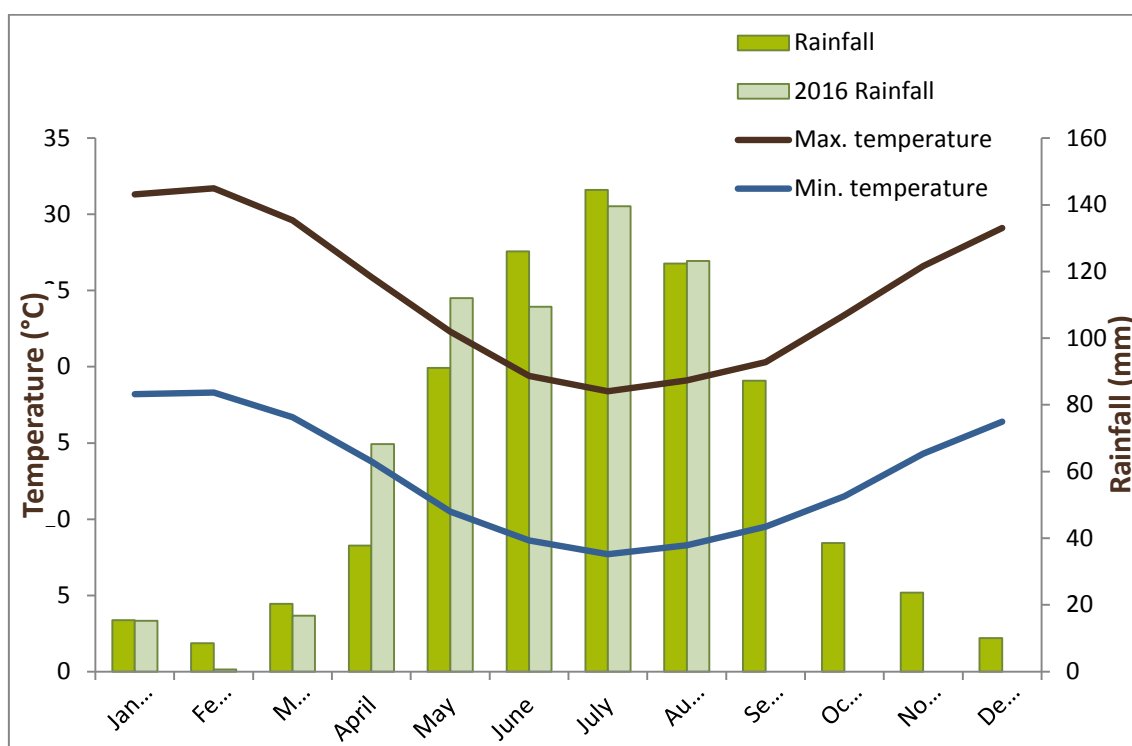


Figure 2: 2016 rainfall and mean rainfall for Perth Weather Station (009225) from 1993 to 2016 (BoM 2016).

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	<p>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.</p>
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:

- 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.

8 Acknowledgements

Ron, Narelle, Laura and all at 360 Environmental would like to thank Greg Ugle - Whadjuk (Traditional Owner) for his participation in the survey and for sharing his knowledge of the area.

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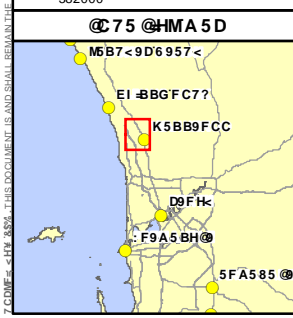
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FIGURES



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- Survey Area (49.71 ha)
- Yca cfd\ JWK YiUbXg
- Conservation
- Resource Enhancement
- Multiple Use
- Not Assessed

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- CADASTRAL BOUNDARY SOURCED FROM LANDGATE 2009
- LOCALITY MAP SOURCED LANDGATE 2006, WETLANDS SOURCED DPAW JAN 2016
- AERIAL PHOTOGRAPHY SOURCED LANDGATE FEB 2016
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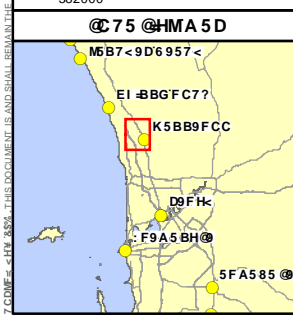
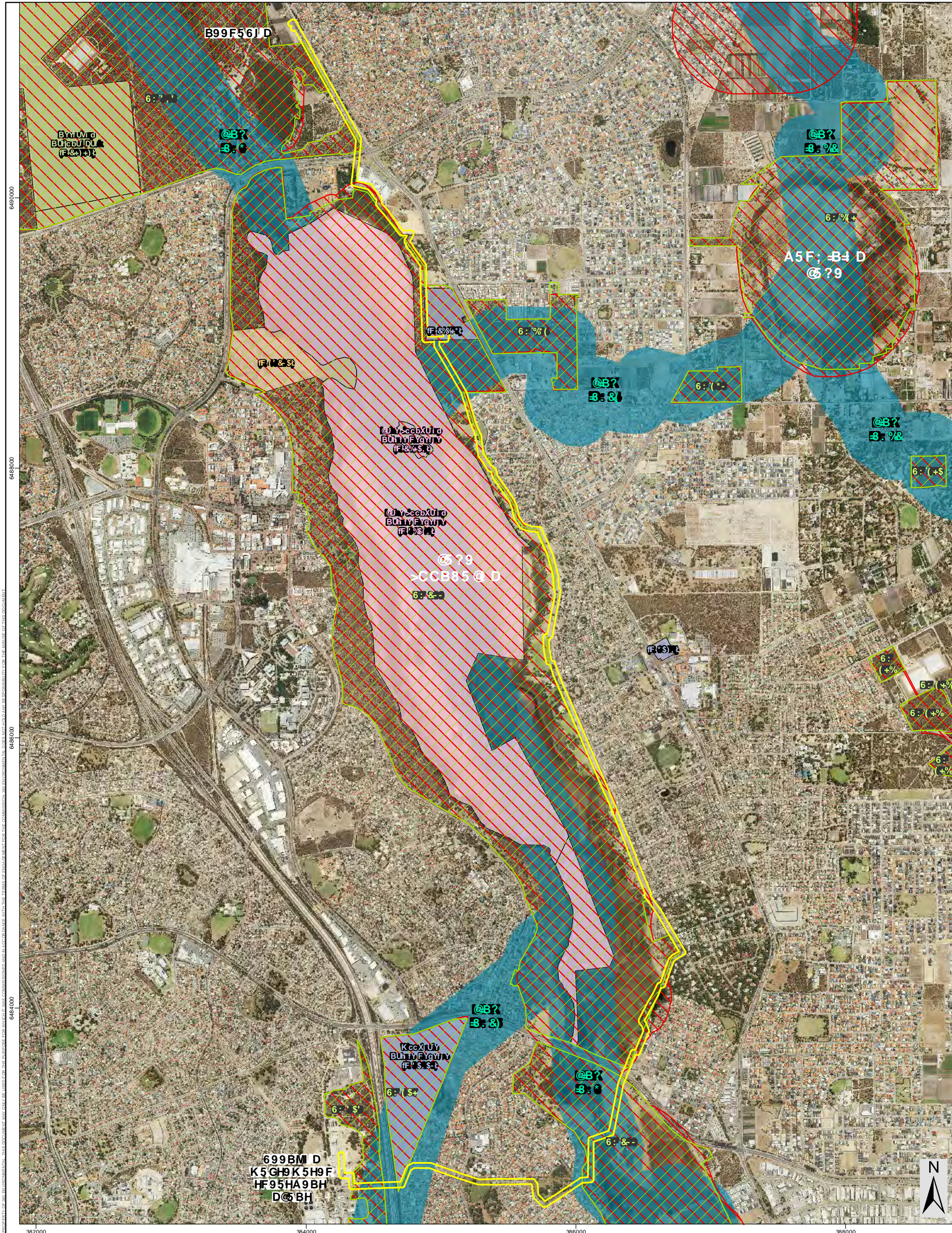
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- Survey Area (49.71 ha)
- Bush Forever Sites
- Environmentally Sensitive Areas
- Perth Regional Ecological Linkages
- Conservation Park
- Miscellaneous Reserve
- National Park
- Nature Reserve

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 - LOCALITY MAP SOURCED LANDGATE 2008, AERIAL PHOTOGRAPHY SOURCED LANDGATE FEB 2016
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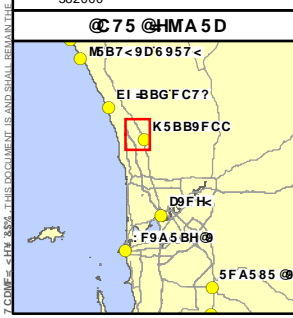
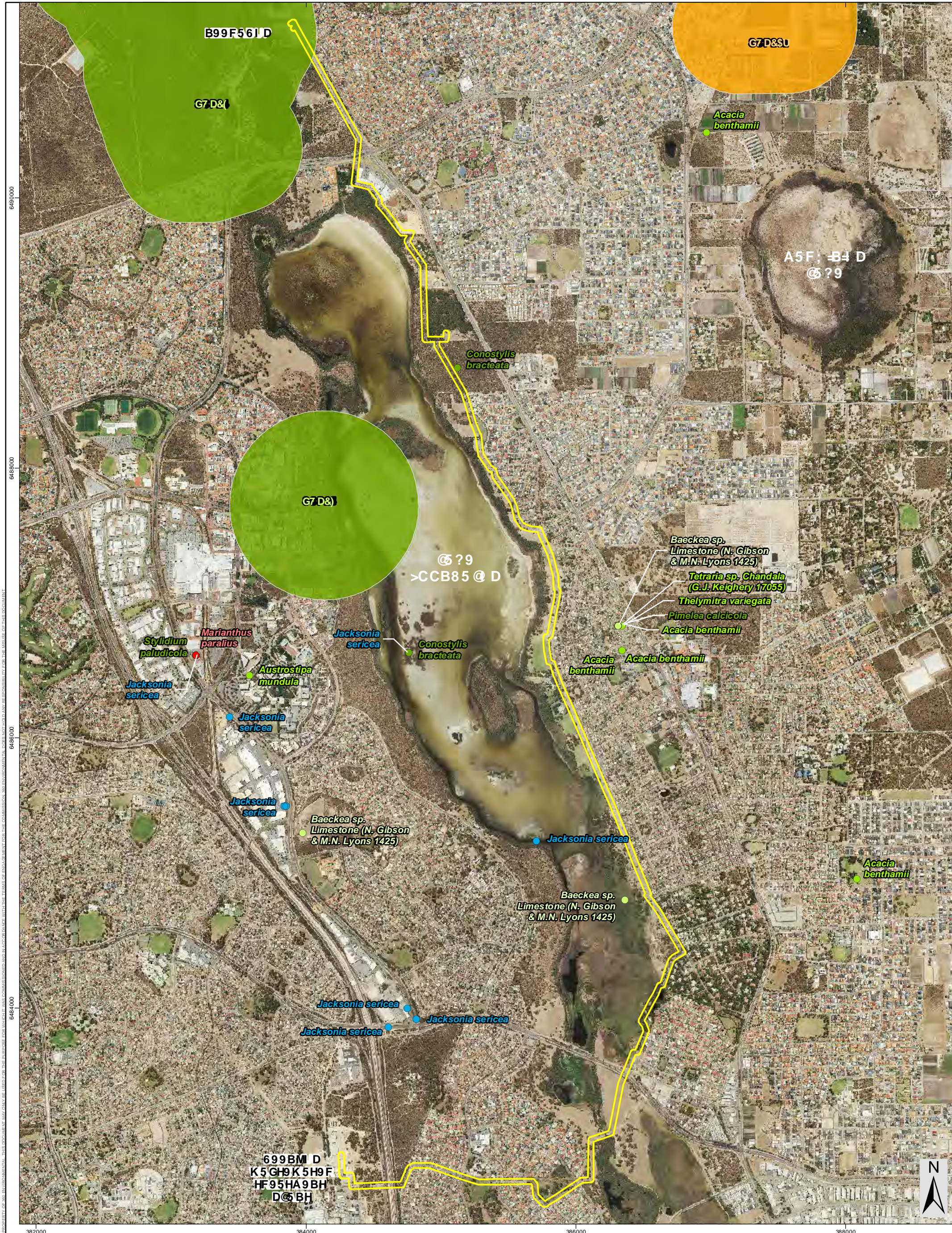
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<p>Survey Area</p> <p>Priority 4</p> <p>Priority 3</p> <p>Priority 2</p> <p>Priority 1</p> <p>Declared Rare</p>	<p>PEC - Priority 4</p> <p>PEC - Priority 3</p> <p>PEC - Priority 2</p> <p>PEC - Priority 1</p> <p>TEC - Vulnerable</p> <p>TEC - Endangered</p> <p>TEC - Critically Endangered</p>	<p>8515 GCI F79G</p> <p>- CADASTRAL BOUNDARY SOURCED FROM LANDGATE 2009</p> <p>- TEC PEC DATA PURCHASED DPW 12 MAY 2016, FLORA DATA PURCHASED DPW 16 MAY 2016 (REF 15-0516FL)</p> <p>- LOCALITY MAP SOURCED LANDGATE 2008, AERIAL PHOTOGRAPHY SOURCED LANDGATE FEB 2016</p> <p>© Western Australian Land Information Authority 2015</p>
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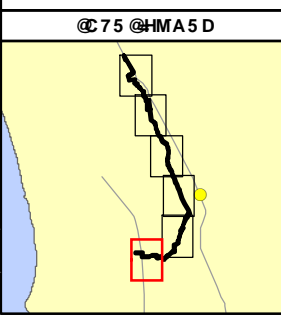
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Vegetation Unit Descriptions

- Af *Allocasuarina fraseriana*
- AfBa *Allocasuarina fraseriana* over *Banksia attenuata*
- As *Acacia saligna*
- Ba *Banksia attenuata*
- BaBg Low open woodland of *Banksia attenuata*, *Banksia grandis*, *Eucalyptus marginata* over *Xanthorrhoea preissii*, *Hakea lissocarpa* and *Hakea prostrata*
- BmJf *Banksia menziesii* over *Jacksonia furcellata* and *Thysanotus dichotomus*
- Cc *Corymbia calophylla*
- CcEmBa Woodland of *Corymbia calophylla*, *Eucalyptus marginata*, *Banksia attenuata*, *Banksia menziesii* and *Allocasuarina fraseriana* over *Hibbertia hypericoides*, *Xanthorrhoea preissii*, *Macrozamia nedleri*, *Mesomelaena pseudostygia*, *Jacksonia sternbergiana*, *Jacksonia furcellata*, *Hibbertia racemosa* and *Desmodium flexuosum*
- Ea *Eucalyptus accedens*
- Eg *Eucalyptus gomphocephala*
- EgEt Woodland of *Eucalyptus gomphocephala*, *Eucalyptus todtiana*, *Eucalyptus calophylla*, Non-endemic *Eucalyptus* sp. and *Banksia* over *Hardenbergia comptonii* and introduced species.
- EgLi *Eucalyptus gomphocephala* over *Lepidosperma longidunale*
- EgPe *Eucalyptus gomphocephala* over *Pteridium esculentum*
- Em *Eucalyptus marginata*
- EmAf Low Woodland of *Eucalyptus marginata*, *Allocasuarina fraseriana*, *Banksia attenuata*, *Banksia prioresis* over *Xanthorrhoea preissii*, *Macrozamia nedleri*, *Hibbertia hypericoides* and **Eriharta calycina*
- EmJf *Eucalyptus marginata* over *Jacksonia furcellata* and *Macrozamia nedleri*
- Er *Eucalyptus rudis*
- ErG *Eucalyptus rudis* over *Garden/non-endemic* species
- Jf *Jacksonia furcellata*
- Ma *Melia azedarach*
- Mr *Melaleuca raphiophylla* isolated trees
- MrEr *Melaleuca raphiophylla* and *Eucalyptus rudis*
- MrLi Low woodland of *Melaleuca raphiophylla* and *Eucalyptus rudis* over *Bauhinia articulata* and *Lepidosperma longidunale*
- Mrpe Low Woodland of *Melaleuca raphiophylla* over *Pteridium esculentum*, *Acacia saligna* and *Acacia rostellifera*
- To *Typha orientalis*
- Cc/Eg *Corymbia calophylla*/*Eucalyptus gomphocephala*
- CcEmEr *Corymbia calophylla*/*Eucalyptus marginata*/*Eucalyptus rudis*
- Eg/Cc *Eucalyptus gomphocephala*/*Corymbia calophylla*
- Eg/Em *Eucalyptus gomphocephala*/*Eucalyptus marginata*
- Eg/G *Eucalyptus gomphocephala*/*Garden/non-endemic* species
- Er/As *Eucalyptus rudis*/*Acacia saligna*
- Er/G *Eucalyptus rudis*/*Garden/non-endemic* species
- Er/Jf *Eucalyptus rudis*/*Jacksonia furcellata*
- G/Af *Garden/non-endemic* species/*Allocasuarina fraseriana*
- To/Er *Typha orientalis*/*Eucalyptus rudis*
- G *Garden/non-endemic* species
- PP **Pinus pinaster*
- Rehabilitation Area
- Completely Degraded
- Built Environment
- Road
- Not Surveyed



85H6 GCI F79G
 - LOCALITY MAP SOURCED LANDGATE 2006
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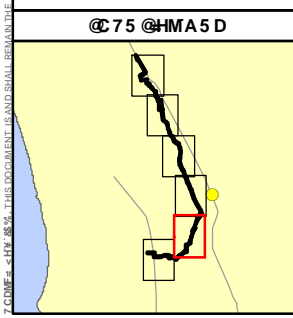


Vegetation Unit Descriptions

Af	<i>Allocasuarina fraseriana</i>
AlBa	<i>Allocasuarina fraseriana</i> over <i>Banksia attenuata</i>
As	<i>Acacia saligna</i>
Ba	<i>Banksia attenuata</i>
BaBg	Low open woodland of <i>Banksia attenuata</i> , <i>Banksia grandis</i> , <i>Eucalyptus marginata</i> over <i>Xanthorrhoea preissii</i> , <i>Hakea lescurii</i> and <i>Hakea prostrata</i>
BmJf	<i>Banksia menziesii</i> over <i>Jacksonia furcellata</i> and <i>Thysanotus dichotomus</i>
Cc	<i>Corymbia calophylla</i>
CcEmBa	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 hypericoides</i> , <i>Xanthorrhoea preissii</i> , <i>Macrozamia nedleri</i> , <i>Masomelaena pseudostygia</i> , <i>Jacksonia scarrbergiana</i> , <i>Jacksonia furcellata</i> , <i>Hibbertia racemosa</i> and <i>Desmodium illexosus</i>
Ea	<i>Eucalyptus accedens</i>
Eg	<i>Eucalyptus gomphocephala</i>
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 comptonii</i> and introduced species
EgLi	<i>Eucalyptus gomphocephala</i> over <i>Leptosperma longidinale</i>
EgPe	<i>Eucalyptus gomphocephala</i> over <i>Pteridium esculentum</i>
Em	<i>Eucalyptus marginata</i>
EmAl	Low Woodland of <i>Eucalyptus marginata</i> , <i>Allocasuarina fraseriana</i> , <i>Banksia attenuata</i> , <i>Banksia prostrata</i> over <i>Xanthorrhoea preissii</i> , <i>Macrozamia nedleri</i> , <i>Hibbertia hypericoides</i> and <i>Ehrharta calycina</i>
EmJf	<i>Eucalyptus marginata</i> over <i>Jacksonia furcellata</i> and <i>Macrozamia nedleri</i>
Er	<i>Eucalyptus rudis</i>
ErG	<i>Eucalyptus rudis</i> over Garden/non-endemic species
Jf	<i>Jacksonia furcellata</i>
Ma	<i>Melia azedarach</i>
Mr	<i>Melaleuca raphiophylla</i> isolated trees
MrEr	<i>Melaleuca raphiophylla</i> and <i>Eucalyptus rudis</i>
MrLi	Low woodland of <i>Melaleuca raphiophylla</i> and <i>Eucalyptus rudis</i> over <i>Baumea articulata</i> and <i>Leptosperma longidinale</i>
Mrpe	Low Woodland of <i>Melaleuca raphiophylla</i> over <i>Pteridium esculentum</i> , <i>Acacia saligna</i> and <i>Acacia rostellifera</i>
To	<i>Typha orientalis</i>
Cc/Eg	<i>Corymbia calophylla</i> / <i>Eucalyptus gomphocephala</i>
CcEm/Er	<i>Corymbia calophylla</i> / <i>Eucalyptus marginata</i> / <i>Eucalyptus rudis</i>
Eg/Cc	<i>Eucalyptus gomphocephala</i> / <i>Corymbia calophylla</i>
Eg/Em	<i>Eucalyptus gomphocephala</i> / <i>Eucalyptus marginata</i>
Eg/G	<i>Eucalyptus gomphocephala</i> /Garden/non-endemic species
Er/As	<i>Eucalyptus rudis</i> / <i>Acacia saligna</i>
Er/G	<i>Eucalyptus rudis</i> /Garden/non-endemic species
Er/Jf	<i>Eucalyptus rudis</i> / <i>Jacksonia furcellata</i>
G/Al	Garden/non-endemic species/ <i>Allocasuarina fraseriana</i>
To/Er	<i>Typha orientalis</i> / <i>Eucalyptus rudis</i>
G	Garden/non-endemic species
PP	* <i>Pinus pinaster</i>
Rehabilitation Area	
Completely Degraded	
Built Environment	
Road	
Not Surveyed	



6484000
6483500
6483000
386000
386500



@75 @HMA5 D	@[YbX	JY[YrUjcb' l b]g	85H6 GCI F79 G
Development Envelope	Ba	EgLi	M
Survey Area	BaBg	EgPe	Ma
Rehabilitation Area	BmJf	Em	Mr
Not Surveyed	Cc	EmAf	MrEr
	CcEmBa	EmJf	MrLi
	Ea	Er	Mrpe
	Eg	ErG	Ne
	EgEt	Jf	To
			Cc/Eg
			Eg/Cc
			Eg/Em
			Eg/G
			Er/As
			Er/G
			Er/Jf
			G/Al
			To/Er
			G
			PP
			Completely Degraded
			Built Environment
			Road
			Priority 3 Species
			Quadrat
			Releve
			BchY Priority 3 species refers to <i>Conosyris bracteata</i>

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HORIZONTAL DATUM: GDA 1994 MGA Zone 50
PROJECT NO: 1663

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1:5,000 @ A3

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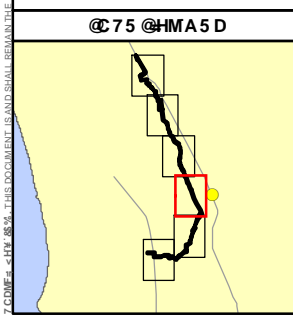
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JY[YrUjcb' 5 ggc VUjcbg



Vegetation Unit Descriptions

Af	<i>Allocasuarina fraseriana</i>
AfBa	<i>Allocasuarina fraseriana</i> over <i>Banksia attenuata</i>
As	<i>Acacia saligna</i>
Ba	<i>Banksia attenuata</i>
BaBg	Low open woodland of <i>Banksia attenuata</i> , <i>Banksia grandis</i> , <i>Eucalyptus marginata</i> over <i>Xanthorrhoea preissii</i> , <i>Hakea lasiocarpa</i> and <i>Hakea prostrata</i>
BmJf	<i>Banksia menziesii</i> over <i>Jacksonia furcellata</i> and <i>Thysanotus dichotomus</i>
Cc	<i>Corymbia calophylla</i>
CcEmBa	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 hypericoides</i> , <i>Xanthorrhoea preissii</i> , <i>Macrozamia nedi</i> , <i>Mesomelaena pseudostygia</i> , <i>Jacksonia sternbergiana</i> , <i>Jacksonia furcellata</i> , <i>Hibbertia racemosa</i> and <i>Desmocladius flexuosus</i>
Ea	<i>Eucalyptus accedens</i>
Eg	<i>Eucalyptus gomphocephala</i>
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 comptoniae</i> and introduced species
EgLi	<i>Eucalyptus gomphocephala</i> over <i>Leptidosperma longitudoale</i>
EgPe	<i>Eucalyptus gomphocephala</i> over <i>Pteridium esculentum</i>
Em	<i>Eucalyptus marginata</i>
EmAf	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 nedi</i> , <i>Hibbertia hypericoides</i> and <i>Ehrharta calycula</i>
EmJf	<i>Eucalyptus marginata</i> over <i>Jacksonia furcellata</i> and <i>Macrozamia nedi</i>
Er	<i>Eucalyptus rudis</i>
ErG	<i>Eucalyptus rudis</i> over Garden/non-endemic species
Jf	<i>Jacksonia furcellata</i>
Ma	<i>Melia azadirach</i>
Mr	<i>Melaleuca raphiophylla</i> isolated trees
MrEr	<i>Melaleuca raphiophylla</i> and <i>Eucalyptus rudis</i>
MrLi	Low woodland of <i>Melaleuca raphiophylla</i> and <i>Eucalyptus rudis</i> over <i>Bauhinia articulata</i> and <i>Leptidosperma longitudoale</i>
Mrpe	Low Woodland of <i>Melaleuca raphiophylla</i> over <i>Pteridium esculentum</i> , <i>Acacia saligna</i> and <i>Acacia rostellifera</i>
To	<i>Typha orientalis</i>
CcEg	<i>Corymbia calophylla</i> / <i>Eucalyptus gomphocephala</i>
CcEmEr	<i>Corymbia calophylla</i> / <i>Eucalyptus marginata</i> / <i>Eucalyptus rudis</i>
EgCc	<i>Eucalyptus gomphocephala</i> / <i>Corymbia calophylla</i>
EgEm	<i>Eucalyptus gomphocephala</i> / <i>Eucalyptus marginata</i>
EgG	<i>Eucalyptus gomphocephala</i> /Garden/non-endemic species
ErAs	<i>Eucalyptus rudis</i> / <i>Acacia saligna</i>
ErG	<i>Eucalyptus rudis</i> /Garden/non-endemic species
ErJf	<i>Eucalyptus rudis</i> / <i>Jacksonia furcellata</i>
QAf	Garden/non-endemic species/ <i>Allocasuarina fraseriana</i>
ToEr	<i>Typha orientalis</i> / <i>Eucalyptus rudis</i>
G	Garden/non-endemic species
PP	* <i>Pinus pinaster</i>
	Rehabilitation Area
	Completely Degraded
	Built Environment
	Road
	Not Surveyed



@75 @HMA5 D	@[YbX	Ba	EgLi	M	Cc/Er/Er	G
Development Envelope	BaBg	EgPe	Ma	Eg/Cc	PP	
Survey Area	BmJf	Em	Mr	Eg/Em	Completely Degraded	
Rehabilitation Area	Cc	EmAf	MrEr	Eg/G	Built Environment	
Not Surveyed	CcEmBa	EmJf	MrLi	Er/As	Road	
JY[YrUjcb' l b]jg	Ea	Er	Mrpe	Er/G	Priority 3 Species	
Af	Eg	ErG	Ne	Er/Jf	Quadrat	
AfBa	EgEt	Jf	To	G/Af	Releve	
As			Cc/Eg	To/Er		

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 PROJECT NO: 1663

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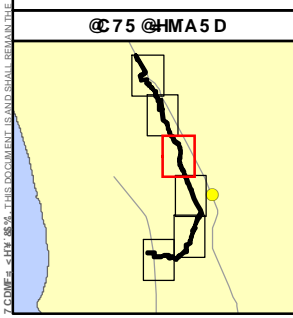
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Vegetation Unit Descriptions

Af	<i>Allocasuarina fraseriana</i>
AfBa	<i>Allocasuarina fraseriana</i> over <i>Banksia attenuata</i>
As	<i>Acacia saligna</i>
Ba	<i>Banksia attenuata</i>
BaBg	Low open woodland of <i>Banksia attenuata</i> , <i>Banksia grandis</i> , <i>Eucalyptus marginata</i> over <i>Xanthorrhoea preissii</i> , <i>Hakea lasiocarpa</i> and <i>Hakea prostrata</i>
BmJf	<i>Banksia menziesii</i> over <i>Jacksonia furcellata</i> and <i>Thysanotus dichotomus</i>
Cc	<i>Corymbia calophylla</i>
CcEmBa	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 hypericoides</i> , <i>Xanthorrhoea preissii</i> , <i>Macrozamia nedleyi</i> , <i>Mesomelaena pseudostygia</i> , <i>Jacksonia sarnbergiana</i> , <i>Jacksonia furcellata</i> , <i>Hibbertia racemosa</i> and <i>Desmodium flexuosum</i>
Ea	<i>Eucalyptus accedens</i>
Eg	<i>Eucalyptus gomphocephala</i>
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 comptonii</i> and introduced species.
EgLi	<i>Eucalyptus gomphocephala</i> over <i>Lepidosperma longitudinale</i>
EgPe	<i>Eucalyptus gomphocephala</i> over <i>Pteridium esculentum</i>
Em	<i>Eucalyptus marginata</i>
EmAf	Low Woodland of <i>Eucalyptus marginata</i> , <i>Allocasuarina fraseriana</i> , <i>Banksia attenuata</i> , <i>Banksia prioresii</i> over <i>Xanthorrhoea preissii</i> , <i>Macrozamia nedleyi</i> , <i>Hibbertia hypericoides</i> and <i>Ehrharta calycina</i>
EmJf	<i>Eucalyptus marginata</i> over <i>Jacksonia furcellata</i> and <i>Macrozamia nedleyi</i>
Er	<i>Eucalyptus rudis</i>
ErG	<i>Eucalyptus rudis</i> over Garden/non-endemic species
Jf	<i>Jacksonia furcellata</i>
Ma	<i>Melia azedarach</i>
Mr	<i>Melaleuca raphiophylla</i> isolated trees
MrEr	<i>Melaleuca raphiophylla</i> and <i>Eucalyptus rudis</i>
MrLi	Low woodland of <i>Melaleuca raphiophylla</i> and <i>Eucalyptus rudis</i> over <i>Bauhinia articulata</i> and <i>Lepidosperma longitudinale</i>
Mrpe	Low Woodland of <i>Melaleuca raphiophylla</i> over <i>Pteridium esculentum</i> , <i>Acacia saligna</i> and <i>Acacia rostellifera</i>
To	<i>Typha orientalis</i>
CcEg	<i>Corymbia calophylla</i> / <i>Eucalyptus gomphocephala</i>
CcEmEr	<i>Corymbia calophylla</i> / <i>Eucalyptus marginata</i> / <i>Eucalyptus rudis</i>
EgCc	<i>Eucalyptus gomphocephala</i> / <i>Corymbia calophylla</i>
EgEm	<i>Eucalyptus gomphocephala</i> / <i>Eucalyptus marginata</i>
EgG	<i>Eucalyptus gomphocephala</i> /Garden/non-endemic species
ErAs	<i>Eucalyptus rudis</i> / <i>Acacia saligna</i>
ErG	<i>Eucalyptus rudis</i> /Garden/non-endemic species
ErJf	<i>Eucalyptus rudis</i> / <i>Jacksonia furcellata</i>
QAf	Garden/non-endemic species/ <i>Allocasuarina fraseriana</i>
ToEr	<i>Typha orientalis</i> / <i>Eucalyptus rudis</i>
G	Garden/non-endemic species
PP	* <i>Pinus pinaster</i>
Rehabilitation Area	
Completely Degraded	
Built Environment	
Road	
Not Surveyed	



@75 @HMA5D	@YbX	Ba	EgLi	M	Cc/Em/Er	G
Development Envelope	BaBg	EgPe	Ma	Eg/Cc	PP	Completely Degraded
Survey Area	BmJf	Em	Mr	Eg/Em	Built Environment	Road
Rehabilitation Area	Cc	EmAf	MrEr	Eg/G	Priority 3 Species	Releve
Not Surveyed	CcEmBa	EmJf	MrLi	Er/As	Priority 3 Species	Releve
JY[YrUjcb' l b]jg	Ea	Er	Mrpe	Er/G	Priority 3 Species	Releve
Af	Eg	ErG	Ne	Er/Jf	Priority 3 Species	Releve
AfBa	EgEt	Jf	To	G/Af	Priority 3 Species	Releve
As			Cc/Eg	To/Er	Priority 3 Species	Releve

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HORIZONTAL DATUM GDA 1994 MGA Zone 50		PROJECT NO 1663		

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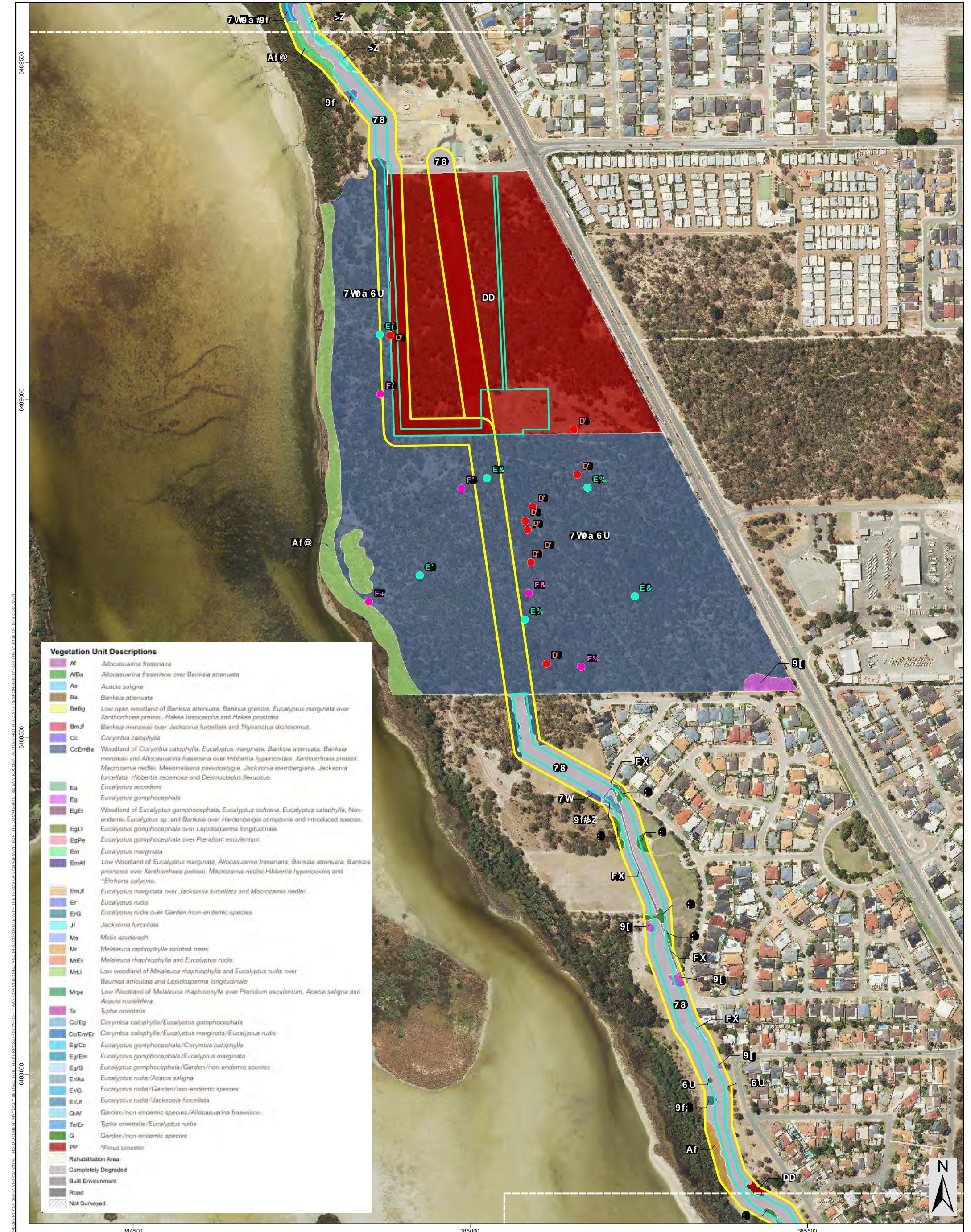
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 NOTE THAT POSITIONAL ERRORS MAY BE >5M IN SOME AREAS

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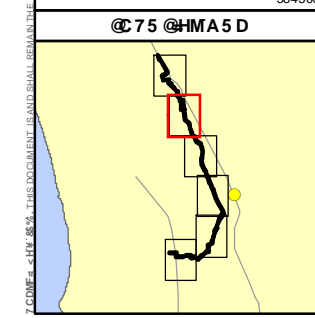
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Vegetation Unit Descriptions	
Af	<i>Allocasuarina fraseriana</i>
AfBa	<i>Allocasuarina fraseriana</i> over <i>Banksia attenuata</i>
As	<i>Acacia saligna</i>
Ba	<i>Banksia attenuata</i>
BaBg	Low open woodland of <i>Banksia attenuata</i> , <i>Banksia grandis</i> , <i>Eucalyptus marginata</i> over <i>Xanthorrhoea preissii</i> , <i>Hakea lasiocarpa</i> and <i>Hakea prostrata</i>
BmJf	<i>Banksia menziesii</i> over <i>Jacksonia furcellata</i> and <i>Thysanotus dichotomus</i>
Cc	<i>Corymbia calophylla</i>
CcEmBa	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 hypericoides</i> , <i>Xanthorrhoea preissii</i> , <i>Macrozamia riedlei</i> , <i>Mesomelaena pseudostygia</i> , <i>Jacksonia scarrbergiana</i> , <i>Jacksonia furcellata</i> , <i>Hibbertia racemosa</i> and <i>Desmodium flexuosum</i>
Ea	<i>Eucalyptus accedens</i>
Eg	<i>Eucalyptus gomphocephala</i>
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 comptonii</i> and introduced species, <i>Eucalyptus gomphocephala</i> over <i>Lepidosperma longitudoale</i>
EgLi	<i>Eucalyptus gomphocephala</i> over <i>Pteridium esculentum</i>
EgPe	<i>Eucalyptus gomphocephala</i> over <i>Pteridium esculentum</i>
Em	<i>Eucalyptus marginata</i>
EmAf	Low Woodland of <i>Eucalyptus marginata</i> , <i>Allocasuarina fraseriana</i> , <i>Banksia attenuata</i> , <i>Banksia prostrata</i> over <i>Xanthorrhoea preissii</i> , <i>Macrozamia riedlei</i> , <i>Hibbertia hypericoides</i> and <i>Ethriarta calycina</i>
EmJf	<i>Eucalyptus marginata</i> over <i>Jacksonia furcellata</i> and <i>Macrozamia riedlei</i>
Er	<i>Eucalyptus rudis</i>
ErG	<i>Eucalyptus rudis</i> over Garden/non-endemic species
Jf	<i>Jacksonia furcellata</i>
Ma	<i>Melia azedarach</i>
Mr	<i>Melaleuca raphiophylla</i> isolated trees
MrEr	<i>Melaleuca raphiophylla</i> and <i>Eucalyptus rudis</i>
MrLi	Low woodland of <i>Melaleuca raphiophylla</i> and <i>Eucalyptus rudis</i> over <i>Bauhinia articulata</i> and <i>Lepidosperma longitudoale</i>
Mrpe	Low Woodland of <i>Melaleuca raphiophylla</i> over <i>Pteridium esculentum</i> , <i>Acacia saligna</i> and <i>Acacia rostellifera</i>
To	<i>Typha orientalis</i>
CcEg	<i>Corymbia calophylla</i> / <i>Eucalyptus gomphocephala</i>
CcEmEr	<i>Corymbia calophylla</i> / <i>Eucalyptus marginata</i> / <i>Eucalyptus rudis</i>
EgCc	<i>Eucalyptus gomphocephala</i> / <i>Corymbia calophylla</i>
EgEm	<i>Eucalyptus gomphocephala</i> / <i>Eucalyptus marginata</i>
EgG	<i>Eucalyptus gomphocephala</i> /Garden/non-endemic species
ErAs	<i>Eucalyptus rudis</i> / <i>Acacia saligna</i>
ErG	<i>Eucalyptus rudis</i> /Garden/non-endemic species
ErJf	<i>Eucalyptus rudis</i> / <i>Jacksonia furcellata</i>
QAf	Garden/non-endemic species/ <i>Allocasuarina fraseriana</i>
ToEr	<i>Typha orientalis</i> / <i>Eucalyptus rudis</i>
G	Garden/non-endemic species
PP	* <i>Pinus pinaster</i>
	Rehabilitation Area
	Completely Degraded
	Built Environment
	Road
	Not Surveyed



@75 @HMA5D	Development Envelope	Ba	EgLi	M	Cc/Er/Em	G
@Y YbX	Survey Area	BaBg	EgPe	Ma	Eg/Cc	PP
	Rehabilitation Area	BmJf	Em	Mr	Eg/Em	Completely Degraded
	Not Surveyed	Cc	EmAf	MrEr	Eg/G	Built Environment
JY[YrUjcb' l b]jg		CcEmBa	EmJf	MrLi	Er/As	Road
	Af	Ea	Er	Mrpe	Er/G	Priority 3 Species
	AfBa	Eg	ErG	Ne	Er/Jf	Quadrat
	As	EgEt	Jf	To	G/Af	Releve
				Cc/Eg	To/Er	

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HORIZONTAL DATUM: GDA 1994 MGA Zone 50
 PROJECT NO: 1663

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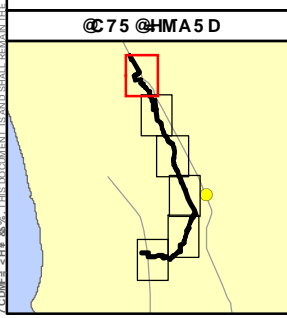
SLIP ENABLER
 NOTE THAT POSITIONAL ERRORS MAY BE >5M IN SOME AREAS

K:\Projects\1.0 EBS\1663 Beenyp Stage 3 Pipeline Surveys\Figures\September Flora Survey\1663 - Figure X Vegetation Units E.mxd



Vegetation Unit Descriptions

Af	Allocasuarina fraseriana
AfBa	Allocasuarina fraseriana over Banksia attenuata
As	Acacia saligna
Ba	Banksia attenuata
BaBg	Low open woodland of Banksia attenuata, Banksia grandis, Eucalyptus marginata over Xanthorrhoea preissii, Hakea lissocarpa and Hakea prostrata
BmJf	Banksia menziesii over Jacksonia furcellata and Thyasotus dichotomus
Cc	Corymbia calophylla
CcEmBa	Woodland of Corymbia calophylla, Eucalyptus marginata, Banksia attenuata, Banksia menziesii and Allocasuarina fraseriana over Hibbertia hypericoides, Xanthorrhoea preissii, Macrozamia nedleri, Mesomelaena pseudostygia, Jacksonia saembergiana, Jacksonia furcellata, Hibbertia racemosa and Desmodium flexuosum
Ea	Eucalyptus accedens
Eg	Eucalyptus gomphocephala
EgEt	Woodland of Eucalyptus gomphocephala, Eucalyptus totitiana, Eucalyptus calophylla, Non-endemic Eucalyptus sp. and Banksia over Hardenbergia comptonia and introduced species
EgLI	Eucalyptus gomphocephala over Lepidosperma longitudinale
EgPe	Eucalyptus gomphocephala over Pteridium esculentum
Em	Eucalyptus marginata
EmAl	Low Woodland of Eucalyptus marginata, Allocasuarina fraseriana, Banksia attenuata, Banksia prionotes over Xanthorrhoea preissii, Macrozamia nedleri, Hibbertia hypericoides and *Eriharta calycina
EmJf	Eucalyptus marginata over Jacksonia furcellata and Macrozamia nedleri
Er	Eucalyptus rudis
ErG	Eucalyptus rudis over Garden/non-endemic species
Jf	Jacksonia furcellata
Ma	Melia azedarach
Mr	Melaleuca raphiophylla isolated trees
MrEr	Melaleuca raphiophylla and Eucalyptus rudis
MrLI	Low woodland of Melaleuca raphiophylla and Eucalyptus rudis over Baumea articulata and Lepidosperma longitudinale
Mrpe	Low Woodland of Melaleuca raphiophylla over Pteridium esculentum, Acacia saligna and Acacia rostellifera
To	Typha orientalis
CcEg	Corymbia calophylla/Eucalyptus gomphocephala
CcEmEr	Corymbia calophylla/Eucalyptus marginata/Eucalyptus rudis
EgCc	Eucalyptus gomphocephala/Corymbia calophylla
EgEm	Eucalyptus gomphocephala/Eucalyptus marginata
EgG	Eucalyptus gomphocephala/Garden/non-endemic species
ErAs	Eucalyptus rudis/Acacia saligna
ErG	Eucalyptus rudis/Garden/non-endemic species
ErJf	Eucalyptus rudis/Jacksonia furcellata
G/Af	Garden/non-endemic species/Allocasuarina fraseriana
ToEr	Typha orientalis/Eucalyptus rudis
G	Garden/non-endemic species
PP	*Pinus pinaster
Rehabilitation Area	Rehabilitation Area
Completely Degraded	Completely Degraded
Built Environment	Built Environment
Road	Road
Not Surveyed	Not Surveyed



85H6 GCI F79G

Development Envelope	Ba	EgLI	M	Cc/Em/Er	G
Survey Area	BaBg	EgPe	Ma	Eg/Cc	PP
Rehabilitation Area	BmJf	Em	Mr	Eg/Em	Completely Degraded
Not Surveyed	Cc	EmAf	MrEr	Eg/G	Built Environment
JY[YrUjcb' l b]tg	CcEmBa	EmJf	MrLI	Er/As	Road
Af	Ea	Er	Mrpe	Er/G	Priority 3 Species
AfBa	Eg	ErG	Ne	Er/Jf	Releve
As	EgEt	Jf	To	G/Af	Bchf
			Cc/Eg	To/Er	Priority 3 species refers to Conosyris bracteata

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

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people planet professional

WATER CORPORATION

CREATED MH	CHECKED NW	APPROVED RF	REVISION 0	DATE 14/10/2016
HORIZONTAL DATUM GDA 1994 MGA Zone 50		PROJECT NO 1663		

0 25 50 100 150 200 250 Meters
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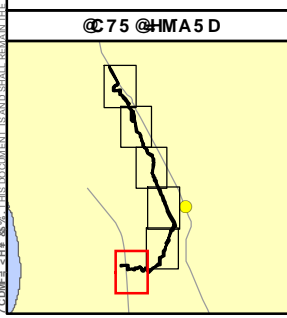
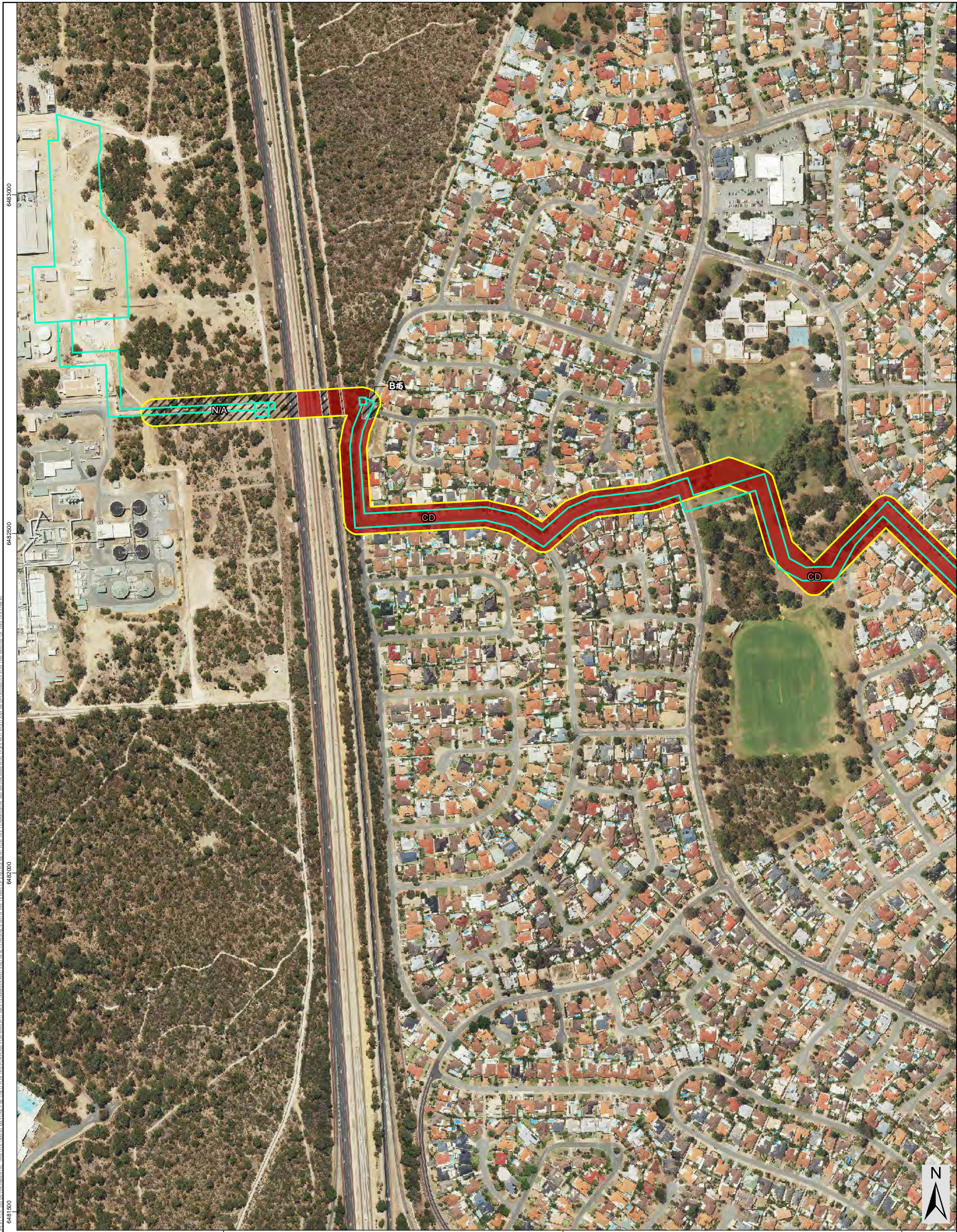
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Survey Area	; . 'Good (1.49 ha)	
Development Envelope	; 18 . 'Good-Degraded (1.63 ha)	
JY[YU]c b 7 c bX]hcb	8 . 'Degraded (0.19 ha)	
J ; . 'Very Good (0.27 ha)	7 8 . 'Completely Degraded (41.56 ha)	
; IJ ; . 'Good-Very Good (0.33 ha)	B#5 . 'Not Applicable (7.53 ha)	
85H5 'GCI F79G	BCH9	b#U indicates paved/built up (roads/paths/buildings) areas and areas
SLIP ENABLER		
<small>- LOCALITY MAP SOURCED LANDGATE 2016 - AERIAL PHOTOGRAPHY SOURCED LANDGATE 2014 © Western Australian Land Information Authority 2015</small>		

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people	planet	professional			
WATER CORPORATION					
CREATED MH	CHECKED NW	APPROVED RF	REVISION 0	DATE 14/10/2016	
HORIZONTAL DATUM GDA 1994 MGA Zone 50			PROJECT NO 1663		
 0 25 50 100 150 200 250 Meters 1:5,000 @ A3					

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