# Tonkin Grade Separated Interchanges

## Biological Survey and Targeted Black Cockatoo Habitat Assessment

MAIN ROADS WESTERN AUSTRALIA

FEBRUARY 2021

WOODMAN ENVIRONMENTAL

**TEL.** (08) 9315 4688
office@woodmanenv.com.au
PO Box 50, Applecross WA 6953
www.woodmanenv.com.au

**Tonkin Grade Separated Interchanges Biological Survey**

Prepared for: Main Roads Western Australia

Job Number: MR19-34

Report Number: MR19-34-01

Cover Photograph: *Diuris magnifica* recorded near quadrat GSI-06 (Woodman Environmental 2019)

**DOCUMENT REVISION AND STATUS**

| Revision | Status | Originator | Internal Reviewer | Internal Review Date | Client Reviewer | Client Review Date |
|---|---|---|---|---|---|---|
| A | Draft Report | KK/AS/MS and BCE | CG/GW | 29/6/2020 | JT | 10/7/2020 |
| 0 | Final Report | KK/AS/MS and BCE | AS/CG/GW | 31/7/2020 | JT | 5/8/2020 |
| 1 | Final Report | KK/AS/MS and BCE | AS/CG | 11/8/2020 | LZ | 15/1/2021 |
| 2 | Final Report | KK/AS/MS and BCE | CG | 18/2/2021 | | |
| | | | | | | |
| | | | | | | |

**DISCLAIMER**

# TABLE OF CONTENTS

**FIGURES**



**TABLES**

**PLATES**

**APPENDICES**

# EXECUTIVE SUMMARY

Main Roads Western Australia (Main Roads) is proposing to develop grade-separated interchanges at three intersections of Tonkin Highway ('the Project'). To inform the environmental impact assessment (EIA) process, Main Roads commissioned Woodman Environmental Consulting Pty Ltd (Woodman Environmental) to conduct a biological survey to identify the key flora, fauna, soil, groundwater and surface water values associated with the Project. Fauna survey works and reporting was provided by Bamford Consulting Ecologists.

The flora and vegetation field survey involved multiple aspects including sampling via quadrats and targeted significant flora searching in specific areas, and was undertaken over seven visits as listed below:

- 27th and 29th August 2019 (reconnaissance and targeted flora survey);
- 17th–20th September 2019 (detailed vegetation survey);
- 1st–3rd October 2019 (detailed vegetation survey);
- 16th and 22nd October 2019 (detailed vegetation survey);
- 26th–28th November 2019 (targeted flora survey);
- 17th–18th December 2019) (targeted flora survey); and
- 17th and 19th March 2020) (targeted flora survey).

A total of 33 non-permanent flora survey quadrats measuring 10 m x 10 m were surveyed in the Assessment Area, with 48 relevés surveyed in areas where limited extent or condition of vegetation precluded quadrat establishment. As much of the Assessed Area is located in cleared or highly modified farmland, areas that were clearly highly modified were sampled via a brief inspection, either on foot or from a vehicle, with notes and photographs taken.

A total of 355 discrete vascular flora taxa were recorded during this survey, representing 67 families and 202 genera. Sixty-eight of the total taxa recorded are introduced taxa. Eleven significant flora were recorded by this survey, including four Threatened taxa and seven Priority flora taxa. These were:

- *Andersonia gracilis* (T);
- *Banksia mimica* (T);
- *Byblis gigantea* (P3);
- *Conospermum undulatum* (T);
- *Isopogon autumnalis* (P3);
- *Jacksonia gracillima* (P3);
- *Johnsonia pubescens* subsp*. cygnorum* (P2);
- *Lasiopetalum bracteatum* (P4);
- *Styphelia filifolia* (P3);
- *Tetraria australiensis* (T); and
- *Verticordia lindleyi* subsp*. lindleyi* (P4).

Eight Vegetation Type (VTs) were defined and mapped within the Survey Area. Seven of these were defined via floristic composition classification, using the results of a classification analysis of quadrat data from the Survey Area. One VT was defined via structural vegetation

classification. Additionally, a number of types of highly modified and revegetated areas were mapped. Additional analyses of quadrat data with the Swan Coastal Plain (SCP) dataset were undertaken with the aim of aligning VTs with SCP Floristic Community Types to assess the significance of the vegetation recorded during the survey.

Two significant vegetation types were identified and mapped in the Survey Area by this survey and three additional significant vegetation types were identified as potentially occurring in the Survey Area with more data required to confirm these occurrences. These are:

- SCP20a - *Banksia attenuata* woodland over species rich dense shrublands (Endangered - WA, forms part of the Commonwealth TEC 'Banksia woodlands of the Swan Coastal Plain');
- Banksia woodlands of the Swan Coastal Plain (Endangered - Commonwealth; Priority 3 – WA);
- Potential SCP20c – Shrublands and Woodlands of the eastern side of the Swan Coastal Plain (Endangered - Commonwealth; Critically Endangered – WA);
- Potential SCP3a – *Corymbia calophylla – Kingia australis* woodlands on heavy soils, Swan Coastal Plain (Endangered - Commonwealth; Critically Endangered – WA); and
- Potential SCP3c – *Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain (Endangered - Commonwealth; Critically Endangered – WA);

The desktop fauna study identified 233 vertebrate fauna species as potentially occurring in the Survey Area: 4 fish, 11 frogs, 40 reptiles, 158 birds and 20 mammals. An additional eight species (2 reptiles, 1 bird and 5 mammals) are considered locally extinct.

Seven major vegetation and substrate associations (VSAs) were identified within the Survey Area during the field surveys carried out on the 13th of September, 2nd to 8th October and 14th and 19th of November 2019.

The fauna study listed 67 species of conservation significance including 31 species that are expected to be resident or regular migrants/visitors to the Survey Area and Development Envelope. The three species of Black-Cockatoo (Forest Red-tailed, Carnaby's and Baudin's Black-Cockatoo) are of the highest level of conservation significance (CS1) and have all been recorded. Surveys for potential nest-trees and forage value mapping were completed for the Development Envelope for these species. Quenda (CS2) appear to make extensive use of the area. A range of CS1 and CS2 short-range endemic invertebrates are known from the broader region but limited ecological information means that it is difficult to ascertain their expected status in the Survey Area. Most of the other conservation significant species that are likely to regularly occur within the Survey Area are lower significance level (CS3) birds that have reduced populations on the Swan Coastal Plain.

# 1. INTRODUCTION

## 1.1 Project Overview

Main Roads Western Australia (Main Roads) is proposing to develop grade-separated interchanges at three intersections of Tonkin Highway ('the Project') including:

- Hale Road in Forrestfield (SLK 16.26);
- Welshpool Road in Wattle Grove (SLK 18.80); and
- Kelvin Road in Orange Grove (SLK 22.40).

Grade separation at the proposed locations is necessary to reduce potential vehicular conflict and improve traffic times, congestion and both vehicle and pedestrian safety.

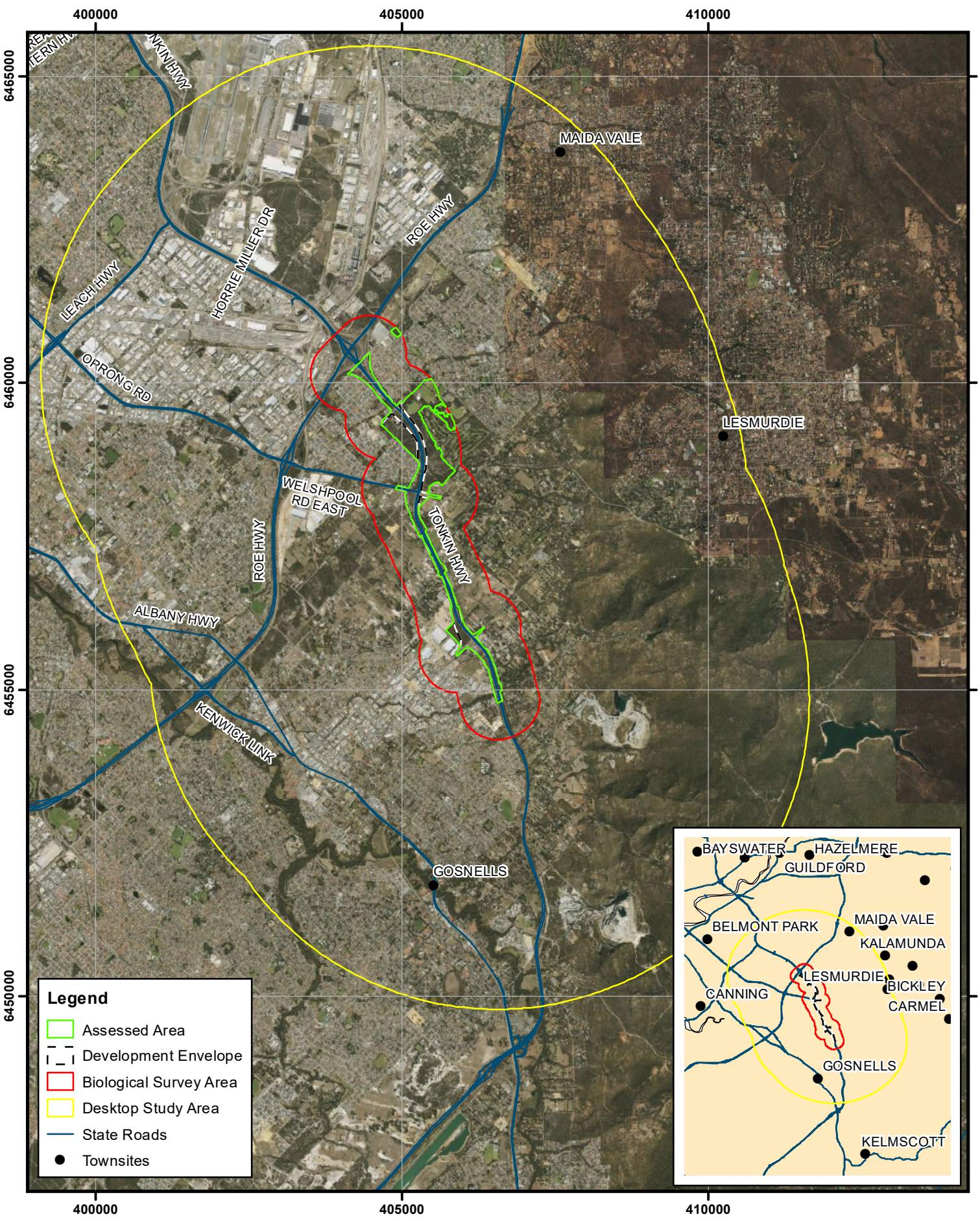
To inform the environmental impact assessment (EIA) process, Main Roads commissioned Woodman Environmental Consulting Pty Ltd (Woodman Environmental) to conduct a biological survey to identify the key flora, fauna, soil, groundwater and surface water values associated with the Project. Bamford Consulting Ecologists undertook the fauna survey and reporting portions of the works.

## 1.2 Survey Area, Assessment Area and Development Envelope Definition

Main Roads has provided the Development Envelope and Biological Survey Area ('the Survey Area'), as presented on Figure 1. The Survey Area encompasses 1068.98 hectares (ha) and is located within the Shire of Kalamunda and City of Gosnells, approximately 12 kilometres (km) south-east of the Perth Central Business District. The Survey Area is located within the Perth Interim Biogeographic Regionalisation for Australia (IBRA) subregion, which has been highly modified due to clearing and other associated impacts. The Development Envelope is located within the Survey Area and encompasses a total of 95.85 ha.

The entire Survey Area was not surveyed primarily due to issues associated with access. The survey focused on all areas within the Development Envelope and blocks of remnant vegetation within the Survey Area which could be accessed and had similar vegetation to the Development Envelope. Areas which were not surveyed are displayed as not assessed (NA) in the results of this report. The total area surveyed and mapped was 177.9 ha and is referred to as the Assessed area.

A Desktop Study Area, for interrogation of databases and searches for relevant literature, has been defined. The Desktop Study Area encompasses a 5 km buffer the Development Envelope, as shown on Figure 1.




| | | |
|---|---|---|
| **Study and Survey Area Parameters** | Author: Marlee Starcevich | |
| | WEC Ref: MR19-34-01 | |
| WOODMAN ENVIRONMENTAL | Filename: MR19-34-01-f01 | **Figure** |
| | Scale: 1:80,000 (A4) | 1 |
| | Projection: GDA 1994 MGA Zone 50 | |
| This map should only be used in conjunction with WEC report MR19-34-01. | Revision: 0 - 30 July 2020 | |

## 1.3 Aim and Objectives

The primary aim of the survey was to provide relevant biological information to support the EIA approvals process for the Project.

The overall objectives of the assessment were to:

- Compile an inventory of vascular flora taxa that occur in assessed areas within the Assessed Area;
- Search for and census populations of significant flora taxa identified occurring or potentially occurring within the Assessed Area, with such taxa defined as one of the following (hereafter referred to as significant flora taxa), to provide context for impact assessment:
    - Listed Threatened species (T) under the *Environment Protection and Biodiversity Conservation* Act *1999* (EPBC Act) (Commonwealth);
    - Threatened flora (T) under the *Biodiversity Conservation Act 2016* (BC Act) (WA);
    - Priority flora taxa (P) as classified by the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA); and
    - Other significant flora taxa as defined by the Environmental Protection Authority (EPA) (2016a; b).
- Identify locations and determine the extent of introduced vascular flora taxa, with particular focus on those that are Weeds of National Significance (WoNS), or Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act);
- Identify, map and describe Vegetation Types (VTs) that occur within the Assessed Area;
- Describe and map vegetation condition within the Assessed Area as per the vegetation condition scale presented in EPA (2016a) (Appendix A);
- Identify, map and describe vegetation that occurs within the Assessed Area that is one of the following (hereafter referred to as significant vegetation), to provide context for impact assessment:
    - Listed Threatened Ecological Communities (TECs) under the EPBC Act;
    - TEC as classified by DBCA and endorsed by the Western Australian (WA) Minister for the Environment;
    - Priority Ecological Communities (PECs) as classified by DBCA;
    - Areas of wetland or riparian vegetation that is ground or surface water-dependent; and
    - Other significant vegetation as defined by EPA (2016a; b).
- Identification and mapping of Black Cockatoo foraging habitat, roosting, potential breeding and actual breeding trees as per Commonwealth guidelines. Black Cockatoo data should include a shapefile for foraging habitat in the survey area. The number and size of hollows shall be included in the metadata for potential and actual breeding tree shapefiles. Locating potential and actual breeding trees should be done with a differential GPS and be provided to Main Roads as a point Shapefile
- Black Cockatoo hollow survey to include measurement of hollow aperture sizes, depth of hollows, angle of hollows and suitability/evidence of hollow use by Black Cockatoos

with the use of a pole camera. The detailed survey needs to be undertaken during the Black Cockatoo breeding season (Sept/Oct 2019) to determine presence of the species
- Identification and mapping of fauna habitat. Habitat mapping should be based on vegetation types and the report should include a summary of which vegetation types are suitable for each conservation significant fauna considered likely or possible to occur, or fauna recorded in the survey area.

The survey and reporting works comply with the following documents:
- Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a);
- Environmental Factor Guideline – Flora and Vegetation (EPA 2016b);
- Technical Guidance – Terrestrial Fauna Surveys (EPA 2016c);
- Environmental Factor Guideline – Terrestrial Fauna (EPA 2016d); and
- Referral Guidelines for three threatened black cockatoo species: Carnaby's Cockatoo, Baudin's Cockatoo and Forest Red-tailed black cockatoo (Department of Agriculture, Water and the Environment (DAWE) 2012).

## 1.4 Level of Assessment

### 1.4.1 Flora and Vegetation

The flora and vegetation assessment of the Survey Area was comprised of a Detailed Survey and Targeted Survey as defined in Section 4.3 of the 'Technical Guidance for Flora and Vegetation Surveys for Environmental Impact Assessment' (EPA 2016a). This is considered appropriate for the Survey Area, as it is likely to support a high diversity of flora and vegetation, may comprise restricted landforms or vegetation types, and is likely to support significant flora or vegetation, as outlined in Section 4.3 of the 'Technical Guidance for Flora and Vegetation Surveys for Environmental Impact Assessment' (EPA 2016a).

### 1.4.2 Fauna

The fauna assessment of the Survey Area was comprised of a Level 1 fauna survey (including both a desktop study and Reconnaissance survey) as defined in Appendix 2 of the 'Technical Guidance – Terrestrial Fauna Surveys' (EPA 2016c). Additional targeted surveys for significant fauna and/or their habitats, including black-cockatoos, were undertaken, as per EPBC Act referral guidelines (DAWE 2012). This was deemed an appropriate level of survey given that the vertebrate fauna of this region has been well surveyed and the scale of the impact (as defined in EPA 2016c) is likely to be moderate to low.

# 2. BACKGROUND

## 2.1 Climate

The Survey Area is located within Swan Coastal Plain (SCP) subregion (Drummond Botanical Subdistrict) of the South-West Forest region as defined by Beard (1990). The climate is classified as warm Mediterranean, with rainfall received mainly during May to September with 5–6 dry months per year (Beard 1990).

Figure 2 presents monthly precipitation totals and mean maximum temperature for 2019 as well as long-term average monthly maximum temperature and long-term average monthly precipitation data (1944–2019) for Perth Airport, the most relevant meteorological station to the Survey Area (Bureau of Meteorology 2020a).

The precipitation recorded from May to August, the period considered to be the most relevant in terms of promoting plant growth and flowering in the region, was well below average (405.6 mm received in 2019 compared to the long-term average of 527.4 mm). In addition, below-average precipitation continued throughout September to December in 2019 and above-average daily maximum temperatures were recorded from February to December (Figure 2).

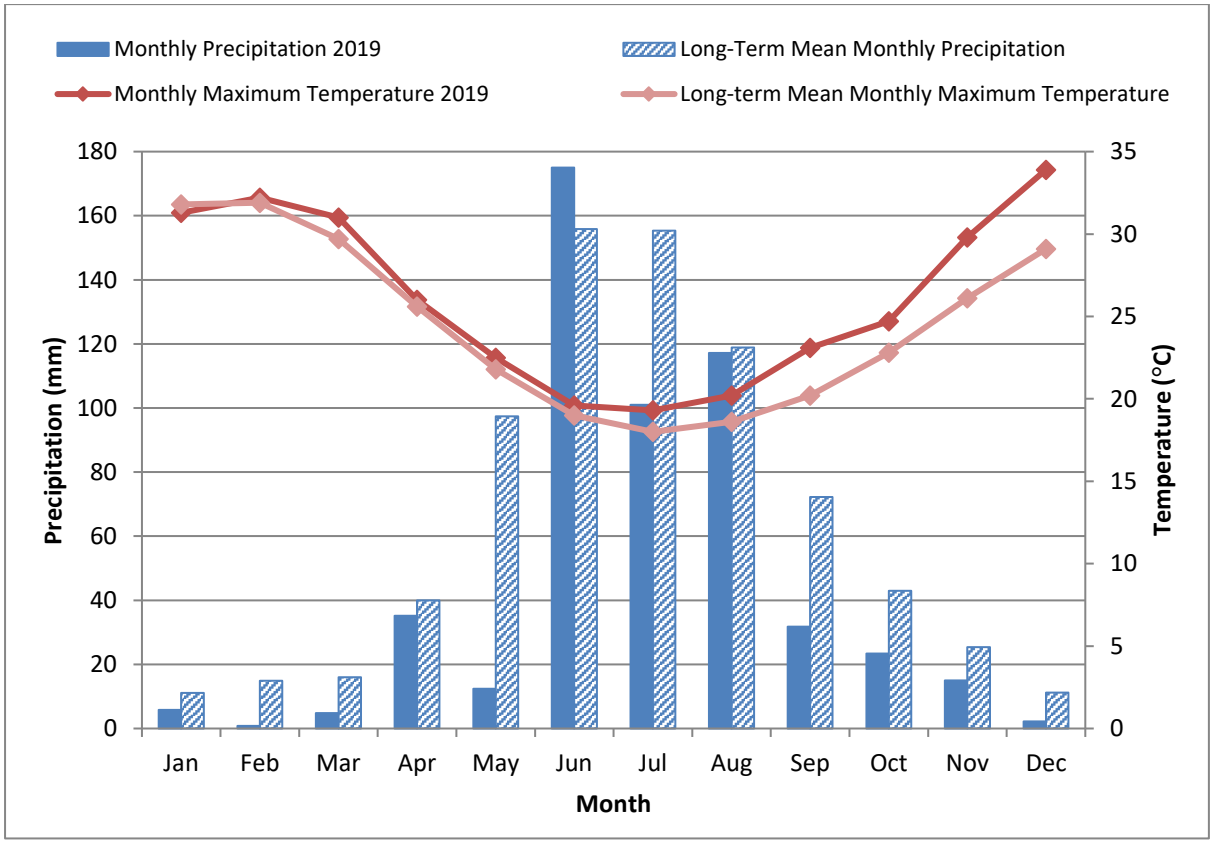



**Figure 2: Average Monthly Maximum Temperature and Total Precipitation for 2019, and Long-term Average Monthly Maximum Temperature and Precipitation for Perth Airport (Bureau of Meteorology 2020a)**

## 2.2 Geology, Landforms and Soils

The Survey Area is located in the SCP subregion as defined by Beard (1981; 1990), which is equivalent to the SCP IBRA region, and specifically the Perth (SWA-2) IBRA subregion (Commonwealth of Australia 2012). The SCP subregion consists of a coastal plain of low-lying, often swampy areas and sandhills, with soils consisting of sands or swamp deposits as well as dissected country rising to the duricrusted Dandaragan Plateau on Mesozoics consisting of mainly yellow sandy soils. The geology of the region is Mesozoic to recent sediments of the Perth Basin (Beard 1990).

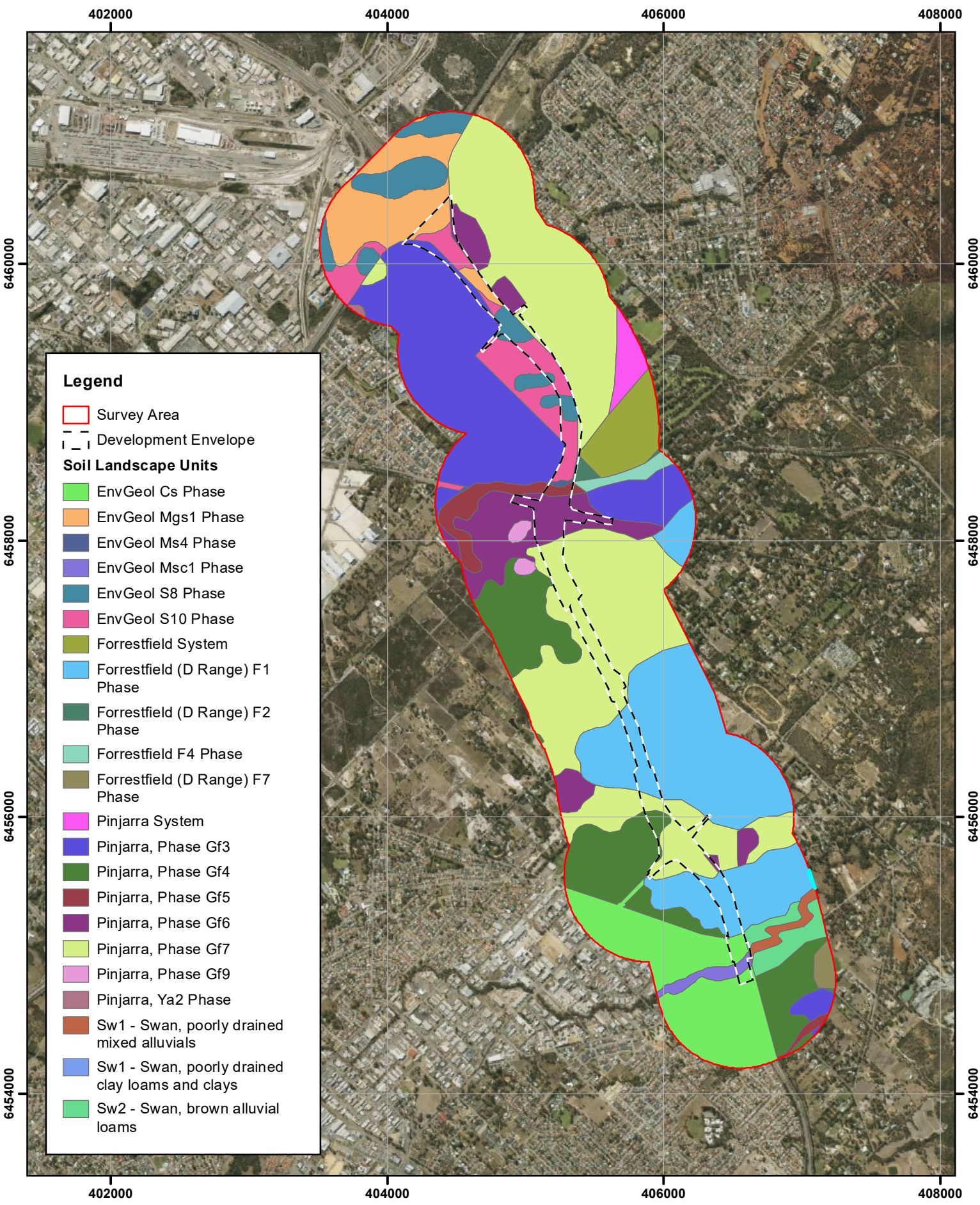
The Survey Area occurs within the Bassendean and Pinjarra Soil-Landscape Zones of the Swan Province. The Bassendean Zone is described as consisting of Mid-Pleistocene Bassendean sand and fixed dunes inland from the coastal dune zone, with non-calcareous sands and podsolised soils with low-lying wet areas. The Pinjarra Zone is described as consisting of early Pleistocene to Recent Alluvial deposits between the Bassendean Dunes Zone and the Darling Scarp, with colluvial and shelf deposits adjacent to the Darling Scarp. The Zone comprises clayey to sandy alluvial soils with wet areas (Purdie *et al.* 2004).

A total of 22 soil-landscape units are mapped within the Survey Area as presented in Figure 3 and defined in Table 1 (DPIRD 2019).

**Table 1: Soil Landscape Units of the Survey Area (DPRID 2019)**

| Unit Name | Description |
|---|---|
| EnvGeol Cs Phase | SANDY CLAY - white-grey to brown, fine to coarse-grained, subangular to rounded sand, clay of moderate plasticity gravel and silt layers near scarp |
| EnvGeol Mgs1 Phase | PEBBLY SILT - strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand |
| EnvGeol Ms4 Phase | SANDY SILT - light yellow brown, blocky, mottled, some fine to medium-grained sand, soft when moist, variable clay content |
| EnvGeol Msc1 Phase | CLAYEY SANDY SILT - pale brown, angular to rounded sand, low cohesion, of alluvial origin |
| EnvGeol S10 Phase | SAND - as S8 as relatively thin veneer over sandy clay to clayey sand. Of eolian origin |
| EnvGeol S8 Phase | SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin |
| Forrestfield (D Range) F1 Phase | Foot and low slopes < 10 % with deep rapidly drained siliceous yellow brown sands, and pale or bleached sands with yellow-brown subsoil. Shrubland of unidentified species |
| Forrestfield (D Range) F2 Phase | Foot and low slopes < 10 %. Well drained gravelly yellow or brown duplex soils with sandy topsoil. Woodland of *E. marginata*, *C. calophylla* and some *B. grandis* |
| Forrestfield (D Range) F7 Phase | Alluvial fans on slopes |
| Forrestfield F4 Phase | Incised stream channels within gentle slopes with deep acidic yellow duplex soils and sandy alluvial gradational brown earths |
| Forrestfield System | Undulating foot slopes of the Darling and Whicher Scarps. Duplex sandy gravels, pale deep sands and grey deep sandy duplexes. Woodland of *E. marginata*, *C. calophylla* and *E. wandoo* and some *B. grandis* |
| Pinjarra System | Swan Coastal Plain from Perth to Capel. Poorly drained coastal plain with variable alluvial and aeolian soils. Variable vegetation includes |

| Unit Name | Description |
|---|---|
| | Jarrah, marri, wandoo, paperbark sheoaks and rudis |
| Pinjarra, Phase Gf3 | Level to very gently sloping plain. Poorly drained mottled yellow earths with loamy topsoil. Low woodland of *Melaleuca* spp., and *E. rudis*. *Casuarina obesa* on salt affected areas |
| Pinjarra, Phase Gf4 | Level to very gently inclined alluvial fans. Variable imperfectly drained soils with layers of sand, sandy loam, clay, grit and weathered granitic detritus. *C. calophylla*. *E. rudis* & *Melaleuca* spp. along streams. *Casuarina* on salt land |
| Pinjarra, Phase Gf5 | Incised drainage channels with poorly drained gradational mottled yellow earths. Shrubland of Melaleucas and other low shrubs |
| Pinjarra, Phase Gf6 | Seasonally inundated swamps with very poorly drained uniform non-cracking clays |
| Pinjarra, Phase Gf7 | Minor rises with deep rapidly drained brownish, siliceous or bleached sands underlain by mottled yellow clay. Low woodland of *B. prionotes* and some tall *C. calophylla* with *E. rudis* along streamlines |
| Pinjarra, Phase Gf9 | Minor sandy rises (aeolian deposits) with moderately deep well drained sands overlying gravelly mottled clay |
| Pinjarra, Ya2 Phase | Seasonally inundated swamps with shallow very poorly drained grey siliceous sand over clay |
| Sw1 - Swan, poorly drained clay loams and clays | Low level, occasionally flooded alluvial terraces with poorly drained variable alluvial soils with dark greyish brown clay loam to clay surfaces |
| Sw1 - Swan, poorly drained mixed alluvials | River margins and low flats with poorly drained variable alluvial soils, subject to frequent flooding |
| Sw2 - Swan, brown alluvial loams | Low level, occasionally flooded, alluvial terraces with imperfectly drained variable alluvial soils with loamy surfaces |




**Soil Landscape Units of the Survey Area**

Author: Marlee Starcevich

WEC Ref: MR19-34-01

WOODMAN ENVIRONMENTAL

Filename: MR19-34-01-f03

Scale: 1:35,000 (A4)

Projection: GDA 1994 MGA Zone 50

Revision: 0 - 30 July 2020

**Figure 3**

This map should only be used in conjunction with WEC report MR19-34-01.

## 2.3 Groundwater and Surface Water Values

The wetlands on the SCP have been mapped, evaluated and assigned a management category that provides guidance on how they should be managed and protected (Hill *et al*. 1996). Wetlands are classified by combining hydrological attributes and landform types as described in the methodology for the evaluation of wetlands on the SCP (DBCA 2017b). There are two types of wetlands within the Survey Area as listed below:

- Palusplain: seasonally waterlogged flat; and
- Creek: seasonally inundated channel.

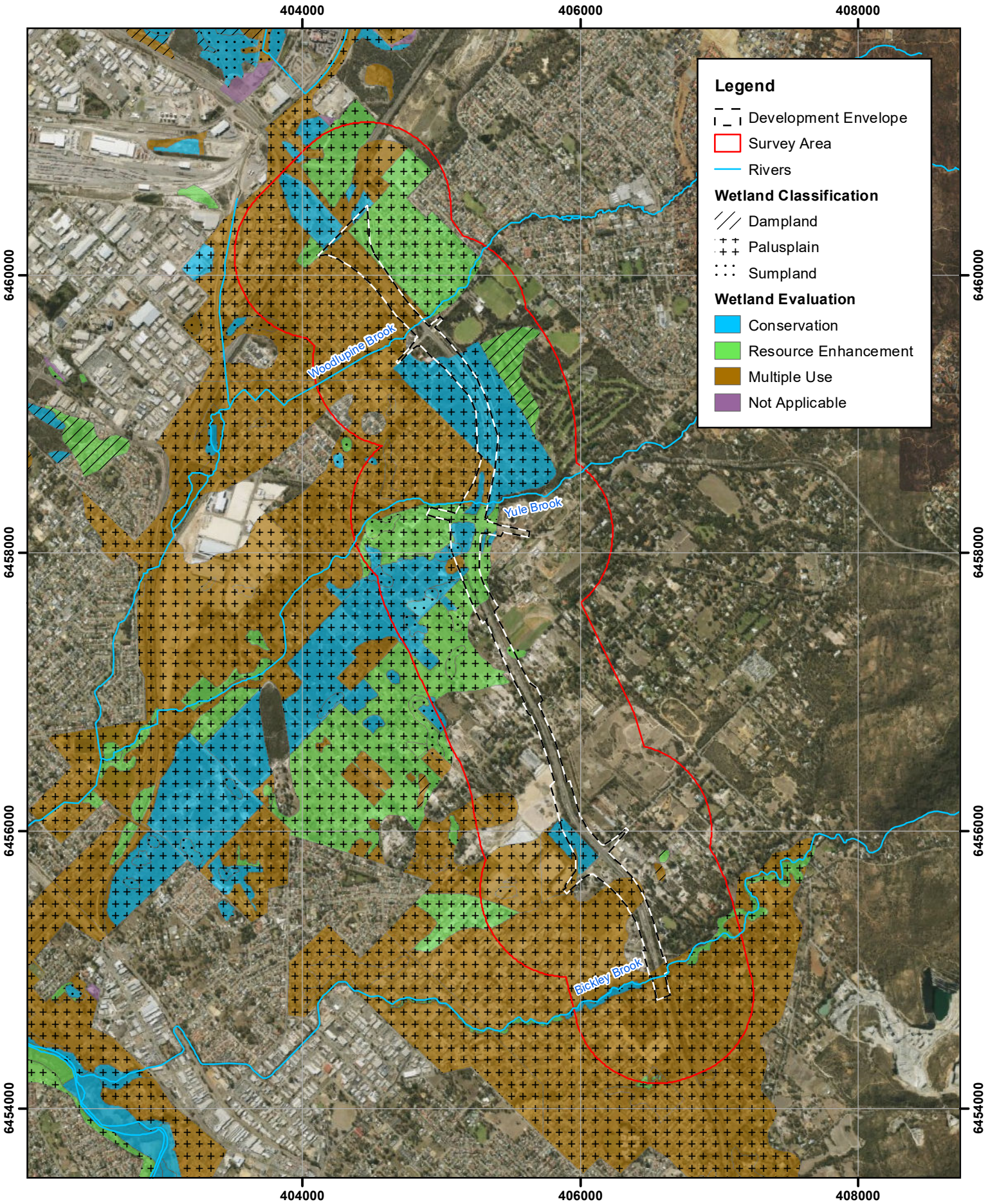
In addition, wetlands have been evaluated and classified into three management categories including Conservation wetlands (Highest priority wetlands), Resource Enhancement wetlands (Priority wetlands) and Multiple Use wetlands (DBCA 2017b).

Development or clearing of Conservation category wetlands is not considered appropriate, as these wetlands are regarded as the most valuable wetlands and any activity that may lead to further loss or degradation is therefore inappropriate. Resource Enhancement category wetlands are viewed as having the potential to be managed, restored and protected with the objective of improving their conservation value and hydrological/hydrogeological regime. The use, development and management of Multiple Use wetlands should be considered in the context of ecologically sustainable development and best management practice catchment planning with their role in managing the natural hydrological and hydrogeological regime of the general area maintained (DBCA 2017b).

Figure 4 presents the geomorphic wetlands mapped within the Survey Area (DBCA 2020a). Areas of Conservation category palusplains occur in the Development Envelope, primarily associated with Hartfield Park in Forrestfield and Bush Forever Site 53 in Orange Grove; however, the largest wetland areas of the Survey Area are classified as Multiple Use and Resource Enhancement palusplains. Woodlupine Brook (located to the north of Hartfield Park, north of Hale Road intersection) and Yule Brook (located in the southern section of Hartfield Park, north of Welshpool Rd intersection) are both mapped as 'Resource Enhancement' palusplain in the eastern section of the Survey Area, and 'Multiple Use' palusplain on the western side. Bickley Brook is located at the southern extent of the Survey Area; the area where it crosses the Development Envelope is classified as 'Multiple Use' palusplain, with 'Conservation' and 'Resource Enhancement' categories mapped within the Survey Area (Figure 4).

In a local groundwater context, according to the Bureau of Meteorology's 'Groundwater Dependent Ecosystem (GDE) Atlas' the majority of the Survey Area is located in Moderate Potential GDE (national assessment) with some areas being located in High Potential GDE (national assessment) and a very small area being located in Known GDE (regional study) (Aquatic GDE) (Bureau of Meteorology 2020b). Aquatic GDEs are described as 'ecosystems that rely on the surface expression of groundwater–this includes surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs' (Bureau of Meteorology 2020b).

.



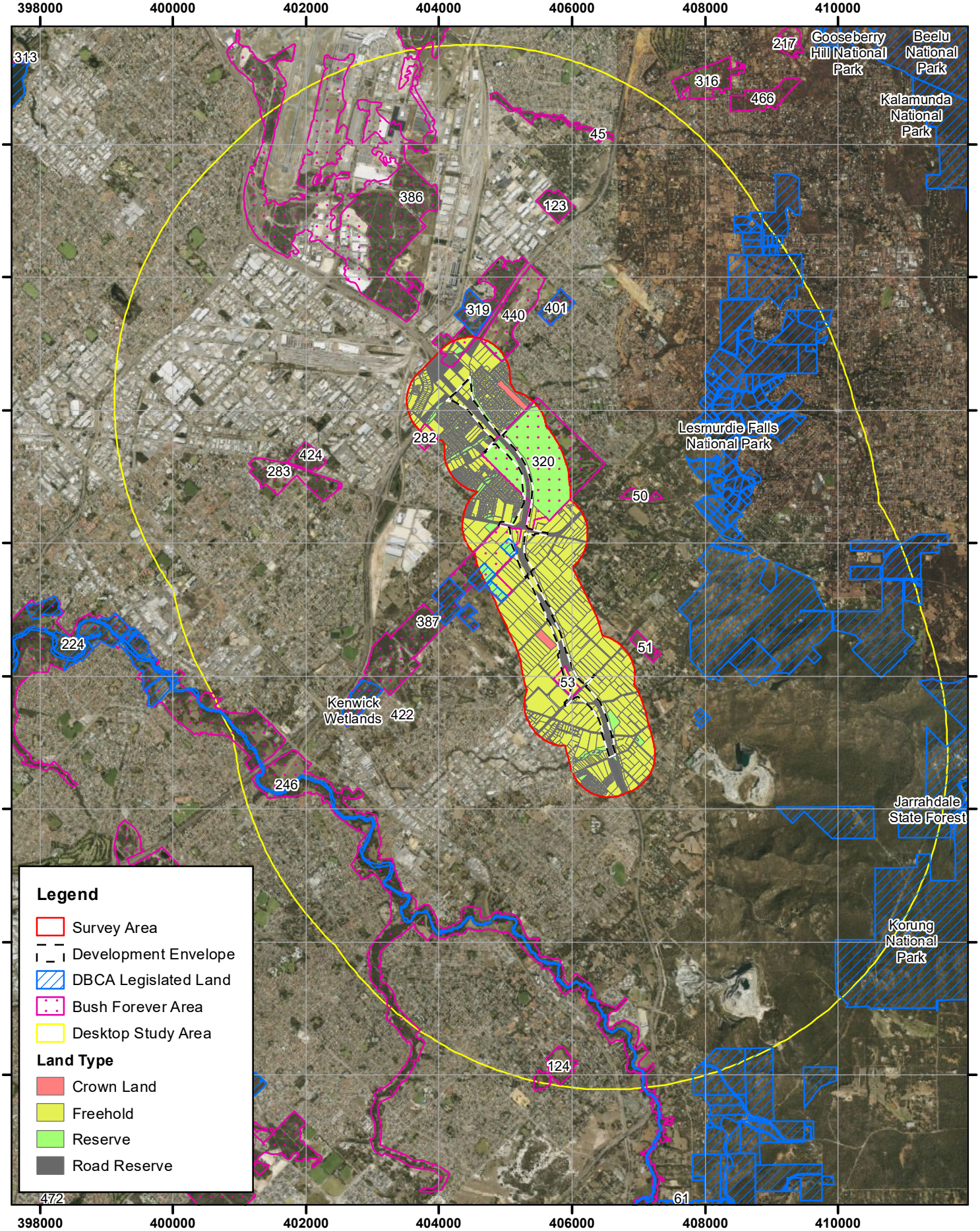

| | | |
|---|---|---|
| **Geomorphic Wetlands Mapping of the Survey Area** | Author: Marlee Starcevich | N |
| | WEC Ref: MR19-34-01 | |
| WOODMAN ENVIRONMENTAL | Filename: MR19-34-01-f04 | **Figure** |
| | Scale: 1:35,000 (A4) | 4 |
| | Projection: GDA 1994 MGA Zone 50 | |
| This map should only be used in conjunction with WEC report MR19-34-01. | Revision: 0 - 30 July 2020 | |

The search of the DAWE Species Profile and Threats (SPRAT) Database with regard to MNES listed under the EPBC Act identified one Wetland of International Importance (Ramsar), being the Forrestdale and Thomsons Lakes. However, this wetland is located outside the Desktop Study Area, approximately 18 km south-west of the Survey Area.

## 2.4 Land Tenure

The majority of the Survey Area is comprised of Freehold land with the remainder consisting of areas of Crown Land, Reserves and Road Reserve (Figure 5). There are two small DBCA reserves in the Survey Area itself including the Brixton Street Wetlands and an unnamed reserve (these are north-east of the Kenwick Wetlands) (Figure 5).

There are several DBCA reserves in the Desktop Study Area including Kenwick Wetlands, Korung National Park, Lesmurdie Falls National Park and a number of unnamed reserves.




| | | |
|---|---|---|
| **Land Tenure of the Desktop Study Area** | Author: Marlee Starcevich | N |
| | WEC Ref: MR19-34-01 | |
| WOODMAN ENVIRONMENTAL | Filename: MR19-34-01-f05 | **Figure** |
| | Scale: 1:75,000 (A4) | 5 |
| | Projection: GDA 1994 MGA Zone 50 | |
| This map should only be used in conjunction with WEC report MR19-34-01. | Revision: 0 - 30 July 2020 | |

# 3. METHODS

## 3.1 Flora and Vegetation

### 3.1.1 Desktop Study Methods

Prior to commencement of the field survey, a review of all publicly available flora and vegetation data relevant to the Desktop Study Area was undertaken. This included obtaining and reviewing copies of reports of previous biological surveys carried out within the vicinity of the Survey Area (where available) (including interrogation of the Index of Biodiversity Surveys for Assessments (IBSA) website) and interrogation of relevant databases and other sources as listed in Table 2.

**Table 2: Searches Undertaken for the Desktop Study (Flora and Vegetation)**

| Source | Search Attributes | Search Purpose |
|---|---|---|
| DBCA Threatened and Priority Ecological Communities Database (data provided by Main Roads – DBCA 2019b) | Database interrogated using Desktop Study Area boundary | Obtain records of WA TECs and/or DBCA-classified PECs within the Desktop Study Area |
| DBCA TEC and PEC lists (DBCA 2018; DBCA 2020b) | Review of current DBCA TEC and PEC lists | Identify whether there are any additional DBCA-listed TECs or PECs that could occur within the Desktop Study Area |
| DBCA Significant Flora Databases (WA Herbarium specimen database and Threatened and Priority Flora (TPFL) database) (data provided by Main Roads) | Database interrogated using Desktop Study Area boundary | Obtain records of listed significant flora within the Desktop Study Area |
| DAWE SPRAT Database (interrogated using the Protected Matters Search Tool) (DAWE 2019) | Database interrogated using approximate Desktop Study Area boundary (exact boundary cannot be used) | Identify Matters of National Environmental Significance (MNES), including Threatened flora and TECs, listed under the EPBC Act, that occur or have the potential to occur within the Desktop Study Area |
| DBCA *NatureMap* (WA Herbarium and TPFL records) (DBCA 2007-) | Database interrogated using approximate Desktop Study Area boundary (exact boundary cannot be used) | Obtain records of listed significant flora and introduced flora within the Desktop Study Area |
| 2018 Statewide Vegetation Statistics (formerly the CAR Reserve Analysis) (Government of Western Australia 2019a and b) | Survey Area | Identify extent of Vegetation System Associations within the Survey Area |

### 3.1.2 Personnel and Licensing

Table 3 lists the personnel involved in both fieldwork and plant identifications for survey. The Project Manager (Kim Kershaw) has extensive experience (> 10 years) in conducting similar flora surveys in the SCP bioregion. David Coultas has extensive experience in undertaking plant identifications of flora from the SCP. All plant material was collected under the *Flora Taking (Biological Assessment) licences* and *Authorisation to Take or Disturb Threatened Species* pursuant to the *Biodiversity Conservation Act 2016*, sections 40, 274 and 275, as listed in Table 3.

**Table 3: Personnel and Licensing Information (Flora and Vegetation)**

| Personnel and Qualifications | Flora Collecting Permit (BC Act) | Experience in the SCP bioregion | Role |
|---|---|---|---|
| Kim Kershaw<br>BSc (Environmental Science) | FB62000054<br>TFL22-1819 | >20 years | Project Manager/ Field Manager |
| David Coultas<br>BSc (Environmental Biology) (Hons) | FB62000051<br>TFL23-1819 | >10 years | Field survey / Plant identifications |
| Marlee Starcevich<br>BSc (Environmental Science) (Hons) | FB62000056<br>TFL26-1819 | >2 years | Field survey / Plant identifications |
| Emalyn Loudon<br>BAg (Hons) | - | >3 years | Field survey |
| Emma Marsh<br>BSc (Biology and Conservation Science) | FB62000233 | <1 year | Field survey |
| Greg Woodman<br>BSc (Environmental Science) (Hons) | FB62000053<br>TFL19-1819 | >20 years | Field survey |
| Jaroslav Hruban<br>BSc (Botany) (Hons)<br>Mgr (Ecological and Evolutionary Biology) | FB62000251 | < 1 year | Field survey |
| Leah Firth<br>BSc (Conservation Biology) | FB62000055<br>TFL145-1920 | < 1 year | Field survey |
| Marco Pratissoli<br>PgD (Environmental Biology and Management) | FB62000057<br>TFL143-1920 | >2 years | Field survey |

### 3.1.3 Aerial Photography Interpretation and Survey Design

Initial interpretation of ortho-rectified aerial photography at a scale of 1:5,000 was conducted to determine preliminary vegetation patterns present within the Assessed Area, with quadrats allocated based on these patterns. A minimum of three quadrats were allocated to each major discernible vegetation pattern where possible. For smaller patterns, fewer quadrats were allocated based on the size of the pattern.

Whilst other historical consultant survey data and reports from within the Survey Area were reviewed during the desktop study (see Section 5.1.1.2), quadrat data from these surveys was not used for floristic analysis purposes, and areas covered by such surveys were re-sampled by Woodman Environmental during the current survey.

### 3.1.4 Field Survey Methods

The flora and vegetation field survey was undertaken over a number of visits as listed below, with survey aspects detailed in parentheses:

- 27th and 29th August 2019 (reconnaissance and targeted flora survey (four person days);
- 17th–20th September 2019 (detailed vegetation survey (14 person days);
- 1st–3rd October 2019 (detailed vegetation survey (12 person days);
- 16th and 22nd October 2019 (detailed vegetation survey (6 person days);
- 26th–28th November 2019 (targeted flora survey (5 person days);
- 17th–18th December 2019 (targeted flora survey (8 person days); and
- 17th and 19th March 2020 (targeted flora survey (7 person days).

The reconnaissance survey involved on-ground inspection of vegetated areas (as defined through initial aerial photography interpretation) within the Assessed Area, with data being collected to allow for preliminary descriptions of the plant communities to be developed. This information formed the basis of a detailed survey plan (including targeted survey), the implementation of which is described below.

The Assessed Area was accessed by vehicle using existing access tracks and via foot transects with access primarily via Tonkin Highway. The detailed survey involved the survey of 33 non-permanent flora survey quadrats in intact vegetation within the Assessed Area in 2019. All quadrats measured 10 m x 10 m covering an area of 100 $m^2$. The quadrat size used is the indicative size for flora and vegetation surveys in the SCP Bioregion, as outlined in Table 1 of the Technical Guidance for Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a). Quadrats were only established in vegetation that was spatially large enough, and in at least Good condition (see Section 3.1.8).

All vascular flora taxa that were visually identifiable within each quadrat were recorded. At least one reference specimen of most taxa encountered (excluding common, distinctive taxa) was collected for verification and identification purposes. The following information was recorded at each quadrat:

- Personnel;
- Unique quadrat number;
- Date of survey;
- Size and shape of quadrat;
- GPS (Global Positioning System) coordinates at start corner of quadrat;
- Site photograph, taken diagonally into quadrat from start corner;
- Compass bearing for two sides of quadrat that commence at start corner of quadrat;
- Topography (including landform type and aspect);
- Soil colour and type (including the presence of any rock outcropping and surface stones);
- Vegetation condition (EPA 2016a; scale presented in Appendix A);
- Approximate time since fire;
- Presence and type of disturbance (if any);
- Percentage foliage cover (for each vascular plant taxon, including cover within the quadrat of individuals rooted outside of the quadrat);
- Height (m) (average for each taxon, excluding climbers/aerial shrubs); and
- Additional flora taxa present immediately outside of the quadrat.

A number of areas of vegetation in the Assessed Area are on narrow road reserves that are not spatially large enough to allow for quadrats to be established. Such areas were also often in Good or poorer condition (see Section 3.1.8). These cases necessitated the establishment and survey of relevés rather than quadrats. Relevés surveyed an area approximately within a radius of 10 m around a central point. All data recorded for quadrats (as listed above) was also recorded for relevés, however, only dominant taxa were generally recorded, as well as taxa not previously observed elsewhere. A total of 48 relevés were established and surveyed in the Assessed Area.

Areas of the Assessed Area that were located in cleared, highly modified or revegetated areas were sampled via a brief inspection, either on foot or from a vehicle, with notes and photographs taken.

Notes on vegetation pattern boundaries and distribution were also taken while traversing the Survey Area, including a GPS location at the point where the notes were taken, a brief description of the vegetation including dominant and characteristic taxa, and a photograph. These notes were used to aid in the mapping of polygons of vegetation patterns that were not allocated quadrats. Not all vegetation pattern polygons received quadrats due condition of vegetation; however, many polygons could be confidently allocated to a final VT using a combination of mapping notes and aerial photograph interpretation. Additional flora taxa were also recorded opportunistically in the Assessed Area during traverses on foot between quadrats and relevés, with GPS locations of such taxa recorded. Locations of any significant flora and introduced flora taxa encountered opportunistically while traversing between quadrats and relevés were also recorded.

Targeted survey for significant flora taxa was undertaken as part of the survey, with a list of significant flora taxa likely to be encountered compiled as part of the desktop study. Such survey was undertaken primarily during spring 2019 to coincide with the flowering period of most of the target taxa. Supplementary survey was conducted in March 2020, following the completion of quadrat surveys in 2019, for specific perennial taxa that can be identified outside of their flowering periods. Appropriate habitat for significant flora taxa in the Assessed Area was specifically transected on foot at spacings of 5 to 10 m. If populations of known significant flora taxa were identified, a representative collection of material was made, and the abundance and spatial distribution of individuals within each population was recorded using GPS coordinates. Locations of significant flora recorded within the Development Envelope were revisited in subsequent field trips and recorded using a Differential GPS (DGPS) for greater accuracy.

Locations of any introduced flora taxa encountered while traversing between quadrats and relevés, and while conducting targeted searching for significant flora taxa, were also recorded using the same method as for significant flora taxa.

### 3.1.5 Plant Collection and Identification

Specimens of any unknown taxa were collected and pressed for later identification at the WA Herbarium. External experts of particular families or genera were consulted for any specimens considered to be difficult to identify or of taxonomic interest.

Taxon nomenclature generally follows *FloraBase* (WA Herbarium 1998-) with all names checked against the current DBCA Max database to ensure their validity. However, in cases where names of plant taxa have been published recently in scientific literature but have not yet been adopted on *FloraBase*, nomenclature in the published literature is followed. The conservation status of each taxon was checked against *FloraBase*, which provides the most up-to-date information regarding the conservation status of flora taxa in Western Australia. Specimens of interest, including significant flora taxa, range extensions of taxa and potential new taxa, will be sent to the WA Herbarium for consideration for vouchering as soon as practicable. However, this process is via donation, and the WA Herbarium may not voucher

all specimens, in accordance with its own requirements. The specimen vouchering will be supported by completed Threatened and Priority Flora Report Forms (TPFRFs) submitted to DBCA (Species and Communities Branch) in the case of listed significant flora (e.g. Threatened and Priority flora taxa).

### 3.1.6 Floristic Analysis

Classification analysis of floristic data from the Survey Area was conducted using 33 quadrats established in the Survey Area by Woodman Environmental. Classification analysis methods generally followed those presented in Gibson *et al.* (1994). As per Gibson *et al.* (1994), singletons (i.e. any taxon occurring only once in the quadrat dataset) were removed from the dataset prior to analysis. A preliminary analysis undertaken with singletons included found that their inclusion had little effect on the analysis results. In contrast to Gibson *et al.* (1994), introduced taxa were also removed from the dataset prior to analysis. It is considered that the distribution of introduced taxa is generally most strongly influenced by the disturbance history of the site rather than other natural ecological drivers, and therefore their inclusion in such an analysis is not desirable. Hybrids were also excluded, as well as taxa whose identification was unclear due to poor available material, except when such a taxon (with multiple records in the dataset) was known to be unique in the dataset (i.e. although not identifiable to species level, there was enough material to indicate a unique taxon).

As per Gibson *et al.* (1994), a single-layer data matrix (i.e. presence/absence data only) was used in the classification analysis, with PATN (V3.12) (Belbin and Collins 2009) utilised to perform the classification and ordination analysis of the data matrix. The Bray-Curtis coefficient was used to generate an association matrix for the classification analysis, also as per Gibson *et al.* (1994). This association matrix consisted of pairwise coefficients of similarities between quadrats based on floristic data. Agglomerative hierarchical clustering, using flexible Unweighted Pair Group Method with Arithmetic Mean (UPGMA) (ß = -0.1), was used to generate a quadrat classification dendrogram (Sneath and Sokal 1973).

The above classification analysis aggregated quadrats into a group classification. The resulting dendrogram and taxon group matrix were initially examined at a group level determined by PATN as potentially appropriate for the dataset, to determine the plausibility of groups with regard to taxon groups, in combination with field observations.

In addition to the above classification analysis, additional classification analyses were conducted using Woodman Environmental quadrats and DBCA's amended SCP floristic quadrat dataset ('amended SCP dataset') (Keighery *et al.* 2012), as well as Woodman Environmental quadrats and DBCA's original SCP dataset (Gibson *et al.* 1994). The amended SCP dataset contains those quadrats established by Gibson *et al.* (1994), as well as over 500 additional sites (quadrats and relevés) established by DBCA subsequent to that survey. This analysis was conducted with the aim of examining the relationship of Woodman Environmental quadrats to those in the SCP quadrat datasets, and therefore their relationships to the vegetation of the wider southern SCP, as opposed to the local vegetation relationships examined by the first classification analysis. As for the first analysis, the resultant dendrogram and taxon group matrices were examined; of particular focus was whether the quadrat groups produced by the first classification analysis were maintained in

the subsequent classification analysis dendrograms. It was assumed that dissolution of groups of quadrats from the first classification analysis likely indicated that the vegetation represented by such quadrats was relatively dissimilar in a regional context; this may not have been obviously evident in the local context of the first classification analysis due to the comparatively limited size of the dataset being analysed.

For the additional classification analyses, methods and parameters were as for the first analysis; however, as per Gibson *et al.* (1994), introduced taxa were included in the dataset.

### 3.1.7 Vegetation Type Definition, Mapping and Description

As outlined in Section 3.1.4, survey of vegetation in the Survey Area used both quadrats and relevés as the size of some areas of vegetation did not allow for the establishment of quadrats. Therefore, VTs were defined using a combination of floristic composition classification (i.e. via a floristic classification analysis as outlined in Section 3.1.6), and structural vegetation classification as defined in the technical guidance for flora and vegetation surveys (EPA 2016a).

The classification analysis of Survey Area floristic data (Section 3.1.6) aggregated quadrats into a group classification. The resulting dendrogram and taxon group matrix were initially examined at a group level determined by PATN as potentially appropriate for the dataset, to determine the plausibility of groups with regard to taxon groups, in combination with field observations. This process determined a final number of clusters which were considered to represent VTs. Although quadrats were initially allocated based on patterns visible on aerial photography, and despite confidence that enough quadrats were allocated to expected vegetation types, the classification analysis split vegetation types in a way that resulted in some VTs with less than three quadrats (Section 5.1.3.2).

Floristic and structural data recorded at relevés were examined to determine whether vegetation sampled by the relevé was analogous to any of the VTs defined by floristic composition classification. Any such vegetation that was not considered to be analogous with any of the VTs defined by floristic composition classification was considered to represent a discrete VT.

VT descriptions have been adapted from the National Vegetation Information System (NVIS) Australian Vegetation Attribute Manual Version 6.0 (Executive Steering Committee for Australian Vegetation Information (ESCAVI) 2003), as stipulated by EPA (2016a). This model follows nationally-agreed guidelines to describe and represent VTs, so that comparable and consistent data are produced nation-wide. It should be noted that the NVIS system utilises vegetation descriptions derived from structural characteristics of the individual community units, while a number of the VTs presented in this report are defined based on the results of a floristic classification analysis, excluding any structural data. Such VTs therefore may include multiple structural types. Considering the effect of disturbance factors such as fire on vegetation structure, this approach is designed to provide a map of VTs that reflect taxon composition and the influences of the physical and chemical environment rather than disturbance history.

It should also be noted that this report describes VTs at the NVIS Sub-Association level, rather than the Association level as stipulated by EPA (2016a). This level is considered more appropriate for the vegetation of the Survey Area, as often the vegetation possessed one or more additional strata to the traditional three-stratum classification system used at the Association level.

For VTs defined via floristic composition classification, indicator taxa were defined via Indicator Taxon Analysis (INDVAL). This was conducted using PC-Ord (V6.08) (McCune and Mefford 2011) via the method of Dufrene and Legendre (1997). This generates INDVAL values (a measure of taxon fidelity to a given VT) that range from 0 to 100; an INDVAL value of 100 indicates that a taxon is present in all quadrats within a particular VT, and absent from all other quadrats included in the analysis. The INDVAL values were then tested for significance of the indicator taxa using a Monte Carlo permutation test. Indicator taxa were defined as taxa with an INDVAL value > 20, and a significance *p* value of either < 0.05, < 0.01 or < 0.001.

The locations of quadrats and/or relevés within each VT were used in conjunction with aerial photograph interpretation and field notes taken during the survey to develop VT mapping polygon boundaries. These VT mapping polygon boundaries were then digitised using Geographic Information System (GIS) software.

### 3.1.8 Vegetation Condition Mapping

Vegetation condition was described using the vegetation condition scale presented in EPA (2016a) (see Appendix A). Notes on vegetation condition were taken during the field survey via vehicle traverses and during foot traverses undertaken within the Survey Area. Vegetation condition was also recorded at all quadrats and relevés. Vegetation condition category polygon boundaries were developed using this information and were digitised using GIS software as for VT polygon boundaries.

### 3.1.9 Significant Flora and Vegetation

#### 3.1.9.1 Significant Flora

As per EPA (2016b), flora taxa may be significant for a range of reasons, including, but not limited to the following:

- Being identified as a Threatened (T) or Priority (P) species (formally listed significant taxa – includes taxa listed under both State and Commonwealth legislation, and classified as Priority by DBCA) (Appendix B presents conservation code classifications as per DBCA (2019a));
- Locally endemic or associated with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems (GDEs));
- New species or species with anomalous features that indicate a potential new species;
- Representative of the range of a species (particularly at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- Unusual species, including restricted subspecies, varieties or naturally occurring hybrids; and
- Relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

Significant taxa recorded within the Survey Area are discussed in Section 5.1.2.2 with reference to the above categories. In this section, point locations, individuals and populations known from the Survey Area are discussed. It is worthy of note that a population in the context of this survey is defined as a discrete group of individuals of a taxon separated by more than 500 m from the nearest discrete group of individuals (DBCA 2017a). However, this definition can only be tentatively applied if the intervening 500 m has not been surveyed.

#### 3.1.9.2 Significant Vegetation

As per EPA (2016b), vegetation may be significant for a range of reasons, including, but not limited to the following:

- Being identified as a TEC or PEC (formally listed significant vegetation – includes vegetation listed under Commonwealth legislation, endorsed as a TEC by the Western Australian Government, or classified as a PEC by DBCA) (Appendix C);
- Having restricted distribution;
- Having a degree of historical impact from threatened processes;
- Playing a role as a refuge; and
- Providing an important function required to maintain ecological integrity of a significant ecosystem.

The vegetation described by the study of the southern SCP by Gibson *et al.* (1994), together with supplementary vegetation description to this study published in Government of Western Australia (2000), is the current baseline used when assessing the significance of vegetation on the southern SCP. The vast majority of terrestrial TECs and PECs that occur on the southern SCP are Floristic Community Types (FCTs) described by this Study; the Study also provides information on the distribution of all FCTs described, as well as their conservation status.

Consequently, further floristic analyses were undertaken to determine relationships between VTs from the Survey Area that were defined via floristic composition classification and SCP FCTs defined by Gibson *et al.* (1994), with the aim of aligning VTs with SCP FCTs. As there is no formal guidance available on the most appropriate way to undertake this process, several different analytical approaches were employed in an attempt to build supporting evidence for aligning VTs with SCP FCTs. These were:

- Analysis of the Woodman Environmental quadrat dataset from the Survey Area with the original SCP dataset (Gibson *et al.* 1994);
- Analysis of the Woodman Environmental quadrat dataset from the Survey Area with the amended SCP dataset (Keighery *et al.* 2012) that includes more than 500 additional survey sites;
- Single site insertion analysis of representative quadrats of VTs described in the Survey Area with the original SCP dataset (Gibson *et al.* 1994) (at least two representative quadrats from each VT analysed, excluding those represented by a single quadrat only); and
- Single site insertion analysis of representative quadrats of VTs described in the Survey Area with the amended SCP dataset (Keighery *et al.* 2012) (at least two representative

quadrats from each VT analysed, excluding those represented by a single quadrat only).

It should be noted that the metadata for the amended SCP dataset explicitly states that it is not suitable for FCT analysis due to "inconsistencies in the grouping and splitting of some species compared to that used in the Gibson *et al.* (1994) analysis". However, the exact dataset that DBCA used (that included the more than 500 additional sites established on the SCP subsequent to the Gibson *et al.* (1994) study), which is referred to in the aforementioned metadata, does not appear to be publicly available. Therefore, the amended SCP dataset was used for analysis by this assessment, as the alternative of not using this dataset, and hence not considering a significant volume of data, was considered inappropriate in the absence of formal guidance on analysis methods. The argument that "inconsistencies in the grouping and splitting of some species compared to that used in the Gibson *et al.* (1994) analysis" is not considered to be reason enough to discount the dataset in this context; such issues are likely to frequently arise when a historical dataset is only periodically updated to reflect current taxonomic concepts. However, it is considered unlikely that such issues would have a significant bearing on the analysis results in this current context.

Further to this, as noted above, a dataset similar to the amended SCP dataset has been re-analysed by DBCA on behalf of the former Department of Environmental Protection (Government of Western Australia 2000) with supplementary SCP FCT descriptions published as a result; however, the methods of this analysis are not documented in Government of Western Australia (2000), and apparently were never fully documented (V. English *pers. comm.* 2015). It is apparent that DBCA used the ALOC non-hierarchical classification technique, whereby the groups of quadrats that formed the basis of the original SCP FCTs were 'locked' in place, and additional quadrats were allocated to these groups or to new groups via analysis (V. English *pers. comm.* 2015). It is assumed, although there is no documented evidence, that the single site insertion approach was then used, whereby quadrats were added singly to the locked dataset. FCTs were then assigned to the additional survey sites contained in the amended SCP dataset based on the results of the analyses (Keighery *et al.* 2012). It is assumed that these methods were used as re-analysis of the entire amended SCP dataset would have caused significant disruption (based on previous unpublished analyses conducted by Woodman Environmental) to the original quadrat groupings that were used to define FCTs in Gibson *et al.* (1994) given such a large volume of data was added. The original FCTs described by Gibson *et al.* (1994) could not have been maintained using this approach. The ALOC analysis approach does not appear to be widely used; DBCA does not appear to have published any studies that have used this method, with recent studies published by DBCA using the classification methods outlined in Section 3.1.6.

Analysis methods and parameters were the same as used for the analysis of the Woodman Environmental quadrat dataset as outlined in Section 3.1.6; as noted in Section 3.1.6, these are the same methods utilised by Gibson *et al.* (1994).

The resultant analysis dendrograms were then reviewed to determine the position of Woodman Environmental quadrats in relation to quadrats from the SCP quadrat datasets;

from this, VT and FCT relationships were inferred. It is important to note that all of the analytical approaches outlined above do not maintain the original quadrat groupings that formed the basis of the original FCTs defined by Gibson *et al.* (1994) in the resultant dendrograms. As a result, there is inherent ambiguity in inferences made from examination of the dendrograms alone. To provide further support for the inferences made, taxon lists of Woodman Environmental quadrats were also compared to the typical species lists for SCP FCTs presented in Gibson *et al.* (1994), as well as quadrat taxon lists, soils, topography and geographical distribution data from this study. Note that quadrats from the amended SCP dataset were not considered as part of this process.

For VTs from the Survey Area defined via structural vegetation classification, only the similarity in dominant taxa, soils, topography and geographical distribution between these VTs and SCP FCTs can be considered when attempting to align VTs with SCP FCTs. Therefore, taxon lists of Woodman Environmental relevés were compared to the typical species lists for SCP FCTs presented in Gibson *et al.* (1994), as well as quadrat taxon lists from this study, with VTs aligned with SCP FCTs if possible where there appeared to be relatively high similarity.

With regard to other TECs and PECs listed in Western Australia that were not described in the Gibson *et al.* (1994) study, generally only broad descriptions are provided in the respective TEC and PEC lists published by DBCA to allow for diagnosis. The vegetation of the Survey Area was therefore manually compared to such descriptions to determine whether any vegetation may represent such a TEC or PEC. A similar process was followed for TECs listed under the EPBC Act, with the vegetation of the Survey Area assessed against the appropriate listing and conservation advice for any TECs likely to occur in the Survey Area.

## 3.2 Fauna

### 3.2.1 Desktop Study Methods

The purpose of the desktop review is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the Survey Area based on unpublished and published data using a precautionary approach.

#### 3.2.1.1 Sources of Information

Information on the fauna assemblage of the Desktop Study Area was drawn from a wide range of sources. These included state and federal government databases and results of regional studies. Databases access are listed in Table 4. Information from those sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were:

- Frogs: Tyler and Doughty (2009) and Anstis (2013)
- Reptiles: Storr *et al.* (1983, 1990, 1999 and 2002) and Wilson and Swan (2017)
- Birds: Johnstone and Storr (1998, 2004) and Barrett *et al.* (2003)
- Mammals: Menkhorst and Knight (2010); Armstrong (2011); Churchill (2008); and Van Dyck and Strahan (2008).

**Table 4: Searches Undertaken for the Desktop Study (Fauna)**

| Source | Search Attributes | Search Purpose |
|---|---|---|
| DBCA Protected Fauna Search (data provided by Main Roads – DBCA 2019c) | Line search: along Tonkin Highway from Roe Hwy to Maddington Road plus 5 km buffer. | Fauna in the DBCA database. Includes historical data and records on Threatened and Priority species in WA. |
| NatureMap (DBCA 2007-) | Line search: along Tonkin Highway from Roe Hwy to Maddington Road plus 5 km buffer. | Records in the WAM and DBCA databases. Includes historical data and records on Threatened and Priority species in WA. |
| BirdLife Australia Atlas Database (BirdLife Australia 2019) | Search over 5 km buffer around Tonkin Highway from Roe Hwy to Maddington Road using polygon search tool. | Records of bird observations in Australia, 1998-2018. |
| Atlas of Living Australia (ALA 2019) | Two point search: -28.8460°, 120.2145° and -28.8141°, 120.3831° plus 40 km buffer. | Contributions of fauna data in Australia, hosted by CSIRO. |
| DAWE SPRAT Database (interrogated using the Protected Matters Search Tool) (DAWE 2019) | Line search: along Tonkin Highway from Roe Hwy to Maddington Road plus 5 km buffer. | Records on matters of national environmental significance protected under the EPBC Act. |

Multiple fauna surveys and studies have been conducted in the general area. References include:

- AECOM (2015). *Tonkin Highway / Hale Road, Tonkin Highway / Welshpool Road and Tonkin Highway / Kelvin Road Biological Assessment*.
- Shepherd, B., Bamford, M.J. and Bamford, A.R. (2018) *City of Armadale Reserves, Forrestdale Lake Nature Reserve Fauna Survey*.
- Bamford Consulting Ecologists (1996). Roe Highway stage 4. Update of fauna assessment.
- Bamford Consulting Ecologists (1998). Roe Highway stages 5, 6 and 7. Report on ecologically sustainable development and biodiversity.
- Bamford Consulting Ecologists (2004). Maddington – Kenwick Strategic Industrial Area. Fauna.
- Metcalf, B. and Bamford, M. (2003). Western Power; southern terminal to Cannington terminal transmission line. Review of faunal impacts

#### 3.2.1.2 Interpretation of Species Lists

Species lists generated from the review of sources of information are generous as they include records drawn from a large region and possibly from environments not represented in the Survey Area. Therefore, some species that were returned by one or more of the data searches have been excluded because their ecology, or the environment within the Survey Area, meant that it is highly unlikely that these species will be present. Such species can include, for example, seabirds that might occur as extremely rare vagrants at a terrestrial, inland site, but for which the site is of no importance. Some waterbirds were included, because there are environments suitable for these species within the project site, such as creeks, ponds and dams.

Species returned from the databases and not excluded on the basis of ecology or environment are therefore considered potentially present or expected to be present in the Survey Area at least occasionally, whether or not they were recorded during field surveys,

and whether or not the survey area is likely to be important for them. This list of expected species is therefore subject to interpretation by assigning each a predicted status in the survey area.

The status categories used are:

- **Resident**: species with a population permanently present in the Survey Area;
- **Regular visitor or migrant**: species that occur within the survey area regularly in at least moderate numbers, such as part of annual cycle and includes breeding migrants;
- **Irregular Visitor**: species that occur within the survey area irregularly such as nomadic and irruptive species. The length of time between visitations could be decades but when the species is present, it uses the Survey Area in at least moderate numbers and for some time;
- **Vagrant**: species that occur within the survey area unpredictably, in small numbers and/or for very brief periods. Therefore, the Survey Area is unlikely to be of importance for the species; and
- **Locally extinct**: species that would have been present but has not been recently recorded in the local area and therefore is almost certainly no longer present in the Survey Area.

These status categories make it possible to distinguish between vagrant species, which may be recorded at any time but for which the site is not important in a conservation sense, and species which use the site in other ways but for which the site is important at least occasionally. This is particularly useful for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile or irruptive, and further recognises that even the most detailed field survey can fail to record species which will be present at times, or may have been previously confirmed as present. The status categories are assigned conservatively. For example, a lizard known from the general area is assumed to be a resident unless there is very good evidence that the site will not support it, and even then it may be classed as a vagrant rather than assumed to be absent if the site might support dispersing individuals.

#### 3.2.1.3 Conservation Significant Species

Bamford Consulting divides conservation significance into three separate classes, denoted as CS1, CS2 and CS3. These are discussed in detail in Appendices D and E. Species classed as CS1 are those listed under Commonwealth and State legislation (EPBC Act and WA BC Act respectively), while those classed as CS2 are formally listed as Priority by the DBCA, but not listed under legislation. The CS3 class is more subjective but includes locally significant species that have declined extensively in an area due to natural or human-induced impacts, and species that occur at the edge of their range. This makes their presence in the Survey Area significant as populations on the edge of a species' range are often less abundant and more vulnerable to extinction than populations at the centre of the range (Curnutt *et al.* 1996).

### 3.2.2 Personnel and Licensing

Table 5 lists all personnel involved in the fauna field surveys undertaken for the project.

**Table 5: Personnel and Licensing Information (Fauna)**

| Personnel and Qualifications | Experience in the SCP bioregion | Role |
|---|---|---|
| Dr Barry Shepherd (B.Sc. Hons. (Env. Biol.), Ph.D. (Ecol.)) | >10 years | Project Manager/ Field survey |
| Andrew Moore (B.Sc. Botany. and Geog., M.Sc. Ren. Energy) | >15 years | Field survey |

The reconnaissance survey was undertaken across the Survey Area on the 13th September 2019 by Dr Barry Shepherd (B.Sc. Hons. (Env. Biol.), Ph.D. (Ecol.)). The Level 1 Survey and targeted Black-Cockatoo Habitat survey of the Development Envelope was subsequently conducted by Barry Shepherd over several visits: 2nd, 3rd, 7th and 8th October, and the 14th and 19th November 2019. A total of six and a half days was spent on survey with the majority of that being within the Development Envelope.

The pole cam inspection of nesting hollows was undertaken on the 19th November and was conducted by Andrew Moore (B.Sc. Botany. and Geog., M.Sc. Ren. Energy). The fauna assessment report was prepared by Dr Barry Shepherd (B.Sc. Hons. (Env. Biol.), Ph.D. (Ecol.)) and reviewed by Dr Mike Bamford ((B.Sc. (Biol.), Hons. (Biol.), Ph.D. (Biol.)).

### 3.2.3 Field Survey Methods

#### 3.2.3.1 Survey Overview

The field survey incorporated a site walkover to:

- Identify Vegetation and Substrate Associations (VSAs) (habitats for fauna)
- Search for suitable vegetation and habitat that could support conservation significant fauna
- Record signs of conservation significant fauna, e.g. Black- Cockatoo nesting hollows, Quenda diggings
- Record opportunistic fauna observations.

The assessment of the environmental features relevant to conservation significant fauna was conducted by vehicle within the surrounding Survey Area, with the site investigation was conducted on foot and vehicle over the Development Envelope. The site visit involved driving and walking over the area to enable environmental descriptions to be prepared and opportunistic observations on fauna to be made.

In the context of fauna assessment, Vegetation System Associations (VSAs) are the environments that provide habitats for fauna. VSAs combine vegetation types (provided by Woodman Environmental), the soils or other substrate with which they are associated, and the landform (as observed in the field assessment), and were mapped in a GIS environment using vegetation type polygons provided by Woodman Environmental in conjunction with site inspection notes taken within the Development Envelope.

#### 3.2.3.2 Black-Cockatoo Nesting Tree Survey

During the Level 1 survey, the Development Envelope was surveyed systematically on foot and potential nest trees for Black-Cockatoos recorded. This included assessing suitably sized trees that appeared to contain hollows of adequate size for nesting Black-Cockatoos. Potential nest trees were those species known to be used for nesting in the area (e.g. Wandoo, Jarrah and Marri) and with a diameter-at-breast-height (DBH) greater than 300 mm (Wandoo) or 500 mm (other species). Habitat plant species included the above eucalypts and known food plants including Banksia, Sheoak, pines etc.

Trees meeting the DBH criterion were then assigned a rank reflecting their likely value for breeding with respect to likelihood or presence of hollows. This ranking system has been developed by Bamford Consulting Ecologists and the ranks are:

1. Active nest observed; adult (or immature) bird seen entering or emerging from hollow. The rank of 1 is retained if a hollow is known to have been used within the previous three years.
2. Hollow of suitable size and angle (i.e. near-vertical) visible with chew marks around entrance. While it cannot with certainty be assumed that such chew marks were made by a Black-Cockatoo, they indicate activity of a parrot at a hollow potentially suitable for use by Black-Cockatoos.
3. Potentially suitable hollow visible but no chew marks present; or potentially suitable hollow present (as suggested by structure of tree, such as large, vertical trunk broken off at a height of >10m).
4. Tree with large hollows or broken branches that might contain large hollows but hollows or potential hollows are not vertical or near-vertical; thus a tree with or likely to have hollows of sufficient size but not to have hollows of the angle preferred by Black-Cockatoos.
5. Tree lacking large hollows or broken branches that might have large hollows; a tree with more or less intact branches and a spreading crown.
0. Dead or stunted tree meeting the DBH requirement but with no potential to form a suitable hollow at a suitable height.

The Survey Area was inspected for the presence of suitable nesting trees and their distribution to place the nesting trees found within the Development Envelope into context. Individual trees within the Survey Area were not recorded and no hollows were inspected.

#### 3.2.3.3 Black-Cockatoo Roosting and Foraging Habitat Survey

The suitability of the Development Envelope for foraging by Black-Cockatoos was assessed by inspecting the Development Envelope on foot, and then calculating a foraging score for areas of suitable vegetation type/condition based upon the types of forage plants present (see Appendix F). The foraging score provides a numerical value that reflects the significance of vegetation as foraging habitat for Black-Cockatoos, and this numerical value is derived to provide the information required by DAWE to assess impact significance and offset requirements. The foraging value of the vegetation depends upon the type, density and condition of trees and shrubs in an area and can be influenced by the context such as the availability of foraging habitat and availability of water nearby. The Bamford Consulting scoring system for value of foraging habitat has three components as detailed in Appendix F.

These three components are drawn from the DAWE offset calculator but with the scoring approach developed by Bamford Consulting:

- A score out of six for the vegetation composition, condition and structure
- A score out of three for the context of the site
- A score out of one for species density.

Foraging value can thus be assigned a score out of six, based upon site vegetation characteristics, or a score out of 10 if context and species density are also considered. In this report, a score out of six is used so that vegetation characteristics and value can be compared across the Survey Area. A score out of 10 is presented for the purposes of aiding offset calculations. The score out of 10 is calculated only for vegetation of at least Low to Moderate foraging value (vegetation characteristics score of ≥ 3). Vegetation with No, Negligible or Low foraging value is effectively assigned context and species density scores of '0' as context and species density are of little relevance if the vegetation does not support foraging by the birds. Foraging value scores are calculated differently for the three Black-Cockatoo species (Appendix F) depending upon the vegetation present. Throughout the survey the surveyors were constantly looking for signs that indicated Black-Cockatoos had foraged in the Survey Area, checking Marri and Jarrah nuts and Banksia and Sheoak cones. Some of these (e.g. Marri nuts) can be used to determine which species of Black-Cockatoo from the shapes of the chew-marks whilst others such as Banksia cones are generally targeted by only one species (Carnabys Black-Cockatoo) at this location. Locations where foraging were noted are not presented in this report, due to the highly mobile nature of the species, however was used to assist in determination of appropriate foraging habitat.

Potential Black-Cockatoo roosting habitat was assessed by making note of areas that appeared suitable (large trees near water). Additionally, records of known roosting sites in the area were consulted (Peck *et al*. 2017).

The broader Survey Area was inspected to assess the availability of foraging and roosting habitat for Black-Cockatoos. This was conducted to place the quantity of Black-Cockatoo habitat within the Development Envelope into context of the surrounding landscape for the three species of Black-Cockatoo endemic to the south west of Western Australia.

### 3.2.4 Taxonomy and Nomenclature

As per the recommendations of EPA (2016c), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's (WAM) Checklist of the Fauna of Western Australia 2017. The authorities used for each vertebrate group were: amphibians (Doughty *et al.* 2019a), reptiles (Doughty *et al*. 2019b), birds (Birdlife Australia 2019), and mammals (Travouillon 2019). In some cases, more widely recognised names and naming conventions have been followed, particularly for birds where there are national and international naming conventions in place (e.g. the BirdLife Australia working list of names for Australian Birds). English names of species where available are used throughout the text; Latin species names are presented with corresponding English names in tables in the appendices.

# 4. ADEQUACY AND LIMITATIONS OF SURVEY

## 4.1 Flora and Vegetation

### 4.1.1 Adequacy of Survey

The Assessed Area covers approximately 177.92 ha, the majority of which (55.6%) is either cleared or highly modified. Within the remaining 44.4 % of the Survey Area (total of 78.97 ha), 33 quadrats and 48 relevés were established in all preliminary vegetation patterns discernible by initial aerial photograph interpretation, both to adequately sample variation in vegetation throughout the Survey Area and to ensure adequacy of sampling for vascular plant taxa. The number of quadrats and relevés established in the Survey Area is considered to be an acceptable number given the limited amount of intact vegetation present. Traverses in the Assessed Area are mapped as track logs in Appendix G along with quadrat and relevé locations.

To provide an indication of the adequacy of this survey, a taxon accumulation curve was produced using PC-Ord (McCune and Mefford 2011). Taxon accumulation curves represent a theoretical model of the relationship between sampling intensity and taxon accumulation; when sampling intensity is increased, taxon accumulation is reduced, and a taxon accumulation curve becomes asymptotic.

The taxon accumulation curve for quadrat data from the Survey Area was generated using all native taxa (both annual and perennial) recorded within each quadrat. Taxon accumulation calculations for the Survey Area were then undertaken utilising the Chao-2 estimator for species richness (Chao 1987) and compared to the actual number of taxa recorded in the Survey Area. This provides some indication as to whether sufficient quadrats were surveyed to adequately sample the species richness in the Survey Area. As the generation of species accumulation curves includes quadrat data only, and not taxa recorded in relevés or during targeted searching or otherwise opportunistically recorded, the indication of adequacy of survey provided is considered to be conservative.

Figure 6 presents the species accumulation curve generated from quadrat data from the Survey Area. Using the Chao-2 estimator, the recorded number of native taxa within quadrats is equivalent to 76.4 % of the estimated native taxon richness in the Survey Area. It is of interest that the estimated number of native taxa in the Survey Area from quadrats only using Chao-2 was 284. When opportunistic records of taxa are included, 287 native taxa were recorded in the Survey Area (Section 5.1.2). Based on this, the analysis indicates that the Survey Area was relatively well-sampled.  despite that fact that only a very small area of vegetation was sampled via quadrats.

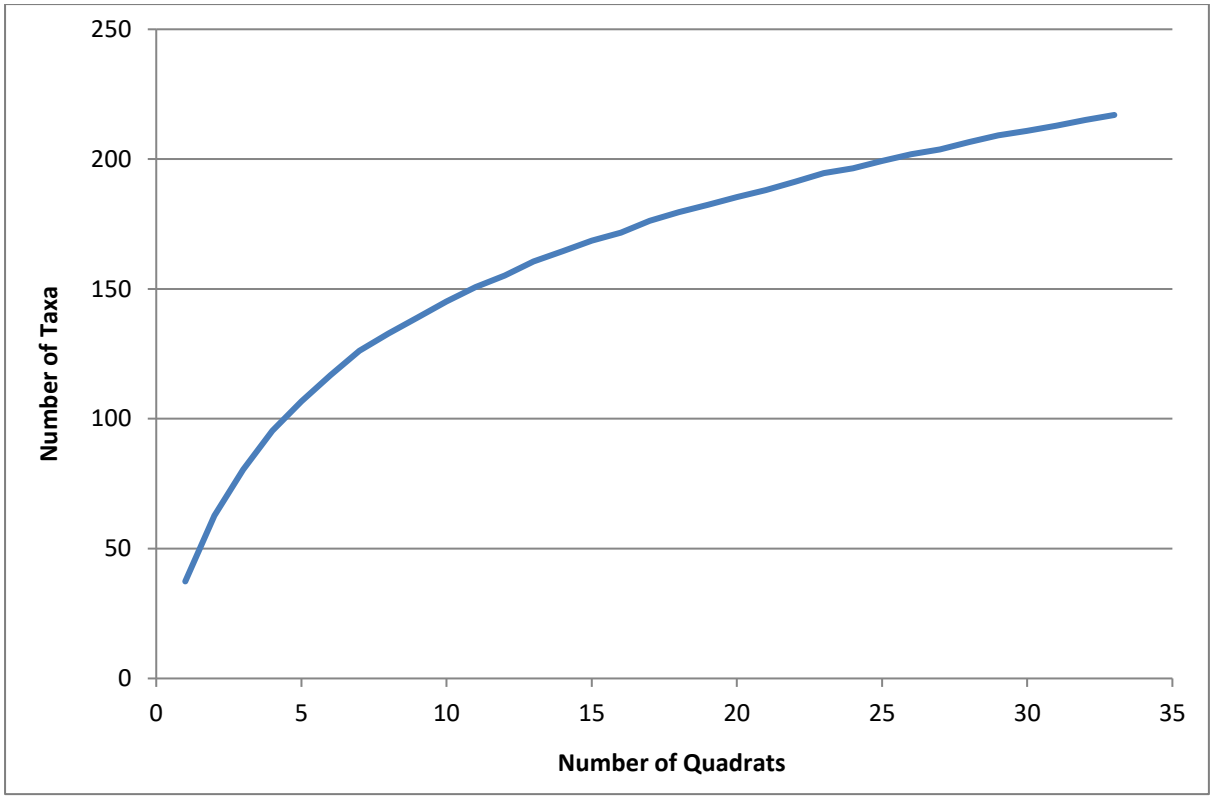



**Figure 6: Survey Area Quadrat Data Species Accumulation Curve**

Another adequacy of survey measure is that developed by Mueller-Dombois and Ellenberg (1974), who suggest that an adequacy cut-off point might be when a 10 % increase in quadrats surveyed results in a 5 % (or less) increase in taxa recorded. This measure was also calculated using all native taxa recorded within each quadrat. The number of quadrats established in the Survey Area satisfies this adequacy measure suggested by Mueller-Dombois and Ellenberg (1974), with the final taxon increase value of 2.86 % recorded following the final 10 % increase in quadrats.

### 4.1.2 Limitations of Survey

Table 6 presents the limitations of the flora and vegetation study of the Survey Area in accordance with EPA (2016a). Overall, there were no significant constraints which affected the results of the survey of the Assessed Area (which includes the Development Envelope), other than the impact of reduced vegetation condition due to previous disturbances and fire on reliability of vegetation type mapping in such areas. The extent of the whole Survey Area is not considered to have been surveyed adequately due to significant access restrictions.

**Table 6: Limitations of the Flora and Vegetation Survey of the Survey Area**

| Limitation | Limitation of Survey | Comment |
|---|---|---|
| Effort and Extent | No | Detailed survey undertaken across the entire Survey Area. Multiple quadrats and/or relevés were established in each vegetation pattern identified in the Survey Area. No constraints prevented appropriate sampling techniques (quadrat establishment, foot transects etc.) being employed. Relative ease of access within the Survey Area enabled detailed vegetation type and condition mapping to be undertaken throughout the Survey Area via foot and vehicle transects. Mapping reliability is therefore considered to be high.<br>During the Targeted Survey for significant flora taxa, areas were searched on foot in their entirety, with transects generally undertaken at 10 m intervals. A 10 m interval was considered to be adequate to provide appropriate data on the distribution of significant flora taxa within the survey area. Due to the intensity of the survey method used the numbers of individuals presented are considered to be an accurate estimate of the numbers of individuals actually present. |
| Competency/experience of the team carrying out the survey | No | Project Manager has extensive experience (> 10 years) in conducting similar assessments on the SCP. Personnel conducting and overseeing plant identifications have > 10 years' experience in identification of SCP flora. Senior personnel provided guidance to less experienced botanists throughout the survey where necessary. Relevant experts at the WA Herbarium were consulted regarding taxonomic identifications where required. The experience and competency of personnel is therefore not considered to be a limitation of the survey. |
| Proportion of flora identified, recorded and/or collected | No | All vascular groups that were present in the Survey Area were sampled. A high proportion of perennial vascular taxa were recorded based on the intensity and method of survey, and almost all could be positively identified. A total of 97.3 % of specimens were identified to species (or subspecies / variant) level. Specimens with incomplete identifications were generally sterile and were likely to be representative of other identified taxa. None of the specimens with incomplete identifications resembled significant flora taxa. A high proportion of annual vascular taxa were recorded based on the intensity and method of survey; however, detection and identification of some annual taxa may have been limited by below average rainfall recorded prior to the survey (Section 2.1; see timing/weather/season/cycle below). Unknown vascular taxa were collected, and specimens were identified at the WA Herbarium. |
| Sources of information e.g. previously available information (whether historic or recent) as distinct from new data | No | Good contextual information for the Survey Area was available prior to the survey. Sources of information used included government databases (including DBCA and DAWE), previous unpublished reports and data from the vicinity of the Survey Area (AECOM 2015; GHD 2015, 2016, 2018; Natural Area 2016; Perth Airport 2018; Strategen 2016, 2019; 360 Environmental 2018) as well as numerous general sources pertaining to the climate, geomorphology, flora and vegetation of the SCP. |

| Limitation | Limitation of Survey | Comment |
|---|---|---|
| Timing/weather/season/cycle | No | The majority of the survey was conducted within what is considered to be the appropriate season for survey in the SCP bioregion (Spring). However, the lower than average rainfall in May–December 2019, in combination with higher than average temperatures in 2019, may potentially have resulted in the abundance of annual taxa being affected, as well as sooner than expected senescence of such taxa. It is not known if the rainfall received was insufficient for germination of any taxa.<br>Some targeted survey was conducted in March 2020; however, this survey targeted perennial taxa that are distinct at any time of year. |
| Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey | Possible | There was evidence of significant impact to vegetation composition and structure throughout the Survey Area as a result of human activities, including clearing and very high levels of introduced (weed) taxa. There were also several areas of vegetation which had been burnt relatively recently (within the last five years) including the block of vegetation between Tonkin Hwy and Hartfield Golf Club. For the most part these disturbances did not affect the results of the survey, with the vegetation able to be confidently assigned to a VT and taxa mature enough to be easily identified or collected. However, in some cases the level of disturbance may have affected the interpretation of Vegetation Type boundaries. In addition, there was a small area adjacent to Woodlupine Brook which contained post-fire coloniser taxa (such as *Acacia pulchella*), making the Vegetation Type of this area difficult to discern. The remainder of the Assessed Area had not been significantly affected by fire in recent years. |
| Remoteness and/or access problems | Yes | The Development Envelope and Assessed Area was accessed either via main roads, tracks or on foot and there were no access issues that hindered the survey extent. Access to the wider Survey Area was restricted due to tenure and landowner permission issues. |

## 4.2 Fauna

The EPA Guidance Statement 56 (EPA 2016a) outlines a number of limitations that may arise during investigations for fauna values. These survey limitations are discussed in the context of the fauna investigation of the project area in Table 7.

Overall, there were no major constraints to vertebrate fauna investigations affecting the results of the survey within the Development Envelope, with extrapolated VSA mapping over the rest of the Assessed Area. As a Level 1 Reconnaissance survey was undertaken no survey work was conducted regarding significant invertebrate. The extent of the whole Survey Area is not considered to have been surveyed adequately due to significant access restrictions

**Table 7: Limitations of the Fauna Survey of the Survey Area**

| Limitation | Limitation of Survey | Comment |
|---|---|---|
| Effort and Extent | No | The Level 1 survey (desktop study and field investigation) was completed to the required expectations. The report provides provisional fauna values for the Survey Area and targeted surveys for Black-Cockatoo. Survey intensity is deemed adequate to fully support detailed regulatory approvals based on the condition of the Survey Area, scale of the project and potential scale of impacts of the development. |
| Competency/experience of the team carrying out the survey | No | The ecologists who conducted the Level 1 and targeted surveys have had extensive experience in conducting fauna surveys and have conducted many similar fauna studies within the region. |
| Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?) | No | Level 1 reconnaissance survey undertaken. The survey focussed on vertebrate fauna, and fauna values for of the significant species potentially occurring. |
| Proportion of fauna identified, recorded and/or collected | No | Level 1 survey and therefore species recorded during the site inspection in October 2019 are considered to be a small proportion of those that are likely to be present. Most species of conservation significance expected in the area were either confirmed or it was concluded they would not be present based upon habitat availability |
| Sources of information e.g. previously available information (whether historic or recent) as distinct from new data | No | Abundant information is available from databases e.g. DBCA, EPBC and previous studies, e.g. AECOM (2015). Shepherd *et al.* (2018). |
| Timing/weather/season/cycle | No | Survey was conducted in October and November 2019 and Level 1 survey can be conducted at any time of the year in this area. Black-Cockatoo surveys can be conducted at any time of the year but is optimal during spring to identify breeding behaviour in the peak breeding period. |
| Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey | No | None |
| Remoteness and/or access problems | Yes | The Development Envelope was accessed either via main roads, tracks or on foot and there were no access issues that hindered the survey extent. Access to the wider Survey Area was restricted due to tenure and landowner permission issues. |

# 5. RESULTS AND DISCUSSION

## 5.1 Flora and Vegetation

### 5.1.1 Desktop Study

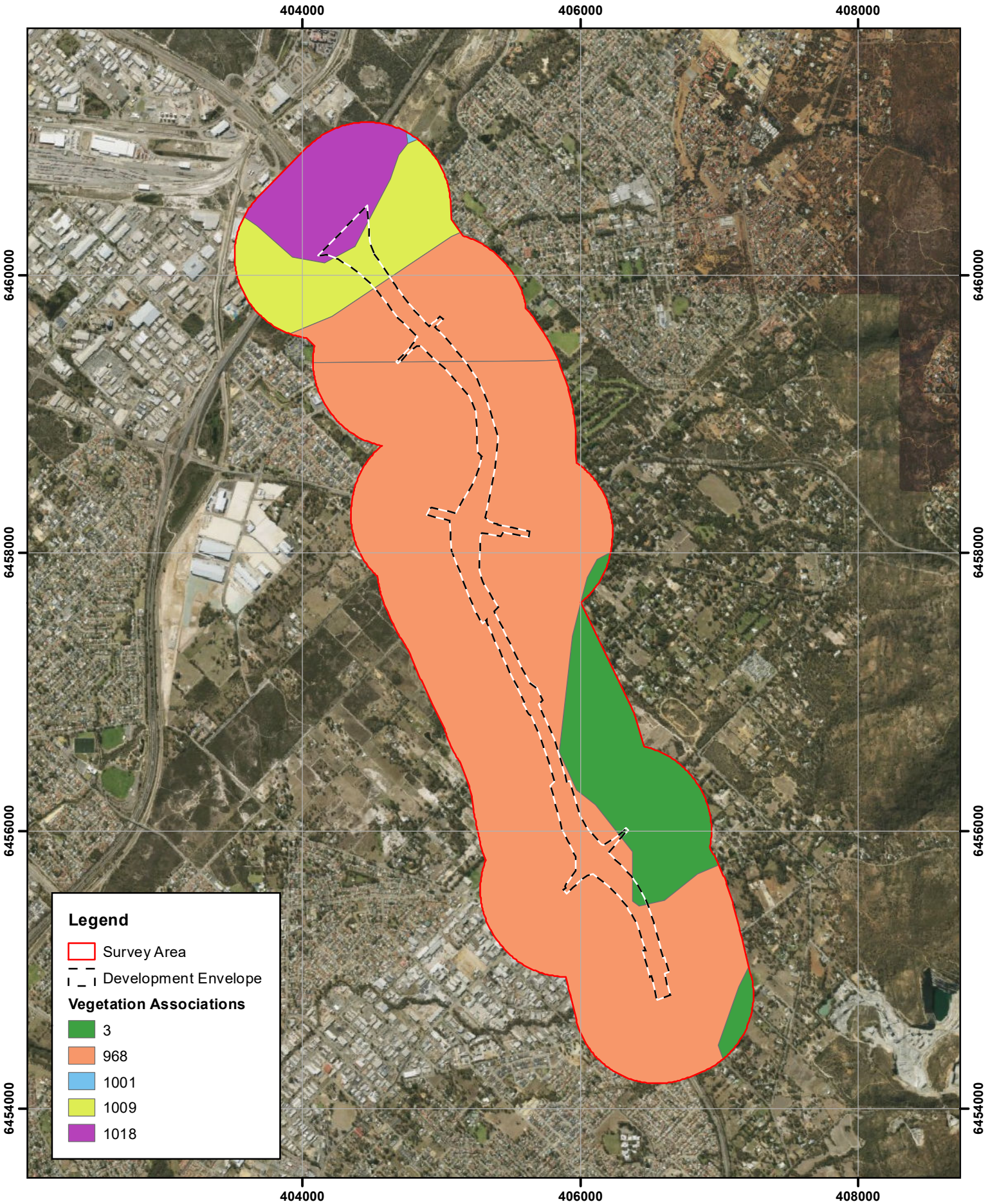
#### 5.1.1.1 Regional Vegetation

The vegetation of Western Australia as it was presumed to have existed prior to European settlement has been mapped at a scale of 1:250,000 as vegetation associations, with the Pre-European Vegetation spatial database created (Beard *et al.* 2013).

A total of five vegetation associations occur in the Survey Area, as summarised in Table 8 and presented on Figure 7. Table 8 also presents the current extent of each vegetation association in relation to its pre-European extent (Government of Western Australia 2019a), and the percentage of the current extent of each vegetation association currently protected for conservation at statewide level. All five vegetation associations have been subject to some clearing, ranging from to 16.5 % remaining (vegetation association 1009) to 67.8 % (vegetation association 3) remaining. There are also limited proportions of each association protected for conservation ranging from 0.02 % (vegetation association 1009) to 26.9 % (vegetation association 3) (Government of Western Australia 2019a).

**Table 8: Vegetation Associations occurring within the Survey Area (Government of Western Australia 2019a)**

| Vegetation Association | Description | Current Extent (ha) | Pre-European Extent Remaining (%) | Current Extent Protected for Conservation (%) |
|---|---|---|---|---|
| 3 | Medium forest; jarrah-marri | 1803437 | 67.8 | 26.9 |
| 968 | Medium woodland; jarrah, marri and wandoo | 95049 | 32 | 11.1 |
| 1001 | Medium very sparse woodland; jarrah, with low woodland; *Banksia* and *Casuarina* | 12660 | 22.1 | 2.8 |
| 1009 | Medium woodland; marri and river gum | 3004 | 16.5 | 0.02 |
| 1018 | Mosaic: Medium forest; jarrah-marri / Low woodland; *Banksia* / Low forest; teatree / Low woodland; *Casuarina obesa* | 2445 | 17.4 | 0.7 |

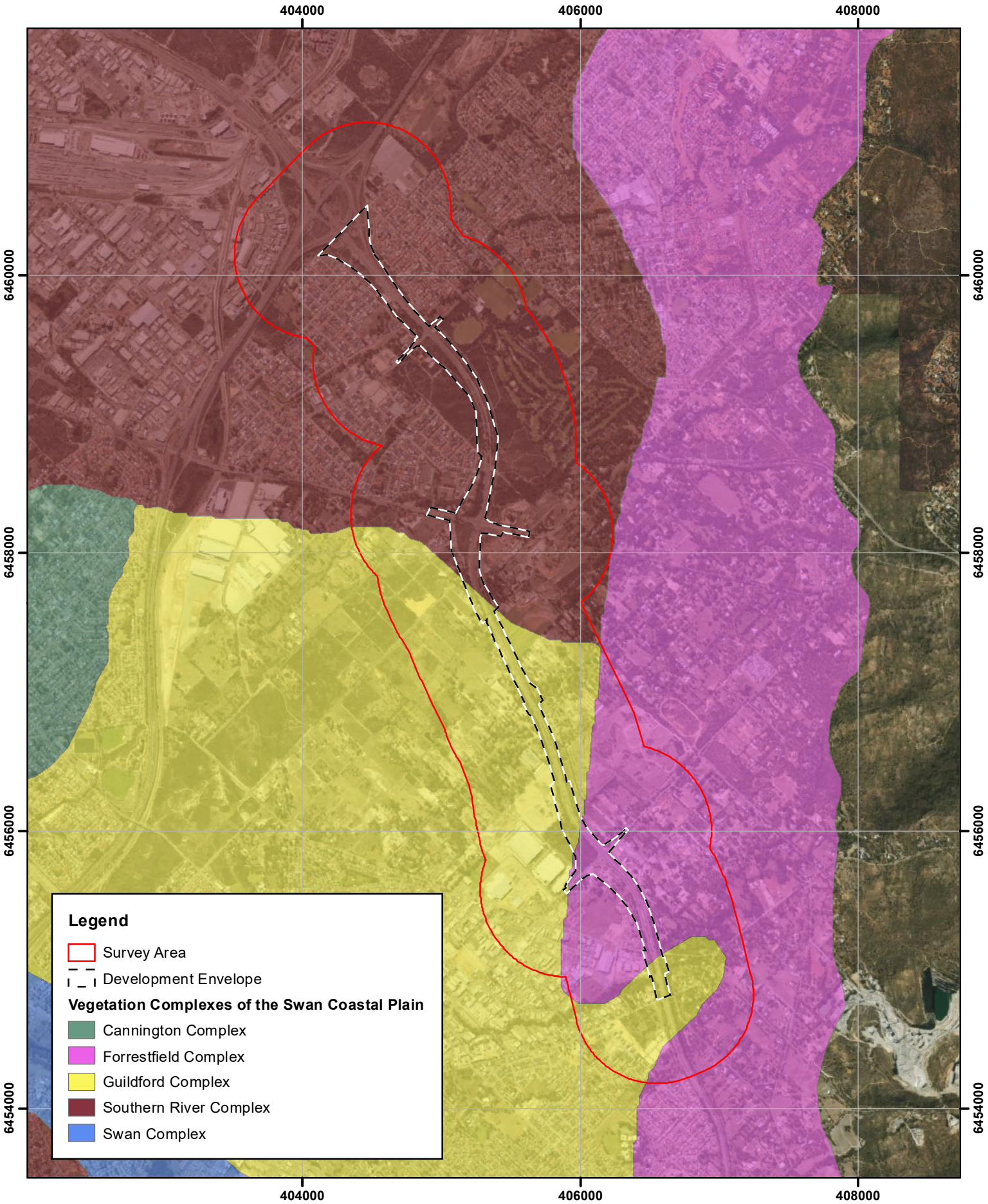



| | | |
|---|---|---|
| **Vegetation Associations of the Survey Area** | Author: Marlee Starcevich | N |
| | WEC Ref: MR19-34-01 | |
| WOODMAN ENVIRONMENTAL | Filename: MR19-34-01-f07 | **Figure** |
| | Scale: 1:35,000 (A4) | 7 |
| | Projection: GDA 1994 MGA Zone 50 | |
| This map should only be used in conjunction with WEC report MR19-34-01. | Revision: A - 05 June 2020 | |

Vegetation within the Perth Metropolitan area has been described by Heddle *et al.* (1980) as vegetation complexes with updates from Webb et al. (2016). Three vegetation complexes occur in the Survey Area, as summarised in Table 9 and presented on Figure 8. Table 9 also presents the current extent of each vegetation complex in relation to its pre-European extent (Government of Western Australia 2019b), and the percentage of the current extent of each vegetation system association currently protected for conservation at statewide level. The Forrestfield, Guildford and Southern River vegetation complexes have less than 20% of their pre-European extent remaining, with a very small proportion (1.4 %, 0.3 % and 1.2 %, respectively) of the remaining extent protected for conservation.

**Table 9: Vegetation Complexes Occurring within the Survey Area (Government of Western Australia 2019b)**

| Vegetation Complex | Description | Current Extent (ha) | Percentage of Pre-European Extent Remaining | Percentage of Current Extent Protected for Conservation |
|---|---|---|---|---|
| Forrestfield Complex (29) | Vegetation ranges from open forest of *Corymbia calophylla* (Marri) - *Eucalyptus wandoo* (Wandoo) - *Eucalyptus marginata* (Jarrah) to open forest of *Eucalyptus marginata* (Jarrah) - *Corymbia calophylla* (Marri) - *Allocasuarina fraseriana* (Sheoak) - Banksia species. Fringing woodland of *Eucalyptus rudis* (Flooded Gum) in the gullies that dissect this landform | 2,803 | 12.3 | 1.4 |
| Guildford Complex (32) | Mixture of open forest to tall open forest of *Corymbia calophylla* (Marri) - *Eucalyptus wandoo* (Wandoo) - *Eucalyptus marginata* (Jarrah) and woodland of *Eucalyptus wandoo* (Wandoo) (with rare occurrences of *Eucalyptus lane-poolei* (Salmon White Gum)). Minor components include *Eucalyptus rudis* (Flooded Gum) - *Melaleuca rhaphiophylla* (Swamp Paperbark) | 4,607 | 5.1 | 0.3 |
| Southern River Complex (42) | Mosaic of low woodland of *Allocasuarina fraseriana - Corymbia ficifolia - Banksia ilicifolia - Banksia attenuata - Banksia occidentalis* on slopes in perhumid zone to sedgeland of Cyperaceae spp., tall shrubland of Myrtaceae spp. and an open woodland of *Melaleuca preissiana* with some *Eucalyptus marginata* subsp. *marginata* on broad depressions in perhumid and humid zones | 10,832 | 18.4 | 1.2 |

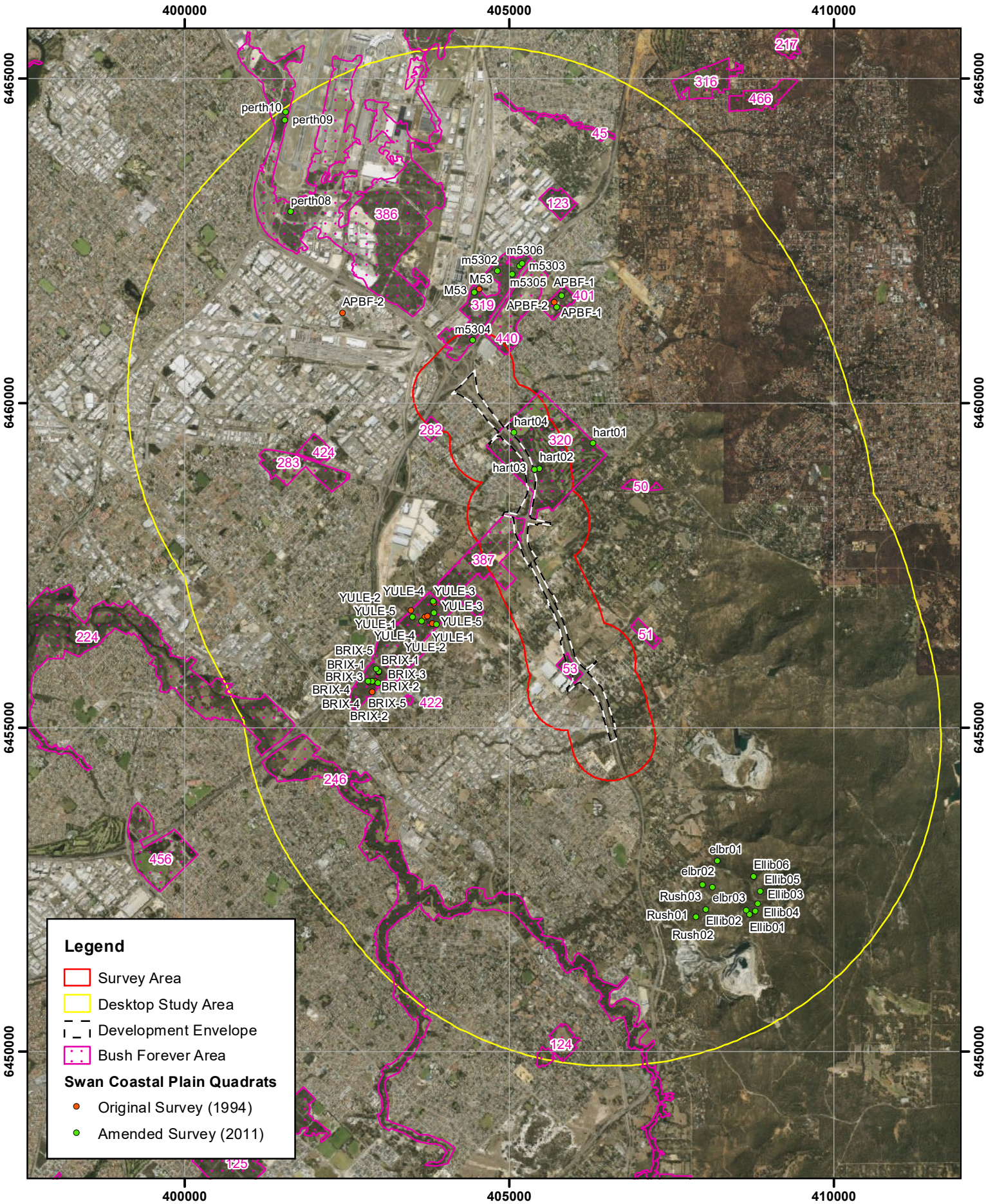



| | | |
|---|---|---|
| **Vegetation Complexes of the Survey Area** | Author: Marlee Starcevich | N |
| | WEC Ref: MR19-34-01 | |
| WOODMAN ENVIRONMENTAL | Filename: MR19-34-01-f08 | **Figure** |
| | Scale: 1:35,000 (A4) | 8 |
| | Projection: GDA 1994 MGA Zone 50 | |
| This map should only be used in conjunction with WEC report MR19-34-01. | Revision: 0 - 30 July 2020 | |

The patterning of plant communities on the southern SCP was the subject of a detailed floristic survey by DBCA (as the Department of Conservation and Land Management) and the Conservation Council (Gibson *et al.* 1994). This survey established quadrats across the SCP, with subsequent classification analysis defining FCTs. Four quadrats (m5304, hart02, hart03 and hart04) were established within the Survey Area (Figure 9). Quadrats hart02, hart03 and hart04 are located within the Hartfield Park Bushland on the eastern side of Tonkin Highway between Hale Road and Welshpool Road. Quadrats hart02 and hart03 are considered to represent FCT S02, which is a community of 'Northern *Pericalymma ellipticum* dense low shrublands'. Quadrat hart04 is considered to represent FCT 23a, which is a community of 'Central *Banksia attenuata* - *Banksia menziesii* woodlands'. FCT 23a corresponds to listed PEC 'Banksia dominated woodlands of the Swan Coastal Plain IBRA region' (P3) in WA, which is a component of the EPBC listed TEC 'Banksia Woodlands of the Swan Coastal Plain ecological community' (Endangered). Quadrat m5304 is located within Dundas Road Bushland near the intersection with Roe Highway and Tonkin Highway. This quadrat is considered to represent FCT 2, which is community of 'Southern wet shrublands'. FCT 2 corresponds to listed TEC SCP02 'Southern wet shrubland, Swan Coastal Plain' in WA (Endangered).

Several areas of remnant vegetation intersected by the Survey Area have previously been identified as areas of regionally significant bushland through the Government of Western Australia's Bush Forever project (Government of Western Australia 2000). The vegetation present within these areas was also described in the context of SCP FCTs. The Bush Forever sites intersected by the Survey Area are:

- Clifford Street Bushland (Site 53) (vegetation north of Kelvin Road, between Clifford Street and Tonkin Highway);
- Tomah Road Bushland (Site 282) (vegetation between Roe Highway and St John Road, in the north-west of the Survey Area outside the Development Envelope);
- Dundas Road Bushland (Site 319) (vegetation between Dundas Road and Roe Highway, near the intersection between Roe Highway and Tonkin Highway, in the Survey Area outside the Development Envelope);
- Hartfield Park Bushland (Site 320) (vegetation on both sides of Tonkin Highway, from Hale Road to Welshpool Road);
- Greater Brixton Street Wetlands (387) (vegetation south of Welshpool Road, on west side of Tonkin Highway); and
- Pioneer Park Bushland (440) (vegetation east of Roe Highway, in the north of the Survey Area outside the Development Envelope).




**SCP Study Quadrats and Bush Forever Sites within the Desktop Study Area**

Author: Marlee Starcevich

WEC Ref: MR19-34-01

WOODMAN ENVIRONMENTAL

This map should only be used in conjunction with WEC report MR19-34-01.

Filename: MR19-34-01-f09

Scale: 1:75,000 (A4)

Projection: GDA 1994 MGA Zone 50

Revision: 0 - 30 July 2020

**Figure 9**

#### 5.1.1.2 Local Flora and Vegetation Surveys

A number of flora and vegetation surveys that are publicly available have been undertaken within the Desktop Study Area, the results of which are summarised in Table 10. Those surveys with study areas that overlap the Development Envelope or Survey Area are shaded in green.

A total of four Priority taxa, three Threatened taxa, one PEC and four TECs have been recorded during previous surveys as presented in Table 9. Of these, the priority taxon *Isopogon autumnalis* (P3), Threatened taxon *Conospermum undulatum* and '*Banksia attenuata* woodlands over species rich dense shrublands (SCP20a)' TEC were recorded by surveys that overlapped the Development Envelope or Survey Area.

Surveys conducted prior to 2016 were undertaken to meet the requirements of a Level 1 or Level 2 Survey, which consisted of background research/desktop study and reconnaissance survey, followed by either a targeted survey (Level 1) or detailed or comprehensive survey (Level 2). The level of survey required was determined from Table 2 of the Environmental Protection Authority's Guidance Statement No. 51 (EPA 2004). Since 2016 the Environmental Protection Authority have released new advice ('Technical Guidance for Flora and Vegetation Surveys for Environmental Impact Assessment' (EPA 2016a)), which supersedes Guidance Statement No 51. The original Level 1 survey has been replaced by a Reconnaissance Survey and Targeted Survey, and Level 2 with a Detailed Survey.

**Table 10: Summary of Flora and Vegetation Surveys Previously Conducted in the Local Area**

| Report Title and Author | Location | Scope | Key Findings (Flora and Vegetation only) |
|---|---|---|---|
| Tonkin Highway / Hale Road, Tonkin Highway / Welshpool Road and Tonkin Highway / Kelvin Road Biological Assessment – Main Roads WA by AECOM Australia Pty Ltd (AECOM) (2015) | Along Tonkin Highway including Hale Road / Welshpool Road and Kelvin Road intersections – overlaps Development Envelope | Level 1 Flora and Vegetation Assessment (now a Reconnaissance Survey and Targeted Survey) – 43.78 ha | • Recorded 151 taxa from 38 families and 102 genera.<br>• Unspecified number of sites assessed.<br>• Field survey was conducted in spring (October) 2014.<br>• One EPBC Act listed threatened taxon was recorded; *Conospermum undulatum.*<br>• Two priority taxa were recorded; *Isopogon drummondii* (now *Isopogon autumnalis*) (P3) and *Verticordia lindleyi* subsp. *lindleyi* (P4).<br>• 33 introduced taxa were recorded.<br>• 21 vegetation communities were mapped within survey area.<br>• Three communities described by this survey were considered to represent the State / EPBC listed TEC *Banksia attenuata* woodland over species rich dense shrublands (SCP20a). |
| PSP Pioneer Park Flora and vegetation survey - GatewayWA Alliance by GHD Pty Ltd (GHD) (2015) | East side of Roe Highway, 0.4 km NE of the Survey Area | Level 1 flora and vegetation assessment (now a Reconnaissance Survey and Targeted Survey) of the Public Shared Path (PSP) – 0.17 ha | • Recorded 29 taxa from 14 families.<br>• Meandering transects of the survey area and one quadrat (10 x 10 m) undertaken.<br>• Field survey was conducted in summer (February) 2015.<br>• No significant flora taxa recorded.<br>• 16 introduced taxa were recorded.<br>• One vegetation community was mapped within the survey area.<br>• Vegetation within the survey area was largely in Good to Degraded condition. |
| Kenwick Freight Facility Flora and Black Cockatoo Habitat Assessment – Public Transport Authority by GHD (2016) | East of Roe Highway, south of Welshpool Road East, 1.1 km west of the Survey Area | Level 1 flora survey (out of season) (now a Reconnaissance Survey and Targeted Survey) – 17.81 ha | • Recorded 55 taxa from 26 families and 47 genera.<br>• Three quadrats were assessed.<br>• Field survey was conducted in autumn (April) 2016.<br>• No significant flora taxa were recorded.<br>• 42 introduced taxa were recorded.<br>• Two vegetation communities were mapped within project area.<br>• None of the vegetation types were considered to be equivalent to any TECs or PECs.<br>• The majority of the vegetation in the project area (89 %) was completely cleared or highly degraded. |

| Report Title and Author | Location | Scope | Key Findings (Flora and Vegetation only) |
|---|---|---|---|
| Hartfield Park Flora Survey – Shire of Kalamunda by Natural Area Holdings Pty Ltd (Natural Area) (2015) | Hartfield Park, Forrestfield bordering the east side of the NE portion of the Survey Area | Level 2 flora survey (now a Detailed survey) – 1.5 ha | • Recorded 84 taxa from 28 families.<br>• Four quadrats (10 x 10 m) were assessed.<br>• Field survey was conducted in spring (October/November) 2014.<br>• No significant flora taxa were recorded.<br>• 24 introduced taxa were recorded.<br>• Two vegetation communities were mapped within the survey area.<br>• One vegetation type was considered to be represent the *Corymbia calophylla* and *Kingia australis* Woodland on heavy soils of the Swan Coastal Plain TEC (SCP3a).<br>• Vegetation condition ranged from Completely Degraded to Excellent within the site, with the majority considered to be in Degraded condition. |
| Spring Flora and Vegetation Survey and Targeted *Conospermum undulatum* Search, Lot 107 Clifford Road, Maddington (CPS7063/1) – Juceda Investments Pty Ltd by Strategen Environmental (Strategen) (2016) | Between Clifford Street and Tonkin Highway within the Survey Area | Flora and vegetation survey and targeted survey – 2.36 ha | • Three quadrats were assessed.<br>• Field survey was conducted in spring (September) 2016.<br>• No significant flora taxa were recorded.<br>• Four vegetation types were mapped within survey area.<br>• Vegetation condition ranged from Good to Completely Degraded. |
| New Runway Project Preliminary Draft Major Development Plan. Volume B: Environment, Heritage and Traffic Assessment – Perth Airport Pty Ltd (Perth Airport) (2018) | Perth Airport proposed New Runway Project – 0.5 km NW of the Survey Area | Compilation of survey data undertaken by numerous consultants from 2013 to 2018 as part of the New Runway Project for Perth Airport – 293 ha | • Two EPBC Act listed threatened taxa were recorded; *Conospermum undulatum* and *Macarthuria keigheryi*.<br>• Three priority taxa were recorded; *Platysace ramosissima* (P3), *Schoenus benthamii* (P3) and *Verticordia lindleyi* subsp. *lindleyi* (P4).<br>• Seven vegetation types were mapped within survey area.<br>• Banksia Woodlands of the Swan Coastal Plain TEC was recorded in the survey area.<br>• Vegetation within the survey area ranged from Excellent to Completely Degraded. |

| Report Title and Author | Location | Scope | Key Findings (Flora and Vegetation only) |
|---|---|---|---|
| Roe Highway and Kalamunda Road Upgrade Flora, Vegetation, Fauna and Black Cockatoo Assessment – Main Roads WA by 360 Environmental Pty Ltd (360 Environmental) (2018) | Along Roe Highway including Kalamunda and Maida Vale Road intersections – approximately 2.3 km NE of the Survey Area | Detailed flora and vegetation survey – 80.8 ha. | • Recorded 120 taxa from 37 families and 95 genera.<br>• Two quadrats (10 x 10 m) and three relevés assessed.<br>• Field survey was conducted in spring (October) 2017.<br>• One EPBC Act listed threatened taxon was recorded; *Conospermum undulatum.*<br>• One priority taxon was recorded: *Isopogon drummondii* (now *Isopogon autumnalis*) (P3).<br>• 34 introduced taxa were recorded.<br>• Five vegetation associations were described, and 17 vegetation units were mapped.<br>• Two vegetation associations were determined to have affiliations with FCT SCP20a and two vegetation associations were determined to have affiliations with FCT SCP3c. |
| Thornlie-Cockburn Link Project Flora and fauna survey – Public Transport Authority by GHD (2018) | Proposed 18 km railway alignment from Beckenham Station to Cockburn Central Station, northern part of alignment is 2.8 km SW of the Survey Area | Detailed flora and vegetation survey – 157.9 ha | • Recorded 187 taxa from 52 families and 140 genera.<br>• 12 quadrats (10 x 10 m) and 9 relevés assessed.<br>• Field survey was conducted in spring (September/October) 2017 and summer/autumn/spring (February/March/September/October) 2018.<br>• One EPBC Act listed threatened taxon was recorded; *Caladenia huegelii.*<br>• No priority taxa were recorded.<br>• 68 introduced taxa were recorded.<br>• 11 vegetation types were mapped within survey area.<br>• Two conservation significant ecological communities were considered to be present within the survey area, these being: Banksia Woodlands of the SCP TEC and the Low lying *Banksia attenuata* woodlands or shrublands PEC (SCP21c). |
| Tonkin Highway Welshpool Road to Hale Road Vegetation condition assessment – Main Roads WA by Strategen Environmental (Strategen) (2019) | Along Tonkin Highway between Roe Highway and approximately 400 m north of Kelvin Road, Wattle Grove – overlaps northern/central Development Envelope | Vegetation condition assessment – 57.1 ha | • Vegetation condition recorded – no flora or vegetation recorded.<br>• 25 sites inspected.<br>• Field survey was conducted in autumn (May) 2019.<br>• Vegetation within the Survey Area was largely in Degraded to Completely Degraded condition. |

#### 5.1.1.3 Significant Flora

The search of the DBCA WA Herbarium specimen Database and TPFL Database (data provided by Main Roads as per Section 3.1.1 (DBCA 2019b)) returned a total of 85 significant vascular flora taxa that have records in the Desktop Study Area. This includes 21 Threatened taxa (as classified under the BC Act) and 64 DBCA-classified Priority flora.

A search of these databases using *NatureMap* (DBCA 2007-) was also undertaken as part of the Desktop Study to check for any recently added records and confirm the records returned from the DBCA WA Herbarium specimen database and TPFL database search (Appendix H). The *NatureMap* search did not return any additional significant flora taxa.

The search of the DAWE SPRAT Database (DAWE 2019) with regard to MNES listed under the EPBC Act identified 29 flora taxa listed as Threatened Species, or habitat for such species, that may occur in the Desktop Study Area. The full results of the DAWE Database search are presented in Appendix I.

A list of significant flora taxa known from within the Desktop Study Area is presented in Table 11 and on Figure 10. This list has been compiled from the results of searches of DBCA's Threatened Flora Databases and DAWE's SPRAT Database. A total of 95 significant taxa are known from the Desktop Study Area including 30 Threatened taxa and 65 Priority taxa. Of these, 15 taxa are known to occur in the Survey Area itself; these are shaded in green in Table 11.

Appendix B presents conservation codes for Western Australia flora (DBCA 2019a).

**Table 11: Significant Flora Taxa Known from Within the Desktop Study Area**

| Taxon | Status | Source* | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) |
|---|---|---|---|---|
| *Acacia anomala* | T | DAWE; DBCA | August to September | Yellow or grey-brown sandy loam or sandy clay with laterite pebbles over laterite. Slopes and flats |
| *Acacia aphylla* | T | DBCA | July to October | Brown or yellow sandy loam or clay loam on laterite and granite outcrops. Slopes and flats |
| *Acacia horridula* | P3 | DBCA | May to November | Brown or yellow loam or sandy loam with granite or laterite. Granite outcrops, slopes |
| *Acacia lasiocarpa* var. *bracteolata* long peduncle variant (G.J. Keighery 5026) | P1 | DBCA | May, August | Sand. Winter-wet flats and swamps |
| *Acacia oncinophylla* subsp. *patulifolia* | P4 | DBCA | March to April or September to December | Granite, occasionally on laterite. Brown loam |
| *Allocasuarina grevilleoides* | P3 | DBCA | September to November | Brown or grey sand or clay loam with laterite and granite. Slopes, outcrops and plains |
| *Andersonia gracilis* | T | DAWE; DBCA | August to November | White or grey sand, sandy clay or gravelly loam. Winter-wet areas and near swamps |
| *Andersonia* sp. Blepharifolia (F. & J. Hort 1919) | P2 | DBCA | September to November | Brown or red sandy loam with granite or laterite. Slopes and hilltops |
| *Anthocercis gracilis* | T | DAWE; DBCA | September to October | Sandy or loamy soils. Granite outcrops |
| *Aponogeton hexatepalus* | P4 | DBCA | February, May to November | Brown, grey or black clay. Growing in shallow water in major drainage lines and wetlands, claypans |
| *Asteridea gracilis* | P3 | DBCA | February, September to October | Brown or yellow sandy loam with laterite and granite. Slopes, flats and plains |
| *Austrostipa bronwenae* | T | DAWE; DBCA | September to November | Brown or grey loam or sandy clay, sometimes on Muchea limestone. Winter-wet flats, swamps and wetlands |
| *Babingtonia urbana* | P3 | DBCA | December to March | Brown clay loam and sand. Winter-wet flats and wetlands |
| *Banksia kippistiana* var. *paenepeccata* | P3 | DBCA | October to November | Slopes and hills. Sandy soils with laterite. |
| *Banksia mimica* | T | DAWE; DBCA | September to January | Grey or white sand. Hilltops, slopes and flats |
| *Banksia pteridifolia* subsp. *vernalis* | P3 | DBCA | August to November | White, grey or brown sand and loamy sand over laterite. Slopes and flats |
| *Beaufortia purpurea* | P3 | DBCA | August to December | Brown sandy loam with laterite, sometimes over granite. Slopes |

| Taxon | Status | Source* | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) |
|---|---|---|---|---|
| *Bolboschoenus fluviatilis* | P1 | DBCA | November to December | Grey or brown sand or silt. Wet soils in littoral zones, edges of watercourses and seeps |
| *Boronia humifusa* | P1 | DBCA | June, September to October | Slopes, valleys and hills. Gravelly sand or loam over laterite. |
| *Boronia tenuis* | P4 | DBCA | August to November | Brown loam or sandy clay over granite or laterite. Slopes and outcrops |
| *Byblis gigantea* | P3 | DBCA | September to January | Sand or sandy loam. Winter-wet flats and drainage lines |
| *Caladenia huegelii* | T | DAWE; DBCA | August to October | Grey or brown sand, clay loam |
| *Calandrinia uncinella* | P1 | DBCA | September to October | Brown, grey or white sand or loam. Swamps, winter-wet flats and saline river flats |
| *Calothamnus accedens* | P4 | DBCA | July to January | Brown or grey loam or clay loam over laterite. Slopes and hilltops |
| *Calothamnus graniticus* subsp. *leptophyllus* | P4 | DBCA | June to August, September, November | Clay or sandy loam with granite or laterite. Hillsides and slopes. |
| *Calytrix breviseta* subsp. *breviseta* | T | DAWE; DBCA | September to November | Grey or brown sandy loam or clay. Flats and winter-wet depressions |
| *Carex tereticaulis* | P3 | DBCA | September to November | Grey or brown loam or sandy clay with laterite. Edges of drainage lines |
| *Chamaescilla gibsonii* | P3 | DBCA | August to November | Brown or grey sandy clay. Winter-wet clay pans and flats |
| *Chamelaucium lullfitzii* | T | DAWE | September to December | Sand, sometimes gravelly. Slopes and undulating plains |
| *Comesperma griffinii* | P2 | DBCA | October to January | Grey or brown clayey sand or sandy loam, sometimes gravelly. Slopes, winter-wet flats and depressions |
| *Comesperma rhadinocarpum* | P3 | DBCA | October to January | Sand or sandy loam with laterite. Slopes, undulating plains and flats |
| *Conospermum undulatum* | T | DAWE; DBCA | May to October | Sand and sandy clay, often over laterite. Flats and slopes |
| *Cyanicula ixioides* subsp. *ixioides* | P4 | DBCA | August to October | Slopes, gullies and hillsides with clay or sandy gravel often with laterite or granite outcropping, |
| *Darwinia apiculata* | T | DAWE; DBCA | July, October to November | Brown or grey sandy loam with granite or laterite. Granite outcrops, ridges and flats |

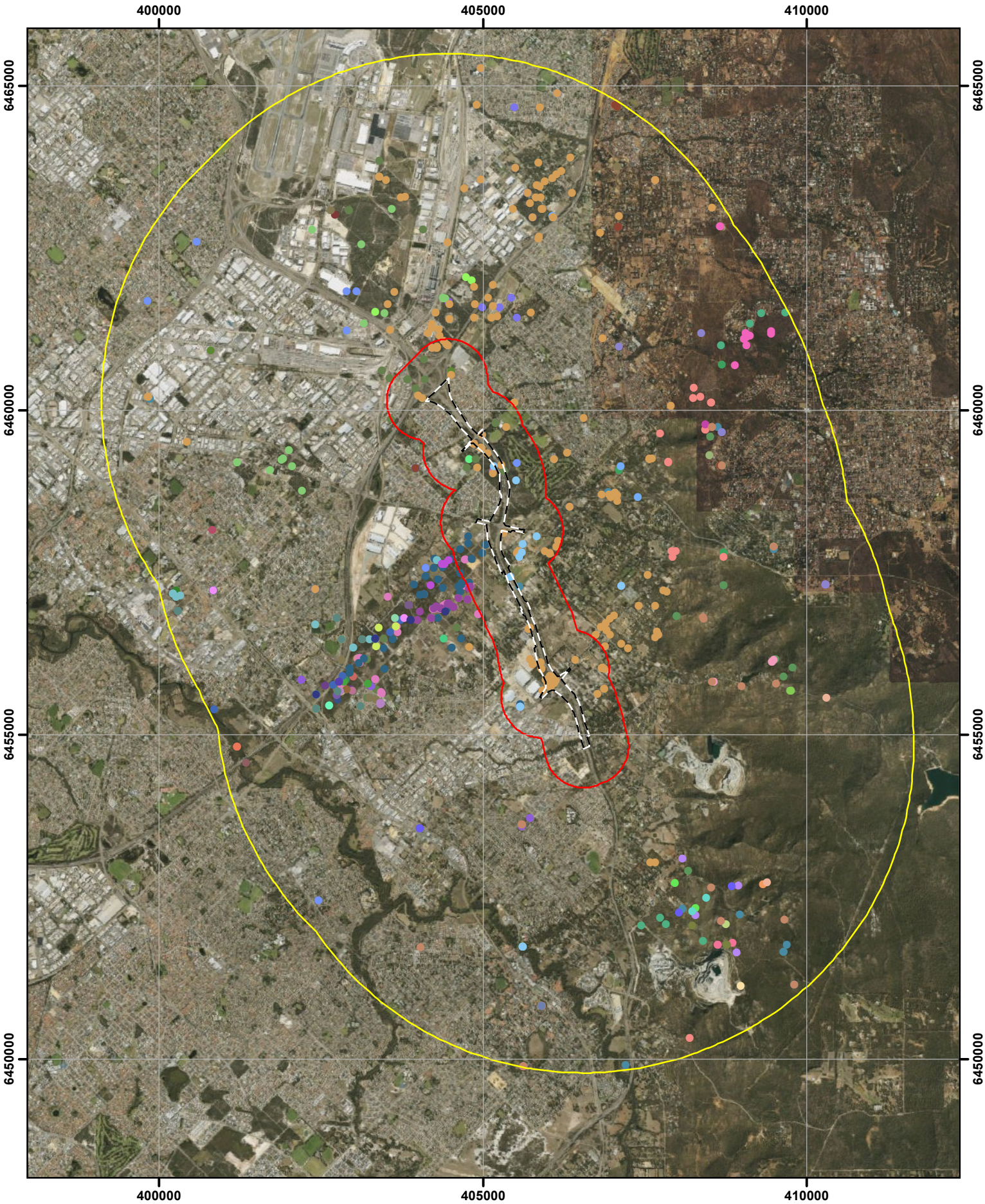
| Taxon | Status | Source* | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) |
|---|---|---|---|---|
| *Diplolaena andrewsii* | T | DAWE | August to November | Brown sandy loam over granite. Granite outcrops and slopes |
| *Diuris drummondii* | T | DAWE | November to December | Wet brown or grey sandy loam or peat. Winter-wet swamps, watercourses and floodplains. |
| *Diuris micrantha* | T | DAWE | September to October | Brown loamy clay. Winter-wet swamps, in shallow water |
| *Diuris purdiei* | T | DAWE; DBCA | September to October | Grey-black sand, moist. Winter-wet swamps |
| *Drakaea elastica* | T | DAWE | October to November | White or grey sand. Low-lying situations adjoining winter-wet swamps |
| *Drakaea micrantha* | T | DAWE | September to November | White-grey sand |
| *Drosera occidentalis* | P4 | DBCA | October to November | Swampy or damp flats, sandy floodplain |
| *Eleocharis keigheryi* | T | DAWE; DBCA | August to November | Clay or sandy loam. Growing in shallow water in creeks and claypans |
| *Eremophila glabra* subsp. *chlorella* | T | DAWE; DBCA | June to January | Brown, grey or white sand or clay. Swamps, winter-wet flats and lower slopes |
| *Eryngium pinnatifidum* subsp. Palustre (G.J. Keighery 13459) | P3 | DBCA | September to November | Grey, brown or black sand or clay. Winter-wet flats and claypans |
| *Eryngium* sp. Subdecumbens (G.J. Keighery 5390) | P3 | DBCA | September to January | Grey clay. Winter-wet flats, claypans and swamps |
| *Eucalyptus x balanites* | T | DAWE | October to December or January to February | Sandy soils with lateritic gravel |
| *Goodenia arthrotricha* | T | DAWE; DBCA | March, November to December | Brown sandy loam, sometimes with laterite and granite. Outcrops, slopes, hilltops and flats |
| *Grevillea curviloba* | T | DAWE | August to October | Grey, white or brown sand or sandy loam. Flats, drainage lines and lower slopes |
| *Grevillea thelemanniana* | T | DAWE; DBCA | September to December | Grey or brown sandy loam and clay. Winter-wet swamps and flats |
| *Haemodorum loratum* | P3 | DBCA | October to November | White, grey or brown sand, sometimes over granite or laterite. Slopes, plains and flats |
| *Halgania corymbosa* | P3 | DBCA | September to October | Brown sandy loam or sandy clay over laterite or granite. Slopes |
| *Haloragis scoparia* | P1 | DBCA | April | Plains or flats with white/grey clay |
| *Hibbertia montana* | P4 | DBCA | August to September | Brown sandy loam with laterite or granite. Slopes, gullies, breakaways and hilltops |

| Taxon | Status | Source* | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) |
|---|---|---|---|---|
| *Hydrocotyle lemnoides* | P4 | DBCA | August to November | Brown or grey clay or clayey sand. Growing in shallow water in wetlands, swamps and claypans |
| *Hydrocotyle striata* | P1 | DBCA | November | Winter wet depressions and creeks with peat or sand. |
| *Isopogon autumnalis* | P3 | DBCA | February to June | Grey or yellow sand, sometimes with laterite. Plains, flats and lower slopes |
| *Isotropis cuneifolia* subsp. *glabra* | P3 | DBCA | September to October | Grey or brown sand or clay. Winter-wet depressions and flats |
| *Jacksonia gracillima* | P3 | DBCA | September to November | Grey sand. Winter-wet flats and wetlands |
| *Lasiopetalum bracteatum* | P4 | DBCA | September to February | Brown or yellow clayey sand, sometimes over granite. Hilltops, slopes and drainage lines |
| *Lasiopetalum glutinosum* subsp. *glutinosum* | P3 | DBCA | September to December | Sandy loam or clay with granite. Granite outcrops and slopes |
| *Lasiopetalum pterocarpum* | T | DAWE | September to November | Red-brown loam or clayey sand with granite or laterite. Sloping banks near creeklines |
| *Lepidosperma rostratum* | T | DAWE; DBCA | June to December | Peaty sand or clay. Winter-wet swamps |
| *Lepyrodia curvescens* | P2 | DBCA | June, September to January | Grey sandy loam or peaty sand. Slopes and winter-wet depressions |
| *Macarthuria keigheryi* | T | DAWE; DBCA | August to November | Grey or white sand. Low-lying plains and low rises, particularly in recently burnt vegetation |
| *Meionectes tenuifolia* | P3 | DBCA | October to December | Wetlands, swamps |
| *Melaleuca viminalis*^ | P2 | DBCA | November to May | Brown or grey sand or sandy clay. Drainage lines and flats |
| *Myriophyllum echinatum* | P3 | DBCA | September to October | Brown or grey sandy clay. Wetlands and winter-wet depressions |
| *Ornduffia submersa* | P4 | DBCA | August to November | Grey or brown clay. Growing in shallow water in wetlands and drainage lines |
| *Pimelea rara* | P4 | DBCA | November to March | Grey, brown or yellow sandy loam with granite or laterite. Ridges and slopes |
| *Pithocarpa corymbulosa* | P3 | DBCA | January to April | Gravelly or sandy loam. Amongst granite outcrops |
| *Platysace ramosissima* | P3 | DBCA | November to January | Sand. Undulating plains, slopes and flats |
| *Ptilotus pyramidatus* | T | DAWE; DBCA | October | Grey or white sandy clay. Flats |
| *Ptilotus sericostachyus* subsp. *roseus* | P1 | DBCA | September to December | - |
| *Schoenus benthamii* | P3 | DBCA | August to November | Grey or white clayey sand. Swamps, wetlands and winter-wet flats |

| Taxon | Status | Source* | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) |
|---|---|---|---|---|
| *Schoenus capillifolius* | P3 | DBCA | October to November | Brown clay or sandy clay. Winter-wet claypans and flats |
| *Schoenus loliaceus* | P2 | DBCA | September to November | Grey or brown clay loam or peaty clay. Growing in shallow water in swamps and winter-wet flats |
| *Schoenus natans* | P4 | DBCA | September to December | Brown or grey sandy clay. Growing in shallow water in creeklines, claypans and wetland |
| *Schoenus pennisetis* | P3 | DBCA | August to November | Grey or peaty sand, sandy clay. Swamps, winter-wet depressions |
| *Schoenus* sp. Beaufort (G.J. Keighery 6291) | P1 | DBCA | September to October | Brown or grey clay. Growing in shallow water in creeklines and claypans |
| *Schoenus* sp. Waroona (G.J. Keighery 12235) | P3 | DBCA | October to November | Brown or grey clay or sandy clay. Winter-wet flats and wetlands |
| *Senecio gilbertii* | P1 | DBCA | September to November | Valleys and slopes with laterite. |
| *Senecio leucoglossus* | P4 | DBCA | October to December | Brown loam with laterite or granite. Slopes |
| *Stackhousia* sp. Red-blotched corolla (A. Markey 911) | P3 | DBCA | September to November | Slopes with clay with granite or sometimes laterite. |
| *Stylidium aceratum* | P3 | DBCA | October to November | Grey or brown sandy loam or clay. Wetlands, swamps and winter-wet flats |
| *Stylidium longitubum* | P4 | DBCA | July to November | Brown or grey clay loam. Wetlands and winter-wet flats |
| *Stylidium striatum* | P4 | DBCA | September to December | Brown or yellow sandy clay with laterite. Slopes and flats |
| *Styphelia filifolia* | P3 | DBCA | February to April | Sand. Sandplains, slopes and flats |
| *Synaphea* sp. Fairbridge Farm (D. Papenfus 696) | T | DAWE; DBCA | September to October | Grey or brown clayey sand or sand with laterite. Winter-wet flats |
| *Tetraria australiensis* | T | DBCA | September to December | Brown or grey sandy loam or sand. Winter-wet flats |
| *Thelymitra dedmaniarum* | T | DAWE | November to January | Grey loam. Granite |
| *Thelymitra magnifica* | P1 | DBCA | September to October | Brown loam with granite or laterite. Granite outcrops, gullies and slopes |
| *Thelymitra stellata* | T | DAWE; DBCA | October to November | Brown or grey sand or clay loam with laterite. Ridges, gullies and rocky slopes |
| *Thysanotus anceps* | P3 | DBCA | November to January | Sand or sandy loam with laterite. Ridges, hilltops and slopes |

| Taxon | Status | Source* | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) |
|---|---|---|---|---|
| *Thysanotus* sp. Badgingarra (E.A. Griffin 2511) | P2 | DBCA | January, December | Slopes and hills with sand or sandy clay with laterite or granite. |
| *Verticordia lindleyi* subsp. *lindleyi* | P4 | DBCA | October to May | Sand or sandy clay. Winter-wet flats and depressions |

* Sources are:
DAWE – SPRAT Database Search (DAWE 2019);
DBCA - DBCA's Significant Flora Databases (data provided by Main Roads) (DBCA 2019b) and NatureMap DBCA (2007-) (see Section 3.1.1)
^ *Melaleuca viminalis* is indigenous to the Kimberley Region of Western Australia and has been introduced to the Survey Area (see Section 5.1.2.6).




| | | |
|---|---|---|
| **Desktop Study Area Significant Flora Records** | Author: Marlee Starcevich | N |
| | WEC Ref: MR19-34-01 | |
| WOODMAN ENVIRONMENTAL | Filename: MR19-34-01-f10-1 | **Figure** |
| | Scale: 1:75,000 (A4) | 10.1 |
| | Projection: GDA 1994 MGA Zone 50 | |
| This map should only be used in conjunction with WEC report MR19-34-01. | Revision: 0 - 30 July 2020 | |

## Legend

- Desktop Study Area
- Development Envelope
- Survey Area

**Significant Flora**

- *Acacia anomala* (T)
- *Acacia aphylla* (T)
- *Acacia horridula* (P3)
- *Acacia lasiocarpa* var. bracteolata long peduncle variant (G.J. Keighery 5026) (P1)
- *Acacia oncinophylla* subsp. *patulifolia* (P4)
- *Allocasuarina grevilleoides* (P3)
- *Andersonia gracilis* (T)
- *Andersonia* sp. Blepharifolia (F. & J. Hort 1919) (P2)
- *Anthocercis gracilis* (T)
- *Aponogeton hexatepalus* (P4)
- *Asteridea gracilis* (P3)
- *Austrostipa bronwenae* (T)
- *Babingtonia urbana* (P3)
- *Banksia mimica* (T)
- *Banksia pteridifolia* subsp. *vernalis* (P3)
- *Beaufortia purpurea* (P3)
- *Bolboschoenus fluviatilis* (P1)
- *Boronia tenuis* (P4)
- *Byblis gigantea* (P3)
- *Caladenia huegelii* (T)
- *Calandrinia uncinella* (P1)
- *Calothamnus accedens* (P4)
- *Calothamnus graniticus* subsp. *leptophyllus* (P4)
- *Calytrix breviseta* subsp. *breviseta* (T)
- *Carex tereticaulis* (P3)
- *Chamaescilla gibsonii* (P3)
- *Comesperma griffinii* (P2)
- *Comesperma rhadinocarpum* (P3)
- *Conospermum undulatum* (T)
- *Darwinia apiculata* (T)
- *Diuris purdiei* (T)
- *Drosera occidentalis* (P4)
- *Eleocharis keigheryi* (T)
- *Eremophila glabra* subsp. *chlorella* (T)
- *Eryngium pinnatifidum* subsp. Palustre (G.J. Keighery 13459) (P3)
- *Eryngium* sp. Subdecumbens (G.J. Keighery 5390) (P3)
- *Goodenia arthrotricha* (T)
- *Grevillea thelemanniana* (T)
- *Haemodorum loratum* (P3)
- *Halgania corymbosa* (P3)
- *Hydrocotyle lemnoides* (P4)
- *Isopogon autumnalis* (P3)
- *Isotropis cuneifolia* subsp. *glabra* (P3)
- *Jacksonia gracillima* (P3)
- *Lasiopetalum bracteatum* (P4)
- *Lasiopetalum glutinosum* subsp. *glutinosum* (P3)
- *Lepidosperma rostratum* (T)
- *Lepyrodia curvescens* (P2)
- *Macarthuria keigheryi* (T)
- *Meionectes tenuifolia* (P3)
- *Melaleuca viminalis* (P2)
- *Myriophyllum echinatum* (P3)
- *Ornduffia submersa* (P4)
- *Pimelea rara* (P4)
- *Pithocarpa corymbulosa* (P3)
- *Platysace ramosissima* (P3)
- *Ptilotus pyramidatus* (T)
- *Stylidium aceratum* (P3)
- *Schoenus benthamii* (P3)
- *Stylidium longitubum* (P4)
- *Schoenus loliaceus* (P2)
- *Schoenus natans* (P4)
- *Schoenus* sp. Beaufort (G.J. Keighery 6291) (P1)
- *Schoenus* sp. Waroona (G.J. Keighery 12235) (P3)
- *Styphelia filifolia* (P3)
- *Schoenus pennisetis* (P3)
- *Stackhousia* sp. Red-blotched corolla (A. Markey 911) (P3)
- *Senecio leucoglossus* (P4)
- *Stylidium striatum* (P4)
- *Schoenus capillifolius* (P3)
- *Synaphea* sp. Fairbridge Farm (D. Papenfus 696) (T)
- *Tetraria australiensis* (T)
- *Thelymitra magnifica* (P1)
- *Thelymitra stellata* (T)
- *Thysanotus anceps* (P3)
- *Verticordia lindleyi* subsp. *lindleyi* (P4)

**Desktop Study Area Significant Flora Records**

Author: Marlee Starcevich

WEC Ref: MR19-34-01

WOODMAN ENVIRONMENTAL

This map should only be used in conjunction with WEC report MR19-34-01.

Filename: MR19-34-01-f10-2

Scale: 1:75,000 (A4)

Projection: GDA 1994 MGA Zone 50

Revision: 0 - 30 July 2020

**Figure**

**10.2**

#### 5.1.1.4 Significant Vegetation

The interrogation of the DBCA TEC and PEC Database (data provided by Main Roads as per Section 3.1.1 (DBCA 2019b) and DAWE's SPRAT Database (DAWE 2019) returned a total of 15 significant communities that have records in (or buffers that intersect) the Desktop Study Area. These are presented in Table 11. The names of the communities in Table 12 are as presented in WA TEC / PEC lists (DBCA 2018; 2020b) unless otherwise noted.

As outlined in Table 12, many of the significant communities are listed by both WA and the Commonwealth, often under slightly different names, or the WA community is listed as a component of a Commonwealth community. Four of the communities are listed as PECs in Western Australia with the remaining communities listed as TECs under either state and/or federal legislation. Nine of these communities have buffer polygons that intersect the Survey Area itself, highlighted in green in Table 12. The locations of significant vegetation are presented on Figure 11.

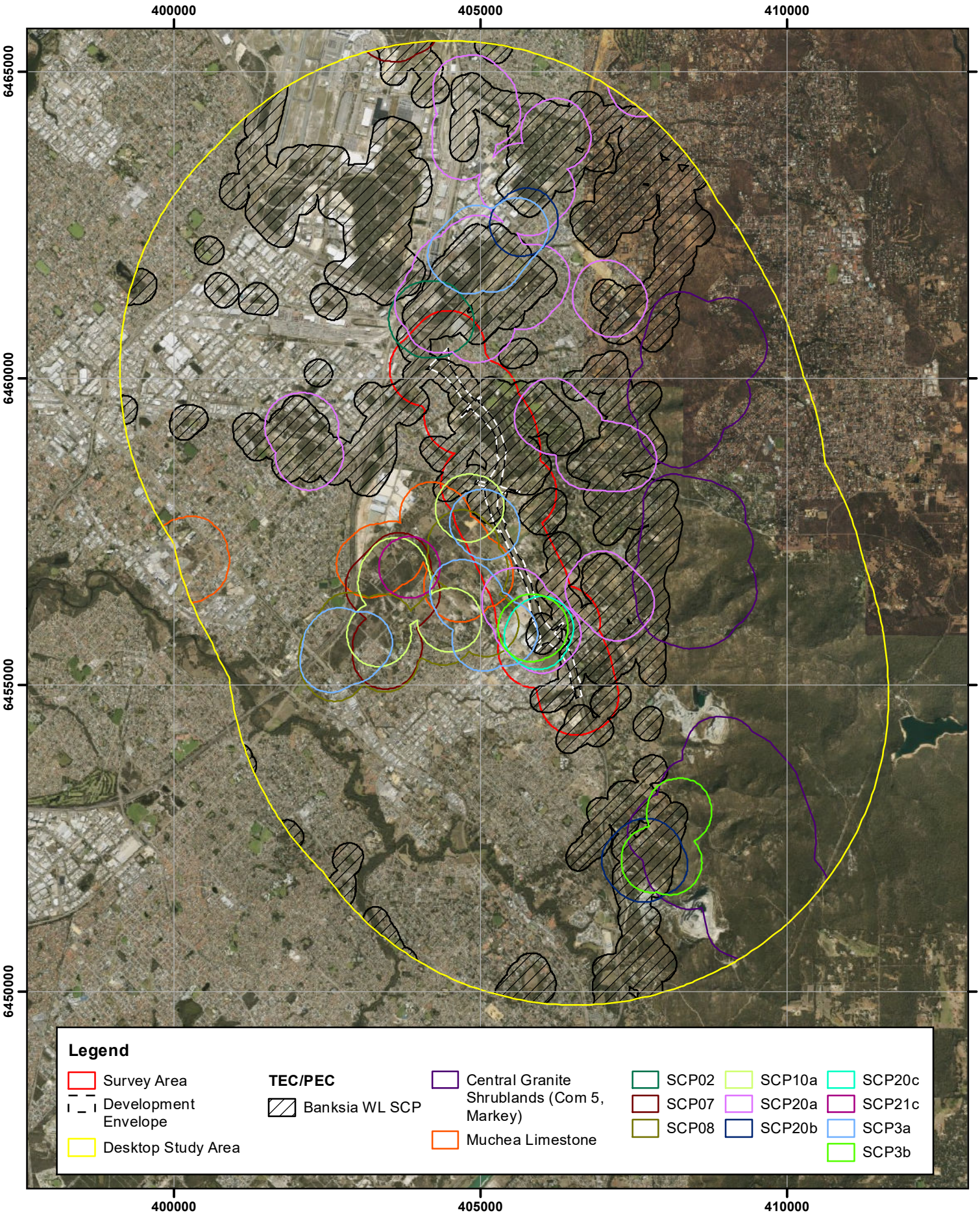
Appendix C presents definitions, categories and criteria for TECs and PECs (DBCA 2013a).

**Table 12: Significant Vegetation Returned from DBCA Database Searches**

| Community | Conservation Status (WA) | EPBC Act Ranking | Source* |
|---|---|---|---|
| Banksia woodlands of the Swan Coastal Plain | Priority 3 | Endangered^ | DBCA; DAWE |
| Central Northern Darling Scarp Granite Shrubland Community (Com 5, Markey) | Priority 4 | - | DBCA |
| SCP02 - Southern wet shrublands, Swan Coastal Plain | Endangered | - | DBCA |
| SCP3a - *Corymbia calophylla -Kingia australis* woodlands on heavy soils, Swan Coastal Plain (WA); *Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain (Commonwealth) | Critically Endangered | Endangered | DBCA ; DAWE |
| SCP3b - *Corymbia calophylla - Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain | Vulnerable | - | DBCA |
| SCP07 - Herb rich saline shrublands in clay pans (WA); Clay Pans of the Swan Coastal Plain (Commonwealth) | Vulnerable | Critically Endangered~ | DBCA ; DAWE |
| SCP08 - Herb rich shrublands in clay pans (WA); Clay Pans of the Swan Coastal Plain (Commonwealth) | Vulnerable | Critically Endangered~ | DBCA ; DAWE |
| SCP10a - Shrublands on dry clay flats (WA); Clay Pans of the Swan Coastal Plain (Commonwealth) | Endangered | Critically Endangered~ | DBCA ; DAWE |
| SCP20a - *Banksia attenuata* woodlands over species rich dense shrublands (WA); Banksia Woodlands of the Swan Coastal Plain (Commonwealth) | Endangered | Endangered^ | DBCA ; DAWE |
| SCP20b - *Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain (WA); Banksia Woodlands of the Swan Coastal Plain (Commonwealth) | Endangered | Endangered^ | DBCA ; DAWE |
| SCP20c - Shrublands and woodlands of the eastern side of the Swan Coastal Plain | Critically Endangered | Endangered | DBCA |
| SCP21c - Low lying *Banksia attenuata* woodlands or shrublands (WA); Banksia Woodlands of the Swan Coastal Plain (Commonwealth) | Priority 3 | Endangered^ | DBCA ; DAWE |
| Shrublands and woodlands on Muchea Limestone | Endangered | Endangered | DBCA |
| Tuart (*Eucalyptus gomphocephala*) woodlands of the | Priority 3 | Critically | DAWE |

| Community | Conservation Status (WA) | EPBC Act Ranking | Source* |
|---|---|---|---|
| Swan Coastal Plain (WA); Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain (Commonwealth) | | Endangered | |

^: can be a component of the EPBC listed TEC 'Banksia Woodlands of the Swan Coastal Plain'.
~: can be a component of the EPBC listed TEC 'Clay Pans of the Swan Coastal Plain'.
* Sources are:
DBCA - DBCA's TEC and PEC Database, data provided by Main Roads (DBCA 2019b) and *NatureMap* (see Section 3.1.1); and
DAWE - SPRAT Database Search (DAWE 2019).




| | | |
|---|---|---|
| **Desktop Study Area Significant Vegetation** | Author: Marlee Starcevich | N |
| | WEC Ref: MR19-34-01 | |
| WOODMAN ENVIRONMENTAL | Filename: MR19-34-01-f11 | **Figure** |
| | Scale: 1:80,000 (A4) | 11 |
| | Projection: GDA 1994 MGA Zone 50 | |
| This map should only be used in conjunction with WEC report MR19-34-01. | Revision: 0 - 30 July 2020 | |

#### 5.1.1.5 Introduced Flora

A total of 280 introduced taxa are known to occur within the Desktop Study Area. Of these, 15 are Declared Pests listed under the BAM Act (DPIRD 2019) and 18 are listed Weeds of National Significance (WoNS) (Australian Weeds Committee (AWC) 2019), as presented in Table 13. The full list of introduced flora taxa known from within the Desktop Study Area is presented in Appendix J. The information presented has been compiled from the DBCA *NatureMap* search (DBCA 2007-) and DAWE's SPRAT Database (DAWE 2019).

**Table 13: Declared Pests and WoNS known from within the Desktop Study Area**

| Taxon | Common Name | Source* | Comments |
|---|---|---|---|
| *Asparagus aethiopicus* | Asparagus Fern | DAWE | WoNS |
| *Asparagus asparagoides* | Bridal Creeper | DAWE | Declared Pest; WoNS |
| *Asparagus declinatus* | Bridal Veil | DAWE | WoNS |
| *Asparagus plumosus* | Climbing Asparagus-fern | DAWE | WoNS |
| *Chrysanthemoides monilifera* subsp. *monilifera* | Boneseed | DAWE; *NatureMap* | Declared Pest; WoNS |
| *Echium plantagineum* | Paterson's Curse | *NatureMap* | Declared Pest |
| *Eichhornia crassipes* | Water Hyacinth | DAWE | WoNS |
| *Genista linifolia* | Flax-leaved Broom | DAWE; *NatureMap* | WoNS |
| *Genista monspessulana* | Cape Broom | DAWE | WoNS |
| *Gomphocarpus fruticosus* | Narrowleaf Cottonbush | *NatureMap* | Declared Pest |
| *Lantana camara* | Lantana | DAWE; *NatureMap* | WoNS |
| *Lycium ferocissimum* | African Boxthorn | DAWE | WoNS |
| *Moraea flaccida* | One-leaf Cape Tulip | *NatureMap* | Declared Pest |
| *Opuntia monacantha* | Barbary Fig | *NatureMap* | Declared Pest; WoNS |
| *Opuntia* spp. | Prickly Pears | DAWE | WoNS |
| *Opuntia stricta* | Common Prickly Pear | *NatureMap* | WoNS |
| *Rubus anglocandicans* | | *NatureMap* | Declared Pest |
| *Rubus fruticosus* aggregate | Blackberry | DAWE | Declared Pest; WoNS |
| *Rubus laudatus* | | *NatureMap* | Declared Pest |
| *Sagittaria platyphylla* | Arrowhead | DAWE | Declared Pest; WoNS |
| *Salix* spp. (except *S.babylonica, S.*x *calodendron* and *S.*x *reichardtii*) | Willows | DAWE | Declared Pest (majority of *Salix* spp.); WoNS |
| *Salvinia molesta* | Salvinia | DAWE; *NatureMap* | WoNS |
| *Solanum linnaeanum* | Apple of Sodom | *NatureMap* | Declared Pest |
| *Tamarix aphylla* | Athel Pine | DAWE | Declared Pest; WoNS |
| *Vicia tetrasperma* | | *NatureMap* | Declared Pest |
| *Zantedeschia aethiopica* | Arum Lily | *NatureMap* | Declared Pest |

* Sources are:
DAWE - DAWE (2019); and
*NatureMap* - DBCA (2007-).

### 5.1.2 Field Survey Results - Flora

#### 5.1.2.1 Vascular Flora Census

A total of 355 discrete vascular flora taxa were recorded in the Survey Area during this survey, representing 67 families and 202 genera. The most well-represented families are Myrtaceae (49 taxa), Fabaceae (45 taxa), Proteaceae (35 taxa) and Cyperaceae (30 taxa). Fifty-six are annual taxa. Sixty-eight of the total taxa recorded are introduced taxa (see Section 5.1.2.6). Given the very small area of intact vegetation in the Survey Area and history of disturbance of this vegetation (most areas are in narrow road reserves), the floristic diversity is considered to be relatively high.

Average taxon richness per quadrat (excluding hybrids) was 46.4 (± 13.7), with the greatest number of taxa recorded in a single quadrat being 79, and the lowest number being 24. A full list of taxa is presented in Appendix K, with raw quadrat data and parameters presented in Appendix L.

#### 5.1.2.2 Significant Flora Taxa

Table 14 presents a summary of data relating to significant flora taxa recorded by Woodman Environmental within the Survey Area. A total of 11 significant flora taxa were recorded within the Survey Area, including four Threatened taxa and seven Priority flora taxa (discussed in Section 5.1.2.3). Appendix B presents conservation codes for Western Australia flora (DBCA 2019a). It should be noted that the data presented in Table 14 is considered to supersede all data previously recorded in the Development Envelope.

There are DBCA records of *Banksia mimica* (T) and *Isopogon autumnalis* (P3), the co-ordinates of which plot within the Development Envelope. These records were investigated and were found to be within cleared road verge with no plants being recorded at this location. Further investigations were conducted with regards to locality information which found the GPS location information for these locations were erroneous.

*Grevillea thelemanniana* is a listed Threatened taxon which is only known from the Brixton Street Wetlands in the Kenwick area. This species is typically found in winter-wet low-lying flats (WA Herbarium 1998-), whereas individuals recorded by Woodman Environmental within the Survey Area were recorded in dry habitats in revegetated areas adjacent to Tonkin Highway. All recorded individuals of this taxon were deemed to be planted and are considered not naturally present in the areas surveyed by Woodman Environmental, therefore have not been considered significant and are not discussed further in this report in the context of significant flora.

Locations of significant flora taxa recorded by Woodman Environmental in the Survey Area are presented in Table 1 of Appendix M, and Appendix N. Completed TPFRFs for significant flora taxa recorded during the survey are presented in Appendix O. Specimens of significant flora taxa that represented new populations were submitted to the WA Herbarium for lodgement under Woodman Environmental transmittal number WTO-422, with WA Herbarium accession number yet to be provided.

**Table 14: Summary of Significant Flora Taxa Recorded within the Survey Area**

| Taxon | Status | Number of Locations Recorded | | | Number of Individuals Recorded | | | Vegetation Types^ |
|---|---|---|---|---|---|---|---|---|
| | | Survey Area outside Development Envelope | Development Envelope | Total | Survey Area outside Development Envelope | Development Envelope | Total | |
| *Andersonia gracilis* | T | 5 | 10 | 15 | 24 | 10 | 34 | 5^ |
| *Banksia mimica* | T | 17 | 2 | 19 | 27 | 3 | 30 | 2^, 4^, 5 |
| *Byblis gigantea* | P3 | 1 | 0 | 1 | 1 | 0 | 1 | 4^ |
| *Conospermum undulatum* | T | 309 | 469 | 778 | 644 | 470 | 1114 | 1^, 2, 3, 4^, 5, 7, 8<br>CC/AC/CU,<br>CC/AC/KG, CC/MV,<br>RV4<br>C<br>NA |
| *Isopogon autumnalis* | P3 | 17 | 12 | 29 | 37 | 12 | 49 | 1^<br>C |
| *Jacksonia gracillima* | P3 | 442 | 155 | 597 | 1493 | 183 | 1676 | 1,2,3,4^,5^,6^,7^,8<br>RV5<br>C<br>NA |
| *Johnsonia pubescens* subsp. *cygnorum* | P2 | 63 | 164 | 227 | 109 | 173 | 282 | 1^, 2, 3, 4^, 5<br>C, CC/AC/CU, LL<br>RV4 |
| *Lasiopetalum bracteatum* | P4 | 2 | 0 | 2 | 4 | 0 | 4 | 3^ |
| *Styphelia filifolia* | P3 | 17 | 10 | 27 | 20 | 10 | 30 | 1^,4^,5, 6<br>C |
| *Tetraria australiensis* | T | 295 | 238 | 533 | 441 | 240 | 681 | 1^, 2^, 3^<br>C, CC/AC/KG, W |
| *Verticordia lindleyi* subsp. *lindleyi* | P4 | 316 | 151 | 467 | 776 | 157 | 933 | 1,2,4,5,6,7<br>C<br>NA |

Note: all data collected by Woodman Environmental, 2019-2020.
^: represents preferred habitat by the taxon.

#### 5.1.2.3 Listed Significant Flora Taxa

***Andersonia gracilis* (Threatened)**

*Andersonia gracilis* (T) is a slender erect or open straggly shrub growing to approximately 0.5 m high (Plate 1) in winter-wet areas (WA Herbarium 1998-). This taxon is endemic to Western Australia (ALA 2020), occurring over a range of 180 km from Perth (Kenwick wetlands) to north-west of Cataby in the north (DBCA 2007-). The Assessed Area is located within this range. There are 61 records of this taxon in Western Australia representing approximately 27 populations, four of which occur in DBCA-managed tenure including Conservation Park (R 49363), Kenwick Wetlands (R 49200 & R 50529) and Wongonderrah Nature Reserve (R 26248) (DBCA 2007-).

This species was searched for as part of targeted survey within the Assessed Area. A total of 34 individuals were recorded at 15 locations with 10 individuals from 10 locations recorded within the Development Envelope (Table 14; Appendix M). It is considered unlikely that any further locations of this taxon occur in the Assessed Area. These records represent one discrete population, occurring within Hartfield Park West of Tonkin Highway (R 17098) (Appendix N, Sheet N1). This species has not been previously recorded in the Hartfield Park Area therefore the population recorded at Hartfield Park is considered to be a new population.

VT 5 represents preferred habitat for this taxon.

**Plate 1:** ***Andersonia gracilis*** **(Threatened) in Cooljarloo (Photo: Woodman Environmental)**

***Banksia mimica* (Threatened)**

*Banksia mimica* (T) is a prostrate, lignotuberous shrub growing to 0.4 m high (Plate 2) on sandy slopes and flats (WA Herbarium 1998-). It is found over a range of approximately 320 km in Western Australia (where it is endemic (ALA 2020)), from south of Busselton to near Mogumber to the north (DBCA 2007-). The Assessed Area is located within this range. This taxon is known from 69 records representing approximately 25 populations, 11 of which occur in DBCA-managed tenure including Blackwood State Forest, Boonanarring Nature Reserve, Fynes Nature Reserve, Jarrahwood State Forrest, Whicher National Park, Crown Freehold – Department Interest blocks - 1497/392, 2745/531, 2654/215 and un-named Nature Reserve (R 46899).

This species was searched for as part of targeted survey within the Assessed Area. A total of 30 individuals were recorded at 19 locations, with three individuals from two locations recorded within the Development Envelope (Table 14; Appendix M). It is considered unlikely that any further locations of this taxon occur in the Assessed Area. These records represent two discrete populations, occurring within Hartfield Park East and West of Tonkin Highway (R 17098) (Appendix N, Sheets N1, N2). Both populations have previously been recorded in the Survey Area and represent DBCA populations 15a and b (DBCA 2019b).

VTs 2 and 4 represent the preferred habitat for this taxon.

**Plate 2:** ***Banksia mimica* (Threatened) (Photo: Woodman Environmental)**

***Byblis gigantea* (P3)**

*Byblis gigantea* (P3) is a small, branched perennial, herb growing to 0.45 m high (Plate 3) in sandy-peat swamps and seasonally wet areas (WA Herbarium 1998-). It is found over a range of approximately 285 km in Western Australia (where it is endemic (ALA 2020)), from north-west of Quindanning in the south to south-east of Cervantes in the north (DBCA 2007-). The Assessed Area is located within this range. This taxon is known from 56 records representing approximately 26 populations, five of which occur in DBCA-managed tenure including Kenwick Wetlands (R 50529), Conservation Park (R 49363), Harris River State Forest, Clare State Forest and Jarrahdale State Forest.

This species was searched for as part of targeted survey within the Assessed Area. One individual of this species was recorded at one location within the Assessed Area (Table 14; Appendix M), within Hartfield Park (R 17098) east of Tonkin Highway (Appendix N, Sheet N1). This species has previously been recorded in the Survey Area (DBCA 2019b), in close proximity to the recorded survey location. It is considered unlikely that any further locations of this taxon occur in the Assessed Area.

VT 4 represents the preferred habitat for this taxon.


**Plate 3:** ***Byblis gigantea* (P3) (Photo: B.A. Fuhrer and J. Hort, courtesy of *Florabase* (WA Herbarium 1998-))**

***Conospermum undulatum* (Threatened)**

*Conospermum undulatum* (T) is an erect, compact shrub growing to 2 m high (Plate 4) in plains, flats and swamps (WA Herbarium 1998-). This taxon is endemic to Western Australia (ALA 2020), occurring over a range of 21 km from near Martin in the south to near Hazelmere in the north (DBCA 2007-). The Assessed Area is located within this range. There are 216 records of this taxon in Western Australia representing approximately 28 populations, three of which occur in DBCA-managed tenure including Kalamunda National Park and Korung National Park (DBCA 2007-).

This species was searched for as part of targeted survey within the Assessed Area. A total of 1114 individuals were recorded at 778 locations with 470 individuals from 469 locations recorded within the Development Envelope (Table 14; Appendix M). These records represent four discrete populations, with two occurring within Hartfield Park East and West of Tonkin Highway (R 17098), one within Bush forever Site 53 in Orange Grove and one adjacent to Tonkin Highway north of Kelvin Road on the eastern road verge (Appendix N: Sheets N1, N2, N3). It is considered unlikely that any further locations of this taxon occur in the Assessed Area. This taxon had previously been recorded in the Survey Area by AECOM (2015) and DBCA (DBCA 2019b) and represent DBCA subpopulations 10a, 10c, 10e, 10g, 13a and 30.

VTs 1 and to a lesser extent VT 4 represent preferred habitat for this taxon.

**Plate 4:** ***Conospermum undulatum* (Threatened) (Photo: Woodman Environmental)**

***Isopogon autumnalis* (P3)**

*Isopogon autumnalis* (P3) is a shrub growing to 1 m high (Plate 5) on sandy soils on slopes and plains (WA Herbarium 1998-). This taxon is found over a range of approximately 260 km in Western Australia (where it is endemic (ALA 2020)), from near Serpentine in the south to north-west of Jurien Bay in the north (DBCA 2007-). The Assessed Area is located within this range. There are 57 records of this taxon in Western Australia representing approximately 44 populations, eight of which occur in DBCA-managed tenure including Lesueur National Park, Moore River Nature Reserve, Boonanarring Nature Reserve, unnamed Crown Conservation Park R 41986, unnamed Crown reserve 2654/215 and unnamed Crown freehold 1497/392 (DBCA 2007-).

This species was searched for as part of targeted survey within the Assessed Area. A total of 49 individuals were recorded at 29 locations with 12 individuals from 12 locations recorded within the Development Envelope (Table 14; Appendix M). It is considered unlikely that any further locations of this taxon occur in the Assessed Area. These records represent three discrete populations, with two occurring within Hartfield Park East and West of Tonkin Highway (R 17098) and one within Bush Forever site 53 in Orange Grove (Appendix N, Sheets N1, N2). This taxon has previously been recorded in the Survey Area by DBCA (DBCA 2019b) and AECOM (2015).

VT 1 represents the preferred habitat for this taxon.

**Plate 5:** ***Isopogon autumnalis* (P3) (Photo: Woodman Environmental)**

***Jacksonia gracillima* (P3)**

*Jacksonia gracillima* (P3) is a prostrate, spreading or scrambling shrub, growing to 1.5 m high (Plate 6) on well drained slopes, flats and wetlands with sand (WA Herbarium 1998-). This taxon is found over a range of approximately 200 km in Western Australia (where it is endemic (ALA 2020)), from near Busselton in the south to Forrestfield in the north (DBCA 2007-). The Assessed Area is located within this range. There are 38 records of this taxon in Western Australia representing approximately 23 populations, five of which occur in DBCA-managed tenure including unnamed Crown freehold reserve, Modong Nature Reserve, Piara Nature Reserve and Shirley Balla Swamp Reserve (DBCA 2007-).

This species was searched for as part of targeted survey within the Assessed Area. A total of 1676 individuals were recorded at 597 locations with 183 individuals from 155 locations recorded within the Development Envelope (Table 14; Appendix M). It is considered unlikely that any further locations of this taxon occur in the Assessed Area. These records represent two discrete populations, occurring within Hartfield Park East and West of Tonkin Highway (R 17098) (Appendix N: Sheets N1, N2). This taxon has previously been recorded within Hartfield Park west of Tonkin Highway (DBCA 2019b), therefore the population recorded within Hartfield Park east of Tonkin Highway is considered to be a new population.

VTs 4, 5 and 7, and to a lesser extent VT 6 represented the preferred habitat for this taxon.

**Plate 6:** ***Jacksonia gracillima* (P3) at Mundijong (Photo: Woodman Environmental)**

***Johnsonia pubescens* subsp. *cygnorum* (P2)**

*Johnsonia pubescens* subsp. *cygnorum* (P2) is a tufted perennial herb, growing to 0.25m high (Plate 7) on flats and seasonally-wet sites with grey-white-yellow sand (WA Herbarium 1998-). This taxon is found over a range of 68 km in Western Australia (where it is endemic (ALA 2020)), from Como in the Perth metropolitan area to Pinjarra in the south (DBCA 2007-). This recording within Assessed Area is a slight range extension approximately 12 kilometres to the east of the northern most extent. There are 17 records of this taxon in Western Australia representing approximately 13 populations, two of which occur in DBCA-managed tenure within the unnamed Nature Reserve (R 51784).

This species was searched for as part of targeted survey within the Assessed Area. A total of 282 individuals were recorded at 227 locations with 109 individuals from 635 locations recorded within the Development Envelope (Table 14; Appendix M). It is considered unlikely that any further locations of this taxon occur in the Assessed Area. These records represent four discrete populations, with two occurring within Hartfield Park East and West of Tonkin Highway (R 17098), one within bush forever site 53 in Orange Grove and one adjacent to Tonkin Highway north of Kelvin Road on eastern road verge (Appendix N: Sheet N1, N2). These represent new populations of this taxon.

*Johnsonia pubescens* subsp. *cygnorum* (P2) has not been recorded by previous surveys within the Assessed Area. No *Johnsonia* species have been recorded at all and it is strongly suspected that this taxon has been missed by previous surveys despite four surveys (reviewed as part of the Desktop Assessment in Section 5.1.1.2) identifying *Johnsonia pubescens* and the typical subspecies *Johnsonia pubescens* subsp. *pubescens* as occurring in the Survey Area during their desktop assessments (GHD 2015, 2016, 2018; 360 Environmental 2018). There was some initial uncertainty when identifying specimens from this current Assessed Area given that it was collected widely across the Assessed Area and had not been reported before. However, the specimens clearly represent subsp. *cygnorum*, possessing the white floral bracts with a central green and fawn stripe, greenish flowers and a generally narrowly cylindrical inflorescence (cf. white floral bracts with a central pink flush, pink/purple flowers and a generally ovoid inflorescence) (Keighery 2001). In addition, the identification of similar, recently collected specimens from the Perth Airport Estate was confirmed as *Johnsonia pubescens* subsp. *cygnorum* (P2) by the WA Herbarium (M. Hislop *pers. comm.* 2019; Woodman Environmental 2019). Although it is noted that the two subspecies are easily distinguished (Keighery 2001), examination of recently collected material from the Perth area at the WA Herbarium indicates that this may not be the case.

Keighery (2001) noted that the two subspecies were separated geographically; recent collections, including from this survey, indicate that this is no longer the case (DBCA 2007-). Further investigation appears to be required to determine whether the current situation of maintaining two subspecies is tenable, or whether the characters used to separate the subspecies occur across a continuum and only a single, variable species should be recognised.

VT 1, and to a lesser extent VT 4 represent the preferred habitat for this taxon.

**Plate 7:** ***Johnsonia pubescens*** **subsp.** ***cygnorum*** **(P2) at Perth Airport (Photo: Woodman Environmental)**

***Lasiopetalum bracteatum*** **(P4)**

*Lasiopetalum bracteatum* (P4) is an erect, open shrub, growing to 1.5 m high (Plate 8) along drainage lines, creeks, gullies and on granite outcrops with sandy-clay, clay or lateritic gravel soil (WA Herbarium 1998-). This taxon is found over a range of 128 km in Western Australia (where it is endemic (ALA 2020)), from near Helena Valley in the west to near Narrogin in the southeast (DBCA 2007-). The Assessed Area is located within this range. There are 48 records of this taxon in Western Australia representing approximately 24 populations, 16 of which occur in DBCA-managed tenure including Beelu National Park, Greenmount National Park, Lesmurdie Falls National Park, Kenwick Wetlands, Korung National Park, Midgegooroo National Park, Youraling State Forest, Jarrahdale State Forest and Lol Gray State Forest.

This species was searched for as part of targeted survey within the Assessed Area. Four individuals of this species were recorded at two locations within the Assessed Area (Table 14; Appendix M). These records represent one population, occurring in the south east corner of Hartfield Park East reserve (Appendix N, Sheet N2); which represents a new population of this taxon. It is considered unlikely that any further locations of this taxon occur in the Assessed Area.

Both records of this taxon were recorded in VT 3, which represents the preferred habitat for this taxon.

**Plate 8:** ***Lasiopetalum bracteatum*** **(P4) (Scanned specimen: Woodman Environmental)**

***Styphelia filifolia*** **(P3)**

*Styphelia filifolia* (P3) is an erect shrub, growing to 0.9 m high (Plate 9) in low-lying situations, usually in Banksia or Jarrah (*Eucalyptus marginata*) woodlands with sandy soil (WA Herbarium 1998-). This taxon is found sporadically over a range of 390 km in Western Australia (where it is endemic (ALA 2020)), from near Bunbury in the south to northwest of Eneabba in the north (DBCA 2007-). The Assessed Area is located within this range. There are 36 records of this taxon in Western Australia representing approximately 34 populations, 19 of which occur in DBCA-managed tenure including Byrd Swamp Nature Reserve, Neaves Road Nature Reserve, Gnangara-Moore River State Forest, Chandala Nature Reserve, Boonanarring Nature Reserve, an unnamed Nature Reserve east of Beekeepers Nature Reserve and an unnamed Crown freehold (1497/392).

This species was searched for as part of targeted survey within the Assessed Area. A total of 30 individuals were recorded at 27 locations with 10 individuals from 10 locations recorded within the Development Envelope (Table 14; Appendix M). These records represent two discrete populations, occurring within Hartfield Park East and West of Tonkin Highway (R 17098) (Appendix N, Sheet N1). It is considered unlikely that any further locations of this taxon occur in the Assessed Area. This taxon has previously been recorded within Hartfield

Park west and east of Tonkin Highway (DBCA 2019b), therefore the populations recorded within Hartfield Park east and west of Tonkin Highway are not considered to be new populations.

VTs 1 and 4 represent preferred habitat for this taxon.

**Plate 9:** ***Styphelia filifolia*** **(P3) (Photo: Woodman Environmental)**

***Tetraria australiensis*** **(Threatened)**

*Tetraria australiensis* (T) is a rhizomatous, tufted perennial herb (sedge) or grass-like plant growing to 1 m high (Plate 10) in winter-wet swampy depressions, drainage lines or rises surrounding swamps in open forests or Marri (*Corymbia calophylla*) woodland on grey sand over clay (Keighery 1993). This taxon is listed as Vulnerable under both the BC Act and EPBC Act (DBCA 2018c, DAWE 2020). It is endemic to Western Australia (ALA 2020), occurring over a range of approximately 197 km from Ferndale (Perth) in the north to near Busselton in the south (DBCA 2007-). This recording within Assessed Area is a slight range extension approximately seven kilometres to the east of the northern most extent. There is currently no Interim Recovery Plan for this taxon and the Approved Conservation Advice is out of date (DAWE 2008); therefore, there is no accurate population and abundance estimate publicly available for the taxon. However, there are 66 location records of this taxon in DBCA's databases; it is currently unknown how many populations these represent, but it appears to be at least 20, with several new populations found recently by Woodman Environmental (field observations). At least three occur in conservation tenure (Watkins Road Nature Reserve, Lambkin Nature Reserve, Ruabon Nature Reserve) (DBCA 2007-).

This species was searched for as part of targeted survey within the survey area. A total of 681 individuals were recorded at 533 locations with 441 individuals from 295 locations recorded within the Development Envelope (Table 14; Appendix M). These records represent one discrete population, occurring within Bush Forever site 53 in Orange Grove (Appendix N, Sheets N2, N3); this population is considered a new population. It is considered unlikely that any further locations of this taxon occur in the Assessed Area.

VTs 1, 2 and 3 represent preferred habitat for this taxon.

**Plate 10:** ***Tetraria australiensis*** **(Threatened) (Photo: Woodman Environmental)**

***Verticordia lindleyi*** **subsp.** ***lindleyi*** **(P4)**

*Verticordia lindleyi* subsp. *lindleyi* (P4) is an erect shrub growing to 0.75 m high (Plate 11) in winter-wet depressions on sand or sandy clay (WA Herbarium 1998-). This taxon is found over a range of 222 km in Western Australia (where it is endemic (ALA 2020)), from near Cervantes in the north to Serpentine in the south east (DBCA 2007-). The Assessed Area is located within this range. There are 112 records of this taxon in Western Australia representing approximately 64 populations, 10 of which occur in DBCA-managed tenure including Moore River National Park, Moore River Nature Reserve, Boonanarring Nature Reserve, Nature Reserve 2654/215 and Kenwick Wetlands.

This species was searched for as part of targeted survey within the Assessed Area. A total of 933 individuals were recorded at 467 locations with 157 individuals from 151 locations recorded within the Development Envelope (Table 14; Appendix M). These records

represent two discrete populations, occurring Hartfield Park East and West of Tonkin Highway (R 17098) (Appendix N, Sheets N1, N2). It is considered unlikely that any further locations of this taxon occur in the Assessed Area. This taxon has previously been recorded in the Survey Area by DBCA (DBCA 2019b) with both populations previously known.

VTs 4 and 5 represent preferred habitat for this taxon.

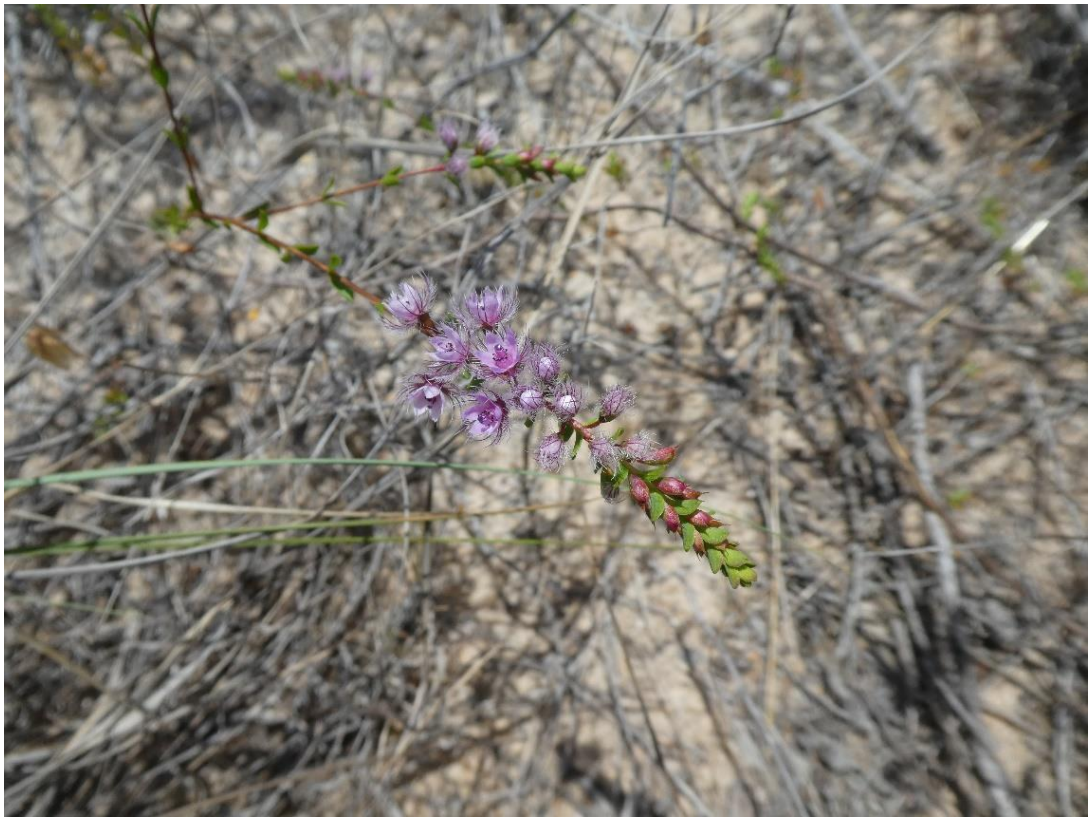


**Plate 11: *Verticordia lindleyi* subsp. *lindleyi* at Perth Airport (P4) (Photo: Woodman Environmental)**

#### 5.1.2.4 Distribution Extensions and Distribution Gaps

Table 15 presents taxa where the collections of flora taxa from the Assessed Area represent extensions to the known distribution of such taxa or otherwise fill gaps within the known distribution of such taxa according to *NatureMap* (DBCA 2007-).

**Table 15: Taxa Where Collections Represent Range Extensions to the Known Ranges of these Taxa or Fill Distribution Gaps (DBCA 2007-)**

| Taxon | Description |
|---|---|
| *Lepidosperma carphoides* | Fills gap in known distribution |

This taxon has a very large range with 75 records within Florabase extending from 175 km east of Esperance to the Cobertup Nature Reserve located west of Albany on the south coast, and from 7 km north of Margaret River to Mt Peron located north east of Jurien on the west coast. The record within the Survey Area is approximately 30 km north of the single previous record in the Perth area located near Mundijong, with a further 215 km gap to the northern most location at Mt Peron.

#### 5.1.2.5 Likelihood of Occurrence of Further Significant Flora Taxa

As detailed in Section 5.1.1.3, a total of 94 significant flora taxa were identified as occurring within the Desktop Study Area prior to survey (excluding *Melaleuca viminalis* (P2)). Of these, 10 were recorded within the Survey Area by this survey as well as an additional taxon, as detailed in Section 5.1.2.2. Table 16 presents an assessment of the likelihood of the remaining 84 taxa being present within the Survey Area and Development Envelope. Of the additional 84 taxa, none are considered likely to occur in the Development Envelope.

**Table 16: Likelihood of Significant Flora Taxa Occurring Within the Survey Area and Development Envelope**

| Taxon | Status | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) | Identifiable During Survey? | Likelihood of Occurrence | |
|---|---|---|---|---|---|---|
| | | | | | Survey Area | Development Envelope |
| *Acacia anomala* | T | August to September | Yellow or grey-brown sandy loam or sandy clay with laterite pebbles over laterite. Slopes and flats | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Acacia aphylla* | T | July to October | Brown or yellow sandy loam or clay loam on laterite and granite outcrops. Slopes and flats | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Acacia horridula* | P3 | May to November | Brown or yellow loam or sandy loam with granite or laterite. Granite outcrops, slopes | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Acacia lasiocarpa* var. *bracteolata* long peduncle variant (G.J. Keighery 5026) | P1 | May, August | Sand. Winter-wet flats and swamps | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |
| *Acacia oncinophylla* subsp. *patulifolia* | P4 | March to April or September to December | Granite, occasionally on laterite. Brown loam | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Allocasuarina grevilleoides* | P3 | September to November | Brown or grey sand or clay loam with laterite and granite. Slopes, outcrops and plains | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Anthocercis gracilis* | T | September to October | Sandy or loamy soils. Granite outcrops | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Andersonia* sp. Blepharifolia (F. & J. Hort 1919) | P2 | September to November | Brown or red sandy loam with granite or laterite. Slopes and hilltops | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Aponogeton hexatepalus* | P4 | February, May to November | Brown, grey or black clay. Growing in shallow water in major drainage lines and wetlands, claypans | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |

| Taxon | Status | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) | Identifiable During Survey? | Likelihood of Occurrence | |
|---|---|---|---|---|---|---|
| | | | | | Survey Area | Development Envelope |
| *Asteridea gracilis* | P3 | February, September to October | Brown or yellow sandy loam with laterite and granite. Slopes, flats and plains | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Austrostipa bronwenae* | T | September to November | Brown or grey loam or sandy clay, sometimes on Muchea limestone. Winter-wet flats, swamps and wetlands | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Babingtonia urbana* | P3 | December to March | Brown clay loam and sand. Winter-wet flats and wetlands | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |
| *Banksia kippistiana* var. *paenepeccata* | P3 | October to November | Slopes and hills. Sandy soils with laterite. | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Banksia pteridifolia* subsp. *vernalis* | P3 | August to November | White, grey or brown sand and loamy sand over laterite. Slopes and flats | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Beaufortia purpurea* | P3 | August to December | Brown sandy loam with laterite, sometimes over granite. Slopes | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Bolboschoenus fluviatilis* | P1 | November to December | Grey or brown sand or silt. Wet soils in littoral zones, edges of watercourses and seeps | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Boronia humifusa* | P1 | June, September to October | Slopes, valleys and hills. Gravelly sand or loam over laterite. | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Boronia tenuis* | P4 | August to November | Brown loam or sandy clay over granite or laterite. Slopes and outcrops | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Caladenia huegelii* | T | August to October | Grey sand, Bassendean dunes | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |

| Taxon | Status | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) | Identifiable During Survey? | Likelihood of Occurrence | |
|---|---|---|---|---|---|---|
| | | | | | Survey Area | Development Envelope |
| *Calandrinia uncinella* | P1 | September to October | Brown, grey or white sand or loam. Swamps, winter-wet flats and saline river flats | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Calothamnus accedens* | P4 | July to January | Brown or grey loam or clay loam over laterite. Slopes and hilltops | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Calothamnus graniticus* subsp. *leptophyllus* | P4 | June to August, September, November | Clay or sandy loam with granite or laterite. Hillsides and slopes. | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Calytrix breviseta* subsp. *breviseta* | T | September to November | Grey or brown sandy loam or clay. Flats and winter-wet depressions | Yes | **Known to occur** | Unlikely: habitat not considered to be present |
| *Carex tereticaulis* | P3 | September to November | Grey or brown loam or sandy clay with laterite. Edges of drainage lines | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Chamaescilla gibsonii* | P3 | August to November | Brown or grey sandy clay. Winter-wet clay pans and flats | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |
| *Chamelaucium lullfitzii* | T | September to December | Sand, sometimes gravelly. Slopes and undulating plains | Yes | Unlikely: similar habitat may be present, however, survey area not close to known range. | Unlikely: similar habitat may be present, however, survey area not close to known range. |
| *Comesperma griffinii* | P2 | October to January | Grey or brown clayey sand or sandy loam, sometimes gravelly. Slopes, winter-wet flats and depressions | Yes | Possible: similar habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |
| *Comesperma rhadinocarpum* | P3 | October to January | Sand or sandy loam with laterite. Slopes, undulating plains and flats | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |

| Taxon | Status | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) | Identifiable During Survey? | Likelihood of Occurrence | |
|---|---|---|---|---|---|---|
| | | | | | Survey Area | Development Envelope |
| *Cyanicula ixioides* subsp. *ixioides* | P4 | August to October | Slopes, gullies and hillsides with clay or sandy gravel often with laterite or granite outcropping, | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Darwinia apiculata* | T | July, October to November | Brown or grey sandy loam with granite or laterite. Granite outcrops, ridges and flats | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Diplolaena andrewsii* | T | August to November | Brown sandy loam over granite. Granite outcrops and slopes | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Diuris drummondii* | T | November to December | Wet brown or grey sandy loam or peat. Winter-wet swamps, watercourses and floodplains. | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Diuris micrantha* | T | September to October | Brown loamy clay. Winter-wet swamps, in shallow water | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Diuris purdiei* | T | September to October | Grey-black sand, moist. Winter-wet swamps | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |
| *Drakaea elastica* | T | October to November | White or grey sand. Low-lying situations adjoining winter-wet swamps | Yes | Unlikely: similar habitat present, but all such habitat surveyed | Unlikely: habitat not considered to be present |
| *Drakaea micrantha* | T | September to November | White or grey sand. Low-lying situations adjoining winter-wet swamps | Yes | Unlikely: similar habitat present, but all such habitat surveyed | Unlikely: habitat not considered to be present |
| *Drosera occidentalis* | P4 | October to November | Swampy or damp flats, sandy floodplain | Yes | **Known to occur** | Unlikely: habitat not considered to be present |
| *Eleocharis keigheryi* | T | August to November | Clay or sandy loam. Growing in shallow water in creeks and claypans | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |

| Taxon | Status | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) | Identifiable During Survey? | Likelihood of Occurrence | |
|---|---|---|---|---|---|---|
| | | | | | Survey Area | Development Envelope |
| *Eremophila glabra* subsp. *chlorella* | T | June to January | Brown, grey or white sand or clay. Swamps, winter-wet flats and lower slopes | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |
| *Eryngium pinnatifidum* subsp. Palustre (G.J. Keighery 13459) | P3 | September to November | Grey, brown or black sand or clay. Winter-wet flats and claypans | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |
| *Eryngium* sp. Subdecumbens (G.J. Keighery 5390) | P3 | September to January | Grey clay. Winter-wet flats, claypans and swamps | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |
| *Eucalyptus x balanites* | T | October to December or January to February | Sandy soils with lateritic gravel | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Goodenia arthrotricha* | T | March, November to December | Brown sandy loam, sometimes with laterite and granite. Outcrops, slopes, hilltops and flats | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Grevillea curviloba* | T | August to October | Grey, white or brown sand or sandy loam. Flats, drainage lines and lower slopes | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Grevillea thelemanniana* | T | September to December | Grey or brown sandy loam and clay. Winter-wet swamps and flats | Yes | **Known to occur** | Unlikely: habitat present, however all potential habitat inspected during survey. Note taxon observed in Development Envelope but as planted individuals |

| Taxon | Status | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) | Identifiable During Survey? | Likelihood of Occurrence | |
|---|---|---|---|---|---|---|
| | | | | | Survey Area | Development Envelope |
| *Haemodorum loratum* | P3 | October to November | White, grey or brown sand, sometimes over granite or laterite. Slopes, plains and flats | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |
| *Halgania corymbosa* | P3 | September to October | Brown sandy loam or sandy clay over laterite or granite. Slopes | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Haloragis scoparia* | P1 | April | Plains or flats with white/grey clay | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Hibbertia montana* | P4 | August to September | Brown sandy loam with laterite or granite. Slopes, gullies, breakaways and hilltops | Yes | Unlikely: habitat not considered to be present. Record in Survey Area erroneous; *H. commutata* complex has been revised and range of *H. montana* no longer coincides with Survey Area (Thiele 2019) | Unlikely: habitat not considered to be present. Record in Survey Area erroneous; *H. commutata* complex has been revised and range of *H. montana* no longer coincides with Survey Area (Thiele 2019) |
| *Hydrocotyle lemnoides* | P4 | August to November | Brown or grey clay or clayey sand. Growing in shallow water in wetlands, swamps and claypans | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |
| *Hydrocotyle striata* | P1 | November | Winter wet depressions and creeks with peat or sand. | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |
| *Isotropis cuneifolia* subsp. *glabra* | P3 | September to October | Grey or brown sand or clay. Winter-wet depressions and flats | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |

| Taxon | Status | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) | Identifiable During Survey? | Likelihood of Occurrence | |
|---|---|---|---|---|---|---|
| | | | | | Survey Area | Development Envelope |
| *Lasiopetalum glutinosum* subsp. *glutinosum* | P3 | September to December | Sandy loam or clay with granite. Granite outcrops and slopes | Yes | Unlikely: habitat not considered to be present. Record in Survey Area erroneous; record is from summit of scarp in Crystal Brook area (WA Herbarium 1998-) | Unlikely: habitat not considered to be present |
| *Lasiopetalum pterocarpum* | T | September to November | Red-brown loam or clayey sand with granite or laterite. Sloping banks near creeklines | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Lepidosperma rostratum* | T | June to December | Peaty sand or clay. Winter-wet swamps | Yes | **Known to occur** | Unlikely: habitat not considered to be present |
| *Lepyrodia curvescens* | P2 | June, September to January | Grey sandy loam or peaty sand. Slopes and winter-wet depressions | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |
| *Macarthuria keigheryi* | T | August to November | Grey or white sand. Low-lying plains and low rises, particularly in recently burnt vegetation | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |
| *Meionectes tenuifolia* | P3 | October to December | Wetlands, swamps, with shallow water | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |
| *Myriophyllum echinatum* | P3 | September to October | Brown or grey sandy clay. Wetlands and winter-wet depressions with shallow water | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |
| *Ornduffia submersa* | P4 | August to November | Grey or brown clay. Growing in shallow water in wetlands and drainage lines | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |

| Taxon | Status | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) | Identifiable During Survey? | Likelihood of Occurrence | |
|---|---|---|---|---|---|---|
| | | | | | Survey Area | Development Envelope |
| *Pimelea rara* | P4 | November to March | Grey, brown or yellow sandy loam with granite or laterite. Ridges and slopes | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Pithocarpa corymbulosa* | P3 | January to April | Gravelly or sandy loam. Amongst granite outcrops | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Platysace ramosissima* | P3 | November to January | Sand. Undulating plains, slopes and flats | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |
| *Ptilotus pyramidatus* | T | October | Grey or white sandy clay. Winter wet clay flats | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |
| *Ptilotus sericostachyus* subsp. *roseus* | P1 | September to December | Unknown | Yes | Unlikely: this taxon has not been recorded in WA for over 100 years | Unlikely: this taxon has not been recorded in WA for over 100 years |
| *Schoenus benthamii* | P3 | August to November | Grey or white clayey sand. Swamps, wetlands and winter-wet flats | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |
| *Schoenus capillifolius* | P3 | October to November | Brown clay or sandy clay. Winter-wet claypans and flats | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |
| *Schoenus loliaceus* | P2 | September to November | Grey or brown clay loam or peaty clay. Growing in shallow water in swamps and winter-wet flats | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |
| *Schoenus natans* | P4 | September to December | Brown or grey sandy clay. Growing in shallow water in creeklines, claypans and wetland | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |

| Taxon | Status | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) | Identifiable During Survey? | Likelihood of Occurrence | |
|---|---|---|---|---|---|---|
| | | | | | Survey Area | Development Envelope |
| *Schoenus pennisetis* | P3 | August to November | Grey or peaty sand, sandy clay. Swamps, winter-wet depressions | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |
| *Schoenus* sp. Beaufort (G.J. Keighery 6291) | P1 | September to October | Brown or grey clay. Growing in shallow water in creeklines and claypans | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |
| *Schoenus* sp. Waroona (G.J. Keighery 12235) | P3 | October to November | Brown or grey clay or sandy clay. Winter-wet flats and wetlands | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |
| *Senecio gilbertii* | P1 | September to November | Valleys and slopes with laterite. | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Senecio leucoglossus* | P4 | October to December | Brown loam with laterite or granite. Slopes | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Stackhousia* sp. Red-blotched corolla (A. Markey 911) | P3 | September to November | Slopes with clay with granite or sometimes laterite. | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Stylidium aceratum* | P3 | October to November | Grey or brown sandy loam or clay. Wetlands, swamps and winter-wet flats | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |
| *Stylidium longitubum* | P4 | July to November | Brown or grey clay loam. Wetlands and winter-wet flats | Yes | Possible: habitat present | Unlikely: habitat present, however all potential habitat inspected during survey |
| *Stylidium striatum* | P4 | September to December | Brown or yellow sandy clay with laterite. Slopes and flats | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |

| Taxon | Status | Flowering Period (WA Herbarium 1998-) | Habitat (WA Herbarium 1998-) | Identifiable During Survey? | Likelihood of Occurrence | |
|---|---|---|---|---|---|---|
| | | | | | Survey Area | Development Envelope |
| *Synaphea* sp. Fairbridge Farm (D. Papenfus 696) | T | September to October | Grey or brown clayey sand or sand with laterite. Winter-wet flats | Yes | Possible: habitat present | Unlikely: habitat not considered to be present |
| *Thelymitra dedmaniarum* | T | November to January | Grey loam. Granite | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Thelymitra magnifica* | P1 | September to October | Brown loam with granite or laterite. Granite outcrops, gullies and slopes | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Thelymitra stellata* | T | October to November | Brown or grey sand or clay loam with laterite. Ridges, gullies and rocky slopes | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Thysanotus anceps* | P3 | November to January | Sand or sandy loam with laterite. Ridges, hilltops and slopes | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |
| *Thysanotus* sp. Badgingarra (E.A. Griffin 2511) | P2 | January, December | Slopes and hills with sand or sandy clay with laterite or granite. | Yes | Unlikely: habitat not considered to be present | Unlikely: habitat not considered to be present |

#### 5.1.2.6 Introduced Taxa

A total of 68 introduced taxa were recorded within the Survey Area during this survey. Table 17 lists the number of locations recorded and comments regarding the significance of these taxa, including ecological impact and invasiveness ratings for each introduced taxon under the *Department of Parks and Wildlife Swan Region Species Prioritisation Process* (DBCA 2016a). Location details of introduced taxa are presented in Table 2 of Appendix MN, with locations mapped in Appendix P.

Four of the recorded taxa, highlighted in yellow in Table 17, are Declared Pests under the BAM Act (DPIRD 2020) within the location of the Survey Area (Perth Metropolitan Region). Two of these taxa are also WoNS (*Asparagus asparagoides* and *Opuntia stricta*). Of the four Declared Pest taxa, one (Prickly Pear; *Opuntia stricta*) is classified as Declared Pest – s22(2) (C3 –Restricted) (for the Whole of the State). C3 management is described as 'Organisms that should have some form of management applied that will alleviate the harmful impact of the organism, reduce the numbers or distribution of the organism or prevent or contain the spread of the organism'.

Three Declared Pest taxa (One-leaf Cape Tulip: *Moraea flaccida*; Bridal Creeper: *Asparagus asparagoides*; and Paterson's Curse: *Echium plantagineum*) are classified as Declared Pest – s22(2) Exempt (for the Whole of State). These taxa are example from keeping; 'No permit or conditions are required for keeping. There may be other requirements under BAM Act such as those required for entry of livestock, pigeons and doves, or waybill requirements for stock movement. An organism in the exempt keeping category may also be regulated by other legislation such as the *Wildlife Conservation Act 1950* (WCA), administered by DPaW' (now BC Act administered by DBCA).

One other introduced taxon (Narrow leaf Cotton Bush: *Gomphocarpus fruticosus*) is a Declared Pest for other regions within Western Australia (s22(2) (C3)) however is not a listed Declared Pest for the Perth Metropolitan Region (DPIRD 2020). This taxon is not highlighted in Table 17.

**Table 17: Summary of Introduced Taxa Recorded within the Survey Area**

| Taxon | Common Name | Number of Locations | Status and Ecological Impact and Invasiveness Rating (DBCA 2016a) |
|---|---|---|---|
| **Acacia iteaphylla* | Flinders Ranges wattle | 1 | High ecological impact and rapid invasiveness |
| **Acacia longifolia* | Sydney Golden Wattle | 4 | High ecological impact and rapid invasiveness |
| **Acacia podalyriifolia* | Queensland Silver Wattle | 4 | High ecological impact and moderate invasiveness |
| **Aira cupaniana* | Hairgrass | 1 | Unknown ecological impact and invasiveness |
| **Arctotheca calendula* | Cape Weed | 4 | High ecological impact and rapid invasiveness |
| **Arundo donax* | Bamboo | 2 | High ecological impact and slow invasiveness |

| Taxon | Common Name | Number of Locations | Status and Ecological Impact and Invasiveness Rating (DBCA 2016a) |
|---|---|---|---|
| **Asparagus asparagoides* | Bridal Creeper | 38 | Declared Pest - s22(2);<br>WoNS;<br>High ecological impact and rapid invasiveness |
| **Avena barbata* | Bearded Oat | 17 | High ecological impact and rapid invasiveness |
| **Brachypodium distachyon* | False Brome | 2 | Unknown ecological impact and rapid invasiveness |
| **Briza maxima* | Blowfly Grass | 34 | Unknown ecological impact and rapid invasiveness |
| **Bromus diandrus* | Great Brome | 9 | High ecological impact and rapid invasiveness |
| **Casuarina cunninghamiana* subsp. *cunninghamiana* | River Sheoak | 2 | Low ecological impact and slow invasiveness |
| **Cenchrus clandestinus* | Kikuyu Grass | 3 | High ecological impact and slow invasiveness |
| **Chamaecytisus palmensis* | Tagasaste | 2 | Medium ecological impact and medium invasiveness |
| **Cortaderia selloana* | Pampas Grass | 1 | High ecological impact and rapid invasiveness |
| **Cucumis myriocarpus* | Prickly Paddy Melon | 1 | Low ecological impact and medium invasiveness |
| **Disa bracteata* | South African Orchid | 1 | Unknown ecological impact and rapid invasiveness |
| **Echium plantagineum* | Paterson's Curse | 9 | Declared Pest - s22(2);<br>High ecological impact and moderate invasiveness |
| **Ehrharta calycina* | Perennial Veldtgrass | 50 | High ecological impact and rapid invasiveness |
| **Ehrharta longiflora* | Annual Veldtgrass | 5 | Medium ecological impact and rapid invasiveness |
| **Eragrostis curvula* | African Lovegrass | 24 | High ecological impact and rapid invasiveness |
| **Erodium botrys* | Long Storksbill | 1 | Unknown ecological impact and moderate invasiveness |
| **Erythrina ×sykesii* | Coral Tree | 1 | Low ecological impact and slow invasiveness |
| **Eucalyptus ?resinifera* | Red Mahogany | 1 | Unknown ecological impact and slow invasiveness |
| **Euphorbia terracina* | Geraldton Carnation Weed | 6 | High ecological impact and rapid invasiveness |
| **Fumaria capreolata* | Climbing Fumitory | 5 | High ecological impact and rapid invasiveness |
| **Gladiolus caryophyllaceus* | Pink Gladiolus | 43 | High ecological impact and rapid invasiveness |
| **Gomphocarpus fruticosus* | Narrow leaf cotton bush | 1 | Declared Pest - s22(2) but not for the Perth Metropolitan Region;<br>High ecological impact and rapid invasiveness |
| **Hesperantha falcata* | Hesperantha | 1 | High ecological impact and rapid invasiveness |
| **Hypochaeris glabra* | Flatweed | 19 | High ecological impact and rapid invasiveness |

| Taxon | Common Name | Number of Locations | Status and Ecological Impact and Invasiveness Rating (DBCA 2016a) |
|---|---|---|---|
| **Ipomoea cairica* | Coast Morning Glory | 2 | High ecological impact and medium invasiveness |
| **Lagurus ovatus* | Hare's Tail Grass | 1 | High ecological impact and rapid invasiveness |
| **Leontodon rhagadioloides* | Cretan Weed | 2 | Ecological impact and invasiveness not assessed |
| **Leptospermum laevigatum* | Victorian Teatree | 25 | High ecological impact and rapid invasiveness |
| **Lolium rigidum* | Wimmera Ryegrass | 1 | High ecological impact and rapid invasiveness |
| **Lotus subbiflorus* | Hairy Birdsfoot Trefoil | 1 | High ecological impact and rapid invasiveness |
| **Lupinus angustifolius* | Narrowleaf Lupin | 1 | High ecological impact and moderate invasiveness |
| **Lysimachia arvensis* | Scarlet Pimpernel | 1 | Unknown ecological impact and rapid invasiveness |
| **Malva parviflora* | Marshmallow | 1 | Low ecological impact and unknown invasiveness |
| **Melilotus indicus* | Common Melilot | 1 | Unknown ecological impact and rapid invasiveness |
| **Moraea flaccida* | One leaf cape tulip | 3 | Declared Pest - s22(2);<br>High ecological impact and rapid invasiveness |
| **Olea europaea* | Olive | 1 | High ecological impact and rapid invasiveness |
| **Opuntia stricta* | Common Prickly Pear | 1 | Declared Pest - s22(2);<br>WoNS;<br>Ecological impact and invasiveness not assessed |
| **Oxalis glabra* | Finger Leaf Oxalis | 5 | High ecological impact and slow invasiveness |
| **Oxalis pes-caprae* | Soursob | 3 | High ecological impact and slow invasiveness |
| **Oxalis* sp. | - | 2 | High ecological impact and slow invasiveness |
| **Paspalum dilatatum* | Paspalum | 1 | High ecological impact and medium invasiveness |
| **Pelargonium capitatum* | Rose Pelargonium | 2 | High ecological impact and rapid invasiveness |
| **Pentameris airoides* subsp. *airoides* | False Hairgrass | 3 | Unknown ecological impact and rapid invasiveness |
| **Pinus pinaster* | Pinaster Pine | 3 | Unknown ecological impact and medium invasiveness |
| **Pinus radiata* | Radiata Pine | 1 | Unknown ecological impact and medium invasiveness |
| **Plantago bellardii* | Hairy Plantain | 1 | Ecological impact and invasiveness not assessed |
| **Raphanus raphanistrum* | Wild Radish | 1 | Unknown ecological impact and medium invasiveness |
| **Ricinus communis* | Castor Oil Plant | 1 | Medium ecological impact and rapid invasiveness |
| **Romulea rosea* | Guildford Grass | 3 | Unknown ecological impact and rapid invasiveness |

| Taxon | Common Name | Number of Locations | Status and Ecological Impact and Invasiveness Rating (DBCA 2016a) |
|---|---|---|---|
| **Schinus terebinthifolius* | Brazilian Pepper | 2 | High ecological impact and medium invasiveness |
| **Solanum nigrum* | Black Berry Nightshade | 1 | Medium ecological impact and rapid invasiveness |
| **Sonchus asper* | Rough Sowthistle | 1 | Unknown ecological impact and rapid invasiveness |
| **Sonchus oleraceus* | Common Sowthistle | 3 | Unknown ecological impact and rapid invasiveness |
| **Stachys arvensis* | Staggerweed | 1 | Unknown ecological impact and rapid invasiveness |
| **Trifolium angustifolium* | Narrowleaf Clover | 1 | Unknown ecological impact and unknown invasiveness |
| **Trifolium campestre* var. *campestre* | Hop Clover | 1 | Unknown ecological impact and unknown invasiveness |
| **Ursinia anthemoides* | Ursinia | 36 | Unknown ecological impact and rapid invasiveness |
| **Urtica urens* | Small Nettle | 1 | Unknown ecological impact and rapid invasiveness |
| **Vicia hirsuta* | Hairy Vetch | 1 | Unknown ecological impact and unknown invasiveness |
| **Vicia sativa* | Common Vetch | 1 | Unknown ecological impact and unknown invasiveness |
| **Vulpia bromoides* | Squirrel's Tail Fescue | 2 | High ecological impact and rapid invasiveness |
| **Vulpia myuros* forma *myuros* | Rat's Tail Fescue | 4 | High ecological impact and rapid invasiveness |
| **Watsonia meriana* | Bulbil Watsonia | 33 | High ecological impact and rapid invasiveness |
| **Watsonia* sp. | - | 1 | High ecological impact and rapid invasiveness |
| **?Watsonia* sp. | - | 1 | High ecological impact and rapid invasiveness |

In addition to the above, a total of 21 taxa were recorded in the Survey Area that are native to WA but are not indigenous to the area. These taxa were either planted or are presumed garden escapes:

- *Agonis flexuosa*;
- *Banksia victoriae*;
- *Callistemon* sp.;
- *Calothamnus rupestris*;
- *Chamelaucium uncinatum*;
- *Darwinia citriodora*;
- *Eucalyptus camaldulensis*;
- *Eucalyptus cornuta*;
- *Eucalyptus decipiens*;
- *Eucalyptus torquata*;
- *Eucalyptus wandoo*;
- *Grevillea leucopteris*;
- *Grevillea obtusifolia*;

- *Grevillea thelemanniana*;
- *Kunzea glabrescens*;
- *Melaleuca huegelii* subsp. *huegelii*;
- *Melaleuca incana* subsp. *incana*;
- *Melaleuca leucadendra*;
- *Melaleuca nesophila*;
- *Melaleuca viminalis*; and
- *Melia azedarach.*

It should be noted that *Melaleuca viminalis* is indigenous to the Kimberley Region of Western Australia and is known from very few locations. It is therefore listed as Priority Flora (P2) in the Kimberley based on this limited natural distribution (it is also indigenous to the Northern Territory, Queensland and New South Wales) (Craven *et al.* 2010). However, this taxon is widely cultivated as a street and garden tree and has become naturalised in some areas of the south-west of WA including the Perth Metropolitan area. Given the recorded individuals of *Melaleuca viminalis* are not naturally present in the areas surveyed by Woodman Environmental, they have not been considered significant and are not discussed further in this report in the context of significant flora.

### 5.1.3 Field Survey Results – Vegetation

Vegetation Types (VTs) (comprising of intact native vegetation), other modified areas (including highly modified areas, revegetation and cleared areas) were mapped within the Survey Area, with the total areas of each presented in Table 18 and described below.

A total of 193.64 ha, equating to 16.6% of the Survey Area was mapped with the units described above (Assessed Area). 'Areas Not Assessed' accounted for the remaining 83.3% of the Survey Area. Areas Not Assessed comprised land tenure where permission to access for survey were withheld.

**Table 18: Total Areas Mapped within the Survey Area**

| Description | Mapped Unit | Mapped Extent (ha) | Survey Area (%) | Assessed Area (%) |
|---|---|---|---|---|
| Vegetation Type Mapping (Table 19) | VT1 | 28.97 | 2.71 | 16.28 |
| | VT2 | 6.58 | 0.62 | 3.70 |
| | VT3 | 8.32 | 0.78 | 4.68 |
| | VT4 | 13.7 | 1.28 | 7.7 |
| | VT5 | 8.13 | 0.76 | 4.57 |
| | VT6 | 2.09 | 0.2 | 1.18 |
| | VT7 | 3.2 | 0.3 | 1.8 |
| | VT8 | 7.99 | 0.75 | 4.49 |
| Highly Modified Areas (Table 20) | AF/CC/CM/EC/ER | 0.4 | 0.04 | 0.23 |
| | AF/EC/ECo | 0.47 | 0.04 | 0.27 |
| | AF/EC/MA | 0.48 | 0.05 | 0.27 |
| | AFr | 0.01 | 0.00 | 0 |
| | AFr/CM/EG/PR | 0.36 | 0.03 | 0.2 |
| | C/P | 0.05 | 0 | 0.03 |
| | CC | 1.13 | 0.11 | 0.64 |
| | CC/AC/CU | 2.07 | 0.19 | 1.16 |
| | CC/AC/KG | 0.25 | 0.02 | 0.14 |

| Description | Mapped Unit | Mapped Extent (ha) | Survey Area (%) | Assessed Area (%) |
|---|---|---|---|---|
| | CC/EC | 1.7 | 0.16 | 0.95 |
| | CC/EC/ER | 0.35 | 0.03 | 0.2 |
| | CC/EC/ES | 0.1 | 0.01 | 0.06 |
| | CC/EC/PR | 0.65 | 0.06 | 0.37 |
| | CC/MP | 0.35 | 0.03 | 0.2 |
| | CC/MV | 3.13 | 0.29 | 1.76 |
| | CC/XP | 0.06 | 0.01 | 0.03 |
| | CM/EM/ER | 0.64 | 0.06 | 0.36 |
| | CO/CC/EM/ER/EW | 1.26 | 0.12 | 0.71 |
| | EC | 0.07 | 0.01 | 0.04 |
| | EC/CQ | 0.29 | 0.03 | 0.16 |
| | EC/ES | 0.17 | 0.02 | 0.09 |
| | EC/PR | 0.22 | 0.02 | 0.12 |
| | ET | 0.14 | 0.01 | 0.08 |
| | LL | 0.53 | 0.05 | 0.3 |
| | LL/AC | 0.21 | 0.02 | 0.12 |
| | W | 0.17 | 0.02 | 0.09 |
| Revegetated Areas (Table 21) | RV1 | 4.87 | 0.46 | 2.74 |
| | RV2 | 0.57 | 0.05 | 0.32 |
| | RV3 | 0.05 | 0.00 | 0.03 |
| | RV4 | 0.4 | 0.04 | 0.22 |
| | RV5 | 0.38 | 0.04 | 0.21 |
| | RV6 | 1.02 | 0.1 | 0.57 |
| Cleared | C | 76.38 | 7.15 | 42.93 |
| Areas Not Assessed | NA | 891.06 | 83.36 | - |
| **TOTAL** | | **1068.98** | **100** | **100** |

#### 5.1.3.1 Floristic Classification Results

The final dataset used in the classification analysis contained 151 taxa. All taxa amalgamated or omitted from the classification analysis (excluding the above noted taxa) are presented in Appendix Q.

The PATN software package (Belbin and Collins 2009) initially suggested that a six-group classification of quadrats may be appropriate for the data analysed. The resulting dendrogram (Appendix R) and taxon group matrix (Appendix S) were therefore initially examined at this level, to determine the plausibility of groups with regard to taxon groups and also field observations. This process identified that one of the groups could feasibly be divided further into two plausible groups. Additionally, review of the resulting dendrogram of the further classification analyses using Woodman Environmental quadrats and DBCA's SCP quadrat datasets (as detailed in Section 3.1.6) also supported this division. This process ultimately determined that there were seven plausible groups that are considered to represent VTs; these groups were resolved at differing levels of similarity. The groups are ordered from 1 to 7 from top to bottom in the dendrogram in Appendix R. The initial six clusters are also indicated on the dendrogram by the colour of each individual quadrat stem.

#### 5.1.3.2 Vegetation Types

As noted above, seven VTs were defined via floristic composition classification. An additional VT was defined via structural vegetation classification following review of relevé data and comparison of such data with quadrat data. A total of eight VTs were therefore defined and mapped in the Survey Area. Vegetation types covered only 78.97 ha (7.38 %) of the Assessed Area.

Table 19 presents a description of each of the VTs mapped in the Survey Area, including location, area mapped, sampling regime, significant flora recorded, indictor taxa, average taxon richness and a description of variation found within the VT. The method of definition (structural or floristic composition) is also denoted under each VT.

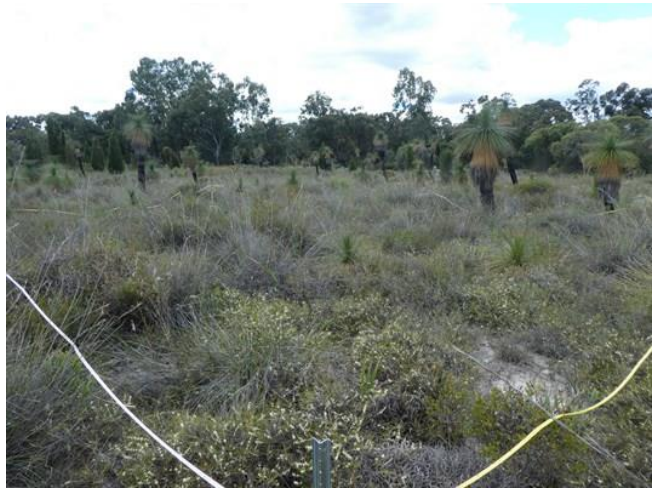
Appendix T presents a taxon-VT matrix, Appendix U the indicator taxa results, and Appendix V presents the detailed vegetation type mapping.

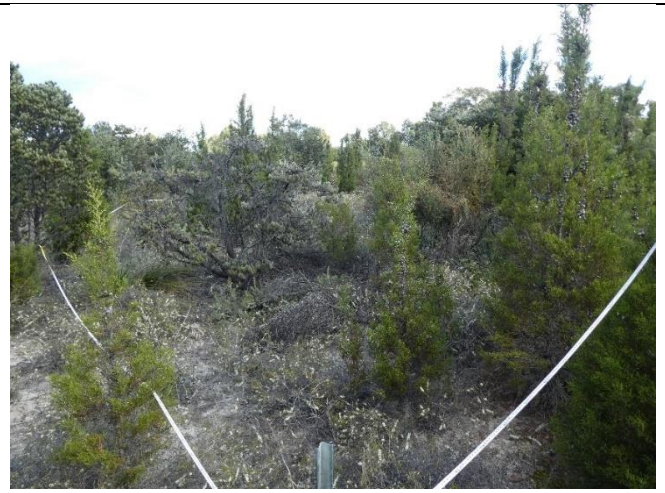
**Table 19: Summary of Vegetation Types Mapped in the Survey Area**

| VT | Summary | Photograph |
|---|---|---|
| 1 | **Description:** Low woodland dominated by *Eucalyptus marginata* subsp. *marginata*, *Banksia menziesii* and *Allocasuarina fraseriana* over tall isolated shrubs dominated by *Xanthorrhoea preissii* and *Adenanthos cygnorum* subsp. *cygnorum* over mid isolated shrubs dominated by *Allocasuarina humilis* and *Melaleuca trichophylla* over low open shrubland dominated by *Hibbertia hypericoides* subsp. *hypericoides* and *Eremaea pauciflora* var. *pauciflora* over mid sparse sedgeland of *Mesomelaena pseudostygia* over mid sparse forbland of *Patersonia occidentalis* var. *occidentalis* and *Dasypogon bromeliifolius* on grey sand on plains and gentle slopes<br><br>**Definition method:** floristic composition classification<br><br>**Area mapped:** 28.97 ha (2.71 % of Survey Area / 16.28 % of Assessed Area / 38.68 % of VT mapped extent)<br><br>**Sampling:** 12 quadrats (GSI-01, GSI-02, GSI-05, GSI-06, GSI-07, GSI-09, GSI-11, GSI-12, GSI-21, GSI-22, GSI-27, GSI-33) and nine relevés (GSI-R03, GSI-R05, GSI-R07, GSI-R09, GSI-R11, GSI-R13, GSI-R23, GSI-R24, GSISITE3)<br><br>**Significant Taxa:** *Conospermum undulatum* (T), *Jacksonia gracillima* (P3), *Johnsonia pubescens* subsp. *cygnorum* (P2), *Styphelia filifolia* (P3)<br><br>**Indicator Taxa:** *Alexgeorgea nitens*, *Allocasuarina fraseriana*, *Bossiaea eriocarpa*, *Burchardia congesta*, *Lomandra hermaphrodita*, *Mesomelaena pseudostygia*, *Patersonia occidentalis* var. *occidentalis*<br><br>**Average taxon richness per quadrat:** 50.1 ± 6.0<br><br>**Total Native Taxa Recorded:** 165<br><br>**Similar VTs:** This VT is floristically most similar to VTs 2 and 3 (Appendix S), however is easily distinguished from both of these VTs by the presence of an upper layer dominated by *Eucalyptus marginata* subsp. *marginata* and *Banksia menziesii*. VT 1 can also be distinguished from VT 3 by the general lack of *Corymbia calophylla* in the upper layer (recorded in only one quadrat in VT 1 but characteristic of VT 3) |  <br>**Plate 12:** Typical VT 1 (Quadrat GSI-01)<br><br>  <br>**Plate 13:** Variant of VT 1 – tree layer absent and mid shrub layer dominated by *Allocasuarina humilis* (Quadrat GSI-06) |

| VT | Summary | Photograph |
|---|---|---|
| | **Variation:** The most noticeable structural variation was the abundance of *Adenanthos cygnorum* subsp. *cygnorum* and *Allocasuarina humilis* in the tall and mid shrub stratum layers, respectively; often these taxa were completely absent, while in some areas the stratum layers approached open shrubland. A structural variant of this VT was observed in one area where the upper tree layer was missing completely (Plate 13) | |
| 2 | **Description:** Mid sparse shrubland of *Lambertia multiflora* var. *darlingensis* or *Hakea undulata* or *Hakea trifurcata* over low sparse shrubland of *Hibbertia hypericoides* subsp. *hypericoides*, *Allocasuarina humilis* and *Eremaea pauciflora* var. *pauciflora* over mid sparse sedgeland of mixed species dominated by *Cyathochaeta equitans* and *Mesomelaena tetragona* over mid sparse forbland of mixed species dominated by *Haemodorum laxum* on grey sand on lower slopes and flats<br><br>**Definition method:** floristic composition classification<br><br>**Area mapped:** 6.58 ha (0.62 % of Survey Area / 3.7 % of Assessed Area / 8.33 % of VT mapped extent)<br><br>**Sampling:** Two quadrats (GSI-04, GSI-39) and one relevé (GSISITE4)<br><br>**Significant Taxa:** *Tetraria australiensis* (T)<br><br>**Indicator Taxa:** *Acacia applanata*, *Caladenia flava*, *Chamaescilla corymbosa* var. *corymbosa*, *Conostylis aurea*, *Conostylis latens*, *Desmocladus fasciculatus*, *Gompholobium confertum*, *Lambertia multiflora* var. *darlingensis*, *Lepidosperma* sp. Margaret River (B.J. Lepschi 1841), *Stylidium tenue* subsp. *majusculum*, *Tripterococcus brunonis*<br><br>**Average taxon richness per quadrat:** 61.5 ± 7.8<br><br>**Total Native Taxa Recorded:** 101<br><br>**Similar VTs:** This VT is floristically most similar to VTs 1 and 3 (Appendix S), however is easily distinguished from both of these VTs by the general absence of an upper tree layer<br><br>**Variation:** This VT demonstrated some structural variation, primarily involving the tree and tall shrub layers. While the understorey taxa were similar, one variant had a low open woodland layer of *Eucalyptus todtiana* and tall shrubland layer of *Hakea undulata* and *Hakea trifurcata* (Plate 15). This variant was characterised by a greater fire age (> 5 years |  <br>**Plate 14:** Typical VT 2 (Quadrat GSI-39)<br>  <br>**Plate 15:** Variant of VT 2 – low open woodland and tall |

| VT | Summary | Photograph |
|---|---|---|
| | since last fire for the variant as opposed to < 5 years for typical VT 2) | shrubland layers (Quadrat GSI-04) |
| 3 | **Description:** Low woodland to closed forest of *Corymbia calophylla* over mid open shrubland of mixed species dominated by *Acacia pulchella* over low sparse shrubland of mixed species dominated by *Gompholobium tomentosum* over mid sparse sedgeland of mixed species dominated by *Mesomelaena pseudostygia* and *Mesomelaena tetragona* on grey-brown sandy clay loam and light clay on lower slopes and flats<br><br>**Definition method:** floristic composition classification<br><br>**Area mapped:** 8.32 ha (0.78 % of Survey Area / 4.68 % of Assessed Area / 10.54 % of VT mapped area)<br><br>**Sampling:** Two quadrats (GSI-08, GSI-35) and three relevés (GSI-37R, GSI-R34, GSISITE1)<br><br>**Significant Taxa:** *Lasiopetalum bracteatum* (P4)<br><br>**Indicator Taxa:** *Corymbia calophylla*, *Gompholobium marginatum*, *Hakea undulata*<br><br>**Average taxon richness per quadrat:** 38.5 ± 13.4<br><br>**Total Native Taxa Recorded**: 83<br><br>**Similar VTs:** This VT is floristically most similar to VTs 1 and 2 (Appendix S), however is easily distinguished from both of these VTs by the upper tree layer dominated by *Corymbia calophylla*. Some areas of VT 4 also have an upper storey of *Corymbia calophylla*; VT 3 can be distinguished from VT4 by the lack of forbland dominated by *Phlebocarya ciliata*, *Dasypogon bromeliifolius* and/or *Dasypogon obliquifolius*<br><br>**Variation:** This VT demonstrated minor structural and floristic variation whereby greater cover of *Corymbia calophylla* in the upper layer corresponded to decreased diversity in the understorey layers |  <br>**Plate 16:** Typical VT 3 (Quadrat GSI-35) |

| VT | Summary | Photograph |
|---|---|---|
| 4 | **Description:** Occasionally with low open woodland of mixed species dominated by *Corymbia calophylla*, *Eucalyptus todtiana* and *Eucalyptus patens* over tall sparse shrubland of mixed species dominated by *Adenanthos cygnorum* subsp. *cygnorum* and *Beaufortia squarrosa* over mid sparse shrubland of mixed species dominated by *Xanthorrhoea preissii* over low open shrubland of mixed species dominated by *Eremaea pauciflora* var. *pauciflora*, *Hypocalymma angustifolium* subsp. Swan Coastal Plain (G.J. Keighery 16777), *Melaleuca seriata* and *Banksia dallanneyi* subsp. *dallanneyi* var. *dallanneyi* over mid sparse sedgeland of mixed species dominated by *Mesomelaena tetragona*, *Cyathochaeta avenacea* and *Cyathochaeta equitans* over low sparse rushland of mixed species dominated by *Alexgeorgea nitens* over low open forbland of mixed species dominated by *Phlebocarya ciliata*, *Dasypogon bromeliifolius* and *Dasypogon obliquifolius* on grey sand and sandy loam on lower slopes and flats<br><br>**Definition method:** floristic composition classification<br><br>**Area mapped:** 13.7 ha (1.28 % of Survey Area / 7.7 % of Assessed Area / 17.35 % of VT mapped extenta)<br><br>**Sampling:** Nine quadrats (GSI-03, GSI-13, GSI-16, GSI-19, GSI-20, GSI-23, GSI-24, GSI-25, GSI-26) and eight relevés (GSI-R04, GSI-R12, GSI-R14, GSI-R15, GSI-R17, GSI-R19, GSI-R25, GSI-R30)<br><br>**Significant Taxa:** *Banksia mimica* (T), *Byblis gigantea* (P3), *Conospermum undulatum* (T), *Johnsonia pubescens* subsp. *cygnorum* (P2), *Styphelia filifolia* (P3), *Verticordia lindleyi* subsp. *lindleyi* (P4)<br><br>**Indicator Taxa:** *Conostylis juncea*, *Dampiera linearis*, *Jacksonia floribunda*, *Stirlingia latifolia*<br><br>**Average taxon richness per quadrat:** 38.1 ± 6.7<br><br>**Total Native Taxa Recorded: 123**<br><br>**Similar VTs:** Areas with *Corymbia calophylla* upper storey are similar to VT 3 (discussed in VT 3 section). The understoreys of VTs 4 and 5 are floristically similar, with both being dominated by *Adenanthos cygnorum* subsp. *cygnorum*, *Beaufortia squarrosa*, *Hypocalymma angustifolium* subsp. Swan Coastal Plain (G.J. Keighery 16777) and *Melaleuca seriata.* VT 4 can be distinguished from VT 5 by the presence of a forbland layer of mixed species |  <br>**Plate 17:** Typical VT 4 (Quadrat GSI-23)<br><br>  <br>**Plate 18:** Variant of VT 4 – tree layer absent (Quadrat GSI-13) |

| VT | Summary | Photograph |
|---|---|---|
| | dominated by *Phlebocarya ciliata*, *Dasypogon bromeliifolius* and *Dasypogon obliquifolius* and the general greater species richness<br><br>**Variation:** This VT demonstrated minor structural variation whereby some areas were lacking the upper tree layer. These areas were typically characterised by greater cover of shrubs in the understorey layers | |
| 5 | **Description:** Tall open shrubland of *Callitris pyramidalis* and *Adenanthos cygnorum* subsp. *cygnorum* over mid sparse shrubland of mixed species dominated by *Hakea sulcata, Beaufortia squarrosa, Melaleuca seriata, Kingia australis* and *Hakea varia* over low sparse shrubland dominated by *Pericalymma ellipticum* var. *floridum* and *Hypocalymma angustifolium* subsp. Swan Coastal Plain (G.J. Keighery 16777) over mid sparse sedgeland of *Mesomelaena tetragona* over mid sparse rushland of *Cytogonidium leptocarpoides* on brown and grey sand and sandy clay loam on lower slopes and flats<br><br>**Definition method:** floristic composition classification<br><br>**Area mapped:** 8.13 ha (0.76 % of Survey Area / 4.57 % of Assessed Area / 10.29 % of VT mapped extent)<br><br>**Sampling:** Five quadrats (GSI-10, GSI-14, GSI-15, GSI-17, GSI-28) and three relevés (GSI-41R, GSI-R21, GSI-R27)<br><br>**Significant Taxa:** *Andersonia gracilis* (T), *Jacksonia gracillima* (P3), *Verticordia lindleyi* subsp. *lindleyi* (P4)<br><br>**Indicator Taxa:** *Schoenus laevigatus*<br><br>**Average taxon richness per quadrat:** 24.8 ± 5.2<br><br>**Total Native Taxa Recorded: 73**<br><br>**Similar VTs:** The understoreys of VTs 4 and 5 are similar (discussed in VT 4 section). VT 5 is floristically most similar to VT 6 (Appendix S) but can be distinguished structurally from VT 6 by the absence of a tree layer of *Melaleuca preissiana*. This VT also demonstrates some floristic similarity to VT 7 (Appendix S) but can be distinguished from this VT by the presence of sedgeland and rushland layers |  <br>**Plate 19:** Typical VT 5 (Quadrat GSI-15) |

| VT | Summary | Photograph |
|---|---|---|
| | **Variation:** This VT demonstrated slight structural variation whereby some areas were characterised by mid closed shrubland layers (Plate 20) |  **Plate 20:** Variant of VT 5 – mid closed shrubland layer (Quadrat GSI-14) |
| 6 | **Description:** Low open forest of *Melaleuca preissiana* over tall sparse shrubland of *Melaleuca viminea* subsp. *viminea* over mid sparse shrubland of *Kingia australis*, *Xanthorrhoea brunonis*, *Xanthorrhoea preissii* and *Regelia ciliata* over low sparse rushland of *Leptocarpus coangustatus* on grey clay loam in drainage lines<br><br>**Definition method:** floristic composition classification<br><br>**Area mapped:** 2.09 ha (0.2 % of Survey Area / 1.18 % of Assessed Area / 2.65 % of VT mapped extent)<br><br>**Sampling:** One quadrat (GSI-18); mapped on Appendix V (Sheet: V1; V4)<br><br>**Significant Taxa:** *Verticordia lindleyi* subsp. *lindleyi* (P4)<br><br>**Indicator Taxa:** NA<br><br>**Average taxon richness per quadrat:** 29.0<br><br>**Total Native Taxa Recorded:** 36 |  **Plate 21:** Typical VT 6 (Quadrat GSI-18) |

| VT | Summary | Photograph |
|---|---|---|
| | **Similar VTs:** This VT is floristically most similar to VTs 5 and 7 but can be distinguished structurally from these VTs by the presence of a tree layer of *Melaleuca preissiana*<br><br>**Variation:** NA | |
| 7 | **Description:** Tall open shrubland of *Melaleuca viminea* subsp. *viminea* over mid sparse shrubland of mixed species dominated by *Verticordia densiflora, Kunzea micrantha* subsp. *micrantha, Kingia australis* and *Petrophile rigida* over low open shrubland dominated by *Hypocalymma angustifolium* subsp. Swan Coastal Plain (G.J. Keighery 16777) on grey-brown sandy clay loam on lower slopes and flats<br><br>**Definition method:** floristic composition classification<br><br>**Area mapped:** 3.20 ha (0.3 % of Survey Area / 1.8 % of Assessed Area / 4.05 % of VT mapped extent)<br><br>**Sampling:** Two quadrats (GSI-29, GSI-31) and one relevé (GSI-R29)<br><br>**Significant Taxa:** *Verticordia lindleyi* subsp. *lindleyi* (P4)<br><br>**Indicator Taxa:** *Adenanthos cygnorum* subsp. *cygnorum*, *Crassula colorata* var. *colorata*, *Hypolaena exsulca*, *Trachymene pilosa*<br><br>**Average taxon richness per quadrat:** 30.5 ± 3.5<br><br>**Total Native Taxa Recorded:** 55<br><br>**Similar VTs:** This VT is floristically most similar to VTs 5 and 6 (Appendix S) (discussed in VT 5 and 6 sections)<br><br>**Variation:** NA |  <br>**Plate 22:** Typical VT 7 (Quadrat GSI-29) |

| VT | Summary | Photograph |
|---|---|---|
| 8 | **Description:** Mid open woodland of *Corymbia calophylla* over low woodland of mixed species dominated by *Eucalyptus rudis*, *Melaleuca rhaphiophylla* and *Melaleuca preissiana* over tall sparse shrubland of mixed species dominated by *Acacia saligna* over mid sparse shrubland of *Acacia pulchella* over mid tussock grassland of mixed species dominated by **Avena barbata*, **Eragrostis curvula* and **Ehrharta calycina* over mid forbland of **Watsonia meriana* on grey and brown sandy loam and clay loam on plains, flats and drainage lines<br><br>**Definition method:** structural vegetation classification<br><br>**Area mapped:** 7.99 ha (0.75 % of Survey Area / 4.49 % of Assessed Area / 10.1 % of VT mapped extent)<br><br>**Sampling:** Nine relevés (GSI-R02, GSI-R06, GSI-R26, GSI-R28, GSI-R31, GSI-R33, GSI-R35, GSI-R37, GSI-R47)<br><br>**Significant Taxa:** *Conospermum undulatum* (T), *Jacksonia gracillima* (P3)<br><br>**Indicator Taxa:** NA<br><br>**Average taxon richness per quadrat:** NA<br><br>**Total Native Taxa Recorded:** 24<br><br>**Similar VTs:** Not especially similar to any other VTs<br><br>**Variation:** This VT demonstrated some variation whereby *Allocasuarina fraseriana* was common at some occurrences. Given the general poor condition of this VT it is possible that this is a function of disturbance or the taxon has colonised areas where the soil has become drier |  <br>**Plate 23:** Typical VT 8 (Relevé GSI-R02) |

#### 5.1.3.3 Other Areas Described

Areas where natural vegetation has been completely and apparently permanently removed, with no native taxa remaining, have been mapped as 'Cleared' (C). This includes roads (and associated infrastructure including culverts), tracks and areas cleared for farming activities. A total of 76.38 ha of 'Cleared' land was mapped, representing 7.15 % of the Survey Area and 42.93% of the Assessed Area (Appendix V).

Due to the long history of disturbance within the Survey Area, there are many areas that still possess tree or large shrub taxa but are highly modified otherwise, with understoreys usually completely comprised of introduced taxa. In many cases the trees or large shrubs are native species and are probably remnant; however, in other cases these taxa have likely colonised the area following disturbance (e.g. in drains). Occasionally, some areas contained a mixture of native taxa and non-native taxa that have presumably been planted or have escaped from nearby plantings. All of the above-described areas have therefore been mapped as 'Highly Modified Areas', and no attempt has been made to align any such areas with VTs. Each HM type has been assigned to either being dominated by native taxa, or non-native taxa, however a mixture of both was generally present. A total of 15.3 ha of 'Highly Modified Areas' were mapped, representing 1.43 % of the Survey Area and 8.6 % of the Assessed Area. Table 20 outlines the different types of 'Highly Modified Areas' mapped in the Assessed Area (Appendix V).

**Table 20: Description of Highly Modified Areas Mapped in the Survey Area**

| Code | Description | Dominated by Native or Non-Native | Area Mapped (ha) | Proportion of Area mapped as Highly Modified (%) |
|---|---|---|---|---|
| AFr | Individual or stands of *Allocasuarina fraseriana* on cleared land | Native | 0.01 | 0.06 |
| AFr/CM/EG/PR | Individual or stands of *Allocasuarina fraseriana*, **Corymbia maculata*, **Eucalyptus globulus* and **Pinus radiata* over *Acacia* sp. and *Melaleuca* sp. on cleared land | Non-Native | 0.36 | 2.38 |
| AF/EC/MA | Individual or stands of *Agonis flexuosa*, *Eucalyptus camaldulensis*, *Eucalyptus* sp., **Melia azedarach* and **Pinus radiata* over *Melaleuca nesophila* and *Melaleuca viminalis* over *Chamelaucium uncinatum* over introduced species including **Avena barbata*, **Ehrharta calycina* and **Eragrostis curvula* on various soils and topographical positions | Native | 0.48 | 3.15 |
| AF/EC/ECo | Individual or stands of *Agonis flexuosa*, *Eucalyptus camaldulensis* and *Eucalyptus cornuta* over **Casuarina cunninghamiana* subsp. *cunninghamiana* over **Acacia iteaphylla* over introduced species including **Ehrharta calycina* and **Ehrharta longiflora* on various soils and topographical positions | Native | 0.47 | 3.1 |

| Code | Description | Dominated by Native or Non-Native | Area Mapped (ha) | Proportion of Area mapped as Highly Modified (%) |
|---|---|---|---|---|
| AF/CC/CM/EC/ER | Individual or stands of *Agonis flexuosa*, *Corymbia calophylla*, **Corymbia maculata*, *Eucalyptus camaldulensis* and **Eucalyptus resinifera* over **Acacia iteaphylla*, **Schinus terebinthifolia* and *Chamelaucium uncinatum* over introduced species on various soils and topographical positions | Native | 0.40 | 2.63 |
| CC | Individual or stands of *Corymbia calophylla* over introduced species including **Avena barbata*, **Bromus diandrus* and **Ehrharta calycina* on various soils and topographical positions | Native | 1.13 | 7.39 |
| CC/AC/CU | Individual or stands of *Corymbia calophylla* over **Acacia iteaphylla*, *Adenanthos cygnorum* subsp. *cygnorum* and *Chamelaucium uncinatum* over introduced species including **Avena barbata*, **Bromus diandrus*, **Ehrharta calycina*, **Eragrostis curvula*, **Lagurus ovatus and* **Leptospermum laevigatum* on various soils and topographical positions | Native | 2.07 | 13.52 |
| CC/AC/KG | Individual or stands of *Corymbia calophylla* over *Adenanthos cygnorum* subsp. *cygnorum and Kunzea glabrescens* over introduced species including **Eragrostis curvula*, **Leptospermum laevigatum* and **Oxalis glabra* on various soils and topographical positions | Native | 0.25 | 1.63 |
| CC/EC | Individual or stands of *Corymbia calophylla* and *Eucalyptus camaldulensis* over **Casuarina cunninghamiana* subsp. *cunninghamiana, Melaleuca preissiana, Jacksonia sternbergiana* and **Schinus terebinthifolia* over introduced species on various soils and topographical positions | Native | 1.70 | 11.09 |
| CC/EC/ER | Individual or stands of *Corymbia calophylla, Eucalyptus camaldulensis* and *Eucalyptus rudis* over introduced species on various soils and topographical positions | Native | 0.35 | 2.29 |
| CC/EC/ES | Individual or stands of *Corymbia calophylla, Eucalyptus camaldulensis* and **Erythrina* x *sykesii* over introduced species on cleared land | Native | 0.10 | 0.68 |
| CC/MP | Individual or stands of *Corymbia calophylla* and **Pinus radiata* over *Melaleuca preissiana* over **Leptospermum laevigatum, Melaleuca nesophila* and **Schinus terebinthifolia* over introduced species on various soils and topographical positions | Native | 0.35 | 2.31 |
| CM/EM/ER | Individual or stands of **Corymbia maculata Eucalyptus marginata* and **Eucalyptus resinifera* on cleared land | Native | 0.64 | 4.19 |

| Code | Description | Dominated by Native or Non-Native | Area Mapped (ha) | Proportion of Area mapped as Highly Modified (%) |
|---|---|---|---|---|
| CC/MV | Individual or stands of *Corymbia calophylla* over *Melaleuca viminalis* over *Calothamnus quadrifidus* subsp. *quadrifidus* and *Chamelaucium uncinatum* over introduced species including **Asparagus asparagoides* on various soils and topographical positions | Native | 3.13 | 20.49 |
| CC/XP | Individual or stands of *Corymbia calophylla* over *Xanthorrhoea preissii* over introduced species including **Avena barbata*, **Ehrharta calycina* and **Eragrostis curvula* on various soils and topographical positions | Native | 0.06 | 0.39 |
| CC/EC/PR | Individual or stands of *Corymbia calophylla*, *Eucalyptus camaldulensis* and **Pinus radiata* over *Acacia saligna* over introduced species on various soils and topographical positions | Native | 0.65 | 4.28 |
| CO/CC/EM/ER/EW | Individual or stands of *Casuarina obesa*, *Corymbia calophylla*, *Eucalyptus marginata*, *Eucalyptus rudis* and *Eucalyptus wandoo* over *Melaleuca huegelii* subsp. *huegelii*, *Melaleuca preissiana* and *Melaleuca rhaphiophylla* over **Leptospermum laevigatum* and **Acacia podalyriifolia* over introduced species on various soils and topographical positions | Native | 1.26 | 8.24 |
| C/P | Individual or stands of Exotic Palms and Callitris on cleared land | Non-Native | 0.05 | 0.34 |
| EC/CQ | Individual or stands of *Eucalyptus camaldulensis* over *Calothamnus quadrifidus* subsp. *quadrifidus, Chamelaucium uncinatum* and *Grevillea thelemanniana* over introduced species including **Bromus diandrus*, **Ehrharta calycina, *Eragrostis curvula, *Euphorbia terracina* and **Oxalis pes-caprae* on various soils and topographical positions. | Native | 0.29 | 1.92 |
| EC | Individual or stands of *Eucalyptus camaldulensis* on cleared land | Native | 0.07 | 0.44 |
| EC/ES | Individual or stands of *Eucalyptus camaldulensis* and **Erythrina x sykesii* on cleared land | Native | 0.17 | 1.09 |
| EC/PR | Individual or stands of *Eucalyptus camaldulensis* and **Pinus radiata* over introduced species on various soils and topographical positions | Native | 0.22 | 1.45 |
| ET | Individual or stands of *Eucalyptus todtiana* on cleared land | Native | 0.14 | 0.92 |
| LL | Individual or stands of **Leptospermum laevigatum* over introduced species on various soils and topographical positions | Non-Native | 0.53 | 3.48 |
| LL/AC | Individual or stands of **Leptospermum laevigatum* over *Adenanthos cygnorum* subsp. *cygnorum* and *Jacksonia sternbergiana* over introduced species on various soils and topographical positions | Native | 0.21 | 1.40 |

| Code | Description | Dominated by Native or Non-Native | Area Mapped (ha) | Proportion of Area mapped as Highly Modified (%) |
|---|---|---|---|---|
| W | Dense *_Watsonia meriana_ within isolated native species on brown clay on flats and drainage lines | Non-Native | 0.17 | 1.08 |

* denotes introduced taxon

Additionally, there are several areas where tree and shrub species have clearly been planted for the purposes of revegetation. Although these areas were often dominated by native taxa, in some cases the majority of the taxa present were not indigenous to the area. As these taxa had clearly been planted the resulting taxon combinations did not resemble remnant vegetation. Areas of non-native revegetation were also mapped, most particularly RV3 which was dominated by the non-native taxon *_Jacaranda mimosifolia_. These areas were mapped as 'Revegetated Areas'. A total of 7.28 ha of 'Revegetated Areas' were mapped, representing 0.68 % of the Survey Area and 4.09 * of the Assessed Area Table 21 outlines the different types of 'Revegetated Areas' mapped in the Survey Area.

**Table 21: Description of Revegetated Areas Mapped in the Survey Area**

| Code | Description | Area Mapped (ha) | Proportion of Areas mapped as Revegetated (%) |
|---|---|---|---|
| RV1 | Recent revegetated road reserve with *_Corymbia calophylla_*, *_Eucalyptus ?resinifera_*, *_Eucalyptus_* sp., *_Eucalyptus torquata_* and *_Casuarina cunninghamiana_* subsp. *_cunninghamiana_* over *_Melaleuca huegelii_* subsp. *_huegelii_* and *_Melaleuca incana_* subsp. *_incana_* over *_Acacia lasiocarpa_*, *_Calothamnus quadrifidus_* subsp. *_quadrifidus_*, *_Grevillea thelemanniana_* and *_Hakea prostrata_* over introduced species including *_Avena barbata_*, *_Bromus diandrus_*, *_Ehrharta calycina_*, *_Eragrostis curvula_*, *_Euphorbia terracina_*, *_Fumaria capreolata_* and *_Sonchus asper_* | 4.87 | 66.93 |
| RV2 | Recent revegetated road reserve with *_Kunzea glabrescens_*, *_Melaleuca incana_* subsp. *_incana_* and *_Melaleuca teretifolia_* over *_Astartea scoparia_* over *_Juncus pallidus_*, *_Schoenoplectus tabernaemontani_* and *_Typha domingensis_* (artificial wetland) | 0.57 | 7.83 |
| RV3 | Historically revegetated road reserve with *_Jacaranda mimosifolia_* over introduced species on cleared land | 0.05 | 0.65 |
| RV4 | Historically revegetated road reserve with *_Allocasuarina fraseriana_*, *_Nuytsia floribunda_* and *_Eucalyptus camaldulensis_* over *_Acacia saligna_*, *_Chamelaucium uncinatum_*, *_Adenanthos cygnorum_* subsp. *_cygnorum_* and *_Leptospermum laevigatum_* over *_Xanthorrhoea preissii_* and *_Cyathochaeta avenacea_* over introduced species including *_Avena barbata_*, *_Ehrharta calycina_*, *_Ehrharta longiflora_* and *_Pelargonium capitatum_* | 0.40 | 5.46 |

| Code | Description | Area Mapped (ha) | Proportion of Areas mapped as Revegetated (%) |
|---|---|---|---|
| RV5 | Historically revegetated road reserve with *Corymbia calophylla*, *Eucalyptus cornuta*, *Eucalyptus rudis* and *Eucalyptus* sp. over *Acacia saligna*, *Grevillea leucopteris* and *Melaleuca viminalis* over *Cyathochaeta avenacea* over introduced species including **Avena barbata*, **Eragrostis curvula* and **Pelargonium capitatum* | 0.38 | 5.16 |
| RV6 | Historically revegetated road reserve with *Eucalyptus camaldulensis* over *Acacia saligna*, *Allocasuarina humilis*, *Calothamnus quadrifidus* subsp. *quadrifidus*, *Grevillea leucopteris*, *Melaleuca huegelii* subsp. *huegelii* and *Melaleuca nematophylla* over introduced species | 1.02 | 13.97 |

#### 5.1.3.4 Relationships of VTs to SCP FCTs

As described in Section 3.1.9.2, further floristic analysis was undertaken to determine relationships between VTs defined by floristic composition classification in the Survey Area and SCP FCTs defined by Gibson *et al.* (1994) with the aim of aligning VTs with SCP FCTs. Several different analytical approaches were employed to build supporting evidence for aligning VTs with SCP FCTs. In addition, taxon lists of Woodman Environmental quadrats were compared to typical species lists for SCP FCTs as presented in Gibson *et al.* (1994), as well as quadrat taxon lists, soil, topography and geographical distribution data from this survey. Table 22 presents a summary of the results of this process.

- As outlined in Table 22, only two of the seven VTs of the Survey Area defined by floristic composition have been confidently aligned with SCP FCTs , with VT 1 and VT 6 being aligned with SCP FCTs 20a and 4 respectively. For the remaining VTs defined via floristic composition classification, the results of the analyses undertaken were inconclusive, and therefore these VTs could not confidently be aligned with any specific SCP FCT. Two of the VTs (VTs 2 and 3) have affinities to two different SCP FCTs (FCT 3 and 20); however, both of these VTs were only represented by two quadrats. It is considered that this limited data likely accounts for the inconclusive analysis results. It is considered likely that VTs 4, 5, and 7 represent communities not sampled by quadrats in the SCP datasets; the areas within which these VTs were mapped are considered poorly sampled in the context of the SCP datasets. Excerpts from classification analysis dendrograms are presented in appendices as follows:
- Analysis of the Woodman Environmental quadrat dataset from the Survey Area with the original SCP dataset (Gibson *et al.* 1994) – Appendix W;
- Analysis of the Woodman Environmental quadrat dataset from the Survey Area with the amended SCP dataset (Keighery *et al.* 2012) – Appendix X;
- Single site insertion analysis of representative quadrats of VTs described in the Survey Area with the original SCP dataset (Gibson *et al.* 1994) – Appendix Y; and
- Single site insertion analysis of representative quadrats of VTs described in the Survey Area with the amended SCP dataset (Keighery *et al.* 2012) – Appendix Z.

The only VT defined via structural vegetation classification, VT 8, was not sampled using quadrats because of the degraded condition of the vegetation, and associated loss of most

of the native understorey. Review of SCP FCT descriptions and relevé taxon lists indicates that VT 8 may possibly represent FCT 11 or 14 however a conclusive determination could not be made due to the degraded condition of this VT.

As discussed in Section 3.1.9.2, due to the lack of formal guidance regarding the appropriate methodology for aligning vegetation with SCP FCTs, and also the lack of information regarding how new quadrats contained in the amended SCP dataset were assigned to SCP FCTs, the VT-FCT alignment determinations presented in Table 22 for VTs 1 and 6 cannot be considered absolutely conclusive. However, the determinations were generally supported by the results of multiple analyses, including analyses that follow DBCA's standard analysis methods. Comparisons of quadrat taxon lists also generally supported the determinations for VTs 1 and 6. There were a number of cases where the results of the analyses did not support the final determination made. This was not unexpected; as discussed in Section 3.1.9.2, quadrat groupings are usually disrupted, sometimes significantly, when data is added to or removed from a dataset and analysed. Even if exactly the same parameters are used, many quadrats that were originally classified together can be re-classified in completely different groups when such changes are made.

## Table 22: Summary of Analyses to Determine Relationships of VTs to SCP FCTs

| VT | Analysis with Survey Area and Original SCP Quadrat Dataset Quadrats (App. T) | Analysis with Survey Area and Amended SCP Quadrat Dataset Quadrats (App. U) | Single Insertion with Original SCP Quadrat Dataset Quadrats (App. V) | Single Insertion with Amended SCP Quadrat Dataset Quadrats (App. W) | Final determination |
|---|---|---|---|---|---|
| 1 | **FCT 20a**<br>Quadrats classified within a group of SCP quadrats that all represent FCT 20a, except for a single quadrat that represents FCT 21c. | **FCT 20a**<br>Quadrats classified within a group of SCP quadrats that all represent FCT 20a, except for a single quadrat that represents FCT 21c. | **FCT 20**<br>Quadrats GSI-01, GSI-02, GSI-06, GSI-09, GSI-12 and GSI-22 analysed:<br>• Quadrat GSI-01 classified in a small group of SCP quadrats that all represent FCT 20a. This group is sister to a group of quadrats that mostly represent FCT 20b.<br>• Quadrat GSI-02 classified with a single quadrat that represents FCT 21c. This group is sister to a group of quadrats that represent FCT 20c;<br>• GSI-06 classified with a single quadrat that represents FCT 20a. This group is sister to a group of quadrats that represent FCT 20c;<br>• Quadrats GSI-09 and GSI-12 classified with a single quadrat that represents FCT 21c. This subgroup is part of a larger group of quadrats that represent FCT 20c;<br>• Quadrat GSI-22 classified with a single quadrat that represents FCT 20a. This group is sister to a group of quadrats that represent FCT 20c | **Inconclusive**<br>Quadrats GSI-01, GSI-02, GSI-06, GSI-09, GSI-12 and GSI-22 analysed:<br>• Quadrat GSI-01 classified in a large group of SCP quadrats that mostly represent FCT 20a. This group is sister to a group of quadrats that are predominately FCT 20b;<br>• Quadrat GSI-02 classified with a single quadrat that represented FCT 21c. This subgroup is part of a larger group of quadrats that mostly represent FCT 20a;<br>• Quadrat GSI-06 classified in a small subgroup with two SCP quadrats that represented FCTs 20a and 21c. This subgroup is part of a larger group of quadrats that represent FCT 20a;<br>• Quadrat GSI-09 classified with one SCP quadrat that represents FCT 23a. This subgroup is part of a larger group of quadrats that mostly represent FCT 23a;<br>• Quadrat GSI-12 classified with one SCP quadrat that represented FCT 20c. This subgroup is part of a larger group of quadrats that represented FCT 20a; | **FCT - 20a**<br>Statistical analysis with the original and amended SCP dataset broadly supports this determination. Some of the single insertion analyses with the amended dataset indicated a relationship with sites which represent FCT 23. SCP quadrat hart04, which occurs within VT1 in the Survey Area, represents FCT 23a accordingly to DBCA; this FCT includes *Banksia menziesii* in the overstorey but the typical understorey taxa do not reflect those of VT 1. SCP quadrats hart01, APBF-1, APBF-2, M53 and m5302, which all occur within 1 km of the Survey Area, represent FCT 20a. |

| VT | Analysis with Survey Area and Original SCP Quadrat Dataset Quadrats (App. T) | Analysis with Survey Area and Amended SCP Quadrat Dataset Quadrats (App. U) | Single Insertion with Original SCP Quadrat Dataset Quadrats (App. V) | Single Insertion with Amended SCP Quadrat Dataset Quadrats (App. W) | Final determination |
|---|---|---|---|---|---|
| | | | | • Quadrat GSI-22 classified in a small subgroup with SCP quadrats that represent FCTs 20a, 23b and S09. This subgroup is part of a larger group of quadrats that represent FCT 23b. | |
| 2 | **Inconclusive - possibly FCT 20**<br>Quadrats formed a small group with study area VT3 quadrats and no SCP quadrats, suggesting similar vegetation not sampled by that study. In the context of the SCP dataset, the most closely related quadrats predominantly represent FCT 20. | **FCT 3**<br>Quadrats from this VT classified in a group with study area VT3 quadrats and SCP quadrats that represent FCT 3a. This group is sister to a group of quadrats that predominantly represent FCT 3b, however with some FCT S08, 20d and 20b. | **FCT 20**<br>Quadrats GSI-04 and GSI-39 analysed:<br>• Quadrat GSI-04 classified within a small group with SCP quadrats that represent FCT 20a. This group is sister to a larger group of quadrats that are predominately FCT 20b;<br>• Quadrat GSI-39 classified with one SCP quadrat that represents FCT 21c within a larger group of quadrats that represent FCT 20c. | **Inconclusive - possibly FCT 3a/20c**<br>Quadrats GSI-04 and GSI-39 analysed:<br>• Quadrat GSI-04 classified within a group of SCP quadrats that all represent FCT 3a;<br>• Quadrat GSI-39 classified with one SCP quadrat that represents FCT 21c within a larger group of quadrats that represent FCT 20c. | **Inconclusive**<br>The analyses undertaken indicate that there is not enough data to confidently align VT 2 (represented by 2 quadrats) with a SCP FCT. The Assessed Area is poorly sampled in the SCP datasets. It is possible this VT represents 2 communities. VT 2 has affinities to 2 different SCP FCTs (FCT 3 and 20). |
| 3 | **Inconclusive - possibly FCT 20**<br>Quadrats formed a small group with study area VT2 quadrats and no SCP quadrats, suggesting similar vegetation not sampled by that study. In the context of the SCP dataset, the most closely related quadrats predominantly represent FCT 20. | **FCT 3**<br>Quadrats from this VT classified in a group with study area VT2 quadrats and SCP quadrats that represent FCT 3a. This group is sister to a group of quadrats that predominantly represent FCT 3b, however with some FCT S08, 20d and 20b. | **FCT - 3c**<br>Quadrats GSI-08 and GSI-35 analysed:<br>• Quadrat GSI-08 classified in a large group with SCP quadrats that predominately represent FCT 3c.<br>• Quadrat GSI-35 classified in a group with SCP quadrats that represent FCT 3c. | **FCT 3**<br>Quadrats GSI-08 and GSI-35 analysed:<br>• Quadrat GSI-08 classified in a subgroup with SCP quadrats that all represent FCT 3c. This subgroup is part of a larger group that includes quadrats that represented FCTs 25, 24, 18 and S08;<br>• Quadrat GSI-35 classified in a group of SCP quadrats that all represent FCT 3a. | **Inconclusive**<br>The analyses undertaken indicate that there is not enough data to confidently align VT 3 (represented by 2 quadrats) with a SCP FCT. The Assessed Area is poorly sampled in the SCP datasets. It is possible this VT represents 2 communities. VT 3 has affinities to 2 different SCP FCTs (FCT 3a and 3c). |
| 4 | **Inconclusive**<br>Quadrats from this VT formed a discrete group with study area | **Inconclusive**<br>Quadrats from this VT formed a discrete group with study area | **Inconclusive**<br>Quadrats GSI-03, GSI-16, GSI-19 and GSI-23 analysed: | **Inconclusive**<br>Quadrats GSI-03, GSI-16, GSI-19 and GSI-23 analysed: | **Inconclusive**<br>Does not align clearly with any SCP FCTs. Has some affinities to |

| VT | Analysis with Survey Area and Original SCP Quadrat Dataset Quadrats (App. T) | Analysis with Survey Area and Amended SCP Quadrat Dataset Quadrats (App. U) | Single Insertion with Original SCP Quadrat Dataset Quadrats (App. V) | Single Insertion with Amended SCP Quadrat Dataset Quadrats (App. W) | Final determination |
|---|---|---|---|---|---|
| | VTs 5, 6 and 7. This indicated that similar vegetation had not been sampled by the original SCP dataset. The three mostly closely related groups are comprised of quadrats that represent SCP FCTs 2, 3a and 3c. | VTs 5, 6 and 7, and two SCP quadrats that represent FCT S02. This indicated that similar vegetation had not been sampled by the original SCP dataset. The three mostly closely related groups are comprised of quadrats that represent SCP FCTs 4, 5 and S02. | • Quadrat GSI-03 classified within a group of SCP quadrats that represent FCT 4, 6, 20b and 21c;<br>• Quadrat GSI-16 classified within a small group with three SCP quadrats which represent FCT 21c; this group is sister to a group of quadrats that represent FCT 20c;<br>• Quadrats GSI-19 and GSI-23 classified within a group of SCP quadrats that predominantly represent FCT 21c. | • Quadrat GSI-03 classified within a group with SCP quadrats that all represent FCT 3a.<br>• Quadrat GSI-16 classified within a group of SCP quadrats that predominately represent FCT 20a, except for one quadrat from FCT 20c;<br>• Quadrats GSI-19 and GSI-23 classified within a group of SCP quadrats that represent FCT 4, 21a, 21c and S02. | the wetter low lying SCP FCT groups (SCP3 & 21). These VT 4 sites appear to have influences from the adjacent wetter areas, however, are drier and slightly higher in the landscape. It is possible that this VT represents undescribed vegetation or transitional vegetation. Although this VT has some affinity with SCP 21c, all quadrats are missing the *Banksia attenuata* and *Banksia menziesii* tree layer which is at variance to the FCT description.<br><br>SCP quadrats hart02 and hart03, both of which are located within vegetation mapped as VT 4 in the study area, represent FCT S02. Limited information is available on SCP FCTs defined by Keighery *et al.* (2012), which includes S02. However, analysis of all WEC quadrats with the amended SCP dataset indicated some degree of similarity between these two quadrats and those of VT 4. |
| **5** | **Inconclusive**<br>Quadrats from this VT formed a discrete group with study area VTs 4, 6 and 7. This indicated that similar vegetation had not been sampled by the original SCP dataset. The three mostly closely related groups are comprised of quadrats that represent SCP FCTs 2, 3a and 3c. | **Inconclusive**<br>Quadrats from this VT formed a discrete group with study area VTs 4, 6 and 7, and two SCP quadrats that represent FCT S02. This indicated that similar vegetation had not been sampled by the original SCP dataset. The three mostly closely related groups are comprised of quadrats | **Inconclusive**<br>Quadrats GSI-10, GSI-14 and GSI-15 analysed:<br>• Quadrat GSI-10 classified within a group of SCP quadrats that represent FCTs 5, 6, 7 and 10a;<br>• Quadrat GSI-14 classified in a small group with SCP quadrats that represent FCT 13. | **Inconclusive**<br>Quadrats GSI-10, GSI-14 and GSI-15 analysed:<br>• Quadrat GSI-10 classified within a group of SCP quadrats that predominantly represent FCT 10a and 10b;<br>• Quadrat GSI-14 classified within a group of SCP quadrats that predominantly represent | **Inconclusive**<br>Does not align clearly with any SCP FCTs. Has some affinities to the wetland SCP FCT groups (SCP4, 5, 6, 7, 10a, 10b, 13 and S02). It is possible that this VT represents undescribed vegetation. SCP quadrats hart02 and hart03, are similar to study area quadrats in VT 5 based on |

| VT | Analysis with Survey Area and Original SCP Quadrat Dataset Quadrats (App. T) | Analysis with Survey Area and Amended SCP Quadrat Dataset Quadrats (App. U) | Single Insertion with Original SCP Quadrat Dataset Quadrats (App. V) | Single Insertion with Amended SCP Quadrat Dataset Quadrats (App. W) | Final determination |
|---|---|---|---|---|---|
| | | that represent SCP FCTs 4, 5 and S02. | • Quadrat GSI-15 classified with one SCP quadrat representing FCT 22. This group is sister to a group which represents FCT 2. | FCT S02, S03 4, 9 and 11, however is most closely related to Hartfield Park S02 quadrats.<br>• Quadrat GSI-15 classified with two SCP quadrats from Hartfield Park that represented FCT S02. This group is sister to a group of quadrats that all represent FCT 2. | analysis results. These quadrats represent FCT S02. Limited information is available on SCP FCTs defined by Keighery *et al*. (2012), which includes S02. |
| **6** | **Inconclusive**<br>Quadrats from this VT formed a discrete group with study area VTs 4, 5 and 7. This indicated that similar vegetation had not been sampled by the original SCP dataset. The three mostly closely related groups are comprised of quadrats that represent SCP FCTs 2, 3a and 3c. | **Inconclusive**<br>Quadrats from this VT formed a discrete group with study area VTs 4, 5 and 7, and two SCP quadrats that represent FCT S02. This indicated that similar vegetation had not been sampled by the original SCP dataset. The three mostly closely related groups are comprised of quadrats that represent SCP FCTs 4, 5 and S02. | **FCT - 4**<br>Quadrat GSI-18 analysed:<br>• Quadrat GSI-18 classified in a group of SCP quadrats that predominantly represented FCT 4**.** | **FCT - 4**<br>Quadrat GSI-18 analysed:<br>• Quadrat GSI-18 classified in a group with SCP quadrats that predominantly represent FCT 4 and 21c. | **FCT - 4**<br>Results of single insert analysis, as well as review of SCP FCT description, quadrat taxon list and quadrat species richness, broadly support this determination. |
| **7** | **Inconclusive**<br>Quadrats from this VT formed a discrete group with study area VTs 4, 5 and 6. This indicated that similar vegetation had not been sampled by the original SCP dataset. The three mostly closely related groups are comprised of quadrats that represent SCP FCTs 2, 3a and 3c. | **Inconclusive**<br>Quadrats from this VT formed a discrete group with study area VTs 4, 5 and 6, and two SCP quadrats that represent FCT S02. This indicated that similar vegetation had not been sampled by the original SCP dataset. The three mostly closely related groups are comprised of quadrats that represent SCP FCTs 4, 5 and S02. | **Inconclusive**<br>Quadrats GSI-29 and GSI-31 analysed:<br>• Quadrat GSI-29 classified in a group of SCP quadrats that predominantly represent FCT 21c;<br>• Quadrat GSI-31 classified in a group of SCP quadrats that predominantly represent FCT 6. This group is sister to a group of quadrats that represent FCT 11. | **Inconclusive**<br>Quadrats GSI-29 and GSI-31 analysed:<br>• Quadrat GSI-29 classified in a group of SCP quadrats that predominantly represent FCT 4, with several quadrats representing FCT 21c;<br>• Quadrat GSI-31 classified in a group of SCP quadrats that predominantly represent FCT 6. | **Inconclusive**<br>The analyses undertaken indicate that there is not enough data to confidently align VT 7 (represented by 2 quadrats) with a SCP FCT. There are taxa present that indicate that this VT has affinities with SCP FCTs 4, 6 and 11. |
| **8** | NA – VT is represented by relevés only, therefore no analysis could | NA – VT is represented by relevés only, therefore no analysis could | NA – VT is represented by relevés only, therefore no analysis could | NA – VT is represented by relevés only, therefore no analysis could | **Inconclusive - possibly FCT 11/14**<br>The poor condition and |

| VT | Analysis with Survey Area and Original SCP Quadrat Dataset Quadrats (App. T) | Analysis with Survey Area and Amended SCP Quadrat Dataset Quadrats (App. U) | Single Insertion with Original SCP Quadrat Dataset Quadrats (App. V) | Single Insertion with Amended SCP Quadrat Dataset Quadrats (App. W) | Final determination |
|---|---|---|---|---|---|
| | be undertaken | be undertaken | be undertaken | be undertaken | associated loss of most of the native understorey of this VT did not allow for sampling via quadrats. Review of FCT descriptions and quadrat taxon lists identifies greatest floristic similarity to FCT 14; however, the Assessed Area is located well outside the range of this FCT. The presence of *Eucalyptus rudis* and *Melaleuca rhaphiophylla* may indicate that this VT could represent FCT 11. While there are no SCP quadrats located within close proximity to the Assessed Area, the Assessed Area is within the range of this FCT. |

#### 5.1.3.5 Significant Vegetation

A total of two formally described significant communities have been identified by this assessment as occurring within the Survey Area. Both of these significant communities are listed TECs under the BC Act or the EPBC Act:

- SCP20a - *Banksia attenuata* woodland over species rich dense shrublands: listed as Endangered under the State BC Act; although is not listed separately under the EPBC Act, it forms part of the EPBC Act-listed TEC 'Banksia woodlands of the Swan Coastal Plain';
- 'Banksia woodlands of the Swan Coastal Plain': listed as Endangered under the EPBC Act; listed as Priority 3 PEC by DBCA (2020b).

A total of five further significant types of vegetation as described by EPA (2016b) were also identified as potentially occurring within the Assessed Area. These include vegetation associated with VTs 2 and 3 (with reference to Table 22):

- SCP 20c - Shrublands and Woodlands of the eastern side of the Swan Coastal Plain: listed as Critically Endangered under the BC Act and Endangered under the EBCA Act. One quadrat of VT 2 has affinities to this TEC;
- SCP 3a - *Corymbia calophylla – Kingia australis* woodlands on heavy soils, Swan Coastal Plain: listed as Critically Endangered under the BC Act and Endangered under the EPBC Act. One quadrat of VT 2, and one quadrat from VT 3 have affinities to this TEC;
- SCP 3c - *Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain: listed as Critically Endangered under the BC Act and Endangered under the EPBC Act. One quadrat of VT 3 has affinities to this TEC.

There are a further three VTs which have not aligned with any SCP FCT. Gibson *et al* 1994 states that a number of land systems (including the Pinjarra Plain) were under sampled. Given the location of the survey area, this finding is not unexpected.

Each significant vegetation type is discussed further below (Table 23). Photographs of the significant vegetation types are presented in Appendix AA. The locations of significant vegetation types are presented in Appendix AB.

**Table 23: Significant Vegetation Occurring within the Survey Area**

| Community | Conservation Status (WA) | Conservation Status (Commonwealth) | Representative VTs | No. of Patches / Occurrences | Total Area Mapped (ha) | Figure |
|---|---|---|---|---|---|---|
| SCP20a - *Banksia attenuata* woodland over species rich dense shrublands (WA) | Endangered (EN B) ii)) | Endangered* | 1 | 10 occurrences | 28.97 | Appendix AB: Figures AB1-3 |
| Banksia woodlands of the Swan Coastal Plain | Priority 3 | Endangered | 1 | 7 patches | 27.93 | Appendix AB: Figures AB1-3 |
| **Potential:** SCP20c – Shrublands and Woodlands of the eastern side of the Swan Coastal Plain | Critically Endangered (CR B) ii)) | Endangered | Potentially part of VT 2 (GSI-39) | 1 occurrence (8 polygons) | 5.5 | Appendix AB: Figures AB1-2 |
| **Potential:** SCP3a – *Corymbia calophylla – Kingia australis* woodlands on heavy soils, Swan Coastal Plain | Critically Endangered (CR b) ii)) | Endangered | Potentially part of VT 2 (GSI-04) | 1 occurrence (2 polygons) | 1.08 | Appendix AB: Figure AB2 |
| **Potential**: SCP3a – *Corymbia calophylla – Kingia australis* woodlands on heavy soils, Swan Coastal Plain | Critically Endangered (CR b) ii)) | Endangered | Potentially part of VT 3 (GSI-35) | 1 occurrence (7 polygons) | 6.77 | Appendix AB: Figures AB1-2 |
| **Potential** SCP3c – *Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain | Critically Endangered (CR b) ii)) | Endangered | Potentially part of VT 3 (GSI-08) | 3 occurrences (7 polygons) | 1.55 | Appendix AB: Figure AB2 |

Note: * indicates that the community itself is not listed by the Commonwealth but can be a component of the Banksia Woodlands of the Swan Coastal Plain TEC (Endangered).

As presented in Section 5.1.1.4, the buffer polygons of 15 significant vegetation types were identified as occurring within the Desktop Study Area, with buffer zones of nine of these significant vegetation types intersecting the Assessed Area. Although the actual occurrence of a significant vegetation type may not be within the Assessed Area or Development Envelope, according to the metadata information from the DBCA TEC and PEC Database. Buffers are placed around occurrences of TECs and PECs to ensure that impacts to surface water or groundwater in the vicinity of TECs or PECs, which the TEC or PEC may depend on, are identified. As the buffer zones of six of the significant vegetation types identified through the desktop review do not occur in the Assessed Area, and no representative vegetation of any of these six significant vegetation types were mapped or otherwise identified in the Assessed Area, these six types will not be discussed further.

Table 24 presents a summary of the presence of the remaining nine significant vegetation types within the buffer polygons in the Assessed Area.

**Table 24: Status of Significant Vegetation Types with Buffer Polygons Intersecting the Survey Area**

| Community | Conservation Status | Comment |
|---|---|---|
| Banksia woodlands of the Swan Coastal Plain | Priority 3 (WA); Endangered (Commonwealth*) | Buffer polygons identified within the Survey Area and Development Envelope, including the northern half and southern portion of the Development Envelope (Figure 11; Appendix AB Sheets 1-3).<br>Vegetation equivalent to this PEC/TEC has been mapped within the buffer polygons, with most vegetation mapped as this TEC occurring in existing buffer polygons; one small area has been mapped outside of the existing buffer polygon (Appendix AB Sheet 2). Further discussion regarding the extent of this PEC/TEC in the assessed area is provided below. |
| SCP02 - Southern wet shrublands, Swan Coastal Plain | Endangered (WA) | One buffer polygon intersects both the Survey Area and northern extent of the Development Envelope (Figure 11; Appendix AB Sheet 1).<br>The vegetation associated with this buffer zone in the assessed area was mapped as RV1 (recently revegetated road reserve).<br>This PEC/TEC does not occur in the assessed area. |
| SCP3a - *Corymbia calophylla -Kingia australis* woodlands on heavy soils, Swan Coastal Plain (WA); *Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain (Commonwealth) | Critically Endangered (WA); Endangered (Commonwealth) | Two buffer polygons intersect the Survey Area and Development Envelope (Figure 11; Appendix AB).<br>The vegetation mapped within the assessed area within the northern buffer polygon (Appendix AB Sheet 2) did not align with SCP3a (VTs 8 and 4). However, a small area of VT 3 which showed affinity to SCP3a was mapped just to the north-east of this buffer zone (Appendix AB Sheets 1-2). Some vegetation showing affinity to SCP3a (VT 2) was mapped within the southern buffer zone (Appendix AB Sheets 2-3), however vegetation showing affinity to SCP 3c (VT 3) was also mapped in this buffer zone area. SCP3a is considered to potentially occur within the Survey Area based on the current level of data available. |

| Community | Conservation Status | Comment |
|---|---|---|
| SCP3b - *Corymbia calophylla - Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain | Vulnerable (WA) | One buffer polygon intersects the Survey Area and Development Envelope (Figure 11; Appendix AB Sheets 2-3).<br>Areas of vegetation in the assessed area showed affinities to SCP 3a and 3c (VTs 2 and 3), as well as confirmed SCP 20a (VT 1) however not to SCP 3b.<br>Other VTs mapped in the buffer polygon (VT 4, VT 8) likewise did not align with SCP3b. SCP3b is not considered to occur in the assessed area. |
| SCP08 - Herb rich shrublands in clay pans (WA); Clay Pans of the Swan Coastal Plain (Commonwealth) | Vulnerable (WA); Critically Endangered~ (Commonwealth) | One buffer polygon intersects the Survey Area however not the Development Envelope (Figure 11; Appendix AB Sheets 2-3). This buffer polygon is associated with locations known from the Brixton St Wetlands extending through the damplands to the east of these wetlands.<br>This buffer polygon did not intersect the assessed area.<br>No vegetation representing SCP08 was mapped within the assessed area. |
| SCP10a - Shrublands on dry clay flats (WA); Clay Pans of the Swan Coastal Plain (Commonwealth) | Endangered (WA); Critically Endangered~ (Commonwealth) | One buffer polygon intersects the Survey Area and the Development Envelope (Figure 11; Appendix AB Sheet 2).<br>Vegetation representing SCP10a was not mapped within the assessed area within this buffer polygon.<br>VTs 4 and 8 were mapped in the assessed area within this buffer polygon, neither of which aligned with SCP10a. Otherwise, vegetation in this buffer polygon in the assessed area was mapped as Highly Modified, Cleared or Not Assessed.<br>No vegetation representing SCP10a was mapped in the assessed area. |

| Community | Conservation Status | Comment |
|---|---|---|
| SCP20a - *Banksia attenuata* woodlands over species rich dense shrublands (WA); Banksia Woodlands of the Swan Coastal Plain (Commonwealth)* | Endangered (WA); Endangered (Commonwealth*) | Two buffer polygons intersect the Survey Area and Development Envelope, with two further buffer polygons intersecting only the Survey Area (Figure 11; Appendix AB1 – 8).<br>Vegetation representing SCP20a was mapped throughout the assessed area.<br>The vegetation in the Development Envelope within the northern buffer zone (Appendix AB1) only contains Highly modified vegetation, and therefore SCP20a associated with this buffer zone is not extant in this area. However, a small area of VT1 (equivalent to SCP20a) was mapped on the edge of the Survey Area in this buffer polygon (Appendix AB2).<br>The north-eastern buffer polygon (Appendix AB2-4) does not intersect the Development Envelope; however, SCP20a was mapped as occurring within this buffer polygon.<br>A relatively large buffer polygon occurs on the southern extent of the Development Envelope; SCP20a was mapped in some intact portions of this area (Appendix AB6-7).<br>One further buffer polygon occurs on the eastern side of the Survey Area (Appendix AB6), however this area was Not Assessed. This area does not intersect the Development Envelope. |
| SCP20c - Shrublands and woodlands of the eastern side of the Swan Coastal Plain | Critically Endangered (WA); Endangered (Commonwealth) | One buffer polygon occurs in the Survey Area and Development Envelope (Appendix AB5-8).<br>None of the intact vegetation of the assessed area is confirmed as representative of SCP20c in this buffer area; SCP20a is known to occur (VT 1).<br>One area of VT2 showing affinity to SCP20c was identified in the Survey Area, however this area occurs outside of the buffer polygon (Appendix AB4).<br>SCP20c is considered to potentially occur within the Survey Area based on the current level of data available. |
| Shrublands and woodlands on Muchea Limestone | Endangered (WA); Endangered (Commonwealth) | One buffer polygon occurs in the Survey Area, however does not occur in the Development Envelope or assessed area (Appendix AB3; AB5).<br>VTs4 and 8 were mapped in the assessed area closest to this buffer polygon; however, neither of these VTs align with this significant community.<br>This significant community does not occur within the assessed area. |

*: can be a component of the EPBC listed TEC 'Banksia Woodlands of the Swan Coastal Plain'.

### Banksia Woodlands of the Swan Coastal Plain

The 'Banksia Woodlands of the Swan Coastal Plain' community is listed as a PEC in WA, and as a TEC under Commonwealth legislation. Therefore, these are discussed together in the context of the Commonwealth-listed TEC.

The Approved Conservation Advice (TSSC 2016) for this community stipulates a stepwise process for identifying this community. These steps are followed in the context of identifying whether vegetation of the Survey Area represents this TEC, as outlined below.

The first step involves key diagnostic characteristics (location and physical environment, soils and landform, structure, and composition). The Assessed Area itself satisfies the first two key diagnostic characteristics, as it occurs within the Swan Coastal Plain IBRA bioregion and contains sandplain and areas of sandy colluvium/aeolian sands. With regard to the remaining two key diagnostic characteristics, Only VT 1 is considered to possess these characteristics, as they almost always have a basic structure of a low woodland dominated by *Banksia attenuata* (with or without emergent trees such as *Eucalyptus marginata* subsp. *marginata*, *Corymbia calophylla* and *Corymbia haematoxylon*) of other species), over a relatively diverse understorey. It is acknowledged that in some areas of the above VTs, *Banksia attenuata* is not dominant, and may occur as isolated trees only, or may be completely absent. However, as outlined in the Approved Conservation Advice under the fourth step of the identification process (further information to assist in determining the presence of the community), this form variation often occurs in patches of the TEC, and therefore does not preclude such areas from being included as part of a larger occurrence of the TEC.

The next steps involve applying condition and size (spatial area) thresholds to patches of vegetation that meet the key diagnostic characteristics; a patch is defined as a discrete and mostly continuous area of the TEC, typically with any breaks (i.e. tracks, roads, vegetation that does not represent the TEC being less than 30 m in distance). A total of 10 patches of the above-mentioned VTs were defined within the Assessed Area using this definition.

The Approved Conservation Advice then specifies that a patch of the TEC must meet the Good vegetation condition category as per Gibson *et al*. (1994) to be considered a patch of the TEC under the EPBC Act; this is the same vegetation condition scale presented in EPA (2016a) that has been used during this current assessment. It then defines minimum patch sizes for each condition rating (Good and higher). However, as outlined under the fourth step of the Approved Conservation Advice, it is stipulated that a patch can vary in condition, and can include vegetation with a lower condition rating than Good; such areas may still retain important natural values and may be critical to protecting those portions of a patch that meet the condition threshold. In these cases, the condition rating mapped over the largest portion of the patch has been used when assessing the patch against the minimum patch size requirements. It also stipulates that vegetation occurring outside of the area of study, in this case the Assessed Area, needs to be considered when calculating patch sizes within the area of study, in cases where vegetation outside the area of study is contiguous with that inside. This was also considered, with the type of vegetation (i.e. is the vegetation also likely the TEC) inferred from aerial photography and field notes.

Using the condition and patch size requirements, a total of seven patches of this TEC are considered to occur within the Survey Area (Appendix AB). The remaining three patches are considered to be in Degraded condition and/or are below the minimum patch size for their entireties, and therefore do not meet the patch size/condition threshold requirements; they are therefore not considered to be patches of the TEC.

The seven patches of the TEC comprise a total of 27.93 ha. This area has been mapped as the following vegetation condition ratings (note; areas rounded for presentation purposes):

- Excellent condition – 17.66 ha;
- Very good condition – 8.54 ha;
- Good condition – 1.22 ha; and
- Degraded condition – 0.54 ha.

No patches (either wholly or partially) of TEC were considered to be in Pristine or Completely Degraded condition.

A summary of condition characteristics of individual patches is presented in Table 25 (note – areas rounded for presentation purposes).

**Table 25: Summary of Condition Characteristics of Patches of 'Banksia Woodlands of the Swan Coastal Plain' TEC within the Survey Area**

| Patch No. | Area (ha) of each Vegetation Condition Rating within Patch | | | | Total Area (ha) |
|---|---|---|---|---|---|
| | Excellent | Very Good | Good | Degraded | |
| 1 | 0 | 1.39 | 0 | 0 | 1.39 |
| 2 | 7.41 | 6.09 | 0.18 | 0.12 | 13.80 |
| 3 | 0.17 | 0.68 | 0.87 | 0.43 | 2.15 |
| 4 | 1.46 | 0 | 0.15 | 0 | 1.61 |
| 5 | 4.34 | 0 | 0 | 0 | 4.34 |
| 6 | 1.10 | 0.07 | 0.02 | 0 | 1.18 |
| 7 | 3.15 | 0.31 | 0 | 0 | 3.46 |
| **Total** | **17.62** | **8.54** | **1.22** | **0.54** | **27.93** |

As outlined in Table 24, the 'Banksia Woodlands of the Swan Coastal Plain' TEC is already known to occur within the Survey Area based on records from DBCA's TEC and PEC database (DBCA 2019a). However, the records provided by the search are polygons that were determined by overlaying broad-scale vegetation over remnant vegetation polygons. Ground-truthing has not been undertaken to confirm occurrences in this dataset in most cases, and they are therefore considered to be indicative only, with on-ground assessment required to determine the actual extent of the TEC (if it is present at all). Therefore, the TEC as presented Appendix AB is considered to represent a more accurate extent than the occurrences contained in DBCA's TEC and PEC database. Consequently, no attempt has been made to correlate the extent of the TEC as defined above and presented in Appendix AB with these occurrences.

**SCP20a - *Banksia attenuata* woodland over species rich dense shrublands**

SCP20a - *Banksia attenuata* woodland over species rich dense shrublands was mapped at 10 occurrences within the Survey Area (Appendix AB (Sheets 1-3)) with statistical analysis with the original and amended SCP dataset broadly supporting this determination. This community is described as *Banksia attenuata* woodlands over species rich dense shrublands occurring on sands at the base of the Darling Scarp between Chittering and Gosnells (DBCA 2016b). The habitat critical to the survival of the community is the area of occupancy of known occurrences, the sandy soils on which the community occurs, the fresh superficial

groundwater that probably helps to sustain key dominant trees in the community, and the catchment for this groundwater (DBCA 2016b). The Interim Recovery Plan (DBCA 2016b) does not provide limitations for occurrences in terms of minimum patch size or condition for the community, therefore all occurrences mapped within the Survey Area are considered to be the TEC.

**Potential SCP 3a (*Corymbia calophylla – Kingia australis* woodlands on heavy soils, Swan Coastal Plain) and Potential SCP 20c (Shrublands and woodlands of the eastern side of the Swan Coastal Plain) - Study Area VT 2**

Study Area VT 2 was mapped at two locations across a total of 10 polygons (Appendix AB (Sheets 1-2) (northern location) and Appendix AB (Sheet2) (southern location)) and was noted during the analysis to have affinities to SCP FCTs 3a and 20c. However, analyses undertaken with the SCP dataset were inconclusive and indicated that there is not enough data to confidently align VT 2 with a SCP FCT (Table 21). In the absence of additional data, VT2 is being treated as potentially significant, and potentially represents SCP FCT 3a and/or SCP FCT 20c.

One quadrat (GSI-39) showing affinities to SCP 20c (Table 22) was established in the northern location of VT 2 (Appendix AB Sheets 1-2), with one potential occurrence mapped in this area. The vegetation in this location was mapped as being in Excellent condition.

TEC SCP 20c ('The Shrublands and Woodlands of the eastern Swan Coastal Plain ecological community') is described as being 'a woodland mainly on the transitional soils of the Ridge Hill Shelf, on the Swan Coastal Plain adjacent to the Darling Scarp, and extends onto the alluvial clays deposited on the eastern fringe of the Swan Coastal Plain, and also into adjacent aeolian deposits. The community mainly occurs as a shrubland, or a woodland of *Banksia attenuata* and *Banksia menziesii*, or *Corymbia calophylla*, sometimes with *Allocasuarina fraseriana*, over a shrub layer that can include *Adenanthos cygnorum*, *Hibbertia huegelii*, *Scaevola repens* var. *repens*, *Allocasuarina humilis*, *Bossiaea eriocarpa*, *Hibbertia hypericoides* and *Stirlingia latifolia*. A suite of herbs including *Conostylis aurea*, *Trachymene pilosa*, *Lomandra hermaphrodita*, *Burchardia umbellata* and *Patersonia occidentalis*, and the sedges *Mesomelaena pseudostygia*, *Mesomelaena tetragona*, and *Lyginia barbata* often occur in the community' (DAWE 2017).

TEC SCP 20c is known from relatively few locations, with two formally recognised occurrences (Talbot Road bushland in Stratton; Bushmead Rifle Range in Helena Valley) known, totalling 130 ha (DAWE 2017). TEC SCP 20c is listed as Critically Endangered under the BC Act and Endangered under the EPBC Act.

One quadrat (GSI-04) showing affinities to SCP 3a (Table 22) was established in the southern location of VT 2 (Appendix AB6-7), with one potential occurrence of the TEC mapped in this area. This location is in an area identified as within the buffer polygons of several significant vegetation types, including EPBC TEC 'Banksia woodlands of the Swan Coastal Plain', TEC SCP 20a, TEC SCP 20c, TEC SCP 3a and TEC SCP 3b (Section 5.1.1.4).

TEC SCP 3a (*Corymbia calophylla – Kingia australis* woodlands on heavy soils, Swan Coastal Plain) is described as 'a woodland community located on heavy soils of the eastern side of

the Swan Coastal Plain between Ruabon and Guildford'; it was listed due to its limited distribution and extent, with the remaining patches being highly fragmented (DAWE 2017b). Currently 41 occurrences with a total area of 192.5ha are known (DAWE 2017b). This TEC is listed as Critically Endangered under the BC Act and Endangered under the EPBC Act.

**Potential SCP 3a (*Corymbia calophylla – Kingia australis* woodlands on heavy soils, Swan Coastal Plain) and Potential SCP3c (*Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain) - Study Area VT 3**

Study Area VT 3 was also mapped at two locations, representing four occurrences across a total of 14 polygons (Appendix AB (Sheets 1-2) (northern location; one occurrence) and Appendix AB5-7 (southern location; three occurrences)); it was noted during the analysis that VT 3 has affinities to SCP FCTs 3a and 3c. Analyses undertaken with the SCP dataset were inconclusive and indicated that there is insufficient data to confidently align VT 3 with a SCP FCT (Table 21). In the absence of additional data, VT3 is being treated as potentially significant, representing SCP FCT 3a and/or SCP FCT 3c.

One quadrat (GSI-35) showing affinities to SCP 3a (Table 22) was established in the northern location of VT 3 (Appendix AB Sheets 1-2), with one potential occurrence mapped in this area. Other than being located in an area where the EPBC TEC 'Banksia woodlands of the Swan Coastal Plain' is noted as being likely to occur (Section 5.1.1.4), this location is not within the buffer polygon of any other known TEC or PEC. One occurrence of this community was mapped in this area, with the vegetation mapped as being in Very Good to Good condition. A description of the vegetation and known extent of TEC SCP 3a (*Corymbia calophylla – Kingia australis* woodlands on heavy soils, Swan Coastal Plain) is provided above.

One quadrat (GSI-08) showing affinities to SCP 3c was established in the southern location of VT 3 (Appendix AB (Sheet 2); three potential occurrences of this TEC community in proximity to one another were mapped in this area. This location is in an area identified as within the buffer polygons of several significant vegetation types, including EPBC TEC 'Banksia woodlands of the Swan Coastal Plain', TEC SCP 20a, TEC SCP 20c, TEC SCP 3a and TEC SCP 3b (Section 5.1.1.4). The condition of the vegetation ranged from Excellent to Degraded.

The TEC SCP 3c (*Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain) is described as being located on 'heavy soils of the eastern side of the Swan Coastal Plain between Bullsbrook, and Capel', with dominant species in the community being '*Corymbia calophylla* (marri), and occasionally *Eucalyptus wandoo* (wandoo); the shrubs *Xanthorrhoea preissii*, *Acacia pulchella*, *Banksia dallanneyi*, *Gompholobium marginatum*, and *Hypocalymma angustifolium* and the herbs *Burchardia congesta*, *Cyathochaeta avenacea* and *Neurachne alopecuroidea*.' A total of 29 occurrences of this community are known with a total area of approximately 115 ha (DAWE 2017c).

### 5.1.3.6 Vegetation Condition

The majority of the Assessed Area was mapped as being either Cleared, Highly Modified or Revegetated (98.9 ha; 55.61 % of the Assessed Area); with the remainder being mapped as VTs (78.97 ha; 44.38 %). There has been significant evidence of impact to vegetation

composition and structure as a result of human activities, including clearing and very high levels of introduced (weed) taxa.

Areas in the Assessed Area that were mapped as 'Cleared' were given the vegetation condition rating of 'Cleared' and made up 42.93 % (76.38 ha) of the Assessed Area. Areas mapped as 'Highly Modified' and 'Revegetated Areas' were also mapped as Completely Degraded and made up 12.68 % (22.6 ha) of the Assessed Area.

Table 26 presents the area (ha) of each VT and corresponding condition rating mapped in the Assessed Area. The condition of the majority of the area mapped as VTs was in either Excellent or Very Good, condition, with limited area in Good, Degraded or Completely Degraded. No vegetation was mapped as being Pristine.

Detailed vegetation condition mapping presented in Appendix P.

**Table 26: Vegetation Condition Ratings for each Vegetation Type Mapped within the Survey Area**

| VT | Completely Degraded | Degraded | Good | Very Good | Excellent | Pristine | Total (ha) |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 1.16 | 1.65 | 8.54 | 17.63 | 0 | 28.97 |
| 2 | 0 | 0 | 0.07 | 0.12 | 6.39 | 0 | 6.58 |
| 3 | 0 | 0.48 | 1.36 | 6.01 | 0.47 | 0 | 8.32 |
| 4 | 0 | 1.62 | 0.61 | 0.34 | 11.14 | 0 | 13.70 |
| 5 | 0 | 0 | 0.53 | 0.36 | 7.24 | 0 | 8.13 |
| 6 | 0 | 0 | 0 | 2.09 | 0 | 0 | 2.09 |
| 7 | 0 | 0 | 0 | 0.35 | 2.85 | 0 | 3.20 |
| 8 | 0.34 | 7.65 | 0 | 0 | 0 | 0 | 7.99 |
| **Total** | **0.34** | **10.90** | **4.22** | **17.81** | **45.71** | **0.00** | **78.97** |

#### 5.1.3.7 Riparian Vegetation, Wetlands and Groundwater Dependent Vegetation

As noted in Section 2.3 and Figure 4, approximately half of the Development Envelope and surrounding lands is categorised within the geomorphic wetlands dataset as Palusplain; such areas are subject to seasonal waterlogging. This includes most of the areas mapped as VTs, as well as areas mapped as Cleared Lands, Highly Modified Types and Revegetated lands. No seasonal or permanent bodies of water were noted during the survey.

With regard to VTs mapped in the Survey Area, the majority of areas of VTs mapped on Appendix V (Sheets 1-2) (including all VTs 1, 2, 3, 4, 5, 6, 7, 8) can be considered to occur on palusplains. Seasonal waterlogging is likely to be longer for periods specifically mapped as VTs 5, 6, 7 and 8, and only for a limited period of time in areas mapped as VTs 1, 2, 3 and 4. VTs 5, 6, 7 and 8 all contain flora taxa which are usually found in wetter sites, including *Pericalymma ellipticum* var. *floridum*, *Hypocalymma angustifolium* subsp. Swan Coastal Plain (G.J. Keighery 16777), *Melaleuca viminea* subsp. *viminea*, *Melaleuca preissiana*, *Eucalyptus rudis* and *Melaleuca rhaphiophylla*.

Vegetation type 6, and some areas of VT 8, were noted to have been associated with drainage lines, with VT 6 mapped at least partially on drainage lines. VT 6 is presented on Appendix V (Sheet 1), south of Woodlupine Brook. Soils and vegetation patterning evident

on aerial photography indicates that, prior to the clearing of the vegetation surrounding Hartfield Park, this area may have been a brook. However it is not apparent that this area forms part of a currently recognisable drainage feature. This area is currently identified as 'Conservation' palusplain within the geomorphic wetlands dataset (Figure 4). VT 8 was mapped in small areas associated with palusplain and includes remnant riparian vegetation on Woodlupine Brook (Appendix V (Sheet 1), Yule Brook (Appendix V (Sheet 2) and Bickley Brook (Appendix V (Sheet 3)). The vegetation associated with all of these three drainage lines was mapped as either Degraded or Completely Degraded (Appendix P (Sheets 1-3)), however where vegetation is present it does represent riparian vegetation.

It is possible that all of the aforementioned VTs may have some dependence on groundwater, depending upon the depth to groundwater. In particular VT 1 (representing TEC SCP20a and TEC 'Banksia woodlands of the Swan Coastal Plain') may be considered locally groundwater dependent (DBCA 2016b). Banksia communities are known to be at least partially groundwater dependent if groundwater sources decline to exceed potential root reach or growth rate, or physiological tolerance (Sommer and Froend 2011).

## 5.2 Fauna

### 5.2.1 Fauna Habitats

Seven key vegetation and substrate associations (VSAs; habitat types for fauna) were recorded during the site visit and subsequently mapped within the Assessed Area. These were:

- VSA 1: Marri and mixed Woodland. Woodland of Marri *Corymbia calophylla*, *Eucalyptus* sp., *Agonis flexuosa* and/or *Allocasuarina* sp. over acacia and other shrubs over grassy weeds on sand to sandy loam flats (Plate 24; 25).
- VSA 2: Eucalypt Woodland. Woodland of *Eucalyptus* spp. and sometimes *Allocasuarina* sp. over acacia and other shrubs over grassy weeds on sand to sandy loam flats (Plate 26).
- VSA 3: Low Forest to tall Shrublands. Mixed small tree and/or tall shrubs over low shrubs on low-lying and seasonally damp flats of sands to clayey loams (Plate 27; 28).
- VSA 4: Parkland cleared. Mixed native and exotic trees over introduced grasses on various soil types (Plate 31).
- VSA 5: Woodland and Shrubland dominated by introduced species (Plate 29).
- VSA 6: Drainage lines and seasonally damp clay flats dominated by weeds (Plate 31).
- VSA 7: Cleared land. Grassland of introduced grasses and occasional shrubs (Plate 30).

Table 27 presents a description of the characteristics of these VSAs, as well as the total area mapped. Example photographs of the VSAs are shown in Plates 24 to 31 below. VSAs are mapped for the development envelope in Figure 12 (northern envelope) and Figure 13 (southern envelope).

**Table 27: Total area of each Vegetation Substrate Association in the Assessment Area**

| VSA | Canopy/Overstorey | Midstorey | Understorey | Substrate | Other characteristics | Total Area (ha) | Percentage of Assessed Area (%) |
|---|---|---|---|---|---|---|---|
| VSA1: Marri and mixed Woodland. Woodland of Marri *Corymbia calophylla*, *Eucalyptus* sp., *Agonis flexuosa* and/or *Allocasuarina* sp. over acacia and other shrubs over grassy weeds on sand to sandy loam flats. | Intact or substantially intact. Retains all or most native species. | Intact or substantially intact. Retains all or most native species. | Variable levels of disturbance/function. | Predominantly sands or sandy-loams. | High proportion of potential hollow-bearing trees species. | 40.20 | 22.60 |
| VSA2: Eucalypt woodland. Woodland of *Eucalyptus* spp. and sometimes *Allocasuarina* sp. over acacia and other shrubs over grassy weeds on sand to sandy loam flats. | Intact or substantially intact. Retains all or most native species. | Intact or substantially intact. Retains all or most native species. | Variable levels of disturbance/function. Considerable incursion of introduced species. | Predominantly sands or sandy-loams. | Moderate proportion of potential hollow-bearing tree species. | 31.99 | 17.98 |
| VSA3: Low Forest to tall Shrublands. Mixed small tree and/or tall shrubs over low shrubs on low-lying and seasonally damp flats of sands to clayey loams. | Intact or substantially intact. Retains all or most native species. | Intact or substantially intact. Retains all or most native species. | Intact or substantially intact. Retains all or most native species. | Sands with some clay component. | Low proportion of potential hollow-bearing tree species. | 20.57 | 11.56 |
| VSA4: Parkland cleared. Mixed native and exotic trees over introduced grasses on various soil types. . | Intact or partially intact. Retains all or most native species. | Effectively (functionally) cleared or removed. | Effectively (functionally) cleared or removed. Where present, replaced with introduced species. | Variable. | High proportion of potential hollow-bearing trees species. | 7.81 | 4.39 |
| VSA5: Woodland and shrubland dominated by introduced species. | Intact or substantially intact. Retains all or most native species. | Replaced with introduced species. | Replaced with introduced species. | Predominantly sands or sandy-loams. | High proportion of potential hollow-bearing trees species. | 0.79 | 0.45 |

| VSA | Canopy/Overstorey | Midstorey | Understorey | Substrate | Other characteristics | Total Area (ha) | Percentage of Assessed Area (%) |
|---|---|---|---|---|---|---|---|
| VSA6: Drainage lines and seasonally damp clay flats dominated by weeds. | Substantially intact. Retains most native species but some incursion of introduced species. | Variable levels of disturbance/function. Considerable incursion of introduced species. | Variable levels of disturbance/function. Considerable incursion of introduced species. | Variable; often with clay component. | Moderate proportion of potential hollow-bearing tree species. Surface water present at least ephemerally. | 0.17 | 0.09 |
| VSA7: Cleared land. | Effectively (functionally) cleared or removed. | Effectively (functionally) cleared or removed. | Replaced with introduced species. | Variable | | 76.38 | 42.93 |
| **TOTAL** | | | | | | 177.9 | 100% |

**Plate 24: VSA 1: Marri and mixed Woodland**

**Plate 25: VSA 1: Marri and mixed Woodland with a high proportion of *Allocasuarina* sp.**

**Plate 26: VSA 2: Eucalypt Woodland**

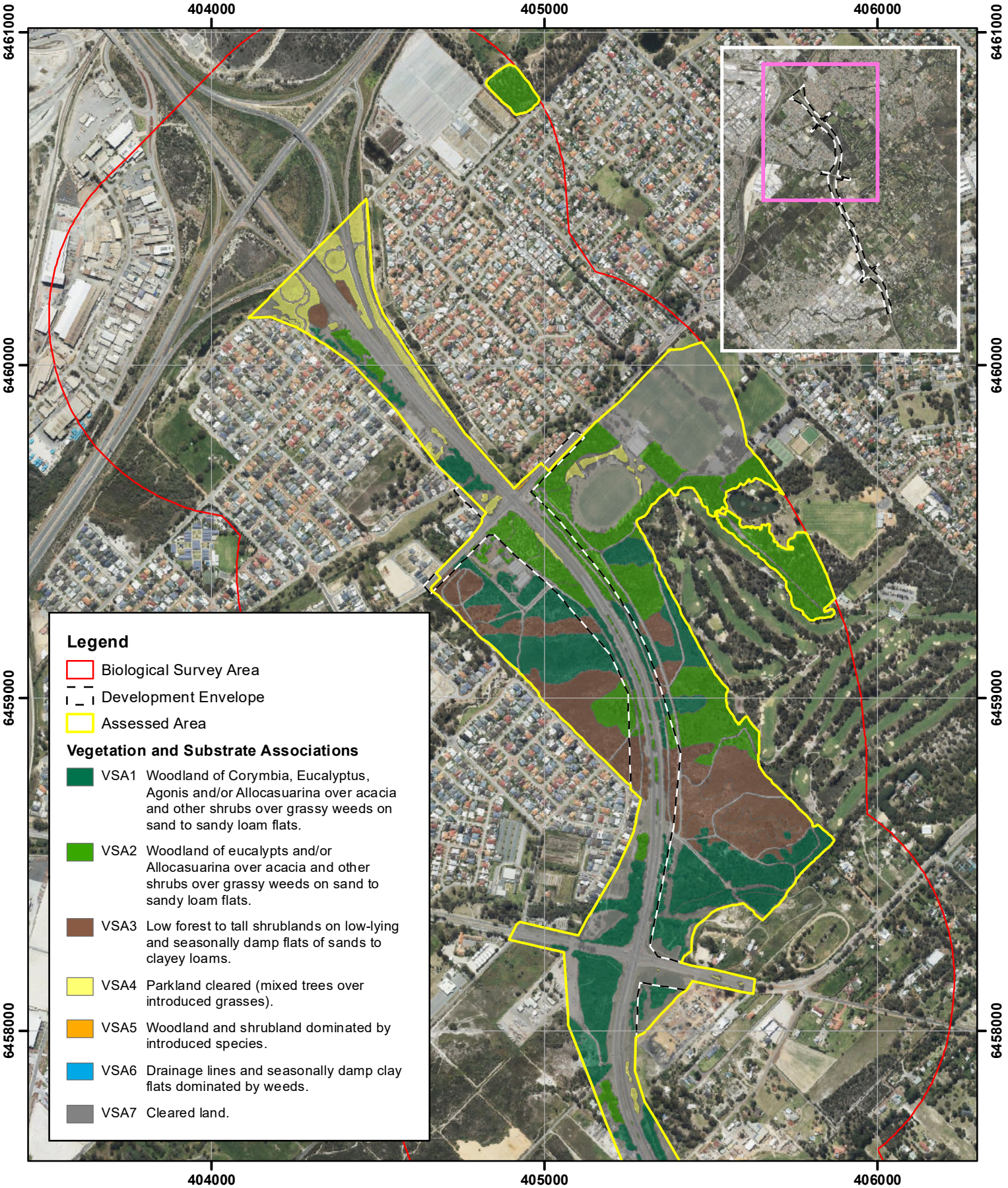
**Plate 27: VSA 3: Low Forest to tall Shrubland**

**Plate 28: VSA 3: Low Forest to tall Shrubland with Marri and mixed Woodland in background**

**Plate 29: VSA 5: Woodland of introduced species; in this case a grove of pine trees over grass.**

**Plate 30: VSA 7: Cleared land**

**Plate 31: VSA 4 Parkland cleared over VSA 6 Drainage lines**




**Vegetation and substrate associations (northern Development Envelope)**

Author: Cathy Godden

WEC Ref: MR19-34-01

Filename: MR19-34-01-f12-13

Scale: 1:15,000

Projection: GDA 1994 MGA Zone 50

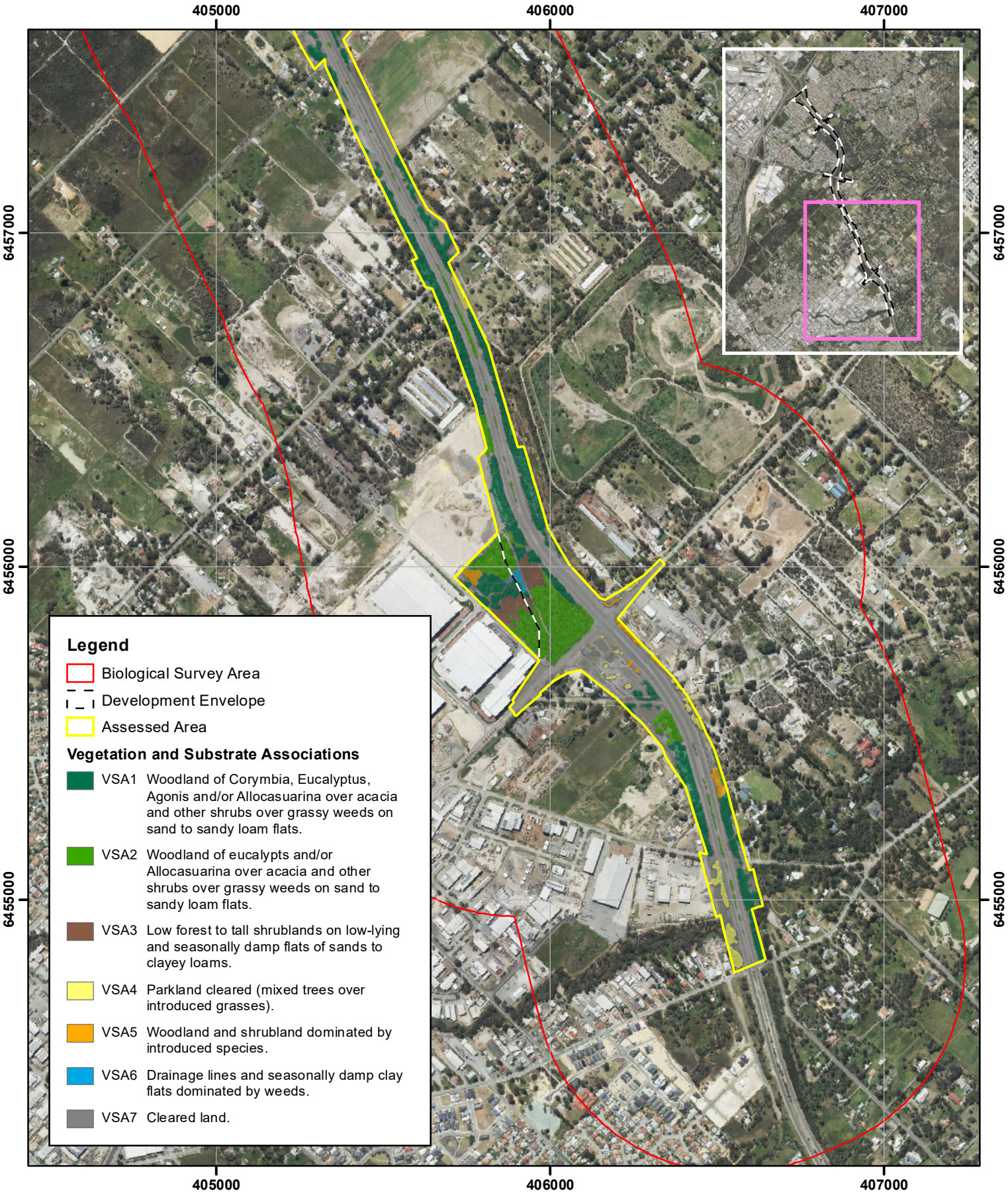
Revision: 1 - 17 February 2021

**Figure 12**

WOODMAN ENVIRONMENTAL

BAMFORD CONSULTING ECOLOGISTS

This map should only be used in conjunction with WEC report MR19-34-01.




**Vegetation and substrate associations (southern Development Envelope)**

Author: Cathy Godden

WEC Ref: MR19-34-01

Filename: MR19-34-01-f12-13

Scale: 1:15,000

Projection: GDA 1994 MGA Zone 50

Revision: 1 - 17 February 2021

**Figure 13**

WOODMAN ENVIRONMENTAL

BAMFORD CONSULTING ECOLOGISTS

This map should only be used in conjunction with WEC report MR19-34-01.

### 5.2.2 Faunal Assemblage

The desktop study identified 233 vertebrate fauna species as potentially occurring in the Survey Area, and therefore also potentially in the Development Envelope (summarised in Table 28 and listed in Appendix AC): four fish (including 1 introduced species); 11 frogs, 40 reptiles, 158 birds (including 8 introduced species) and 20 mammals (including 5 introduced species), as described further below. The assemblage includes 67 species of conservation significance (see Table 29 and discussed in Section 5.2.3). Note that this assemblage comes from databases and includes species that may occur occasionally in the Survey Area/Development Envelope, but for which it is not important (such as birds that rarely fly overhead). Many species may also occur as vagrants at the site. Some species occur in the region but have specific habitat requirements that are not present in the Survey Area. Eight species (two reptiles, one bird and five mammals) are considered to be locally extinct in the Survey Area (see Appendix AD). Species returned from databases that are unlikely to occur due to habitat requirements have been removed from the expected species list and are displayed separately in Appendix AE.

A total of 72 native vertebrate species were confirmed present during the six and a half days of survey in September, October and November 2019, including two frogs, eight reptiles, 59 birds and three mammals. A further six introduced birds and five introduced mammals or their signs were also recorded. This number is relatively rich for a Level 1 survey, but is reflective of the time spent conducting the Level 1 and targeted Black-Cockatoo survey. All records taken of fauna within the site are provided in Appendix AF and are also included in the fauna list in Appendix AD.

**Fish.** Up to four fish species may be present in the Survey Area and all are considered to be regular visitors given the uncertain permanency of damplands and watercourses in the area (all species require permanent water to persist). Should there be permanent water bodies within the Survey Area then some of the fish may be resident. The drainage systems that flow through the Survey Area, including Woodlupine Brook, Yule Brook and Bickley Brook, are likely to provide connectivity between permanent water bodies up and downstream of the Survey Area and are therefore important to provide dispersal opportunities in the wider area for these species; however, as no permanent water bodies are present in the Development Envelope it is unlikely that any of these taxa persist year-round in the Development Envelope, and no fish species were recorded during the survey. None of the expected fish species are conservation significant.

**Frogs.** Up to 11 frog species may be present in the Survey Area (and the Development Envelope) and all are considered resident, although adults may leave the survey area to breed in other areas. Two frog species were confirmed present through calls heard during survey. Most of the frog species are locally common and are regionally widespread. With the exception of *Myobatrachus gouldii* (Turtle Frog) which breeds independently of surface standing water, all other frogs in the area breed in association with wetlands, lakes and ponds where some such as *Heleioporus eyreii* (Moaning Frog) require natural hydrological cycles before neonates can develop and emerge. All the frog species rely on seasonal freshwater for breeding and are therefore sensitive to changes in hydrology and water

quality. Two frogs of conservation significance are expected to occur, and these are locally significant (CS3) as they tend to do poorly in urban environments.

**Reptiles.** Up to 40 reptile species (seven confirmed present) can be expected in the Survey Area (and the Development Envelope), but distributions can be patchy and therefore not all 40 species may be present in the development envelope. Those that are will most likely be resident (Table 28). The mosaic of VSAs is likely to support a diverse range of reptiles, but it is noted that many of these are unlikely to occur in the disturbed and degraded areas. The areas of native vegetation in the few reserves abutting the development envelope are likely to contain majority of the species expected in the area. Many species have specific habitat preferences and there are those that are well adapted to certain VSAs. For example, the loose-sandy substrate of VSA 1 is likely to support a range of fossorial species such as the sand swimmers *Lerista* spp. Two species of reptile are considered conservation significant and these are described in Section 5.2.3 below.

**Birds.** Up to 158 bird species may be present within the Survey Area, 65 of which were confirmed, visually or aurally. Within the Survey Area (including the Development Envelope) up to 49 are expected to be resident, 42 regular visitors, 26 irregular visitors and 41 vagrants (Table 28). This relatively high diversity is due to the area containing a wide range of environments including the urban, parkland, and minor waterways. Close proximity to the Darling Range to the east also influences the number of species potentially present. The bird assemblage includes a suite of up to 47 conservation significant species discussed in Section 5.2.3.

**Mammals.** The mammal assemblage is likely to be depauperate with several locally extinct species including the Woylie, Brush Wallaby, Honey Possum and Quokka (Appendix AD). Fifteen native mammals and five introduced mammal species may occur in the Survey Area and therefore also the Development Envelope, of which the Black Rat, House Mouse, Cat and Red Fox are known to impact on the diversity and abundance of native wildlife. The reduced diversity is typical of urban environments in the Perth region with a long history of development. Visual confirmation or signs (tracks, scats, burrows) of three native and five introduced mammals were acquired in the Survey Area, including an encounter with a mob of Western Grey Kangaroos within 20 m of the highway verge just north west of Kelvin Road. Quenda diggings were present throughout but more common adjacent the larger stands of native vegetation. Echidna tracks and diggings were found in the bush to the south of Hartfield Oval and the reserve that lies between Maamba Road and Tonkin Highway. These areas also had signs of Quenda. Signs of rat, cat and domestic dog were present throughout including the skull of a cat in the reserve that lies between Maamba Road and Tonkin Highway. Seven mammals of conservation significance are likely to occur in the Survey Area and therefore also the Development Envelope, and are discussed in Section 5.2.3.

The key features of the fauna assemblage expected in the Survey Area are:

- Uniqueness: The assemblage is likely to be reflective of the Perth Metropolitan region but with a few additional species due to the proximity with the Darling Scarp. Most species that are expected to occur in the Survey Area and Development Envelope are

widespread in the area, with a few species, such as the Lined Lerista, having restricted distributions.

- Completeness: The vertebrate fauna assemblage is expected to be incomplete for the eastern side of the Swan Coastal Plain. This is due to the impacts from development, reduced habitat availability and the presence of a number of introduced pest species, including Rainbow Lorikeets, foxes, rats, cats and domestic dogs. Due to the generally degraded and reduced diversity of the vegetation along the highway verge, the expected fauna will be reduced further within the development area whilst the fauna within the Survey Area will be markedly higher due to the wider variety of environments and better condition of the vegetation in reserves and other large stands.

**Table 28: Composition of the Vertebrate Fauna Assemblage Expected in the Survey Area**

| Taxon | Number of species | Number of species in each status category | | | | |
|---|---|---|---|---|---|---|
| | | Resident | Migrant or regular visitor | Irregular visitor | Vagrant | Locally extinct |
| Fish | 4 | - | 4 | - | - | - |
| Frogs | 11 | 11 | - | - | - | - |
| Reptiles | 40 | 33 | - | 7 | - | 2 |
| Birds | 158 | 49 | 42 | 26 | 41 | 3 |
| Mammals | 20 | 9 | 9 | - | 2 | 4 |
| **Total** | **233** | **102** | **55** | **33** | **43** | **9** |

### 5.2.3 Fauna of Conservation Significance

Sixty seven species of conservation significance may occur in the Survey Area, of which 31 are likely to be residents or regular visitors/migrants to the site (Table 30 and Appendix AD). A summary of the numbers in each vertebrate class (and also all invertebrates) is presented in Table 29. These species of conservation significance are indicated in the complete species list (Appendix AD) but are also listed in Table 30.

A map of the results of the DBCA threated fauna search (data provided by Main Roads) is presented in Appendix AC.

A full explanation of the three levels of conservation significance used is provided in Appendix D but, in summary, species classed as CS1 are those listed under legislation (EPBC Act and BC Act), while those classed as CS2 are listed as Priority by the DBCA, but not listed under legislation. The CS3 class is more subjective but includes locally significant species that have declined extensively in an area due to natural or human-induced impacts, and species that occur at the edge of their range. This makes their presence in the Survey Area and Development Envelope significant as populations on the edge of a species' range are often less abundant and more vulnerable to extinction than populations at the centre of the range (Curnutt *et al.* 1996).

**Table 29: Composition of Extant Conservation Significant Vertebrate Fauna within the Survey Area**

See Appendix D for full explanation of Conservation Significance (CS) levels: CS1 = listed under WA State and/or Commonwealth legislation; CS2 = listed as Priority by DBCA; CS3 = considered locally significant.

| Taxon | Conservation Significant Fauna | | | Total |
|---|---|---|---|---|
| | CS1 | CS2 | CS3 | |
| Invertebrates | 2 | 9 | - | 11 |
| Fish | - | - | - | 0 |
| Frogs | - | - | 2 | 2 |
| Reptiles | - | 2 | - | 2 |
| Birds | 11 | 1 | 35 | 47 |
| Mammals | 1 | 2 | 2 | 5 |
| **Total** | **14** | **14** | **39** | **67** |

## Table 30: Conservation Significant Fauna Species Expected to Occur within both the Survey Area and Development Envelope

Species are listed in taxonomic order.
CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix D for full explanation.
EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory (see Appendix D).
WA Biodiversity Conservation Act 2016 listings: S1 to S7 = Schedules 1 to 7 (see Appendix D).
DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix D).
LS = considered by BCE to be of local significance (see Appendix D).
HS = habitat specialists with reduced populations on the Swan Coastal Plain by (DEP 2000).
WR = wide-ranging species with reduced populations on the Swan Coastal Plain (DEP 2000).

| | | | | Marri and mixed Woodland. | Eucalypt Woodland. | Low Forest to tall Shrublands. | Parkland cleared. | Woodland and Shrubland dominated by introduced species. | Drainage lines. | Cleared land. |
|---|---|---|---|---|---|---|---|---|---|---|
| **SPECIES** | **COMMON NAME** | **STATUS** | **EXPECTED OCCURRENCE** | **VSA 1** | **VSA 2** | **VSA 3** | **VSA 4** | **VSA 5** | **VSA 6** | **VSA 7** |
| *Westralunio carteri* | Carter's Freshwater Mussel | CS1 (V, S3) | Uncertain | | | | | | + | |
| *Idiosoma sigillatum* | Swan Coastal Plain Trapdoor Spider | CS2 (P3) | Uncertain | + | + | + | | | | |
| *Austroconops mcmillani* | McMillan's Biting Midge (Swan Coastal Plain) | CS2 (P2) | Uncertain | ? | ? | ? | ? | ? | ? | ? |
| *Australotomurus morbidus* | Cemetery Springtail | CS2 (P3) | Uncertain | + | + | + | ? | ? | ? | ? |
| *Austrosaga spinifer* | Spiny Katydid (Swan Coastal Plain) | CS2 (P2) | Uncertain | + | + | + | | | | |
| *Kawaniphila pachomai* | Grey Vernal Katydid (Southwest) | CS2 (P1) | Uncertain | + | + | + | | | | |

| | | | | Marri and mixed Woodland. | Eucalypt Woodland. | Low Forest to tall Shrublands. | Parkland cleared. | Woodland and Shrubland dominated by introduced species. | Drainage lines. | Cleared land. |
|---|---|---|---|---|---|---|---|---|---|---|
| **SPECIES** | **COMMON NAME** | **STATUS** | **EXPECTED OCCURRENCE** | **VSA 1** | **VSA 2** | **VSA 3** | **VSA 4** | **VSA 5** | **VSA 6** | **VSA 7** |
| *Throscodectes xiphos* | Stylet Bush Cricket, Stylet Throsco (Jandakot) | CS2 (P1) | Uncertain | + | + | + | | | | |
| *Synemon gratiosa* | Graceful Sunmoth | CS2 (P4) | Uncertain | + | + | + | | | | |
| *Glossurocolletes bilobatus* | a short-tongue bee | CS2 (P2) | Uncertain | ? | ? | ? | ? | ? | ? | ? |
| *Hylaeus globuliferus* | Woollybush Bee | CS2 (P3) | Uncertain | + | + | + | | | | |
| *Leioproctus douglasiellus* | a short-tongued bee | CS1 (CE, S2) | Uncertain | ? | ? | ? | ? | ? | ? | ? |
| *Crinia georgiana* | Quacking Frog | CS3 (LS) | Resident | | | + | | | + | |
| *Myobatrachus gouldii* | Turtle Frog | CS3 (LS) | Resident | + | + | + | | | | |
| *Lerista lineata* | Perth Lined Lerista | CS2 (P3) | Resident | + | + | | | | | |
| *Neelaps calonotos* | Black-striped Snake | CS2 (P3) | Irregular Visitor | + | + | | | | | |
| *Phaps chalcoptera* | Common Bronzewing | CS3 (HS) | Resident | + | + | + | + | + | + | + |
| *Phaps elegans* | Brush Bronzewing | CS3 (HS) | Irregular Visitor | + | + | + | + | + | + | + |
| *Apus pacificus* | Fork-tailed Swift | CS1 (M, S5) | Irregular Visitor | + | + | + | + | + | + | + |
| *Plegadis falcinellus* | Glossy Ibis | CS1 (M, S5) | Irregular Visitor | | | | + | | + | + |

| | | | | Marri and mixed Woodland. | Eucalypt Woodland. | Low Forest to tall Shrublands. | Parkland cleared. | Woodland and Shrubland dominated by introduced species. | Drainage lines. | Cleared land. |
|---|---|---|---|---|---|---|---|---|---|---|
| **SPECIES** | **COMMON NAME** | **STATUS** | **EXPECTED OCCURRENCE** | **VSA 1** | **VSA 2** | **VSA 3** | **VSA 4** | **VSA 5** | **VSA 6** | **VSA 7** |
| *Ardea modesta* | Eastern Great Egret | CS1 (M, S5) | Irregular Visitor | | | | | | + | |
| *Lophoictinia isura* | Square-tailed Kite | CS3 (WR) | Irregular Visitor | + | + | + | + | + | + | + |
| *Haliastur sphenurus* | Whistling Kite | CS3 (WR) | Regular Visitor | + | + | + | + | + | + | + |
| *Accipiter fasciatus* | Brown Goshawk | CS3 (WR) | Resident | + | + | + | + | + | + | + |
| *Accipiter cirrocephalus* | Collared Sparrowhawk | CS3 (WR) | Resident | + | + | + | + | + | + | + |
| *Aquila audax* | Wedge-tailed Eagle | CS3 (WR) | Regular Visitor | + | + | + | + | + | + | + |
| *Hieraaetus morphnoides* | Little Eagle | CS3 (WR) | Regular Visitor | + | + | + | + | + | + | + |
| *Falco berigora* | Brown Falcon | CS3 (WR) | Vagrant | + | + | + | + | + | + | + |
| *Falco peregrinus* | Peregrine Falcon | CS1 (S7) | Regular Visitor | + | + | + | + | + | + | + |
| *Turnix varius* | Painted Button-quail | CS3 (WR) | Irregular Visitor | + | + | + | | + | + | |
| *Tringa glareola* | Wood Sandpiper | CS1 (M, S5) | Vagrant | | | | | | + | |
| *Tringa nebularia* | Common Greenshank | CS1 (M, S5) | Vagrant | | | | | | + | |

| | | | | Marri and mixed Woodland. | Eucalypt Woodland. | Low Forest to tall Shrublands. | Parkland cleared. | Woodland and Shrubland dominated by introduced species. | Drainage lines. | Cleared land. |
|---|---|---|---|---|---|---|---|---|---|---|
| **SPECIES** | **COMMON NAME** | **STATUS** | **EXPECTED OCCURRENCE** | **VSA 1** | **VSA 2** | **VSA 3** | **VSA 4** | **VSA 5** | **VSA 6** | **VSA 7** |
| *Tringa stagnatilis* | Marsh Sandpiper | CS1 (M, S5) | Vagrant | | | | | | + | |
| *Calidris acuminata* | Sharp-tailed Sandpiper | CS1 (M, S5) | Vagrant | | | | | | + | |
| *Calyptorhynchus banksii naso* | Forest Red-tailed Black-Cockatoo | CS1 (V, S3) | Resident | + | + | + | + | + | + | |
| *Calyptorhynchus latirostris* | Carnaby's Black-Cockatoo | CS1 (E, S2) | Regular Visitor | + | + | + | + | + | + | |
| *Calyptorhynchus baudinii* | Baudin's Black-Cockatoo | CS1 (E, S2) | Regular Visitor | + | + | + | + | + | + | |
| *Platycercus icterotis* | Western Rosella | CS3 (WR) | Vagrant | + | + | + | + | + | + | |
| *Ninox connivens connivens* | Barking Owl | CS2 (P2) | Vagrant | + | + | + | + | + | + | |
| *Malurus splendens* | Splendid Fairy-wren | CS3 (HS) | Resident | + | + | + | | + | + | |
| *Stipiturus malachurus* | Southern Emu-wren | CS3 (HS) | Vagrant | + | + | + | | + | + | |
| *Sericornis frontalis* | White-browed Scrubwren | CS3 (HS) | Resident | + | + | + | | + | + | |
| *Smicrornis brevirostris* | Weebill | CS3 (HS) | Resident | + | + | + | + | + | + | |
| *Acanthiza chrysorrhoa* | Yellow-rumped Thornbill | CS3 (HS) | Resident | + | + | + | + | + | + | + |
| *Acanthiza inornata* | Western Thornbill | CS3 (HS) | Resident | + | + | + | | | + | |

| | | | | Marri and mixed Woodland. | Eucalypt Woodland. | Low Forest to tall Shrublands. | Parkland cleared. | Woodland and Shrubland dominated by introduced species. | Drainage lines. | Cleared land. |
|---|---|---|---|---|---|---|---|---|---|---|
| **SPECIES** | **COMMON NAME** | **STATUS** | **EXPECTED OCCURRENCE** | **VSA 1** | **VSA 2** | **VSA 3** | **VSA 4** | **VSA 5** | **VSA 6** | **VSA 7** |
| *Acanthiza apicalis* | Inland Thornbill | CS3 (HS) | Regular Visitor | + | + | + | | + | + | |
| *Anthochaera lunulata* | Western Wattlebird | CS3 (WR) | Resident | + | + | + | + | + | + | |
| *Glyciphila melanops* | Tawny-crowned Honeyeater | CS3 (WR) | Regular Visitor | + | + | + | + | + | + | |
| *Melithreptus chloropsis* | Gilbert's Honeyeater | CS3 (WR) | Regular Visitor | + | + | + | + | + | + | |
| *Phylidonyris niger* | White-cheeked Honeyeater | CS3 (WR) | Resident | + | + | + | + | + | + | |
| *Phylidonyris novaehollandiae* | New Holland Honeyeater | CS3 (WR) | Resident | + | + | + | + | + | + | |
| *Daphoenositta chrysoptera* | Varied Sittella | CS3 (HS) | Irregular Visitor | + | + | + | + | + | + | |
| *Pachycephala occidentalis* | Western Whistler | CS3 (HS) | Regular Visitor | + | + | + | + | + | + | |
| *Colluricincla harmonica* | Grey Shrike-thrush | CS3 (HS) | Regular Visitor | + | + | + | | | + | |
| *Artamus cinereus* | Black-faced Woodswallow | CS3 (WR) | Regular Visitor | + | + | + | + | + | + | + |
| *Artamus cyanopterus* | Dusky Woodswallow | CS3 (WR) | Vagrant | + | + | + | + | + | + | |
| *Artamus personatus* | Masked Woodswallow | CS3 (WR) | Vagrant | + | + | + | + | + | + | + |
| *Strepera* | Grey Currawong | CS3 | Vagrant | + | + | + | + | + | + | + |

| | | | | Marri and mixed Woodland. | Eucalypt Woodland. | Low Forest to tall Shrublands. | Parkland cleared. | Woodland and Shrubland dominated by introduced species. | Drainage lines. | Cleared land. |
|---|---|---|---|---|---|---|---|---|---|---|
| **SPECIES** | **COMMON NAME** | **STATUS** | **EXPECTED OCCURRENCE** | **VSA 1** | **VSA 2** | **VSA 3** | **VSA 4** | **VSA 5** | **VSA 6** | **VSA 7** |
| *versicolor* | | (WR) | | | | | | | | |
| *Eopsaltria georgiana* | White-breasted Robin | CS3 (LS) | Vagrant | | | | | | + | |
| *Melanodryas cucullata* | Hooded Robin | CS3 (LS) | Vagrant | + | + | + | | + | + | |
| *Petroica boodang* | Scarlet Robin | CS3 (HS) | Irregular Visitor | + | + | + | | + | + | |
| *Petroica goodenovii* | Red-capped Robin | CS3 (HS) | Vagrant | + | + | + | | + | + | |
| *Microeca fascinans* | Jacky Winter | CS3 (HS) | Vagrant | + | + | + | | + | + | |
| *Tachyglossus aculeatus* | Short-beaked Echidna | CS3 (LS) | Resident | + | + | + | + | + | + | |
| *Dasyurus geoffroii* | Chuditch | CS1 (V, S3) | Vagrant | + | + | + | | + | + | |
| *Isoodon fusciventer* | Quenda, Southern Brown Bandicoot | CS2 (P4) | Resident | + | + | + | + | + | + | + |
| *Trichosurus vulpecula* | Common Brushtail Possum | CS3 (LS) | Regular Visitor | + | + | + | + | + | + | |
| *Hydromys chrysogaster* | Water-rat, Rakali | CS2 (P4) | Regular Visitor | | | | | | + | |

#### 5.2.3.1 Conservation Significance 1

Carter's Freshwater Mussel

Listed as Vulnerable under the EPBC Act and the BC Act, and with an uncertain expected occurrence in the survey area. DBCA database records (Appendix AC) show this species has been recorded both upstream (along Bickley Brook) and downstream (along Yule Brook) of the drainage lines that pass through the Survey Area (that also include a third drainage line, an upper tributary of Yule Brook: Woodlupine Brook).

*Leioproctus douglasiellus* (a short-tongued bee)

Listed as Critically Endangered under the EPBC Act and as Schedule 2 under the BC Act, and with an uncertain expected occurrence in the survey area. The species is only known from three locations (ranging from Cannington to Forrestdale) and has a very restricted geographic distribution. An inferred decline of suitable habitat (due to a large portion of the Swan Coastal Plain being significantly altered for human habitation and use) has reduced the potential area of occupancy for this species. *L. douglasiellus* has been collected on two plant species (both DBCA Priority Flora): *Goodenia filiformis* and *Anthotium junciforme.* The nearest record from the DBCA search (Appendix AC) is approximately 3 km from the Development Envelope.

Fork-tailed Swift

Listed as Migratory under the EPBC Act and as Schedule 5 under the BC Act. The swift is a largely aerial species of unpredictable occurrence in south-western Western Australia. Being aerial, it is effectively independent of terrestrial ecosystems.

Migratory waterbirds (waders, terns and the Glossy Ibis)

Species in this group are all listed as Migratory under the EPBC Act and as Schedule 5 under the BC Act, and are known to occur locally and regionally over a wide variety of wetland environments. All are expected to occur in the Survey Area as vagrants or irregular visitors (if at all), when favourable conditions, such as occur after considerable rainfall, prevail.

The international migrant waders in this category are: Eastern Great Egret, Wood Sandpiper and Common Greenshank, Marsh Sandpiper and Sharp-tailed Sandpiper. Given the limited areas of open wetland within the Survey Area, even when present these species would only ever be expected in very low numbers.

The Glossy Ibis occurs only in small numbers in the South-West region in general, and would be expected in the survey area only rarely, probably as transiting individuals that might stop occasionally at temporary wetlands.

Peregrine Falcon

Listed as Schedule 7 under the BC Act and is considered likely to be a regular visitor in the Survey Area. This species is almost certainly a resident of the Darling Scarp to the east and may forage out of the Survey Area on occasion. It is highly unlikely to be a resident in the Survey Area.

Forest Red-tailed Black-Cockatoo

Listed as Vulnerable under the EPBC Act and as Schedule 3 under the BC Act, and is considered to be a resident in the Survey Area. It feeds extensively on the seeds of Marri and Jarrah, and is also adapting to foraging on urban (introduced) plant species. As a result of the latter, Forest Red-tailed Black-Cockatoos have become increasingly common in the metropolitan area on the Swan Coastal Plain in the last decade. Breeding is possible within the Survey Area.

Carnaby's Black-Cockatoo

Listed as Endangered under the EPBC Act and as Schedule 2 under the BC Act, and is considered likely to be a regular migrant to the Survey Area. The Carnaby's Black-Cockatoo forages in proteaceous heath, banksia woodlands, eucalypt woodlands, gardens and streetscapes, and this foraging habitat is present throughout the Survey Area. Breeding is possible within the survey area. Some roost sites are known in the general region. These are discussed in more detail in the black-cockatoo habitat analysis.

Baudin's Black-Cockatoo

Listed as Vulnerable under the EPBC Act and as Schedule 2 under the BC Act, and is considered likely to be a regular visitor to the Survey Area. As for Forest Red-tailed Black-Cockatoo, this species relies on the seeds of Marri and Jarrah as a mainstay of its diet. In recent years there also appears to be an increase in the occurrence of Baudin's Black-Cockatoo west of the Darling Scarp on the Swan Coastal Plain. Breeding is unlikely within the Survey Area.

Chuditch

Listed as Vulnerable under the EPBC Act and as Schedule 3 under the BC Act, and is considered to be a vagrant to the Survey Area. The Chuditch is likely to be a wide-ranging resident in Marri-Jarrah woodland areas along the Darling Range, east of the survey area. The status of this species on the adjacent Swan Coastal Plain (including the survey area) is tenuous, although it may be present irregularly and unpredictably in very low numbers.

#### 5.2.3.2 Conservation Significance 2

Short-range endemic invertebrates

Listed as Priority 1, 2, 3 or 4 by DBCA with an uncertain expected occurrence in the Survey Area. These species have a restricted distribution, generally, that has been exacerbated by urban development on the Swan Coastal Plain. The species in this category are: Swan Coastal Plain Trapdoor Spider, McMillan's Biting Midge (Swan Coastal Plain), Cemetery Springtail, Spiny Katydid (Swan Coastal Plain), Grey Vernal Katydid (Southwest), Stylet Bush Cricket, Stylet Trosco (Jandakot), Graceful Sunmoth, *Glossurocolletes bilobatus* (a short-tongue bee) and Woollybush Bee.

Scant information on the ecology of most of these species means that it is very difficult to ascertain their expected status in the Survey Area without a comprehensive survey. In some cases species are only potentially detectable seasonally, during brief periods of activity. While all species are a possibility of being present (even as vagrants) the dependency of these fauna on the Survey Area is unknown. Some further information follows:

- The Swan Coastal Plain Trapdoor Spider may occur in remnant habitats, usually Banksia woodland and heathland on sandy soils, within the Perth metropolitan area (including the Survey Area) where it is the dominant species in its genera (Rix *et al*. 2018). The eastern limit of the range of the Swan Coastal Plain Trapdoor Spider is along the sandy foothills of the Darling Escarpment where it abuts the western limits of the ranges of its congenerics *Idiosoma jarrah* and *I. mcclementsorum* (Rix *et al*. 2018).
- McMillan's Biting Midge (Swan Coastal Plain) is known from only a small number of very localised populations between Yanchep and Darkan where it appears to be associated with areas of damp soil or open water (Borkent and Craig 2004). There were no DBCA records of this species within 5 km of the Survey Area (Appendix AC).
- The Cemetery Springtail is known from four urban remnants within the Perth region, where it occurs in Banksia heath (Greenslade and Jordana 2014). Two records of this species to the north-west of the Survey Area (in the vicinity of Perth Airport) were returned by the DBCA search (see Appendix AF).
- The Grey Vernal Katydid (Southwest), like other katydids, is likely to occur in areas of heath or mixed woodland (Rentz 1993) and is predominantly a near-coastal species (Moulds 2019).
- The Graceful Sunmoth was once a scheduled species under the (then) WA Wildlife Conservation Act 1950 but extensive surveys have revealed a broader distribution and greater population size than was initially thought. It now has a reduced conservation listing (priority by DBCA). This species is strongly associated with two mat rush (*Lomandra*) species (Bishop *et al*. 2010). This may be in Banksia woodland on deep sands (*L. hermaphrodita*) or in open areas of herbland, heathland and shrubland on sand and limestone (*L. maritima*). If either of these species are present within the Survey Area then the Graceful Sunmoth may occur but, probably, this species is likely to be, at most, an irregular visitor.
- The Woollybush Bee occurs south-west of a line from Dongara to Hopetoun with most Swan Coastal Plain records north of the Swan River (ALA 2020). If it were to occur in the Survey Area it would likely extend its metropolitan distribution (and there were no known records from DBCA within 5 km of the site; see Appendix AC). There is little specific information available on the distribution and habitat of this species but it known to forage on the flowers of Woollybush (*Adenanthos cygnorum*) and *Banksia attenuata*, which are both present in Banksia woodland of the Survey Area. Advice from the WA Museum (T. Houston *pers. comm*.) suggests that the Woollybush Bee may be more widespread and common than realised.

<u>Perth Lined Lerista and Black-striped Snake</u>

Both listed as Priority 3 by DBCA. The Perth Lined Lerista is restricted to the Swan Coastal Plain south of the Swan River and is considered to be a resident in remnant woodlands and suburban gardens the Survey Area. The Black-striped snake is restricted to the west coast region from south of Dongara to Mandurah. The species is threatened by encroaching land development and has been recorded from coastal dunes and sandplains with heath and Banksia woodland; as such it could be an irregular visitor in the survey area.

Barking Owl
Listed as Priority 3 by DBCA and considered to be a vagrant to the survey area. This species has undergone a dramatic range reduction on the Swan Coastal Plain but may persist in the forests of the Darling Range to the east of the Survey Area.

Quenda, Southern Brown Bandicoot
Listed as Priority 4 by DBCA and considered to be a resident in the Survey Area. Extensive evidence of Quenda was noted throughout the site (see Appendix AF).

Water-rat, Rakali
Listed as Priority 3 by DBCA and considered to be an irregular visitor to the Survey Area. There are historic records of this species along the drainage lines (upstream) that pass through the survey area (see Appendix AC). Therefore, Water-rats may occasionally pass through the survey area but, given the ephemeral and small nature of the water courses, are unlikely to be resident.

#### 5.2.3.3 Conservation Significance 3

Quacking Frog and Turtle Frog
Both species are expected to be residents within the Survey Area and are notable because they are uncommonly encountered within the urban matrix on the Swan Coastal Plain.

Ground-feeding granviorous birds and Western Rosella
These species are listed as either habitat specialists or wide-ranging species with reduced populations on the Swan Coastal Plain by DEP (2000) and forage on the ground for seeds They may occur in the Survey Area as either residents or irregular visitors (see Table 30). The species in this category are: Common Bronzewing; Brush Bronzewing, Painted Button-quail and Western Rosella.

Birds of prey
These species are listed as either habitat specialists or wide-ranging species with reduced populations on the Swan Coastal Plain by DEP (2000) and forage on other fauna (e.g. reptiles, birds and mammals). They may occur in the Survey Area as either residents, regular visitors, irregular visitors or vagrants (see Table 30). The species in this category are: Square-tailed Kite, Whistling Kite, Brown Goshawk, Collared Sparrowhawk, Wedge-tailed Eagle, Little Eagle and Brown Falcon.

Insectivorous passerine birds and Grey Currawong
These species are listed as either habitat specialists or wide-ranging species with reduced populations on the Swan Coastal Plain by DEP (2000) and forage predominantly for invertebrates throughout (and above) the vegetation strata. They may occur in the Survey Area as either residents, regular visitors, irregular visitors or vagrants (see Table 29). The species in this category are: Splendid Fairy-wren, Southern Emu-wren, White-browed Scrubwren, Weebill, Yellow-rumped Thornbill, Western Thornbill, Inland Thornbill, Varied Sittella, Western Whistler, Grey Shrike-thrush, Black-faced Woodswallow, Dusky Woodswallow, Masked Woodswallow, White-breasted Robin, Hooded Robin, Scarlet Robin, Red-capped Robin, Jacky Winter and Grey Currawong.

Nectarivorous birds

These species are listed as either habitat specialists or wide-ranging species with reduced populations on the Swan Coastal Plain by DEP (2000) and forage on nectar within the vegetation strata. They may occur in the Survey Area as either residents, regular visitors or vagrants (see Table 29). The species in this category are: Western Wattlebird, Tawny-crowned Honeyeater, Gilbert's Honeyeater, White-cheeked Honeyeater and New Holland Honeyeater.

Short-beaked Echidna and Common Brushtail Possum

Both species have fragmented distribution within the metropolitan area on the Swan Coastal Plain. If present as residents then populations would be of local significance. Signs of the echidna were noted during the site inspection (and is considered a resident on the precautionary principle) and the possum is considered to be a regular visitor to the Survey Area (with a broader population base in the Darling Range to the east).

### 5.2.4 Black-Cockatoo Habitat Analysis

#### 5.2.4.1 Breeding Tree Assessment

A total of 333 potential Black-Cockatoo nest-trees from at least six species were identified within the Development Envelope, as listed in Table 31. The numbers of potential nest-trees of each species recorded in each ranking category are shown in Table 32, and the locations of these trees are mapped in Figure 14.

**Table 31: Species and Number of Potential Black-Cockatoo Nest-trees Recorded within the Development Envelope**

| Tree Species | Number of Trees |
|---|---|
| *Corymbia calophylla* Marri | 159 |
| *Eucalyptus gomphocephala* Tuart | 2 |
| *Eucalyptus marginata* Jarrah | 12 |
| *Eucalyptus rudis* Flooded Gum | 40 |
| *Eucalyptus todtiana* Coastal Blackbutt | 18 |
| Planted, non-native | 89 |
| Stag | 13 |
| **Total** | **333** |

The vast majority (c99.4%) of potential nest-trees surveyed did not have hollows suited to Black-Cockatoos. No active nests were located, although seven trees had potential nest hollows for Black-Cockatoos.

The seven trees that had potential nest-hollows for black-cockatoos (i.e. category 2 and 3 trees) were further investigated by pole-camera. The raw results are presented in Appendix AG and a summary is provided in Table 33. No black-cockatoo nests were located. Five of the pole-camera-inspected trees had their nest-tree rank revised down (as indicated in

Table 33 and Appendix AG) where apparent hollows (as viewed from the ground on initial inspection) were subsequently found to not be suitable for black-cockatoo nesting. One tree (ID 204) was located on private property and, as such, unable to be inspected. This tree had evidence of Black Cockatoo chew marks however such chew marks are not necessarily evidence of use for breeding. One tree (ID 281) had at least one hollow that was unable to be accessed by the pole-camera. These two trees have retained their initial rank.

There is no present evidence to suggest that black-cockatoos nest within the Development Envelope and the number of potential nest-hollow bearing trees within the envelope is likely to be two or less (two trees that were not accessible or were unable to be assessed by pole-camera).

**Table 32: The Number of Potential Nest-trees of each Species in each Nest-tree Rank Category in the Development Envelope**

| Category | | Number of Trees | | | | | | | TOTAL | Percentage (of Grand Total) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Marri | Planted, non-native | Flooded Gum | Coastal Blackbutt | Stag (dead, unidentified) | Jarrah | Tuart | | |
| 1 | Active nest. | - | - | - | - | - | - | - | - | 0.0 |
| 2 | Potential hollow with chew-marks. | - | - | - (1) | 1 (1) | - (1) | - | - | 1 (3) | 0.3 |
| 3 | Potential hollow, no chew marks. | - | - | - | - (1) | 1 (2) | - (1) | - | 1 (4) | 0.3 |
| 4 | Potential hollow, unsuitable orientation. | 1 | 1 | 2 (1) | 1 | 5 (4) | 1 (-) | - | 11 (8) | 3.3 |
| 5 | Sufficient DBH, no observable hollows. | 138 | 77 | 34 | 4 (3) | 7 (6) | 8 | 2 | 270 (268) | 81.1 |
| 0 | Sufficient DBH, otherwise unsuitable. | 20 | 11 | 4 | 12 | - | 3 | - | 50 | 15.0 |
| | **TOTAL:** | 159 | 89 | 40 | 18 | 13 | 12 | 2 | **333** | 100 |
| **Percentage (of Grand Total)** | | 48.8 | 47.7 | 26.7 | 12.0 | 5.4 | 3.9 | 3.6 | 0.6 | 100 |

Numbers in parentheses show tallies prior to the pole-camera inspections


**Figure 14**: **Location of Potential Nest-trees within the Development Envelope**

**Table 33: Summary Results from the Camera-pole Assessment of Potential Black-Cockatoo Nest-trees**

| Date | Tree ID | Easting | Northing | Tree Species | DBH (mm) | Status | Initial Rank | Pole-camera Inspection Notes | Revised Rank |
|---|---|---|---|---|---|---|---|---|---|
| 7/10/2019 | 182 | 405879 | 6456051 | Jarrah | 1300 | Alive | 3 | No suitable hollow. Active bee hive in base of tree. | 4 |
| 7/10/2019 | 184 | 405843 | 6456060 | Stag | 1400 | Dead | 2 | No suitable hollows. | 4 |
| 7/10/2019 | 199 | 405784 | 6456489 | Stag | 900 | Dead | 3 | Two hollows were inspected - hollows appear too shallow for black-cockatoos. Note active bee hive in base of tree so no photos recorded. | 5 |
| 7/10/2019 | 204 | 405715 | 6456658 | Coastal Blackbutt | 900 | Alive | 2 | Tree appears to be on private property. Not inspected. | NA |
| 8/10/2019 | 279 | 405274 | 6458902 | Coastal Blackbutt | 800 | Alive | 3 | Not a hollow. | 5 |
| 8/10/2019 | 281 | 405267 | 6458969 | Stag | 1400 | Dead | 3 | Hollow at end of upright branch appears too shallow for black-cockatoos. Other hollows inaccessible due to other trees blocking access. | NA |
| 8/10/2019 | 304 | 404831 | 6459583 | Flooded Gum | 600 | Alive | 2 | Hollows appear too shallow for black-cockatoos. Note active bee hive in base of tree. | 4 |

### 5.2.4.2 Foraging Habitat Assessment

The foraging value of the Development Envelope was assessed on-ground for all three species of Black-Cockatoos that occur in the vicinity as summarised in Table 34.

**Table 34: Areas (ha) and Proportions (%) of each Category (vegetation score, combined foraging score) of Foraging Habitat in the Development Envelope for the three Black-Cockatoo species present in south-western Australia**

See Appendix F for explanation of vegetation, context, species density and (combined) foraging scores.

| | Forest Red-tailed Black-Cockatoo | | Carnaby's Black-Cockatoo | | Baudin's Black-Cockatoo | |
|---|---|---|---|---|---|---|
| | | | | | | |
| 6: High | 0 | 0 | 0 | 0 | 0 | 0 |
| 5: Moderate to High | 11.9 | 12.3 | 0 | 0 | 11.9 | 12.3 |
| 4: Moderate | 9.6 | 9.9 | 25.3 | 26.1 | 9.9 | 10.2 |
| 3: Low to Moderate | 11.1 | 11.5 | 7.5 | 7.8 | 11 | 11.3 |
| 2: Low | 4.5 | 4.6 | 3.9 | 4 | 4.3 | 4.4 |
| 1: Negligible | 3.6 | 3.7 | 4 | 4.2 | 3.6 | 3.7 |
| 0: Nil | 56.3 | 58 | 56.3 | 58 | 56.3 | 58 |
| TOTAL | 97 | 100 | 97 | 100 | 97 | 100 |
| **Context Score** | 1 | | 1 | | 1 | |
| **Species Density Score** | 1 | | 1 | | 1 | |
| **Foraging Score** | | | | | | |
| 10 | - | - | - | - | - | - |
| 9 | - | - | - | - | - | - |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 11.9 | 12.3 | 0 | 0 | 11.9 | 12.3 |
| 6 | 9.6 | 9.9 | 25.3 | 26.1 | 9.9 | 10.2 |
| 5 | 11.1 | 11.5 | 7.5 | 7.8 | 11 | 11.3 |
| NA (Vegetation Score < 3) | 64.4 | 66.3 | 64.2 | 66.2 | 64.2 | 66.1 |
| TOTAL | 97 | 100 | 97 | 100 | 97 | 100 |

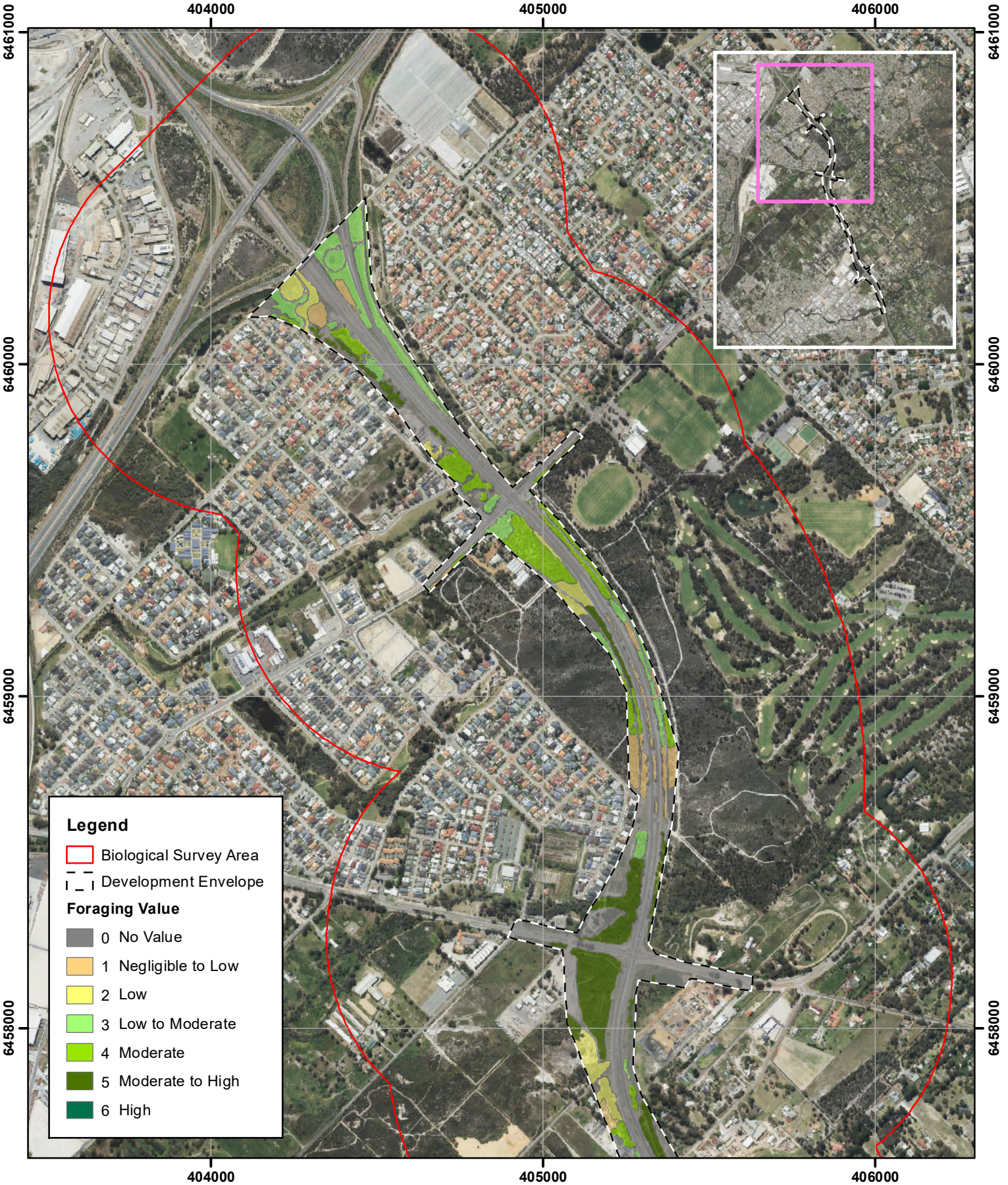
***Forest Red-Tailed Black-Cockatoo***

Foraging habitat for Forest Red-tailed Black-Cockatoo was present throughout the Development Envelope. This is primarily due to the occurrence of Marri, Jarrah and She-oak, known to be mainstays of the Forest Red-tailed Black-Cockatoo diet (Johnstone and Kirkby 1999). These trees were present in variable densities (from absent to high) across the Development Envelope. Maps of vegetation scores of the Development Envelope for Forest Red-tailed Black-Cockatoo foraging are presented in Figure 15 (northern envelope) and Figure 16 (southern envelope). The areas (and percentages) of each vegetation score are shown in Table 34.

There are approximately 16,231 ha of remnant native vegetation (as assessed by DPIRD 2020) within 12 km of the Development Envelope, which itself has c. 20.5 ha of native vegetation. Therefore, the site comprises c. 0.12% of the native vegetation in the 'local area'

(as per the methods outlined in Appendix F). It is certain that the Forest Red-tailed Black-Cockatoo breeds within the local area, given the proximity to the Jarrah-Marri forests of the Darling Scarp (to the east). Thus, a 'context' score of 1 (out of 3) has been assigned to the development envelope for this species (see Appendix F). The Development Envelope was assigned a species density score for Forest Red-tailed Black-Cockatoo of 1 (out of 1; see Appendix F). These values have been added on to the vegetation scores to yield the overall foraging value scores (with areas and percentages) that are also presented in Table 34.

There was evidence of foraging by Forest Red-tailed Black-Cockatoos throughout the Development Envelope, particularly in the north-west and south-east. The Development Envelope is, generally, of moderate to low value for foraging by Forest Red-tailed Black-Cockatoos but there was evidence to show that this species presently (and previously) uses the site for feeding. Foraging evidence locations are presented in Appendix AH and locations maps are presented in Appendix AI.




**Distribution of Forest Red-tailed Black-Cockatoo Foraging Habitat (northern Development Envelope)**

Author: Cathy Godden

WEC Ref: MR19-34-01

WOODMAN ENVIRONMENTAL

BAMFORD CONSULTING ECOLOGISTS

Filename: MR19-34-01-f15-16

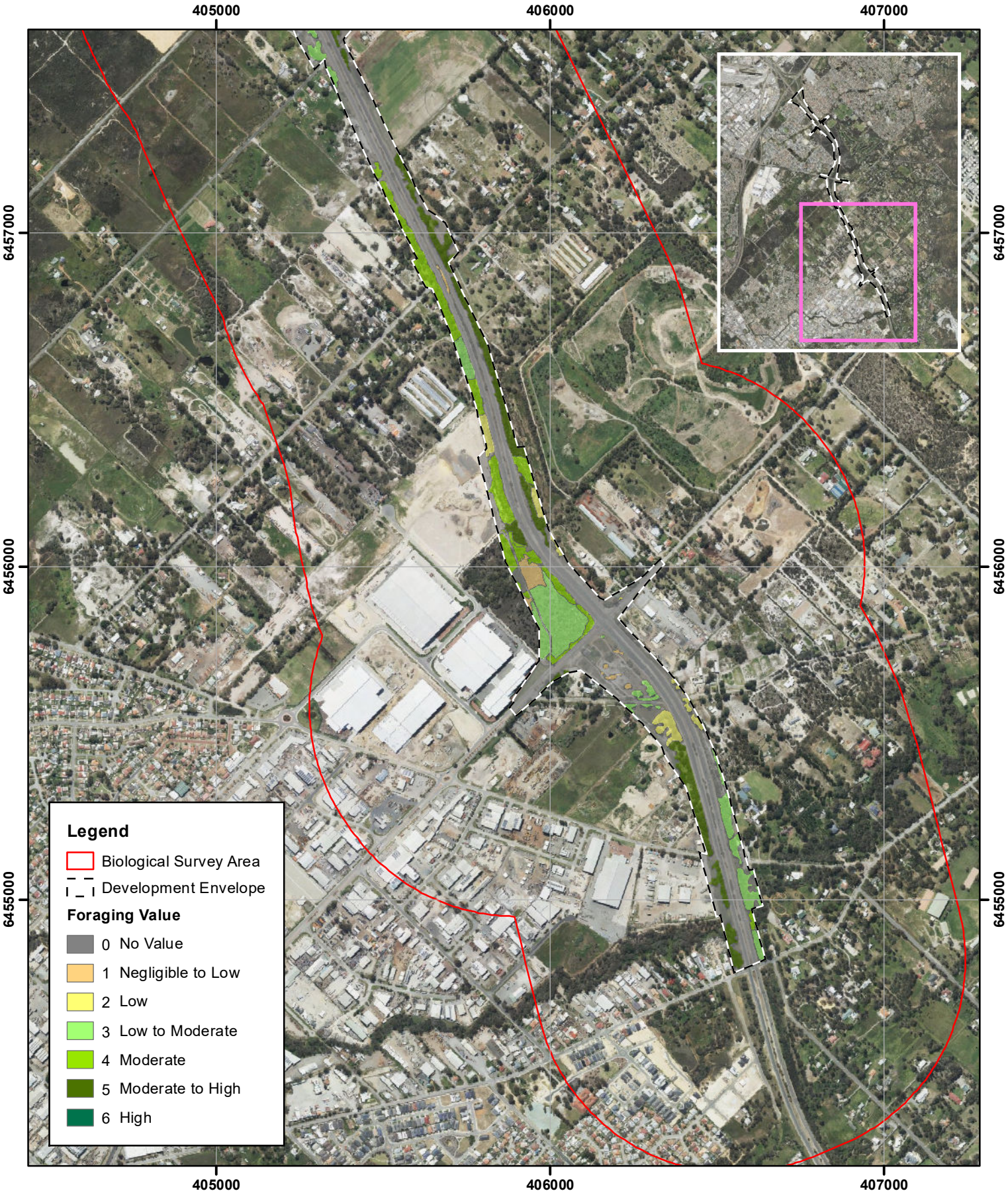
Scale: 1:15,000

Projection: GDA 1994 MGA Zone 50

Revision: 1 - 17 February 2021

**Figure 15**

This map should only be used in conjunction with WEC report MR19-34-01.




**Distribution of Forest Red-tailed Black-Cockatoo Foraging Habitat (southern Development Envelope)**

Author: Cathy Godden

WEC Ref: MR19-34-01

Filename: MR19-34-01-f15-16

Scale: 1:15,000

Projection: GDA 1994 MGA Zone 50

Revision: 1 - 17 February 2021

**Figure 16**

WOODMAN ENVIRONMENTAL

BAMFORD CONSULTING ECOLOGISTS

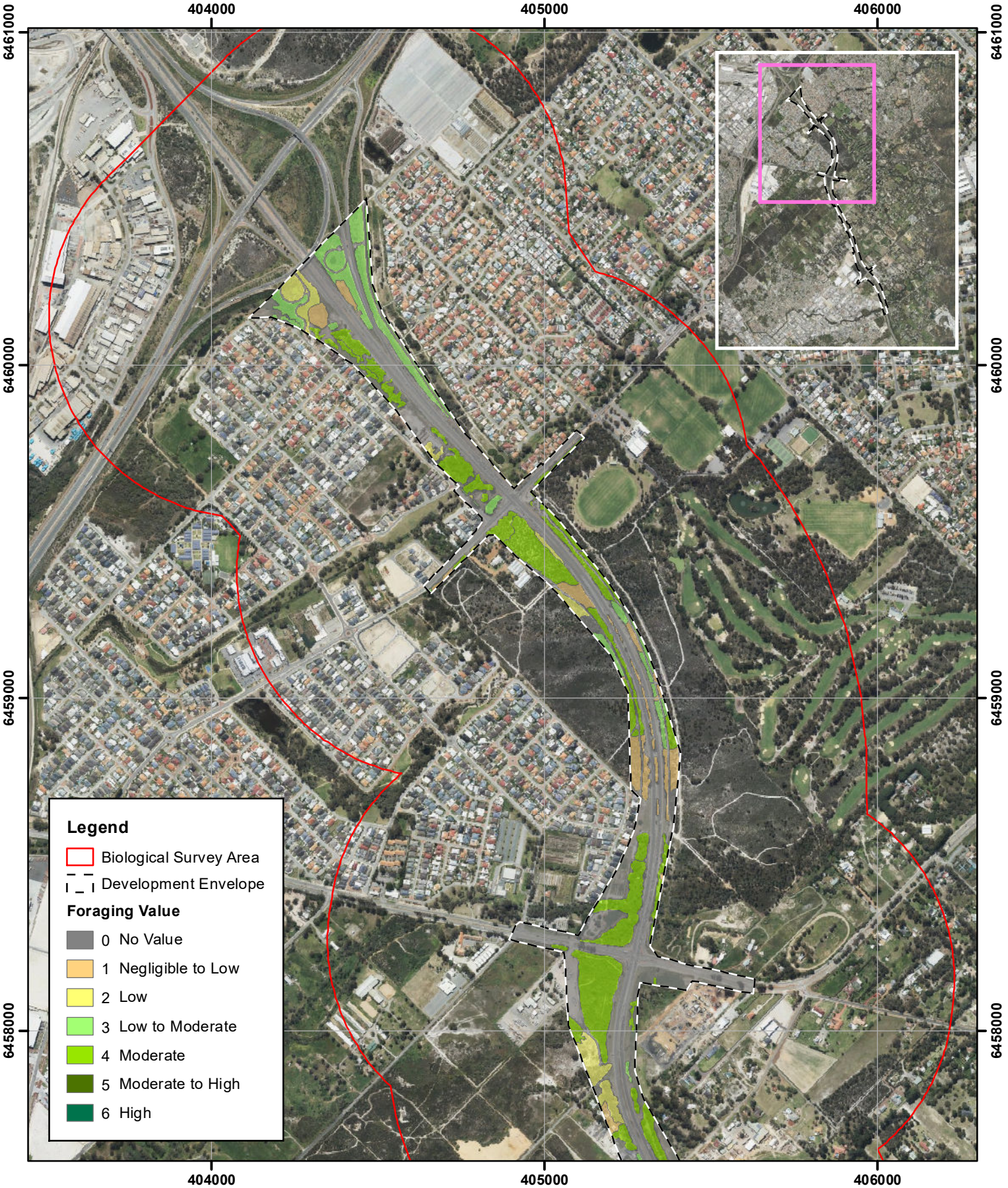
This map should only be used in conjunction with WEC report MR19-34-01.

***Carnaby's Black-Cockatoo***

Foraging habitat for Carnaby's Black-Cockatoo was present throughout the Development Envelope. This is predominantly due to the presence of several plant species known to be mainstays of the Carnaby's Black-Cockatoo diet including *Banksia attenuata*, *B. menziesii* and Marri (Groom 2011). These trees were present in variable densities (from absent to high) across the development envelope. Maps of vegetation scores of the Development Envelope for Carnaby's Black-Cockatoo foraging are presented in Figure 17 (northern envelope) and Figure 18 (southern envelope). The areas (and percentages) of each vegetation score are shown in Table 35.

As noted for the Forest Red-tailed Black-Cockatoo the Development Envelope supports c. 0.12% of the native vegetation in the 'local area' (12 km buffer). It is likely that the Carnaby's Black-Cockatoo breeds within the local area, given the proximity to the Jarrah-Marri forests of the Darling Scarp (to the east). Thus, a 'context' score of 1 (out of 3) has been assigned to the development envelope for this species (see Appendix F). The Development Envelope was assigned a species density score for Carnaby's Black-Cockatoo of 1 (out of 1; see Appendix F). These values have been added on to the vegetation scores to yield the overall foraging value scores (with areas and percentages) that are also presented in Table 34. The Development Envelope is, generally, of moderate to low value for foraging by Carnaby's Black-Cockatoo.

In addition to the above, DBCA also provide indicative Carnaby's Black-Cockatoo feeding habitat for the Swan Coastal Plain and Jarrah Forest (DBCA 2020c, 2020d). Potential Carnaby's Black-Cockatoo feeding habitat is mapped for the local region (12 km) in Figure 19 and the areas of potential feeding habitat within the region, Survey Area and Development Envelope are provided in Table 35. The percentage of potential Carnaby's Black-Cockatoo feeding habitat within the Development Envelope (33.9%) is slightly higher than the regional representation of this habitat (28.7% of region). If all potential Carnaby's Black-Cockatoo feeding habitat was removed within the Development Envelope it would represent c. 0.1% of the available regional (12 km) habitat, and c. 13.2% of the available habitat within the Survey Area.




**Distribution of Carnaby's Black-Cockatoo Foraging Habitat (northern Development Envelope)**

Author: Cathy Godden

WEC Ref: MR19-34-01

Filename: MR19-34-01-f17-18

Scale: 1:15,000

Projection: GDA 1994 MGA Zone 50

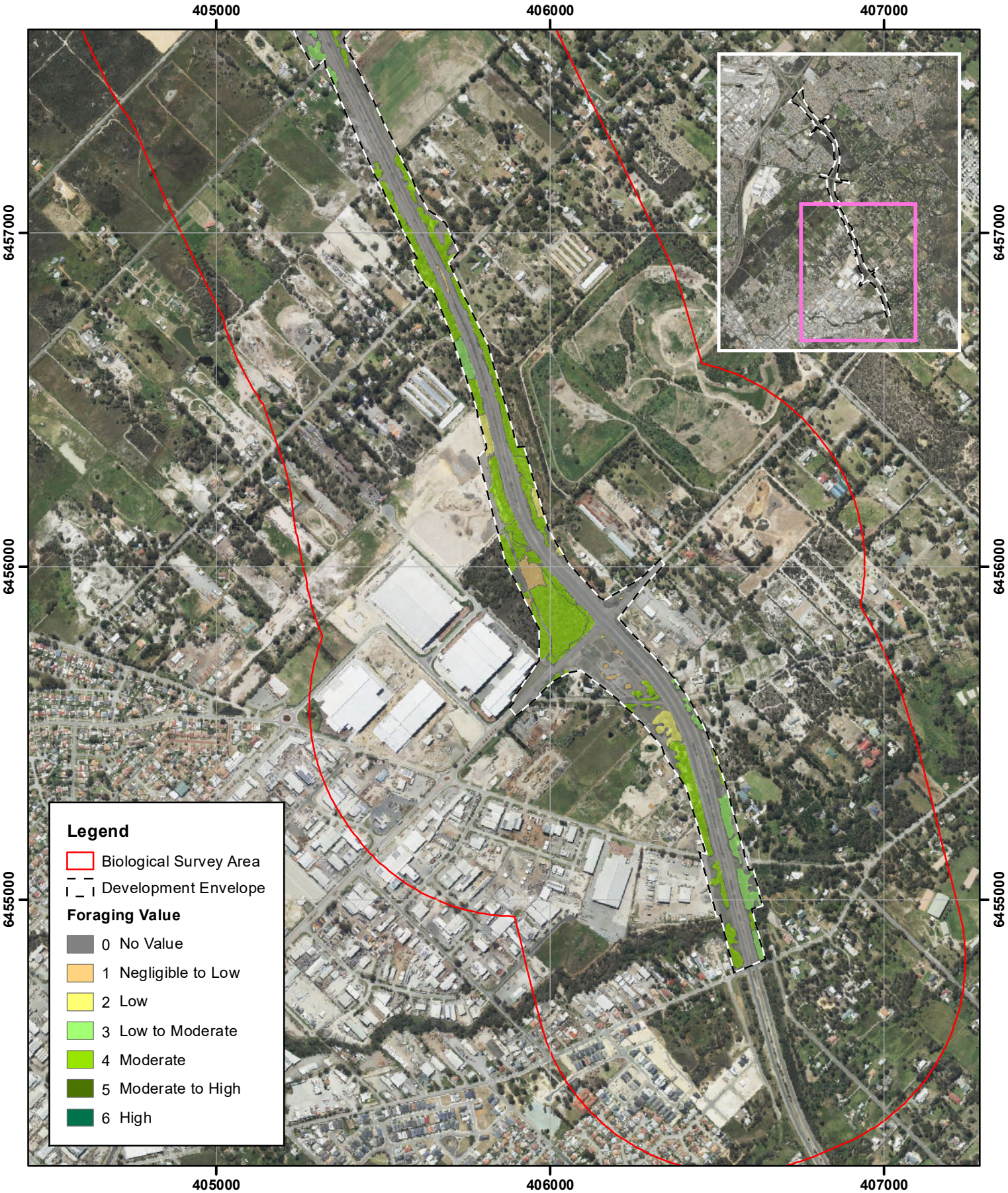
Revision: 1 - 17 February 2021

**Figure 17**

WOODMAN ENVIRONMENTAL

BAMFORD CONSULTING ECOLOGISTS

This map should only be used in conjunction with WEC report MR19-34-01.




**Distribution of Carnaby's Black-Cockatoo Foraging Habitat (southern Development Envelope)**

Author: Cathy Godden

WEC Ref: MR19-34-01

Filename: MR19-34-01-f17-18

Scale: 1:15,000

Projection: GDA 1994 MGA Zone 50

Revision: 1 - 17 February 2021

**Figure 18**

WOODMAN ENVIRONMENTAL

BAMFORD CONSULTING ECOLOGISTS

This map should only be used in conjunction with WEC report MR19-34-01.

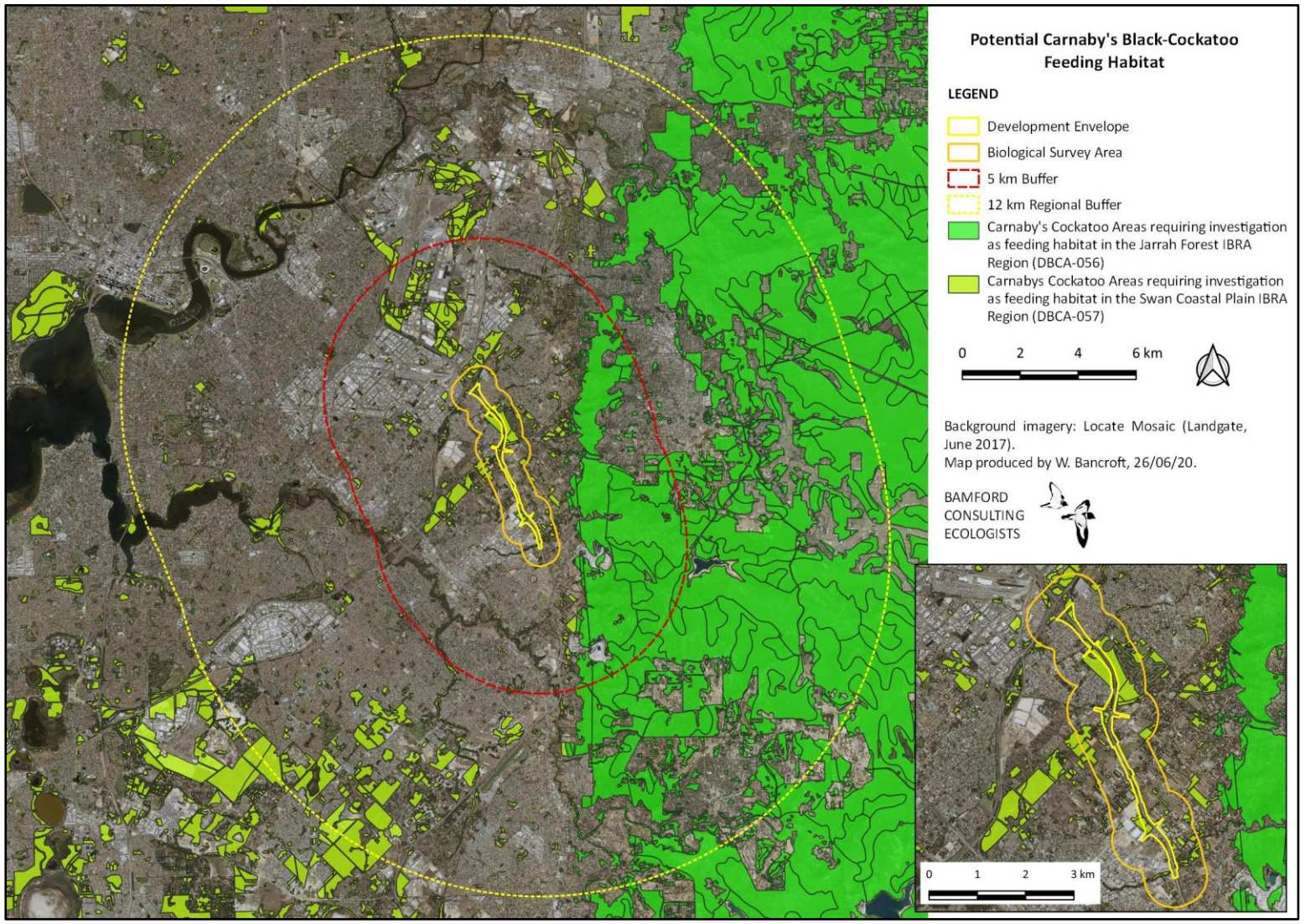



**Figure 19: Potential Carnaby's Black-Cockatoo Feeding habitat (DBCA) within the 12 km regional buffer**

**Table 35: Potential Carnaby's Black-Cockatoo feeding habitat (DBCA) within the Region, Survey Area and Development Envelope**

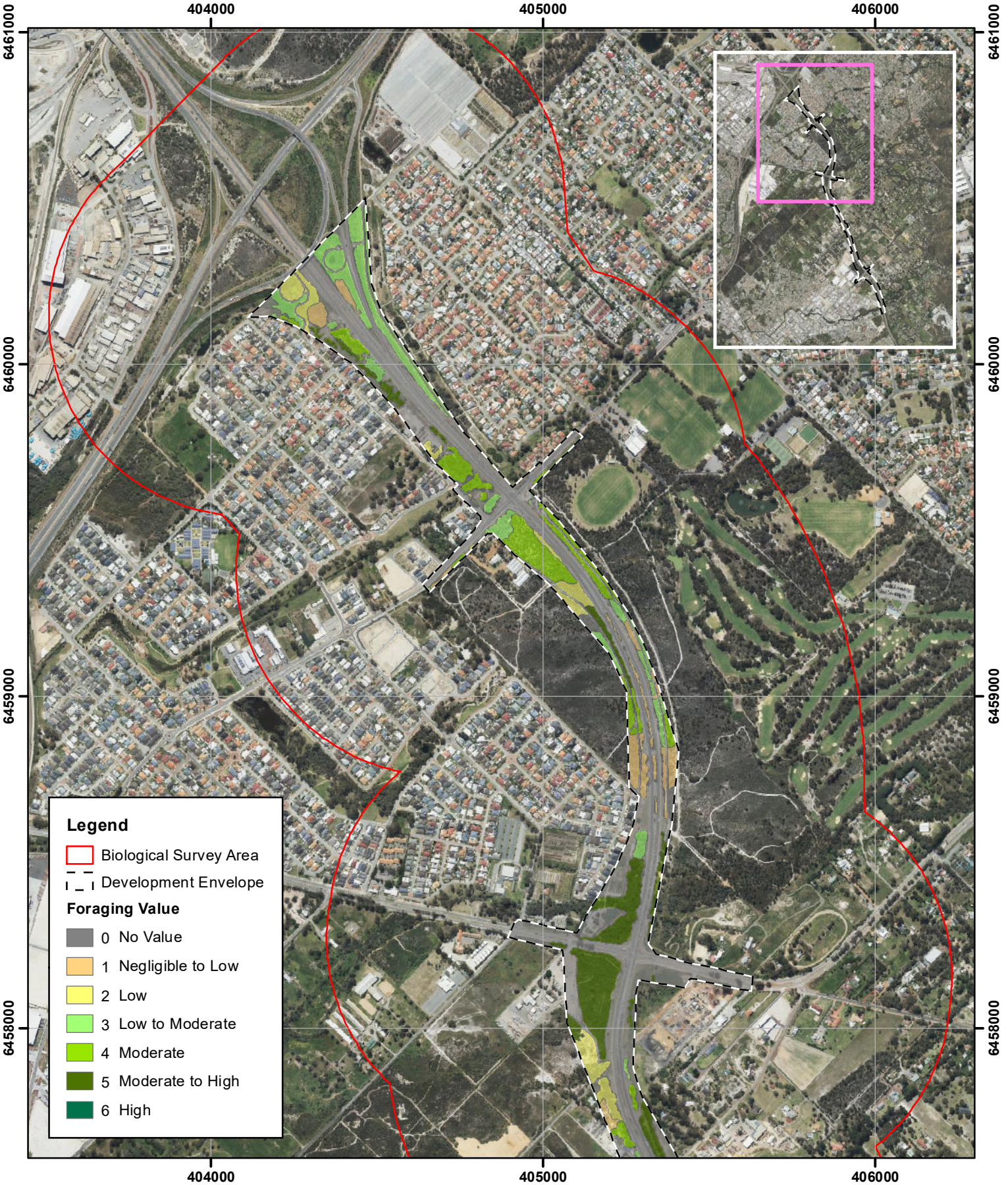
| | Total Area (ha) | Area of DBCA Carnaby's Potential Feeding Habitat (ha) | % |
|---|---|---|---|
| Regional (12km) Buffer | 60811.2 | 17479.6 | 28.7 |
| Biological Survey Area | 1069.6 | 157.5 | 14.7 |
| Development Envelope | 97 | 32.8 | 33.8 |

***Baudin's Black-Cockatoo***

Foraging habitat for Baudin's Black-Cockatoo was present throughout the Development envelope. This is primarily due to the occurrence of Marri, known to be the cornerstone of the Baudin's Black-Cockatoo diet, although the species will also forage on proteaceous shrubs/trees, insect larvae, orchard fruit and ornamental plants (Johnstone and Kirkby 2008, Lee *et al*. 2013. Marri trees were present in variable densities (from absent to high) across the Development Envelope. Maps of vegetation scores of the development envelope for Baudin's Black-Cockatoo foraging are presented in Figure 20 (northern envelope) and Figure Figure 21 (southern envelope). The areas (and percentages) of each vegetation score are shown in Table 33.

As noted for the other species, the Development Envelope supports c. 0.12% of the native vegetation in the 'local area' (12 km buffer). While the breeding biology of this species is poorly understood and that it is thought that most breeding occurs in the southernmost parts of the south-west of WA, it is possible that the Baudin's Black-Cockatoo breeds within 12 km of the Development Envelope (Johnstone and Kirby (2008). These authors noted a nest in the Jarrah forest near Serpentine and while, at present, it seems a stretch to consider this species would breed on the Swan Coastal Plain near Perth, the Forest Red-tailed Black-Cockatoo (a similar 'forest' cockatoo) has expanded its breeding range through metropolitan area in the last decade. Baudin's Black-Cockatoo has also been recorded more frequently in these areas (during the non-breeding period) in recent years. Thus, a 'context' score of 1 (out of 3) has been assigned (using the precautionary principle) to the Development Envelope for this species (see Appendix F). The Development Envelope was assigned a species density score for Baudin's Black-Cockatoo of 1 (out of 1; see Appendix F). These values have been added on to the vegetation scores to yield the overall foraging value scores (with areas and percentages) that are also presented in Table 34.

There was extensive evidence of foraging by Baudin's Black-Cockatoo throughout the Development Envelope. The Development Envelope is, generally, of moderate to low value for foraging by Baudin's Black-Cockatoo but there was evidence to show that this species presently (and previously) uses the site for feeding. Foraging evidence locations are presented in Appendix AH and locations maps are presented in Appendix AI.




**Distribution of Baudin's Black-Cockatoo Foraging Habitat (northern Development Envelope)**

Author: Cathy Godden

WEC Ref: MR19-34-01

WOODMAN ENVIRONMENTAL

BAMFORD CONSULTING ECOLOGISTS

Filename: MR19-34-01-f20-21

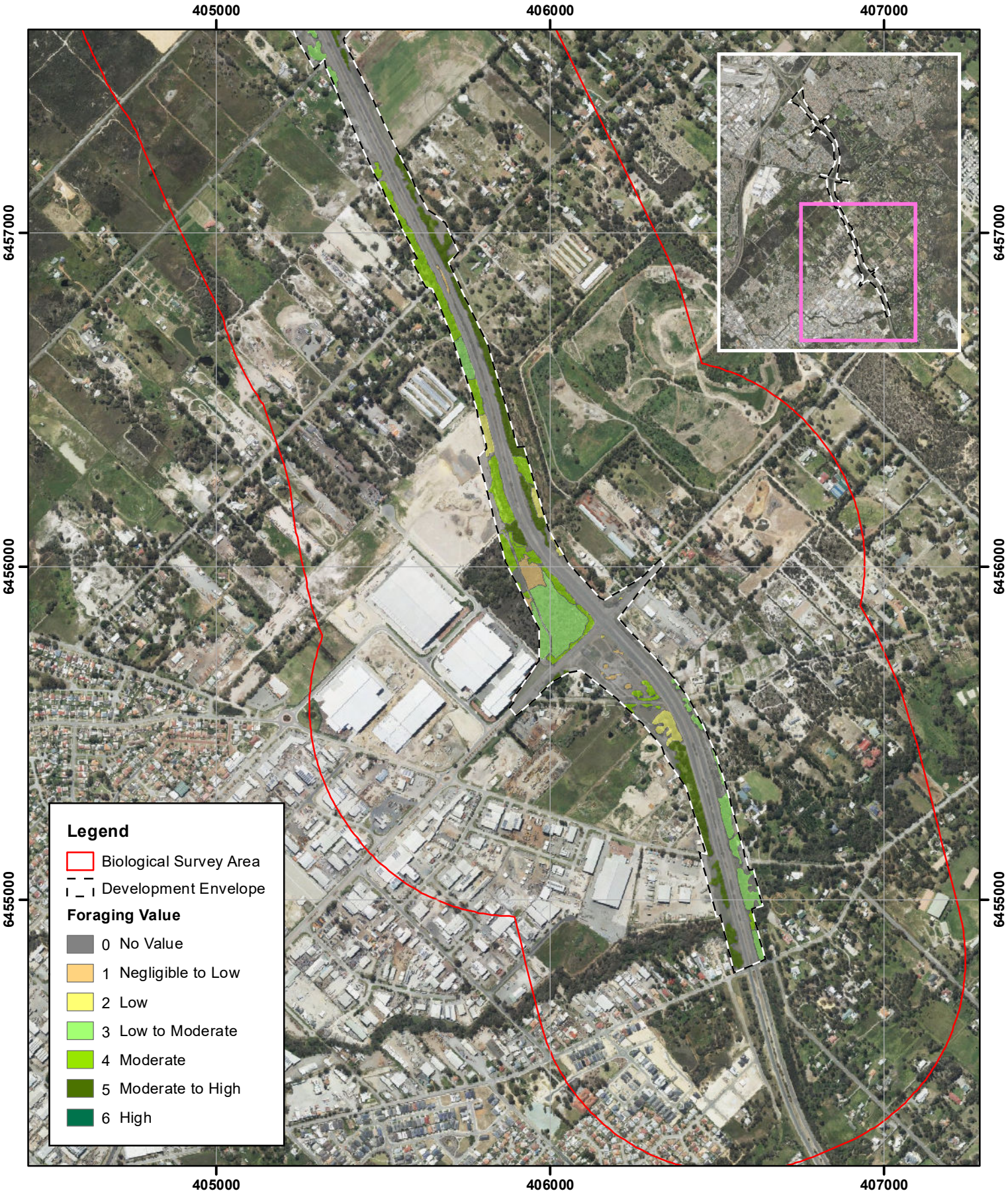
Scale: 1:15,000

Projection: GDA 1994 MGA Zone 50

Revision: 1 - 17 February 2021

**Figure 20**

This map should only be used in conjunction with WEC report MR19-34-01.




**Distribution of Baudin's Black-Cockatoo Foraging Habitat (southern Development Envelope)**

Author: Cathy Godden

WEC Ref: MR19-34-01

WOODMAN ENVIRONMENTAL

BAMFORD CONSULTING ECOLOGISTS

Filename: MR19-34-01-f20-21

Scale: 1:15,000

Projection: GDA 1994 MGA Zone 50

Revision: 1 - 17 February 2021

**Figure 21**

This map should only be used in conjunction with WEC report MR19-34-01.

#### 5.2.4.3 Roosting Habitat Assessment

The locations of confirmed, potential and unconfirmed black-cockatoo roost sites are mapped in Figure 22 (based on the Great Cocky Count 2017 records, Peck *et al.* 2017, and available DBCA data). There are no known roost sites within the Development Envelope. There may be one site within the Survey Area: the location appears to be in the vicinity of the Hartfield Golf Club (see Figure 22); no specific location details are available as only 1 km buffered locations are provided by DBCA). Most of the known roost sites within the region are located on the Darling Range (to the east of the Survey Area) or in the mid-Swan Coastal Plain (to the west of the Survey Area). Any areas with tall trees (especially eucalypts, pines; and in association with water bodies) may provide roost-sites for Black-Cockatoos.

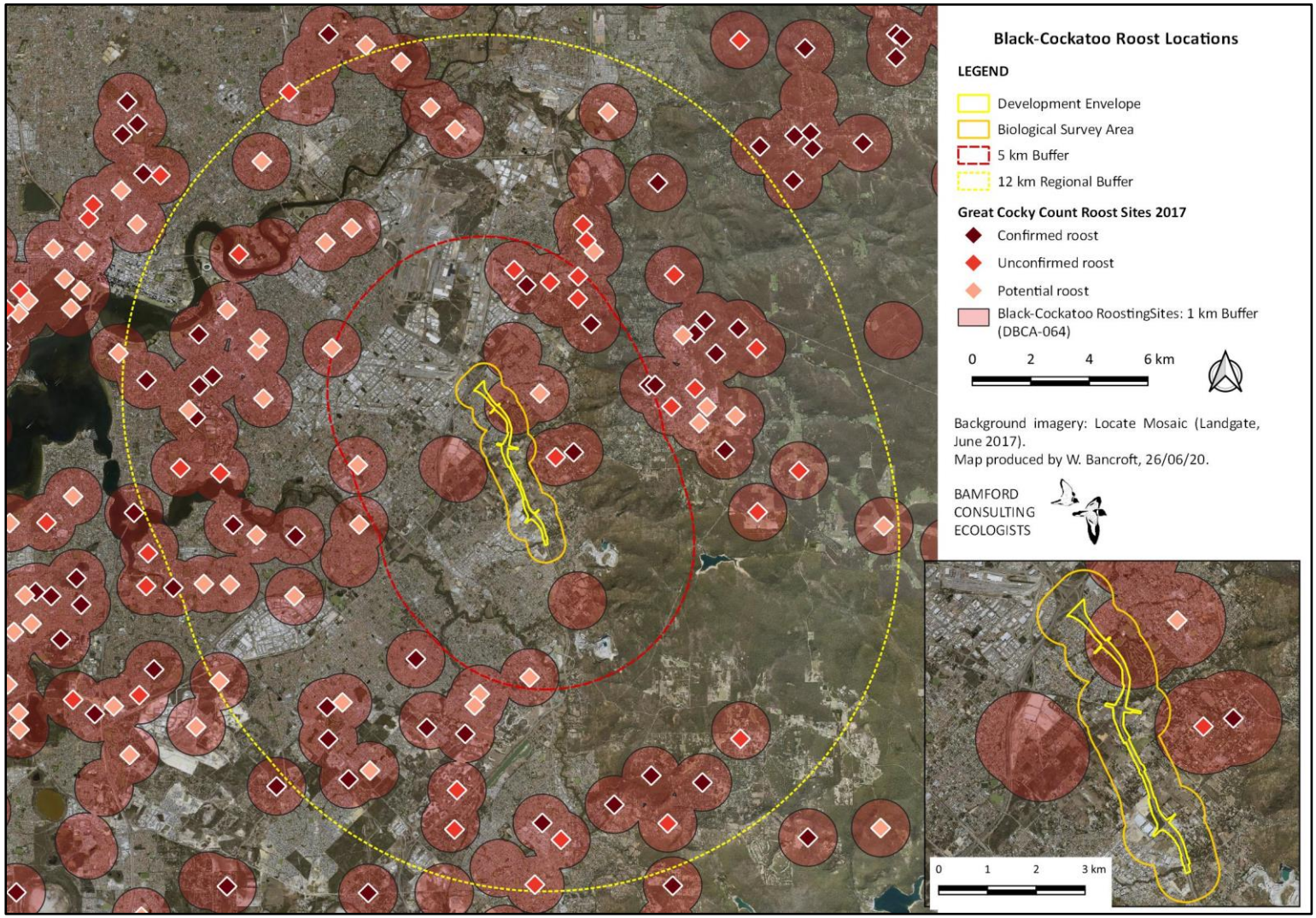



**Figure 22: Black-Cockatoo Roost Locations within the 12 km Regional Buffer, based on point locations from Peck *et al*. (2017) and 1 km-buffered DBCA data (DBCA-064)**

# 6. REFERENCES

AECOM Australia Pty Ltd (AECOM) (2015)
*Tonkin Highway / Hale Road, Tonkin Highway / Welshpool Road and Tonkin Highway / Kelvin Road Biological Assessment*. Unpublished report prepared for Main Roads WA, December 2015.

Antis, M. (2013)
*Tadpoles and Frogs of Australia*. New Holland Publishers, Chatswood, New South Wales

Atlas of Living Australia (ALA) (2019)
The Australasian Virtual Herbarium. Council of Heads of Australasian Herbaria. Available: http://avh.chah.org.au. Fauna search accessed November 2019.

Atlas of Living Australia (ALA) (2020)
The Australasian Virtual Herbarium. Council of Heads of Australasian Herbaria. Available: http://avh.chah.org.au. Last accessed February 2020.

Australian Weeds Committee (AWC) (2019)
*Weeds Australia - Weeds of National Significance.* Available: http://www.weeds.org.au/WoNS/. Last accessed May 2020.

Bamford Consulting Ecologists (1996)
*Roe Highway Stage 4. Update of Fauna Assessment*. Unpublished report prepared for Main Roads WA.

Bamford Consulting Ecologists (1998)
*Roe Highway Stages 5, 6 and 7. Report on ecologically sustainable development and biodiversity.* Unpublished report prepared for ERM Mitchell McCotter.

Bamford Consulting Ecologists (2004)
*Maddington – Kenwick Strategic Industrial Area.. Fauna.* Unpublished report prepared for BSD Consultants.

Bamford, M. J., Bancroft, W. J. and Sibbel, N. (2010)
Twenty years and two transects; spatial and temporal variation in local patterns of biodiversity*. Ecological Society of Australia Conference, Canberra, Australian Capital Territory.*

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

Beard, J. S. (1981)
*Vegetation Survey of Western Australia, Swan 1:1 000 000*. Map and Explanatory Notes to Sheet 7. Published by University of Western Australia Press, Perth.

Beard, J.S. (1990)
Plant Life of Western Australia. Kangaroo Press, Perth.

Beard, J.S., Beeston, G.R., Harvey, J.M., Hopkins, A.J.M. and Shepherd, D.P. (2013)
The vegetation of Western Australia at the 1:3,000,000 scale. Explanatory memoir. Second edition. *Conservation Science Western Australia* 9: 1-152.

Belbin, L. and Collins, A. (2009)
*PATN*. Version 3.12, Blatant Fabrications Pty Ltd.

BirdLife Australia. (2019)
*The BirdLife Australia Working List of Australian Birds*; Version 3.0. www.birdlife.org.au/documents/BWL-BirdLife_Australia_Working_List_v3.xlsx

Bishop, C., Williams, M., Mitchell, D. and Gamblin, T. (2010)
*Survey guidelines for the Graceful sun-moth (Synemon gratiosa) & site habitat assessments.* Department of Environment and Conservation. http://www.dec.wa.gov.au/content/view/5695/1813/

Borkent, A. and Craig, D. A. (2004)
*Austroconops* Wirth and Lee, a Lower Cretaceous genus of biting midges yet living in Western Australia: a new species, first description of the immatures and discussion of their biology and phylogeny (Diptera: Ceratopogonidae). *American Museum Novitates* **2004**: 1-67.

Burbidge, A. A. and McKenzie, N. L. (1989)
Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. *Biological Conservation* **50**: 143-198.

Bureau of Meteorology (2020a)
Climate Statistics for Australian Locations – Perth Airport. Available: http://www.bom.gov.au/climate/data/. Sourced March, 2020.

Bureau of Meteorology (2020b)
Groundwater Dependent Ecosystems Atlas. Available: http://www.bom.gov.au/water/groundwater/gde/map.shtml. Accessed May 2020.

Calver, M. C., Lymbery, A. J., McComb, J. and Bamford, M. J. (2009)
*Environmental Biology*. Cambridge University Press, Melbourne, Australia.

Chao, A. (1987)
Estimating the population size for capture-recapture data with unequal catchability. *Biometrics* 43: 783-791.

Clevenger, A. P. and Waltho, N. (2000)
Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. *Conservation Biology* **14**: 1-11.

Churchill, S.K. (1998)
Australian Bats. Reed New Holland, Frenchs Forest, New South Wales.

Commonwealth of Australia (2012)
*Interim Biogeographic Regionalisation for Australia, Version 7*. Department of Sustainability, Environment, Water, Population and Communities. Available: http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html#ibra

Craven, L.A., Lepschi, B.J. and Cowley, K.J. (2010)
*Melaleuca* (Myrtaceae) of Western Australia: five new species, three new combinations, one new name and a new state record. *Nuytsia* 20: 27-36.

Curnutt, J. L., Pimm, S. L. and Maurer, B. A. (1996)
Population variability of sparrows in space and time. *Oikos* **76**: 131-144.

Department of Agriculture, Water and the Environment (DAWE) (as Department of the Environment, Water, Heritage and the Arts) (2008a)
Approved Conservation Advice for *Dryandra mimica* (Summer Honeypot). Department of the Environment, Water, Heritage and the Arts, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/20348-conservation-advice.pdf.

Department of Agriculture, Water and the Environment (DAWE) (as Department of the Environment, Water, Heritage and the Arts) (2008b)
Approved Conservation Advice for *Tetraria australiensis* (Southern Tetraria). Department of the Environment, Water, Heritage and the Arts, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/10137-conservation-advice.pdf.

Department of Agriculture, Water and the Environment (DAWE) (as Department of Sustainability, Environment, Water, Populations and Communities) (2012)
*EPBC Act referral guidelines for three threatened black cockatoo species: Carnaby's cockatoo (endangered) Calyptorhynchus latirostris, Baudin's cockatoo (vulnerable) Calyptorhynchus baudinii, Forest red-tailed black cockatoo (vulnerable) Calyptorhynchus banksii naso.* Department of Sustainability, Environment, Water, Populations and Communities, Canberra.

Department of Agriculture, Water and the Environment (DAWE) (2017a)

Approved Conservation Advice for Shrublands and Woodlands of the Eastern Swan Coastal Plain (s226B of the *Environmental Protection and Biodiversity Conservation Act 1999*). Approved by Delegate of the Minister 13th July 2017. Available: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/20-conservation-advice.pdf

Department of Agriculture, Water and the Environment (DAWE) (2017b)

Approved Conservation Advice for *Corymbia calophylla – Kingia australis* woodlands on heavy soils of the Swan Coastal Plain (s226B of the *Environmental Protection and Biodiversity Conservation Act 1999*). Approved by Delegate of the Minister 13th July 2017. Available: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/17-conservation-advice.pdf

Department of Agriculture, Water and the Environment (DAWE) (2017c)

Approved Conservation Advice for *Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands of the Swan Coastal Plain (s226B of the *Environmental Protection and Biodiversity Conservation Act 1999*). Approved by Delegate of the Minister 13th July 2017. Available: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/18-conservation-advice.pdf

Department of Agriculture, Water and the Environment (DAWE) (as Department of the Environment and Energy) (DAWE) (2019)

Interrogation of Species Profile and Threats (SPRAT) Database using Protected Matters Search Tool. Queried 22/11/19, report reference 8TGOSF. Available: https://www.environment.gov.au/epbc/protected-matters-search-tool.

Department of Biodiversity, Conservation and Attractions (DBCA) (2007-)

*NatureMap: Mapping Western Australia's Biodiversity*. Available: https://naturemap.dpaw.wa.gov.au/. Last accessed May 2020.

Department of Biodiversity, Conservation and Attractions (DBCA) (as Department of Parks and Wildlife) (2013a)

*Definitions, Categories and Criteria for Threatened and Priority Ecological Communities*. Current January 2013. Available: https://www.dpaw.wa.gov.au/images/plants-animals/threatened-species/definitions_categories_and_criteria_for_threatened_and_priority_ecological_communities.pdf

Department of Biodiversity, Conservation and Attractions (DBCA) (as Department of Parks and Wildlife) (2013b)

*A methodology for the evaluation of specific wetland types on the Swan Coastal Plain, Western Australia*. Trial for 12 month period, August 2013.

Department of Biodiversity, Conservation and Attractions (DBCA) (as Department of the Parks and Wildlife) (2016a)

*Ecological Impact and Invasiveness Ratings from the Department of Parks and Wildlife Swan Region Species Prioritisation Process 2016*. Available: https://www.dpaw.wa.gov.au/plants-and-animals/plants/weeds/156-how-does-dpaw-manage-weeds.

Department of Biodiversity, Conservation and Attractions (DBCA) (as Department of the Parks and Wildlife) (2016b)

*Banksia attenuata woodlands over species rich dense shrublands (Swan Coastal Plain community type 20a – Gibson et al. 1994). Interim Recovery Plan No. 359*. Parks and Wildlife, Kensington, Western Australia.

Department of Biodiversity, Conservation and Attractions (DBCA) (2017a)

Threatened and Priority Flora Report Form – Field Manual. Version 1.3, August 2017. Available: https://www.dpaw.wa.gov.au/images/documents/plants-animals/monitoring/forms/threatened-priority-flora-field-manual.pdf

Department of Biodiversity, Conservation and Attractions (DBCA) (2017b)

*A methodology for the evaluation of wetlands on the Swan Coastal Plain*, draft prepared by the Wetlands Section of the Department of Biodiversity, Conservation and Attractions and the Urban Water Branch of the Department of Water and Environmental Regulation, Perth, December 2017.

Department of Biodiversity, Conservation and Attractions (DBCA) (2018)

*List of Threatened Ecological Communities (TECs) Endorsed by the Western Australian Minister for Environment*. Department of Biodiversity, Conservation and Attractions, 28th June 2018

Department of Biodiversity, Conservation and Attractions (DBCA) (2019a)

*Conservation Codes for Western Australian Flora and Fauna.* Current 3rd January 2019. Available: https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/conservation_code_definitions.pdf

Department of Biodiversity, Conservation and Attractions (DBCA) (2019b)

Interrogation of the DBCA Western Australian Herbarium specimen database, Threatened and Priority Flora database and Threatened and Priority Flora List, search performed and data supplied by Main Roads.

Department of Biodiversity, Conservation and Attractions (DBCA) (2019c)

Interrogation of the DBCA Western Australian Threatened and Priority Fauna database, search performed and data supplied by Main Roads.

Department of Biodiversity, Conservation and Attractions (DBCA) (2020a)

Geomorphic Wetlands, Swan Coastal Plain Dataset. Available: https://catalogue.data.wa.gov.au/dataset/geomorphic-wetlands-swan-coastal-plain. Accessed January 2020.

Department of Biodiversity, Conservation and Attractions (DBCA) (2020b)
*Priority Ecological Communities for Western Australia, Version 28*. Species and Communities Program, Department of Biodiversity, Conservation and Attractions, 5th May 2020.

Department of Biodiversity, Conservation and Attractions (DBCA) (2020c)
Carnabys Cockatoo Areas requiring investigation as feeding habitat in the Jarrah Forest IBRA Region (DBCA-056). Department of Biodiversity, Conservation and Attractions. https://catalogue.data.wa.gov.au/dataset/carnabys-cockatoo-unconfirmed-feed-areas-jf

Department of Biodiversity, Conservation and Attractions (DBCA) (2020d)
Carnabys Cockatoo Areas requiring investigation as feeding habitat in the Swan Coastal Plain (SCP) IBRA Region (DBCA-057). Department of Biodiversity, Conservation and Attractions. https://catalogue.data.wa.gov.au/dataset/carnabys-cockatoo-unconfirm-feeding-areas-scp

Department of Environment and Conservation (DEC) (2007)
Records held in DEC's Declared Flora Database and rare flora files, Department of Environment and Conservation, Perth.

Department of Primary Industries and Regional Development (DPIRD) (2019)
Soil-landscape zones Western Australia. Zones derived from soil-landscape mapping (best available) Version April 2018.

Department of Primary Industries and Regional Development (DPIRD) (2020)
Declared Organism Search. Available: http://www.agric.wa.gov.au/organisms. Last accessed June 2020.

Department of Primary Industries and Regional Development (DPIRD) (2020a)
Native Vegetation Extent (DPIRD-005) Department of Primary Industries and Regional Development. https://catalogue.data.wa.gov.au/dataset/native-vegetation-extent

Doughty, P., Ellis, P. and Bray, R. (2019a)
Checklist of the Frogs of Western Australia. Department of Terrestrial Zoology, Western Australian Museum, Welshpool, Western Australia.

Doughty, P., Ellis, P. and Bray, R. (2019b)
Checklist of the Reptiles of Western Australia. Department of Terrestrial Zoology, Western Australian Museum, Welshpool, Western Australia.

Dufrene, M. and Legendre, P. (1997)
Species Assemblages and Indicator Species: The need for a flexible asymmetrical approach. *Ecological Monographs* 67: 345-366.

Dufty, A. C. (1989)
Some population characteristics of *Perameles gunnii* in Victoria. *Wildlife Research* **18**: 355-365.

Environmental Protection Authority (2004)
*Guidance for the Assessment of Environmental Factors – Terrestrial Flora and Vegetation surveys for Environmental Impact Assessment in Western Australia, No. 51, June 2004*. Unpublished report produced by the Environmental Protection Authority, Western Australia.

Environmental Protection Authority (EPA) (2016a)
*Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment*. EPA, Western Australia, December 2016.

Environmental Protection Authority (EPA) (2016b)
*Environmental Factor Guideline – Flora and Vegetation*. Published 13th December 2016 (www.epa.wa.gov.au/).

Environmental Protection Authority (EPA) (2016c)
*Technical Guidance – Terrestrial Fauna Surveys*. EPA, Western Australia.

Environmental Protection Authority (EPA) (2016d)
*Environmental Factor Guideline – Terrestrial Fauna*. EPA, Western Australia, December 2016.

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

Fox, B. J. (1982)
Fire and mammalian secondary succession in an Australian coastal heath. *Ecology* **63**: 1332-1341.

GHD Pty Ltd (2015)
*PSP Pioneer Park Flora and Vegetation Survey.* Unpublished report prepared for GatewayWA Alliance, February 2015.

GHD Pty Ltd (2016)
*Kenwick Freight Facility Flora and Black Cockatoo Habitat Assessment.* Unpublished report prepared for Public Transport Authority, May 2016.

GHD Pty Ltd (2018)
*Thornlie-Cockburn Link Project Flora and fauna survey.* Unpublished report prepared for Public Transport Authority, October 2018.

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

Gill, A. M., Groves, R. H. and Noble, I. R. (Eds). (1981)
*Fire and the Australian Biota*. Australian Academy of Science, Canberra, Australian Capital Territory.

Gleeson, J. and Gleeson, D. (2012)
*Reducing the Impacts of Development on Wildlife*. CSIRO Publishing, Collingwood, Victoria, Australia.

Government of Western Australia (2000)
*Bush Forever Volume 2*. Directory of Bush Forever Sites. Published by the Department of Environmental Protection, Perth.

Government of Western Australia (2019a)
*2018 Statewide Vegetation Statistics (formerly the CAR Reserve Analysis) (Full Report).* Report 1b. Current as of March 2019. WA Department of Biodiversity, Conservation and Attractions. Available: https://catalogue.data.wa.gov.au/dataset/dbca-statewide-vegetation-statistics.

Government of Western Australia (2019b)
*2018 South West Vegetation Complex Statistics Report*. Current as of March 2019. CAR Report SCP External. WA Department of Biodiversity, Conservation and Attractions. Available: https://catalogue.data.wa.gov.au/dataset/dbca/resource/3d067960-2896-42fd-ba52-1aa46b2edf13.

Greenslade, P. J. M. and Jordana, R. (2014)
Description and conservation status of a new species of *Australotomurus* (Collembola: Entomobryidae: Orchesellinae) from urban Perth remnant bushland. *Zootaxa* **3872**: 561-76.

Groom, C. (2011)
*Plants Used by Carnaby's Black Cockatoo.* Department of Environment and Conservation, Perth, Western Australia.

Harrington, R. (2002)
The effects of artificial watering points on the distribution and abundance of avifauna in an arid and semi-arid mallee environment. PhD thesis. Department of Zoology, Univesity of Melbourne, Melbourne, Victoria.

Harvey, M. S. (2002)
Short-range endemism among the Australian fauna: some examples from non-marine environments. *Invertebrate Systematics* **16**: 555-570.

Heddle, E.M., Havel, J.J. and Loneragan, O.W. (1980)
*Vegetation Complexes of the Darling System, Western Australia*. In: Atlas of natural resources darling system, Western Australia. Department of Conservation and Environment, Perth.

Hill, A.L., Semeniuk, C.A., Semeniuk, V. and Del Marco, A. (1996)
*Wetlands of the Swan Coastal Plain* (Vol. 2). Wetland mapping, classification and evaluation. Water and Rivers Commission and Department of Environmental Protection.

How, R. A. and Dell, J. (1990)
Vertebrate fauna of Bold Park, Perth. *Western Australian Naturalist* **18**: 122-131.

IUCN. (2012)
*IUCN Red List Categories and Criteria, Version 3.1. Second edition*. International Union for the Conservation of Nature, Gland, Switzerland and Cambridge, UK.

Jackson, S. D. and Griffin, C. R. (2000)
A Strategy for Mitigating Highway Impacts on Wildlife. In: Messmer, T. A. and West, B. (Eds), *Wildlife and Highways: Seeking Solutions to an Ecological and Socio – economic Dilemma,* pp. 143-159. The Wildlife Society,

Johnstone, R. E. and Kirkby, T. (1999)
Food of the Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso* in south-west Western Australia. *The Western Australian Naturalist* 22: 167-177.

Johnstone, R. E. and Kirkby, T. (2008)
Distribution, status, social organisation, movements and conservation of Baudin's Cockatoo (*Calyptorhynchus baudinii*) in South-west Western Australia. *Records of the Western Australian Museum* 25: 107-118.

Johnstone, R.E. and Storr, G.M. (1998)
Handbook of Western Australian Birds. Volume 1: Nonpasserines (Emu to Dollarbird). Western Australian Museum, Perth.

Johnstone, R.E. and Storr, G.M. (2004)
Handbook of Western Australian Birds. Volume 2: Passerines (Blue-winged Pitta to Goldfinch). Western Australian Museum, Perth.

Jones, M. E. (2000)
Road upgrade, road mortality and remedial measures: impacts on a population of Eastern Quolls and Tasmanian Devils. *Wildlife Research* **27**: 289-296.

Keighery, B.J., Keighery, G.J., Longman, V.M. and Clarke, K.A. (2012)
*Native and Weed Flora of the Southern Swan Coastal Plain: 2005 Dataset*. Department of Environment and Conservation, Kensington, WA.

Keighery, G.J. (1993)
'Re-discovery of Tetraria australiensis C.B.Clarke (Cyperaceae)', *Western Australian Naturalist, Vol. 19.*

Keighery, G.J. (2001)
Taxonomic notes on the genus Johnsonia (Anthericaceae). *Nuytsia* 13 (3): 479-481.

Kofoed, P. (1998)
A wizard with wavelengths. *Ecos* **96**: 32-35.

Lee, J. G. H., Finn, H. C. and Calver, M. C. (2013)
Ecology of black cockatoos at a mine-site in the eastern jarrah-marri forest, Western Australia. *Pacific Conservation Biology* 19: 76-90.

Letnic, M., Dickman, C. R., Tischler, M. K., Tamayo, B. and Beh, C. L. (2004)
The responses of small mammals and lizards to post-fire succession and rainfall in arid Australia. *Journal of Arid Environments* **59**: 85-114.

McCune, B. and Mefford, M.J. (2011)
*PC-Ord. Multivariate Analysis of Ecological Data, Version 6.08.* MjM Software, Gleneden Beach, Oregon.

Metcalf, B. and Bamford, M. (2003)
*Western Power; southern terminal to Cannington terminal transmission line. Review of faunal impacts.* Unpublished report prepared for Woodman Environmental

Moulds, T. (2019)
Conservation Significant and Short Range Endemic invertebrate desktop habitat assessment for Thornlie-Cockburn Link Proposal, Perth, Western Australia. Unpublished report for the Public Transport Authority by Invertebrate Solutions, Victoria Park, Western Australia.

Mueller-Dombois, D. and Ellenberg, H. (1974)
*Aims and Methods of Vegetation Ecology*. Wiley and Sons, Canada.

Natural Area Holdings Pty Ltd (Natural Area) (2015)
*Hartfield Park Flora Survey*. Unpublished report prepared for the Shire of Kalamunda, February 2015.

Perth Airport Pty Ltd (Perth Airport) (2018)
*New Runway Project Preliminary Draft Major Development Plan*. Volume B: Environment, Heritage and Traffic Assessment. May 2018. Available: https://www.perthairport.com.au/Home/corporate/planning-and-projects/projects/new-runway-project/section-downloads.

Purdie, B R, Tille, P J, and Schoknecht, N R. (2004)
*Soil-landscape mapping in south-Western Australia: an overview of methodology and outputs*. Department of Agriculture and Food, Western Australia. Report 280, 160p.

Rentz, D. C. F. (1993)
*Tettigoniidae of Australia 2. The Austrosaginae, Zaprochilinae and Phasmodinae*. CSIRO Publishing, Australia.

Rich, C. and Longcore, T. (Eds). (2006)
*Ecological Consequences of Artificial Night Lighting*. Island Press, Washington D.C., USA.

Rix, M. G., Huey, J. A., Cooper, S. J. B., Austin, A. D. and Harvey, M. S. (2018)
Conservation systematics of the shield-backed trapdoor spiders of the nigrum-group (Mygalomorphae, Idiopidae, Idiosoma): integrative taxonomy reveals a diverse and threatened fauna from south-western Australia. *ZooKeys* **756**: 1-121.

Scheick, B. K. and Jones, M. D. (1999)
Locating wildlife underpasses prior to expansion on Highway 64 in North Carolina. In: Evink, G. L., Garrett, P. and Ziegler, D. (Eds), *Proceedings of the Third International Conference on Wildlife Ecology and Transportation,* pp. 247-252. Florida Department of Transportation, Tallahassee, Florida, USA.

Shepherd, B., Bamford, M.J. and Bamford, A.R. (2018)
*City of Armadale Reserves, Forrestdale Lake Nature Reserve Fauna Survey.* Unpublished report prepared for the City of Armadale

Sneath, P.H.A, and Sokal, R.R. (1973)
*Numerical Taxonomy: The Principles and Practice of Numerical Classification*. Published by Freeman, San Francisco.

Sommer, B and Froend R (2011)
*Resilience of phreatophytic vegetation to groundwater drawdown: is recovery possible under a drying climate?* J Ecohydrology. 4: 67-82.

Soule, M. E., Mackey, B. G., Recher, H. F., Williams, J. E., Woinarski, J. C. Z., Driscoll, D., Dennison, W. C. and Jones, M. E. (2004)
The role of connectivity in Australian conservation *Pacific Conservation Biology* **10**: 266-279.

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

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1990)
Lizards of Western Australia. III. Geckoes and Pygopods. Western Australian Museum, Perth.

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

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

Strategen Environmental (2016)
*Spring Flora and Vegetation Survey and Targeted Conospermum undulatum Search, Lot 107 Clifford Road, Maddington (CPS7063/1).* Unpublished report prepared for Juceda Investments Pty Ltd, 2016.

Strategen Environmental (2019)
*Tonkin Highway Welshpool Road to Hale Road Vegetation condition assessment.* Unpublished report prepared for Main Roads WA, June 2019.

Thiele, K.R. (2019)
A revision of the *Hibbertia commutata* (Dilleniaceae) species group. *Australian Systematic Botany*, 32(1), 71-109.

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

Travouillon, K. (2019)
Checklist of the Mammals of Western Australia. Department of Terrestrial Zoology, Western Australian Museum, Welshpool, Western Australia.

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

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

Van Dyck , S.and Strahan, R. (eds) (2008)
The Mammals of Australia. 3rd Edition. Australian Museum/Reed Books, Sydney.

Webb A, Kinloch J, Keighery G, Pitt G (2016)
*The extension of vegetation complex mapping to landform boundaries within the Swan Coastal Plain landform and forested region of south-west Western Australia*. Department of Parks and Wildlife, Bunbury, Western Australia.

Western Australian Herbarium (WA Herbarium) (1998-)
*Florabase*. Available: https://florabase.dpaw.wa.gov.au/. Last accessed August, 2019.

Wilson, S. and Swan, G. (2017)
*A Complete Guide to Reptiles of Australia* New Holland, Australia.

Woodman Environmental Pty Ltd (Woodman Environmental) (2019)
*Perth Airport Estate Flora and Vegetation Assessment*. Unpublished report (PAIR18-71-01) prepared for Perth Airport Pty Ltd, November 2019.

360 Environmental Pty Ltd (360 Environmental) (2018)
*Roe Highway and Kalamunda Road Upgrade Flora, Vegetation, Fauna and Black Cockatoo Assessment.* Unpublished report (Report ref. 2385AB) prepared for Main Roads WA, January 2018.