Appendix A Morley-Ellenbrook Line - Environmental Constraints Desktop Analysis

Morley-Ellenbrook Line
Environmental Constraints Desktop Analysis

Public Transport Authority

MEL-MNO-ELA-EN-RPT-0002.01

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Template 2.8.1

Executive Summary

The Morley-Ellenbrook Line (MEL), a component of the State government's METRONET program to increase the size of Perth's railway network, will connect the existing Midland line to Perth's northeast suburbs, terminating in Ellenbrook. As the MEL is likely to require environmental approvals under the State *Environmental Protection Act 1986* (EP Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), this report has been prepared to identify known and potential environmental constraints relevant to the MEL project.

A desktop assessment of publicly available information, reports relevant to the MEL project and reports for areas within the immediate vicinity of the MEL project and a literature review of relevant environmental reports provided by the Public Transport Authority (PTA) has been undertaken to inform this environmental constraints desktop analysis. A summary of key findings is presented in Table ES-1.

Table ES-1: Key findings of the environmental constraint desktop analysis

Environmental Factor	Key environmental constraints
Flora and Vegetation	• Banksia Woodlands of the Swan Coastal Plain Threatened Ecological Community (TEC) (confirmed) / Banksia dominated woodlands of the Swan Coastal Plain IBRA region Priority Ecological Community (PEC) (confirmed). • Three State-listed Priority flora species. • Regionally significant vegetation within five Bush Forever sites. • Gnangara-Moore River State Forest. • Groundwater dependent ecosystems. • Three ecological linkages associated with the Reid Highway road reserve, Bennett Brook and Whiteman Park.
Terrestrial Fauna	• Various fauna habitat types, some of which have the potential to support conservation significant fauna, in particular areas of woodland, wetland and dampland with intact native vegetation through the Malaga, Whiteman Park South and Lord Street sections of the ERB. • Black cockatoo habitat including: o Known foraging habitat for Carnaby's Cockatoo and Forest Red-tailed Black Cockatoo, and potential foraging habitat for Baudin's Cockatoo, which may visit irregularly and infrequently; o Potential roosting habitat for all three species of black cockatoo; and o Potential breeding habitat for Forest Red-tailed Black Cockatoo and Carnaby's Cockatoo. • Confirmed occurrence of Quenda and Glossy Ibis and possible occurrence of nine other species of conservation significance. • Conservation areas with importance for fauna habitat and connectivity values including Bush Forever sites, wetlands and Bennett Brook. • Management of the kangaroo population in and around Whiteman Park.
Terrestrial Environmental Quality	• High probability of acid sulfate soils (ASS) occurrence in low lying areas in the northern half of the environmental review boundary (ERB). • 24 registered classified contaminated sites. • Possibility of further *Possibly Contaminated – Investigation Required* sites.

Environmental Factor	Key environmental constraints
Inland Waters	• 10 conservation category wetlands. • Gnangara Mound Public Drinking Water Source Area (PDWSA). • Bennett Brook. • Water quality. • Groundwater contamination.
Social Surroundings	• Aboriginal heritage sites. • European heritage sites in the Bayswater area. • Whiteman Park, particularly its social, recreational and conservation values
Subterranean Fauna	Due to low species richness on the Swan Coastal Plain and low likelihood of highly restricted distributions, subterranean fauna is not likely to pose a key environmental constraint to the environmental approvals process for the MEL project. However, information on the project area is limited.
Landforms	No landforms are present within the project area that are likely to be considered 'significant landforms' by the EPA. Therefore, landforms are not expected to be a key environmental constraint to environmental approvals process for the MEL project.
Matters of National Environmental Significance	• One listed TEC: o Banksia Woodlands of the Swan Coastal Plain (SCP) ecological community (confirmed). • Two listed Threatened fauna species recorded within the ERB including: o Carnaby's Cockatoo; o Forest Red-tailed Black Cockatoo. • Five listed Threatened fauna species likely or with potential to occur in the ERB: o *Apus pacificus* (Fork-tailed Swift); o *Ardea modesta* (Eastern Great Egret); o *Calyptorhynchus baudinii* (Baudin's Cockatoo); o *Botaurus poiciloptilus* (Australasian Bittern); and o *Galaxiella nigrostriata* (Black-stripe minnow). • One listed Threatened flora species: o Grand Spider Orchid (*Caladenia huegelii*) (potential) • One listed migratory species recorded within the ERB: o Glossy Ibis (*Plegadis falcinellus*)

A fuller and more comprehensive understanding of some of the key constraints listed in Table ES-1 will be required in order to support future environmental impact assessment. Additional work will be required to:

- meet the relevant technical guidance in terms of scope, currency and quality of studies and investigations;
- address spatial gaps in existing survey coverage; and
- conduct more thorough investigations building on existing preliminary studies and/or with more project-specific design information as the project is further developed and defined.

The conclusions from this environmental constraints desktop analysis shall inform the next steps for the approval process for the MEL project. Recommendations will be provided to the PTA separately.

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Abbreviations

Abbreviation	Description
ASRIS	Australian Soil Resource Information System
ASS	acid sulfate soils
BAM Act	*Biosecurity and Agriculture Management Act 2007*
BC Act	*Biodiversity Conservation Act 2016*
CCW	conservation category wetland
DAA	Department of Aboriginal Affairs
DAF	Department of Agriculture and Food
DBCA	Department of Biodiversity Conservation and Attractions
DBH	diameter at breast height
DotEE	Department of the Environment and Energy
DPIRD	Department of Primary Industries and Regional Development
DWER	Department of Water and Environmental Regulation
ELA	Eco Logical Australia
EP Act	Environmental Protection Act 1986
EPA	Environmental Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ERB	environmental review boundary
ERBT	Ellenbrook Rapid Bus Transit
FAL	Forrestfield Airport Link
FCT	floristic community type
FRTBC	Forest Red-Tailed Black Cockatoo
GDE	groundwater dependent ecosystem
IBRA	Interim Biogeographic Regionalisation for Australia
LWDF	Liquid Waste Disposal Facility
MEL	Morley Ellenbrook Line
MNES	Matters of National Environmental Significance
MUW	multiple use wetland
NVIS	National Vegetation Information System
PDNH	Perth-Darwin National Highway
PDWSA	Public Drinking Water Source Area
PEC	Priority Ecological Community
PMST	Protected Matters Search Tool
PSI	Preliminary Site Investigation
PTA	Public Transport Authority

Abbreviation	Description
REW	resource enhancement wetland
RIWI Act	*Rights in Water and Irrigation Act 1914*
SCP	Swan Coastal Plain
SLIP	Landgate Shared Locations Information Platform
SRE	short-range endemic
TEC	Threatened Ecological Community
TGS	Tonkin Grade Separation
WAH	Western Australian Herbarium
WAOL	Western Australian Organism list
WONS	Weeds of National Significance

1. Introduction

1.1 Project description

The Morley-Ellenbrook Line (MEL) is a component of the State government's METRONET program, a program of projects to increase the size of Perth's railway network and support the growth of the Perth metropolitan region. The Public Transport Authority (PTA) has responsibility for the implementation of the MEL, which will connect the existing Midland line, east of Bayswater, to Perth's northeast suburbs, terminating at Ellenbrook. Existing communities will be supported by the MEL project through improved transport connections, and new communities are intended to be created through integrated station precincts.

1.2 Legislative approvals process

The MEL project is likely to require environmental approvals under the State *Environmental Protection Act 1986* (EP Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It is anticipated that a proposal will be referred to the Department of the Environment and Energy (DotEE) and to the Environmental Protection Authority (EPA) and that the EPA will set a 'Public Environmental Review' level of assessment.

1.3 Scope and purpose of this report

Work undertaken to inform this report includes:

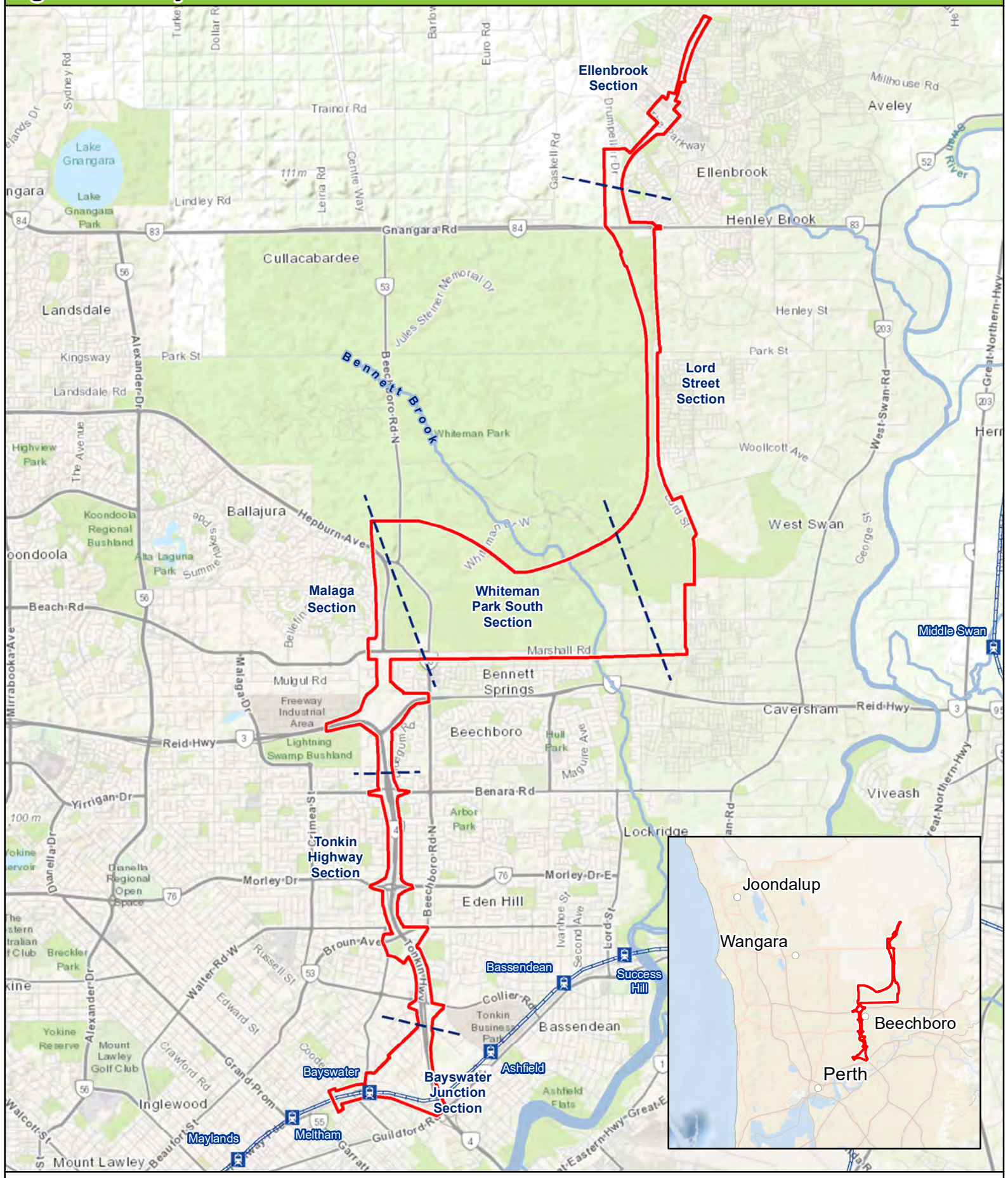
- A desktop assessment of publicly available information and reports relevant to the environmental values of the MEL project area and immediate vicinity.
- A literature review of all relevant environmental reports and information provided to ELA by the PTA.

The purpose of this report is to identify known and potential environmental constraints relevant to the MEL project. This work will guide efforts in relation to obtaining approvals through EPA and the Department of the Environment and Energy (DotEE) environmental impact assessment processes. Recommendations for further work are not included in this report but will be provided to the PTA separately.

The PTA has provided a study area on which to base this desktop assessment and literature review. The boundary of the study area is shown in Figure 1-1 and is referred to in subsequent chapters as the environmental review boundary (ERB). For the purposes of discussion within this report, portions of the ERB are referred to using six labels relating to sections of the ERB, with approximate boundaries of the sections shown on Figure 1-1. From south to north, these sections are:

- Bayswater Junction section
- Tonkin Highway section
- Malaga section
- Whiteman Park South section
- Lord Street section
- Ellenbrook section

Figure 1-1: Project location



Legend

- Environmental review boundary
- Railway station
- Railway line
- Reserve

0 0.5 1 2
Kilometres
Datum/Projection:
GDA 1994 MGA Zone 50

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1.4 Format of this document

This document has been structured in accordance with the factors and matters underpinning the respective EPA and DotEE environmental impact assessment and approval processes. Table 1-1 lists the EPA's environmental factors (EPA 2018a) and the matters addressed by the EPBC Act (matters of national environmental significance (MNES) and other matters) and identifies relevance and in which chapters these have been considered in this review.

Table 1-1: EPA factors and matters protected under the EPBC Act

EPA theme	Factor	Relevance	Chapter
Land	Flora and Vegetation	Relevant	2
	Terrestrial Fauna	Relevant	3
	Terrestrial Environmental Quality	Relevant	5
	Subterranean Fauna	Possibly relevant	7
	Landforms	Possibly relevant	8
Water	Inland Waters	Relevant	4
People	Social Surroundings	Relevant	6
	Human Health	Not relevant. EPA assessment of the Human Health factor is limited to consideration of radiation. Radiation is not expected in association with construction of a railway or associated infrastructure, and as such Human Health does not represent a constraint to environmental approvals for the MEL project.	–
Air	Air Quality	Not relevant. Based on assessment of recent PTA projects, Air Quality is not expected to represent a major consideration in, or constraint to, environmental approvals. Impacts to air quality as a result of the MEL project is expected to be positive based on a comparison with conventional vehicle modes of transport, though information to support this was not available for review.	–
Sea	All Factors	Not relevant. Marine and coastal values are not present within the vicinity of the project.	–
Matter type	**EPBC matter**	**Relevance**	**Chapter**
MNES	World and national heritage	Not relevant. There are no world or national heritage sites in proximity to the environmental study area.	–
	Wetlands of international importance	Not relevant. There are no wetlands of international importance (Ramsar listed) in proximity to the environmental study area.	–
	Listed threatened species and ecological communities	Relevant	9
	Migratory species	Relevant	9
	Commonwealth marine areas	Not relevant	–
	Nuclear actions	Not relevant	–

EPA theme	Factor	Relevance	Chapter
	Water resource (coal related)	Not relevant	–
Other matters	Commonwealth land	Not relevant. PTA have advised there is no Commonwealth land within the ERB.	–
	Commonwealth agencies	Not relevant	–

1.5 Information sources

Eco Logical Australia (ELA) has interrogated a range of publicly available datasets and databases to support this review. Details of these searches are provided in subsequent sections of the report.

In addition, ELA was provided with a range of documents and information by the PTA relating to projects undertaken by the PTA and others within and adjacent to the ERB. A literature review was undertaken including, but not limited to, documents relating to the projects listed in Table 1-2.

Table 1-2: Projects for which literature was provided to contribute to the review

Infrastructure projects	Urban or industrial land use change	Locality assessments
Ellenbrook Rapid Bus Transit	Albion	Bennett Brook catchment
Forrestfield Airport Link	Balwyn Estate	City of Bayswater
New Lord Street	Bennett Springs	City of Swan
Perth Darwin National Highway Swan Valley Section (NorthLink)	Brabham	Ellenbrook
Reid Highway	Caversham	Swan Canning catchment
Tonkin Grade Separations (NorthLink)	Dayton	Whiteman Park
Tonkin Highway	Ellenbrook Village	
	Henley Brook	
	Marshall Road precinct	
	North-East Urban Grown Corridor	
	West Ellenbrook	
	West Swan East	
	West Swan West	
	Whiteman Edge	

2. Flora and Vegetation

The EPA defines flora as native vascular plants and vegetation as groupings of different flora patterned across the landscape that occur in response to environmental conditions. The EPA is of the view that vegetation can be an effective surrogate for ecological processes and the diversity of interactions in terrestrial ecosystems.

The EPA's objective for the flora and vegetation factor is "to protect flora and vegetation so that biological diversity and ecological integrity are maintained" (EPA 2016a).

This chapter provides information relating to flora and vegetation in association with the ERB and identifies associated potential constraints to the MEL project.

2.1 Relevant guidance

The following policies and guidance are relevant to the flora and vegetation factor:

- Environmental Factor Guideline: Flora and Vegetation (EPA 2016a).
- Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016b).
- State Planning Policy No. 2.8 Bushland Policy for the Perth Metropolitan Region (WAPC 2010).

2.2 Information sources

2.2.1 Databases searches

The following database search was undertaken to support this analysis:

- DotEE Protected Matters Database for MNES.

Other database searches have been completed as part of a recent flora and vegetation assessment undertaken for the MEL project (RPS 2018a), including:

- Department of Biodiversity Conservation and Attractions (DBCA) Threatened and Priority Flora Database, and the Western Australian Herbarium (WAH) Specimen Database.
- DBCA Threatened Ecological Community (TEC)/Priority Ecological Community (PEC) database.
- Department of Primary Industries and Regional Development (DPIRD) Declared Plants list.
- Department of Agriculture and Food (DAF) Western Australian Organism List (WAOL) pursuant to the *Biosecurity and Agriculture Management Act 2007* (BAM Act).

RPS (2018) conducted the searches using a project area approximately equivalent to the ERB, with an alternative route between Malaga and Ellenbrook via the Perth–Darwin National Highway (PDNH) also included. As a 5 km buffer was used (3 km buffer for ecological communities), these searches are considered to adequately cover the ERB in full and as such have not been repeated for this analysis.

2.2.2 Reports provided by the PTA or publicly available

Several flora and vegetation surveys have been undertaken that intersect the ERB. The surveys varied between Level 1, Level 2, reconnaissance, detailed and targeted levels, as defined by the relevant guidance in effect at the time of survey. The primary reports that have been reviewed are RPS (2019a), Terratree (2017), AECOM (2016), Coffey (2015a), GHD (2014) and 360 Environmental (2014a). A targeted search for *Caladenia huegelii* was undertaken by RPS (2019b). This report and a desktop assessment by Jacobs (2018) were also reviewed. A summary of key surveys and reports relevant to the ERB is provided in Table 2-1.

Table 2-1: Key reports reviewed relevant to flora and vegetation

Title	Author	Year	Summary of scope	Year of fieldwork
Field surveys				
Detailed Flora and Vegetation Assessment: METRONET Ellenbrook Alignment (Draft Report)	RPS Australia West Pty Ltd	2019	Level 2 Flora and Vegetation Survey Assessment (in accordance with EPA's Technical Guidance: *Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016b)). To describe flora and vegetation values of the survey area and determine the spatial location and conservation significance of these values.	2017, 2018
Morley-Ellenbrook Line: Targeted *Caladenia huegelii* Search 2018	RPS Australia West Pty Ltd	2019	Targeted search for *Caladenia huegelii* (Grand Spider Orchid) (in accordance with Guidelines for Detecting Orchids listed as 'threatened' under EPBC Act (Commonwealth of Australia 2013)). To identify any individual *Caladenia huegelii* within remnant Banksia woodland vegetation within the MEL indicative development envelopment.	2018
MEL Flora and Vegetation Detailed Assessment – Progress update	RPS Australia West Pty Ltd	2018	A progress report detailing further survey effort from the detailed flora and vegetation assessment (in accordance with EPA's Technical Guidance: *Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016b)). To Identify the flora and vegetation, identify the presence and extent of conservation significant flora and ecological communities.	2018
Level 2 Flora and Vegetation Assessment of Hepburn, Beechboro, and Marshall Road Sites	Terratree	2017	Level 2 Flora and Vegetation Assessment (in accordance with EPA's Guidance Statement No. 51 *Terrestrial Flora and Vegetation Surveys for Environmental Impact in Western Australia* (EPA 2004) and Technical Guidance*: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016b)). To inform a feasibility study.	2016
Ellenbrook Bus Rapid Transit Biological Assessment	AECOM Australia Pty Ltd	2016	Level 1 Flora and Vegetation Assessment (in accordance with EPA's Guidance Statement No. 51 *Terrestrial Flora and Vegetation Surveys for Environmental Impact in Western Australia* (EPA 2004)). To identify key flora and vegetation values of the study area.	2015
Level 2 Flora and Vegetation Assessment:	Coffey	2015	Level 2 Flora and Vegetation Assessment (in accordance with EPA's Guidance Statement No. 51 *Terrestrial Flora and Vegetation Surveys for Environmental Impact in*	2014

Title	Author	Year	Summary of scope	Year of fieldwork
Perth-Darwin National Highway			*Western Australia* (EPA 2004)). To identify and assess the values and significance of the flora and vegetation, describe and assess the potential direct and indirect impacts.	
Forrestfield Airport Link Environmental Investigation	GHD Pty Ltd	2014	Level 1 Flora Assessment (Reconnaissance survey) and Level 2 Targeted spring flora survey (in accordance with EPA Guidance Statement No. 51. *Terrestrial Flora and vegetation Surveys for Environmental Impact in Western Australia* (EPA 2004)). To verify the accuracy of the desktop study, delineate and characterise the flora and range of vegetation units and identify potential impacts.	2013
Flora, Vegetation and Fauna Survey: Tonkin Grade Separations	360 Environmental	2014	Level 1 Flora and Vegetation Assessment (in accordance with EPA Guidance Statement No. 51. *Terrestrial Flora and vegetation Surveys for Environmental Impact in Western Australia* (EPA 2004)). To identify potential constraints and assist the preliminary evaluation of potential impacts to flora and vegetation communities.	2013
Desktop assessments				
Morley to Ellenbrook Route protection study	JACOBS	2018	Environment and Heritage Assessment (Desktop only). Option 2 assessed through multi criteria process, which included environmental and heritage impacts to determine a preferred overall corridor alignment.	–

2.2.3 Information coverage

Several Level 1 and 2 flora and vegetation surveys have been undertaken within the ERB. Collectively these studies provide considerable information regarding the vegetation assemblages present within the ERB; however, there are areas within the ERB that have not had on-ground survey.

The GHD (2014) study for Forrestfield Airport Link (FAL) generally covers the Bayswater Junction section of the MEL, the southernmost section of the ERB. The study does not cover the western extent of the ERB around Bayswater Station. In the zone broadly from the existing Midland Line to Tonkin Highway, south of the Collier Road intersection, the GHD study area is limited to the industrial and vegetated areas between Clavering Road, Bassendean Road and Tonkin Highway. Parts of the ERB not covered by GHD (2014) are mostly residential, commercial and industrial land uses; however, there are a small number of public open space or road reserves with vegetation.

The 360 Environmental (2014a) study for the Tonkin Grade Separations project (TGS) generally covers the Tonkin Highway section of MEL. The study area covers the Tonkin Highway road reserve from approximately Railway Parade in the south to Reid Highway interchange in the north. Parts of the ERB not covered by 360 Environmental include Wotton Reserve and parts of Addlestone Reserve to the east of the ERB and small industrial or residential areas along Tonkin Highway.

The southern section of PDNH coincides with the Malaga section of the MEL. The Coffey (2015a) study area covers the Tonkin Highway and Reid Highway road reserves as well as an area north along Hepburn Avenue and Beechboro Road North, which is the study area's approximate eastern extent.

The AECOM (2016) study for the Ellenbrook Bus Rapid Transit (ERBT) project generally corresponds to the Lord Street and Ellenbrook sections of the MEL. The study area covers a narrow strip parallel to and west of Lord Street south of Marshall Road, intersects Lord Street at Youle-Dean Road, follows Drumpellier Drive to The Promenade in Ellenbrook. Parts of the ERB not covered by AECOM (2016) include the section north of The Promenade and a narrow strip west of Drumpellier Drive.

The following surveys have been undertaken for the MEL project by RPS (2018, 2019a,b):

- A detailed flora and vegetation survey of previously unsurveyed intact remnant native vegetation within their study area (along Beechboro Road North, within Whiteman Park South section and the southern section of Lord Street).
- A reconnaissance flora and vegetation survey of the remainder of their study area (entire length of the ERB, limited to areas that "do not represent 'intact remnant native vegetation'" but excluding a small part in the Whiteman Park South section).
- Targeted Threatened and Priority Flora survey of known or potentially suitable habitat for each targeted species within their project area. The Grand Spider Orchid (*Caladenia huegelii*) was searched for in September 2018 (within remnant Banksia Woodland areas) and other target species in October and December 2018.

The aforementioned RPS (2018) study generally considered the entire length of the ERB, though not always at the full width of the ERB. The study also considered an alternative route from Malaga to Ellenbrook via the PDNH, though this is not part of the ERB. The survey for this study was limited to discrete areas within the northern half of the ERB. Supplementary fieldwork was undertaken in 2018 as an update to the 2017 fieldwork documented in RPS (2018). Unlike the earlier report on the 2017 fieldwork (RPS 2018), the 2019 report (RPS 2019a) focuses only on the northern half of the current ERB. RPS (2019a) is therefore the primary source of information for the Whiteman Park South section, which includes the Marshall Road paddock. However, it includes neither the portion of the ERB south of Marshall Road beneath Western Power's 330 kV transmission lines nor the southwest corner of Whiteman Park east of Beechboro Road North and north of the Marshall Road paddock.

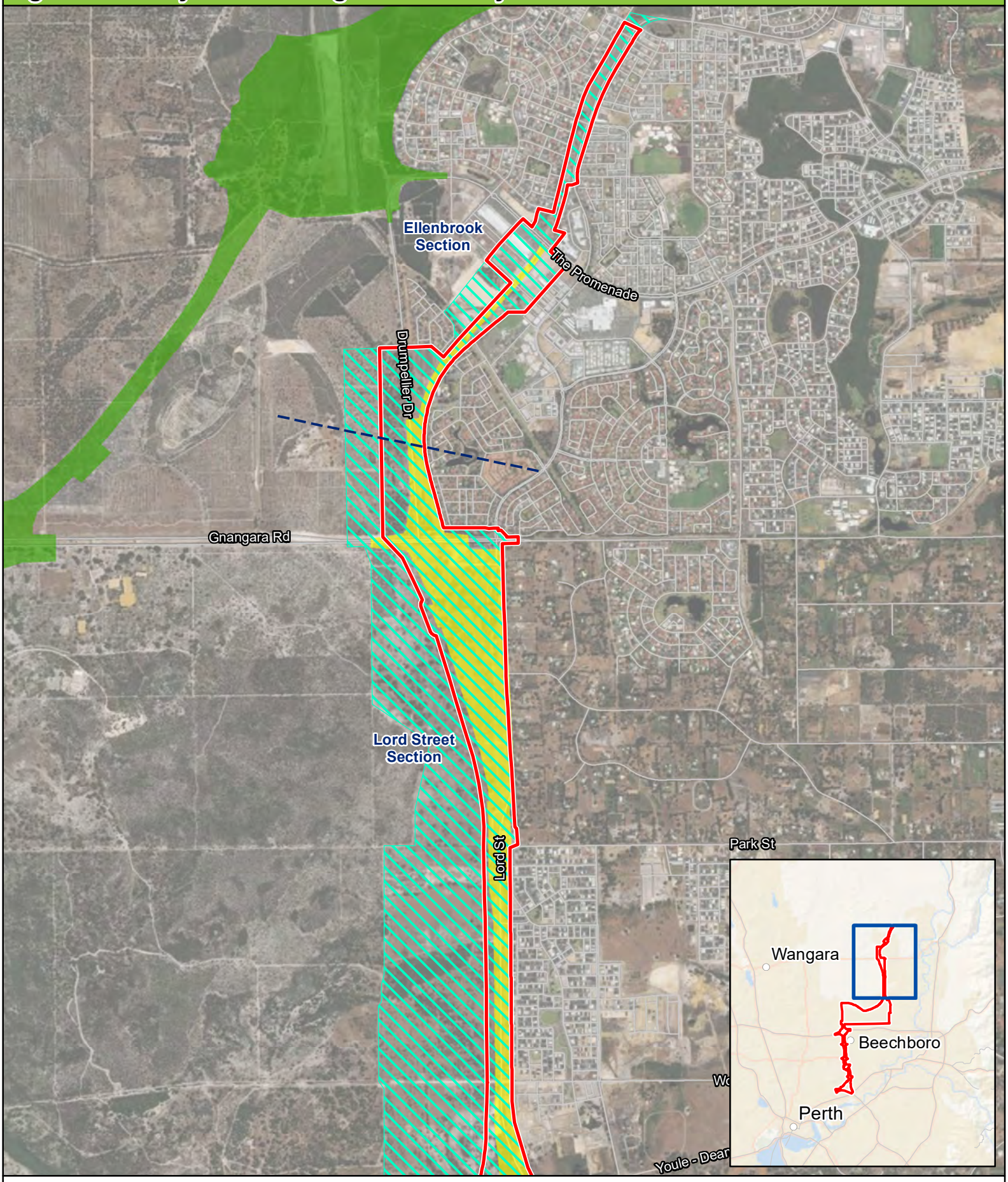
Given the recent nature of all these projects (2014 to 2018), the information within the reports is considered by ELA to be generally sufficient for the identification of values relating to the flora and vegetation within the ERB. It should be noted that while previous reports/surveys have indicated the presence of an environmental value, as a result of the project's implementation these values may no longer be present. Further verification of presence/ absence may be required at a later date.

As indicated, the ERB includes some areas that have not been specifically covered in the abovementioned previous surveys, namely:

- The southwest corner of Whiteman Park, east of Beechboro Road North and north of the Marshall Road paddock.
- Private landholdings in the Whiteman Park South section.

Figure 2-1 shows the extent of previous flora and vegetation surveys undertaken in relation to the ERB.

Figure 2-1a: Key flora and vegetation survey areas



Legend

- Environmental review boundary
- Level 2 Flora and Vegetation Assessment, 2018 (RPS 2019)
- Level 2 Flora and Vegetation Assessment, 2014 (Coffey 2016)
- Level 1 Flora and Vegetation Assessment, 2015 (AECOM 2016)

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

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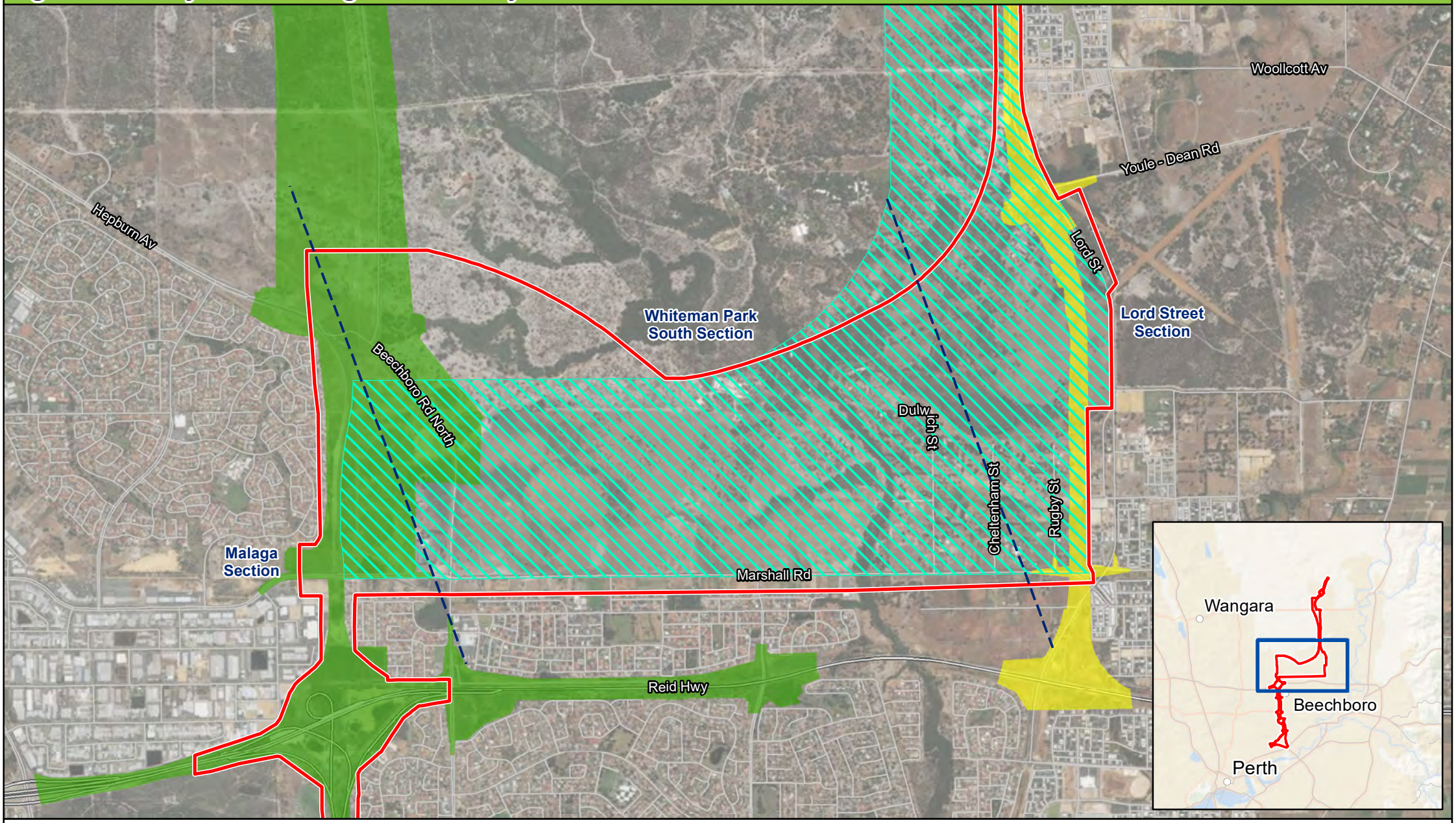
Figure 2-1b: Key flora and vegetation survey areas



Legend

- Environmental review boundary
- Level 2 Flora and Vegetation Assessment, 2018 (RPS 2019)
- Level 2 Flora and Vegetation Assessment, 2014 (Coffey 2016)
- Level 1 Flora and Vegetation Assessment, 2015 (AECOM 2016)

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

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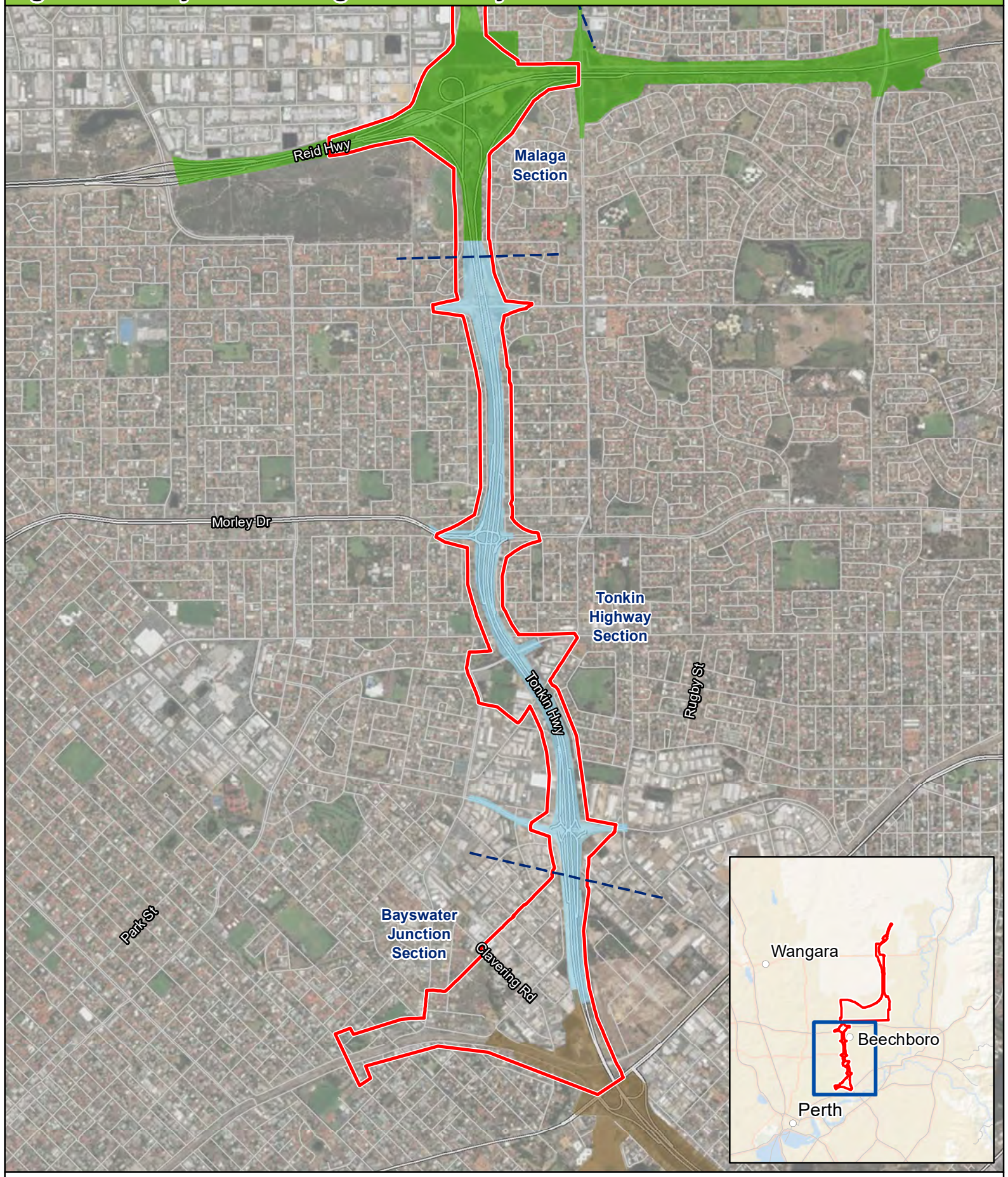
Figure 2-1c: Key flora and vegetation survey areas



Legend

- Environmental review boundary
- Level 2 Flora and Vegetation Assessment, 2014 (Coffey 2016)
- Level 2 Targeted Flora assessment, 2013 (GHD 2014)
- Level 1 Flora and Vegetation Assessment, 2013 - Indicative only (360 Environmental 2014)

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

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2.3 Description of relevant environmental values

2.3.1 Regional vegetation

2.3.1.1 Beard vegetation mapping

The ERB is located on the Swan Coastal Plain and has been broadly characterised by Beard (1990). It is within the Drummond Botanical Subdistrict of the Swan Coastal Plain Subregion (Beard 1990). This subdistrict comprises *Banksia* spp. low woodland on leached sands with *Melaleuca* spp. swamps in poorly drained areas, woodland of Tuart (*Eucalyptus gomphocephala),* Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) on less leached sands.

The Perth region was mapped by Beard (1979) at a 1:250,000 scale and Shepherd et al. (2002) has updated it to reflect the National Vegetation Information System (NVIS) standards. There are four broad-scale vegetation associations (Beard 1979, Shepherd et al. 2002) within the ERB (Table 2-2).

Table 2-2: Broad-scale vegetation associations within the ERB

Vegetation Association	Description
1001	Medium very sparse woodland; Jarrah, with low woodlands; Banksia and Casuarina (*Casuarina obesa)*
1018	Mosaic: Medium forest; Jarrah-Marri / Low woodland; Banksia/ Low forest; Teatree (*Melaleuca* spp.) / Low woodland; *Casuarina obesa*
1009	Medium woodland; Marri and River Gum
949	Low woodland; *Banksia* spp.

The extent of the vegetation associations within State, Swan Coastal Plain (SCP) bioregion and local government boundaries are provided in Table 2-3. Vegetation association 949 has over 50% of its pre-European extent remaining within the Perth (SWA02) Bioregion, however vegetation associations 1001, 1018 and 1009 have between 10% and 30% of their pre-European extent remaining within the Perth (SWA02) Bioregion. Vegetation may be considered significant for a number of reasons including but not limited to restricted distribution and degree of historical impact from threatened processes (such as clearing) (EPA 2016a). The National Objectives and Targets for Biodiversity Conservation 2001 – 2005 recognises that the retention of 30% of pre-European vegetation communities is important for biological diversity (Environment Australia 2001). Within more constrained and intensely developed areas of the Perth Metropolitan Region, the retention target for vegetation complexes is reduced to 10% of pre-European extents (EPA 2015). The ERB is located within the area subject to the lower 10% retention target.

Table 2-3: Vegetation system associations

Vegetation Association	Scale	Pre-European extent (ha)	Current extent (ha) remaining	% Pre-European extent remaining	% of current extent in secure tenure
1001	Western Australia	57,410	12,792	22.28%	2.80%
	SWA02 Bioregion	57,410	12,792	22.28%	2.80%
	City of Swan	8,868	2,354	26.54%	2.21%
	City of Bayswater	2,848	84.97	2.98%	0.00%
1018	Western Australia	14,059	2,415	17.18%	0.71%
	SWA02 Bioregion	13,946	2,389	17.13%	0.71%
	City of Swan	6,013	961	15.98%	8.98%
	City of Bayswater	20.45	0	0.00%	0.00%
1009	Western Australia	18,225	2,995	16.43%	0.02%
	SWA02 Bioregion	18,183	2,973	16.35%	0.02%
	City of Swan	8,522	369	4.33%	0.00%
	City of Bayswater	496	37	7.51%	0.00%
949	Western Australia	218,194	123,039	53.39%	13.77%
	SWA02 Bioregion	184,476	104,034	56.39%	14.88%
	City of Swan	16,235	7,965	49.06%	2.74%
	City of Bayswater	0	0	0.00%	0.00%

Source: Government of Western Australia (2016) cited in RPS (2018)

2.3.1.2 Vegetation complexes

Heddle et al. (1980) mapped a large part of the SCP for vegetation complexes. This has been recently revised by Webb et al. (2016). Three vegetation complexes occur across the ERB (Table 2-4). The extent of vegetation complexes within SCP and local government boundaries are provided in Table 2-5. Vegetation complexes Bassendean Complex Central and South and Southern River Complex have below 30% of their pre-European extent remaining within the SCP, though neither is below the 10% retention target for intensely developed areas.

Table 2-4: Vegetation complexes within the ERB

Vegetation Complex	Description
Bassendean Complex Central and South	Vegetation ranges from woodland of Jarrah (*Eucalyptus marginata*) to Sheoak (*Allocasuarina fraseriana*) to Banksia (*Banksia* spp.) on the sand dunes to low woodland of *Melaleuca* spp. and sedgelands on low-lying depressions and swamps. This area includes the transition of Jarrah (*E. marginata*) to Prickly bark (*E. todtiana*) near Perth.
Bassendean Complex North	Vegetation ranges from low open forest and low woodland of Banksia (*Banksia* spp.) and Prickly Bark (*Eucalyptus todtiana*), to low woodland of *Melaleuca* spp. and sedgelands which occupy wetter sites.
Southern River Complex	Open woodland of Marri (*Corymbia calophylla*), Jarrah (*Eucalyptus marginata)* and Banksia *(Banksia spp*.) on elevated areas with fringing woodland of Flooded gum (*Eucalyptus rudis*) and Swamp Paperbark (*Melaleuca rhaphiophylla*) along streams.

Source: Heddle et al. 1980 revised by Webb et al. 2016.

Table 2-5: Vegetation complexes

Vegetation Complex	Scale	Pre-European extent (ha)	Current extent remaining (ha)	% pre-European extent remaining	% of current extent in secure tenure
Bassendean Complex Central and South	Swan Coastal Plain	87,476.25	23,533.09	26.90%	1.86%
	City of Swan	4,676.35	1,503.87	32.16%	–
	City of Bayswater	2,887.84	61.64	2.13%	–
Bassendean Complex North	Swan Coastal Plain	79.057.35	56,575.80	71.56%	25.93%
	City of Swan	14,216.87	7,273.75	51.16%	–
	City of Bayswater	0.00	0.00	0.00%	–
Southern River Complex	Swan Coastal Plain	58,781.48	10,828.04	18.42%	1.18%
	City of Swan	8,627.35	1,460.48	16.93%	–
	City of Bayswater	100.33	16.58	16.52%	–

Source: Government of Western Australia (2018).

2.3.2 Local vegetation community mapping

Previous flora and vegetation surveys have mapped broad vegetation communities, ranging from as few as four vegetation communities for the TGS project in the Tonkin Highway section (360 Environmental 2014a) to as many as 15 for the EBRT project in the Lord Street and Ellenbrook sections (AECOM 2016).

Floristic analyses conducted as part of the previous assessments compared the vegetation communities with floristic community types (FCTs) determined in the original and/or updated Floristic Survey of the Swan Coastal Plain (Gibson et al. 1994, Keighery et al. 2012). Table 2-6 summarises the relationships between vegetation communities and FCTs, including the conservation significant FCTs identified and their locations. Note that discussion of the ecological communities represented by conservation significant FCTs is continued in Section 2.3.4.

Table 2-6: Broad vegetation communities and conservation significance floristic community types

Study reference	Number of broad vegetation communities recorded	Number of vegetation communities representing one or more FCTs	Conservation significant FCTs represented*	Location of conservation significant FCTs
RPS (2019a)	6	3	FCTs17, FCT23a, FCT23c	Within ERB - FCTs17 (Lord Street section) Within ERB - FCT23a and 23c throughout Malaga, Whiteman Park South and Lord Street sections
Terratree (2017)	8	2	Banksia dominated woodlands of the SCP (P3)	Within ERB – Whiteman Park South section
AECOM (2016)	15	0	–	–
Coffey (2015a)	8	2	SCP21c, SCP23b, Banksia dominated	Within ERB – between Tonkin Highway, Marshall Road and

Study reference	Number of broad vegetation communities recorded	Number of vegetation communities representing one or more FCTs	Conservation significant FCTs represented*	Location of conservation significant FCTs
			woodlands of the SCP (P3)	Beechboro Road North (Malaga section)
			SCP22^, SCP24^	Within ERB – Tonkin Highway and Reid Highway interchange
			SCP02^†	Within ERB – near Marshall Road (Malaga section)
			SCP20a	Outside ERB – corner of Reid Highway and Beechboro Road North
360 Environmental (2014a)	4	1	Banksia dominated woodlands of the SCP (P3)	Within ERB – (Tonkin Highway section - road reserve)
GHD (2014)	10	3	SCP3a, SCP3c, SCP20b, SCP20a, SCP20c	Outside the ERB

* Note equivalence between 'FCT' and 'SCP' identifiers, e.g. for this analysis assume SCP20a is equivalent to FCT20a.
^ FCT no longer considered likely to occur in this location due to more recent clearing associated with other projects.
† FCT02 is no longer considered as occurring in this location due to further analysis undertaken by Coffey (2016).

2.3.3 Groundwater dependent ecosystems

Groundwater dependent ecosystems (GDEs) are ecosystems that require access to groundwater to meet all or part of their water requirements for the community of plants, animals and ecological processes they support to be maintained (Richardson et al. 2011).

Given shallow water tables and extensive areas of wetland within the ERB (see Section 4 for further discussion) vegetation within the ERB is highly likely to include GDEs.

Coffey considered GDEs as part of the assessment undertaken for the PDNH. For that project, *Banksia ilicifolia* presented the greatest susceptibility and lowest net recovery to groundwater abstraction (Groom et al. 2000). Plants with shallow roots rely on moisture in the vadose zone (i.e. above the watertable) and stratigraphic changes which affect the vadose zone will impact on the health and survival of these species (Coffey 2015a). Several flora species were considered groundwater dependent (Table 2-7).

Table 2-7: Groundwater dependent flora

Flora species	Hydrological classification
Astartea scoparia	Subsurface – perched
Banksia ilicifolia	Groundwater dependent (obligate)
Banksia littoralis	Groundwater dependent (obligate)
Baumea articulata	Groundwater or surface water (obligate)
Baumea juncea	Groundwater or surface water (obligate)
Corymbia calophylla	Groundwater dependent (facultative)
Eucalyptus rudis	Groundwater dependent (obligate)
Eucalyptus todtiana	Groundwater dependent (facultative)
Hypocalymma angustifolium	Vadose (saturated) zone
Leptocarpus scariosa	Groundwater or surface water (obligate)
Melaleuca lateritia	Groundwater dependent (obligate)
Melaleuca preissiana	Groundwater dependent (obligate)
Melaleuca teretifolia	Groundwater dependent (obligate)
Scholtzia involucrata	Vadose (saturated) zone
Stirlingia latifolia	Vadose (saturated) zone
Taxandria linearifolia	Groundwater dependent (obligate)

Based on vegetation units containing the species in Table 2-7, Coffey (2015a) mapped several potential occurrences of GDEs along the PDNH alignment and within the ERB. However, the mapping was limited to a high-level desktop comparison of vegetation units with existing wetland mapping. Based on the likely similarity of vegetation extending beyond the PDNH study area and into the ERB, particularly in the southern part of Whiteman Park, it is expected that GDEs and/or species dependent to some extent on groundwater are also present elsewhere within the ERB.

GDEs were not considered by the other primary studies.

2.3.4 Threatened and Priority Ecological Communities

Ecological communities are naturally occurring groups of plants, animals and other organisms interacting in a unique habitat (DBCA 2019a). TECs are formally protected under the Western Australian *Biodiversity Conservation Act 2016* (BC Act) and/or the Commonwealth EPBC Act. The DBCA also maintains a list of PECs for ecological communities of conservation concern not listed under the BC Act. PECs are typically those that have been the subject of little research and/or are known from only a few collections or sight records under threat from potential impacts.

A DBCA ecological communities database search was undertaken in 2018 within a 3 km radius of the ERB (RPS 2019b). A buffered search was used to ensure that conservation significant values nearby to the ERB are detected. Database records are also buffered to ensure that they are returned in nearby searches and to avoid revealing their precise location. Nine State-listed TECs and PECs (or their buffers) were found from 348 records in the search area (RPS 2019b).

During field survey, RPS (2019a) recorded two TECs within the ERB:

- Banksia woodlands of the Swan Coastal Plain TEC (listed as Endangered under the EPBC Act) (hereafter referred to as Banksia woodlands TEC).
- An unconfirmed occurrence of Communities of Tumulus Springs (Organic Mound Springs) of the Swan Coastal Plain TEC (listed as Critically Endangered under the BC Act, with a related listing as Endangered under the EPBC Act; hereafter referred to as Tumulus Springs TEC).

After seeking further advice from the DBCA, the unconfirmed occurrence of Communities of Tumulus Springs (Organic Mound Springs) of the Swan Coastal Plain TEC has been found as not meeting the criteria for the TEC (English, pers. comm. 2018).

RPS (2019b) did not record any PECs within the ERB. However, Coffey (2015a) recorded the following four PECs within the ERB:

- Banksia dominated woodlands of the Swan Coastal Plain IBRA region PEC (Priority 3) (hereafter referred to as Banksia woodlands PEC);
- SCP21c – Low lying *Banksia attenuata* woodlands or shrublands (Priority 3);
- SCP23b – Swan Coastal Plain *Banksia attenuata* – *Banksia menziesii* woodlands (Priority 3); and
- SCP24 – Northern Spearwood shrublands and woodlands ('community type 24') (Priority 3).

A number of these were mapped within the Tonkin Highway, Reid Highway interchange, expected to now have been cleared through the NorthLink project and outside the RPS (2019a) survey area, however areas of Banksia woodlands PEC, SCP21c and SCP23b were mapped by Coffey within the RPS (2019a) survey area (Figure 2-2). It is acknowledged that the results of the multivariate statistical analysis (which is used to determine alignment of vegetation communities to FCTs) can produce variable results depending on the methods and data selection used. The analysis undertaken by RPS was comprehensive and adequately considered the potential for occurrence of the FCTs aligned with PECs.

Table 2-8 summarises all state TECs and PECs identified from DBCA database searches within 3 km of the ERB or recorded within the ERB. Related EPBC Act-listed TECs are also shown where there is a relationship to a state TEC or PEC (e.g. where there are similar definitions, or where the TEC/PEC forms part of an EPBC Act-listed TEC). Table 2-8 also summarises the presence of TECs and PECs within and near to the ERB. Note that EPBC Act-listed TECs are discussed in Section 9.3.1 in further detail, including those with no related state-listed TEC or PEC.

Figure 2-2 shows the location of TEC and PEC records in relation to the ERB. Note that DBCA database records are shown as buffered records, which are much larger than the actual extent of those communities.

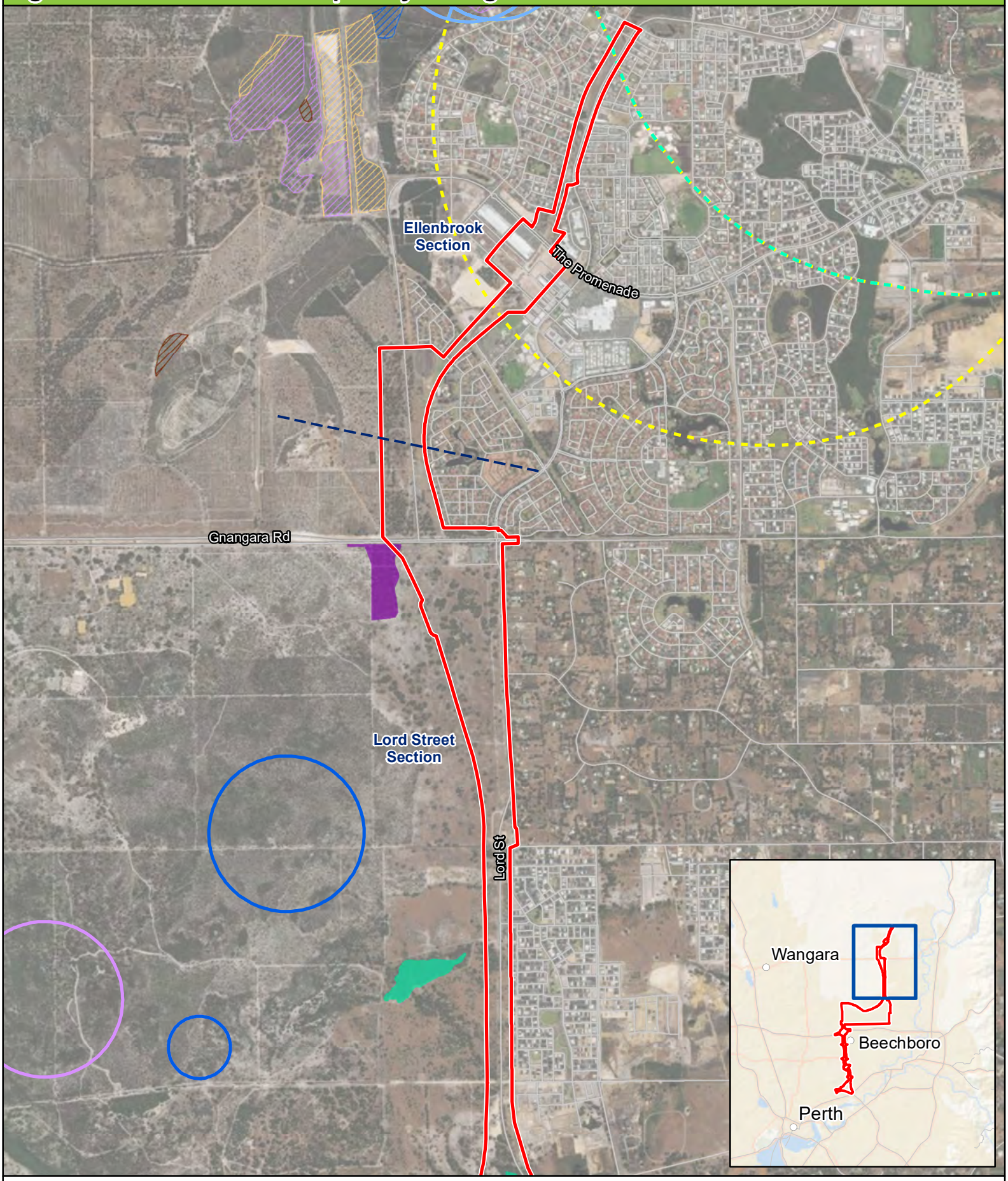
Table 2-8: TECs and PECs in or within 3 km of the ERB

Ecological community (WA)	Related EPBC Act-listed TEC*	Presence within the ERB
Banksia dominated woodlands of the Swan Coastal Plain IBRA region PEC (Priority 3)	Banksia woodlands of the Swan Coastal Plain TEC (Endangered)	The PEC was not discussed by RPS (2019a) but was **confirmed present within the ERB** by Coffey (2015a). The PEC was also identified from database records. The TEC was **confirmed present within the ERB** by RPS (2019a). Both the PEC and TEC were recorded in remnant bushland on Marshall Road, between Hepburn Avenue and Beechboro Road North (Figure 2-2). The PEC and TEC are similar, though the TEC has stricter criteria and is typically a subset of the PEC as a result. An occurrence of this PEC mapped by Coffey (2015a) within the ERB at the Tonkin Highway and Reid Highway interchange is expected to now have been cleared as a result of the NorthLink project. Other records of the PEC and TEC were identified within 3 km of (but not immediately adjacent to) the ERB.
Subtropical and Temperate Coastal Saltmarsh (Priority 3)	Subtropical and Temperate Coastal Saltmarsh TEC (Vulnerable)	Not recorded within the ERB, but it has been identified from database records within 3 km of the ERB.
Shrublands and woodlands on Muchea limestone TEC (Endangered)	Shrublands and woodlands on Muchea limestone of the Swan Coastal Plain TEC (Endangered)	ERB intersects a database record buffer in Ellenbrook associated with one or more records of the TEC northeast of the ERB. The TEC was not identified within the ERB (RPS 2019b). The TEC has the potential to occur within unsurveyed portions of the ERB, however based on available information it is not expected to occur within the ERB.
Communities of Tumulus Springs (Organic Mound Springs) of the Swan Coastal Plain TEC (Critically Endangered)	Assemblages of plants and invertebrate animals of tumulus (organic mound springs) of the Swan Coastal Plain TEC (Endangered)	This TEC was recorded within the ERB at three locations in Whiteman Park west of Lord Street by RPS (2019b). However, the DBCA has since advised that these occurrences do not meet the criteria for the TEC (English, pers. comm. 2018). Identified in database records within 3 km of the ERB.
SCP02 – Southern wet shrubland, Swan Coastal Plain TEC (Endangered)	–	Not recorded within the ERB, but it has been identified from database records within 3 km of the ERB. Coffey (2015b) identified a suspected occurrence of SCP02 adjacent to Hepburn Avenue in the Malaga section but later found it did not represent SCP02 (Coffey 2016).

Ecological community (WA)	Related EPBC Act-listed TEC*	Presence within the ERB
SCP20a – *Banksia attenuata* woodlands over species rich dense shrublands TEC (Endangered)	A component of the Banksia woodlands of the Swan Coastal Plain TEC (Endangered)	This TEC was **confirmed present adjacent to the ERB** at the southeast corner of Reid Highway and Beechboro Road North by Coffey (2015a). It was also mapped north of the ERB along Beechboro Road North (Coffey 2015a) and identified in database records within 3 km of the ERB.
SCP21c – Low lying *Banksia attenuata* woodlands or shrublands PEC (Priority 3)		This PEC was mapped by Coffey (2015a) in remnant bushland north of Marshall Road, between Hepburn Avenue and Beechboro Road North. The record overlaps with the occurrence of the Banksia dominated woodlands of the Swan Coastal Plain PEC. This record was not substantiated by further survey and multivariate analysis work undertaken in the same area by RPS (2019b). Coffey mapped other occurrences of this PEC along Beechboro Road North, north of the ERB. Additional database records exist within 3 km of the ERB. An occurrence of this PEC mapped by Coffey (2015a) within the ERB at the Tonkin Highway and Reid Highway interchange is likely to now have been cleared as a result of the NorthLink project.
SCP22 – *Banksia ilicifolia* woodlands PEC (Priority 2)		Identified in database records within 3 km of the ERB. One database record located within the ERB at the Tonkin Highway and Reid Highway interchange is likely to now have been cleared. The PEC was not otherwise identified within the ERB. Other database records exist in Whiteman Park.
SCP24 – Northern Spearwood shrublands and woodlands ('community type 24')		One occurrence mapped by Coffey (2015a) within the ERB at the Tonkin Highway and Reid Highway interchange is likely to now have been cleared as a result of the NorthLink project. The PEC was not otherwise identified within the ERB.
SCP23b – Swan Coastal Plain *Banksia attenuata* – *Banksia menziesii* woodlands PEC (Priority 3)		This PEC was mapped by Coffey (2015a) in remnant bushland north of Marshall Road, between Hepburn Avenue and Beechboro Road North. The record overlaps with the occurrence of the Banksia dominated woodlands of the Swan Coastal Plain PEC. This record was not substantiated by further survey and multivariate analysis work undertaken in the same area by RPS (2019a). Coffey mapped other occurrences of this PEC along Beechboro Road North, north of the ERB. Additional database records exist within 3 km of the ERB.

Source: adapted from RPS (2018; 2019b) and Coffey (2015a, b).
* Section 9.3.1 discusses EPBC Act-listed TECs in further detail, including those with no related state-listed TEC or PEC.

Figure 2-2a: Threatened and priority ecological communities



Legend

Environmental review boundary

Threatened and priority ecological communities (DBCA Buffer)

- Tumulus Springs SCP TEC, Critically Endangered
- Muchea Limestone TEC, Endangered
- SCP21c, Priority 3
- SCP22, Priority 3
- SCP23b, Priority 3

Threatened and priority ecological communities (RPS extent)

- Banksia Woodlands of the Swan Coastal Plain
- Tumulus Springs (Organic Mound Springs Swan Coastal Plain) - Unconfirmed

Threatened and priority ecological communities (Coffey extent)

- Banksia dominated woodlands on the Swan Coastal Plain, Priority 3
- SCP21c, Priority 3
- SCP22, Priority 3
- SCP24, Priority 3

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

N

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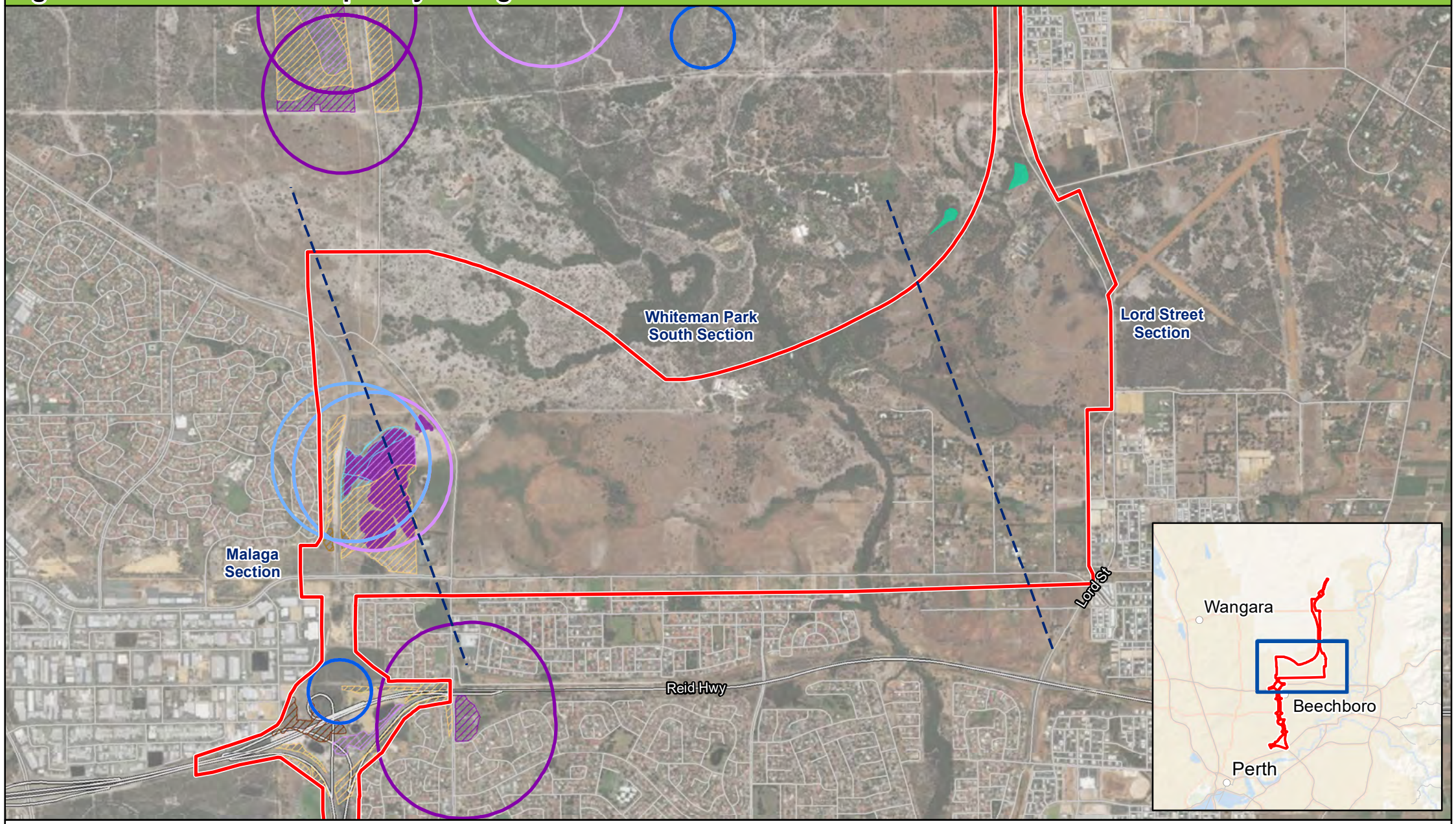
Figure 2-2b: Threatened and priority ecological communities



Legend

- Environmental review boundary

Threatened and priority ecological communities (DBCA Buffer)

- SCP20a, Endangered
- SCP21c, Priority 3
- SCP22, Priority 3
- SCP23b, Priority 3

Threatened and priority ecological communities (RPS extent)

- Banksia Woodlands of the Swan Coastal Plain
- Tumulus Springs (Organic Mound Springs Swan Coastal Plain) - Unconfirmed

Threatened and priority ecological communities (Coffey extent)

- Banksia dominated woodlands on the Swan Coastal Plain, Priority 3
- SCP02, Endangered
- SCP20a, Endangered
- SCP21c, Priority 3
- SCP23b, Priority 3
- SCP24, Priority 3

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

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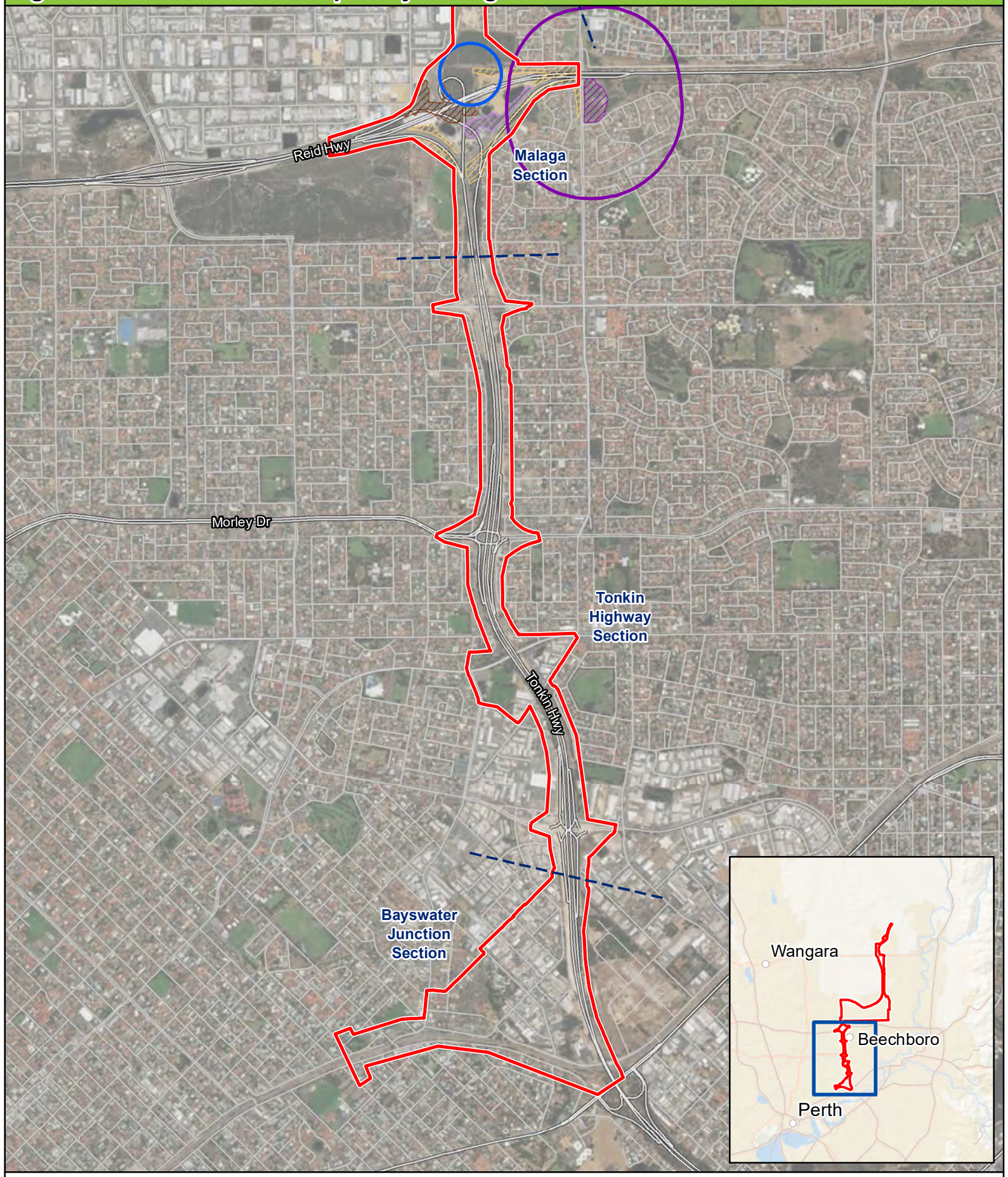
Figure 2-2c: Threatened and priority ecological communities



Legend

Environmental review boundary

Threatened and priority ecological communities (DBCA Buffer)

- SCP20a, Endangered
- SCP21c, Priority 3
- SCP22, Priority 3

Threatened and priority ecological communities (Coffey extent)

- Banksia dominated woodlands on the Swan Coastal Plain, Priority 3
- SCP20a, Endangered
- SCP21c, Priority 3
- SCP24, Priority 3

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

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2.3.4.1 Banksia Woodlands of the Swan Coastal Plain TEC

The Banksia woodlands TEC is described as an ecological community woodland associated with the Swan Coastal Plain. It is characterised by a prominent Banksia tree layer with scattered Eucalypts and other tree species present within or above the Banksia canopy. Species richness is high within this ecological community and is characterised by high endemism and considerable localised variation in species composition across its range (Commonwealth of Australia 2016).

The TEC was recorded by RPS (2018; 2019a) from the Malaga and Whiteman Park South sections between Hepburn Avenue and Beechboro Road North and south of Gnangara Road in the Lord Street section. The comprehensive analysis of the occurrence of the TEC used multivariate analysis, floristics, soil, landform and geography, as well as key diagnostic criteria listed in the conservation advice. All four Banksia Woodland Floristic Community Types within the ERB, were found to comprise the EPBC Act-listed TEC (RPS 2018). There are several other locations in the surrounding area where this TEC is recorded in DBCA's database (Figure 2-2). The other primary surveys covering the ERB do not consider the TEC as they predate its listing under the EPBC Act.

There is a relationship between this TEC and Banksia woodlands PEC. The TEC has a very comprehensive definition with criteria for location, soils and landform, structure, composition, patch size and condition (TSSC 2016). The PEC has a much shorter, general description as its definition, generally encompassing a wider range of Banksia-dominated vegetation than the TEC. The PEC may exist on its own, particularly where minimum patch size and condition thresholds defined for the TEC are not met. The TEC may exist on its own in specific circumstances.

2.3.4.2 Tumulus Springs (Organic Mound Springs) of the Swan Coastal Plain TEC

The EPBC Act-listed TEC Assemblages of plants and invertebrate animals of tumulus (organic mound) springs of the SCP (Tumulus Springs TEC) habitat is characterised by continuous discharge of groundwater in elevated areas of peat. This provides a constant and permanently damp series of microhabitats. The community has an overstorey of *Melaleuca preissiana, Banksia littoralis, Agonis linearifolia* and *Eucalyptus rudis,* with common understorey of *Agonis linearifolia, Pteridium esculentum* and *Cyclosorus interruptus* (CALM 2006). There are currently only four locations where intact vegetated Tumulus Springs TEC is found: Muchea, Ellenbrook and two sites in Bullsbrook.

The floristic analysis completed by RPS (2018) determined that three sites within the wetlands of Whiteman Park (one within the ERB in the Lord Street section and the other two approximately 120 m west of the ERB) were likely to represent the Tumulus Springs TEC. This TEC was not confirmed at the time but potentially represented up to three new occurrences. However, the DBCA has since advised that none of these occurrences meet the criteria for the TEC, primarily due to the absence of elevated areas of peat (English, pers. comm. 2018). The nearest known occurrence of this TEC is one kilometre to the northeast of the ERB in Ellenbrook, with the northernmost part of the ERB intersecting the record's buffer (Figure 2-2).

2.3.4.3 Priority Ecological Communities

Four State-listed PECs were recorded by Coffey (2015b) within the ERB:

- SCP21c (P3)
- SCP23b (P3)

- SCP24 (P3)
- Banksia woodlands (P3)

The PECs SCP21c, SCP23b and SCP24 were either recorded within areas now likely to have been cleared as a result of the NorthLink project or were not substantiated by further survey and analysis undertaken subsequently in the same area by RPS (2019b).

Although not mentioned by RPS (2019b), the presence of the Banksia woodland TEC implies the presence of the Banksia woodlands PEC (P3), as recorded by Coffey (2015b). The EPBC Act-listed TEC has specific criteria which have to be met including size and condition of the Banksia woodland. The State listed PEC – Banksia dominated woodland of the Swan Coastal Plain IBRA region does not have such a rigorous guide and is described as (DBCA 2019):

Canopy is most commonly dominated or co-dominated by Banksia attenuata *and/or* Banksia menziesii*. Other Banksia species that can dominate in the community are* Banksia prionotes *or* Banksia ilicifolia*. It typically occurs on well drained, low nutrient soils on sandplains landforms, particularly deep Bassendean and Spearwood sands and occasionally on Quindalup sands; it is also common on sandy colluvium and aeolian sands of the Ridge Hill Shelf, Whicher Scarp and Dandaragan Plateau and in other less common scenarios.*

If the TEC is present it is likely that the PEC is also present, however this may not be the case in reverse.

2.3.5 Conservation significant flora

RPS (2019a) conducted a desktop search of DBCA and WAH Specimen database and identified a total of 47 species of conservation significance which occurred within a 5 km radius of the RPS (2019a) survey area (Figure 2-3). This included five Threatened flora species, three Priority 1, five Priority 2, 22 Priority 3 and 11 Priority 4 flora taxa.

Of the 47 species identified with the potential to occur, 15 species were assessed as having a high or moderate likelihood of occurring within the ERB based on habitat preference and proximity of known records to the survey area (Table 2-9) (RPS 2019a).

Table 2-9: Threatened and Priority flora recorded within a 5 km radius of the ERB with a moderate to high likelihood of occurrence

Species	Conservation status			Preferred habitat (soil and landform)	Likelihood of occurrence
	EPBC Act	BC Act[1]	DBCA		
Anigozanthos humilis subsp. *Chrysanthus*	–	–	P4	Slope with white to grey sand. Underlying geology: Bassendean Dune System	High
Caladenia huegelii	En	Cr	–	Grey or brown sand, clay loam	High
Calectasia elegans	–	–	P2	Grey sand	Moderate
Carex tereticaulis	–	–	P3	Watercourse, wet. Organic litter. Grey Bassendean Sand over sand. Black peaty sand	Moderate

Species	Conservation status			Preferred habitat (soil and landform)	Likelihood of occurrence
	EPBC Act	BC Act[1]	DBCA		
Conospermum undulatum	Vu	Vu	–	Low plain/swamp. White-grey sand. Bassendean-Southern River complex. Seasonal dampland. Probably burnt within last 5 years.	Moderate
Cyathochaeta teretifolia	–	–	P3	Grey sand, sandy clay. Swamps, creek edges	High
Eryngium pinnatifidum subsp. Palustre (G. J. Keighery 13459)	–	–	P3	Dampland; grey sand	Moderate
Hydrocotyle striata	–	–	P1	Clay. Springs	Moderate
Jacksonia sericea	–	–	P4	Calcareous and sandy soils	Moderate
Poranthera moorokatta	–	–	P2	Dampland; light grey to grey sand over light grey-grey clay	Moderate
Stachystemon sp. Keysbrook (R. Archer 17/11/99)	–	–	P1	Dry flat, grey sand some humus, over humus and sand, well drained	Moderate
Stylidium longitubum	–	–	P4	Sandy clay, clay. Seasonal wetlands	Moderate
Stylidium trudgenii	–	–	P3	Dampland – wetland. Peat, soggy	Moderate
Trithuria occidentalis	En	Cr	–	In water, muddy open	Moderate
Verticordia lindleyi subsp. *lindleyi*	–	–	P4	Gravelly soil	High

Source: adapted from RPS 2019a and Wildlife Conservation (Rare Flora) Notice 2018

1. *Biodiversity Conservation Act 2016*

No Threatened flora species listed under BC Act or the EPBC Act were recorded within the RPS (2019a) project area.

Of particular note is *Caladenia huegelii,* a cryptic orchid species. Surveying for this species can present many challenges. Due to the conservation significance of this species, and the high likelihood of its occurrence (due to the proximity of known records and habitat preference) within the ERB, further survey effort to determine the presence or absence of this species has been conducted. RPS (2019b) undertook a review of the potential for remnant Banksia woodland vegetation within Whiteman Park to support *Caladenia huegelii* and observed no *Caladenia huegelii* individuals in any of the remnant Banksia woodland vegetation within Whiteman Park.

Three State-listed Priority flora species have been recorded within or immediately adjacent to the ERB: two from RPS (2018) one from Terratree (2017). The species identified and their respective locations within the ERB are outlined in Table 2-10**.**

Table 2-10: State-listed Priority flora recorded within the ERB

Flora species	Conservation status	Quadrat	Location	Section
Cyathochaeta teretifolia	P3	PTAQ13	Within resource enhancement wetland (REW) dampland (UFI 8679), west of but adjacent to the ERB	In the Lord Street section between Park St and Woollcott Avenue
		PTAQ20 METQ07	Within conservation category wetland (CCW) sumpland (UFI 8548, west of but adjacent to the ERB	
		1 quadrat	Adjacent to the ERB on the northeast side of the Tonkin Highway and Reid Highway interchange	Adjacent to the Malaga section – outside the ERB
Anigozanthos humilis subsp. *chrysanthus*	P4	PTAQ08 PTAQ12	Between Hepburn Avenue, Marshall Road and Beechboro Road North	North end of Malaga section, within Whiteman Park
Conostylis bracteata	P3	4 quadrats	Between Hepburn Avenue, Marshall Road and Beechboro Road North	Whiteman Park South section

Although *Cyathochaeta teretifolia* (P3) was not recorded within the ERB, it should be considered highly likely to occur within the ERB given that it was recorded as a dominant understorey species in RPS's 2018 quadrats (RPS 2019a) immediately adjacent to the ERB.

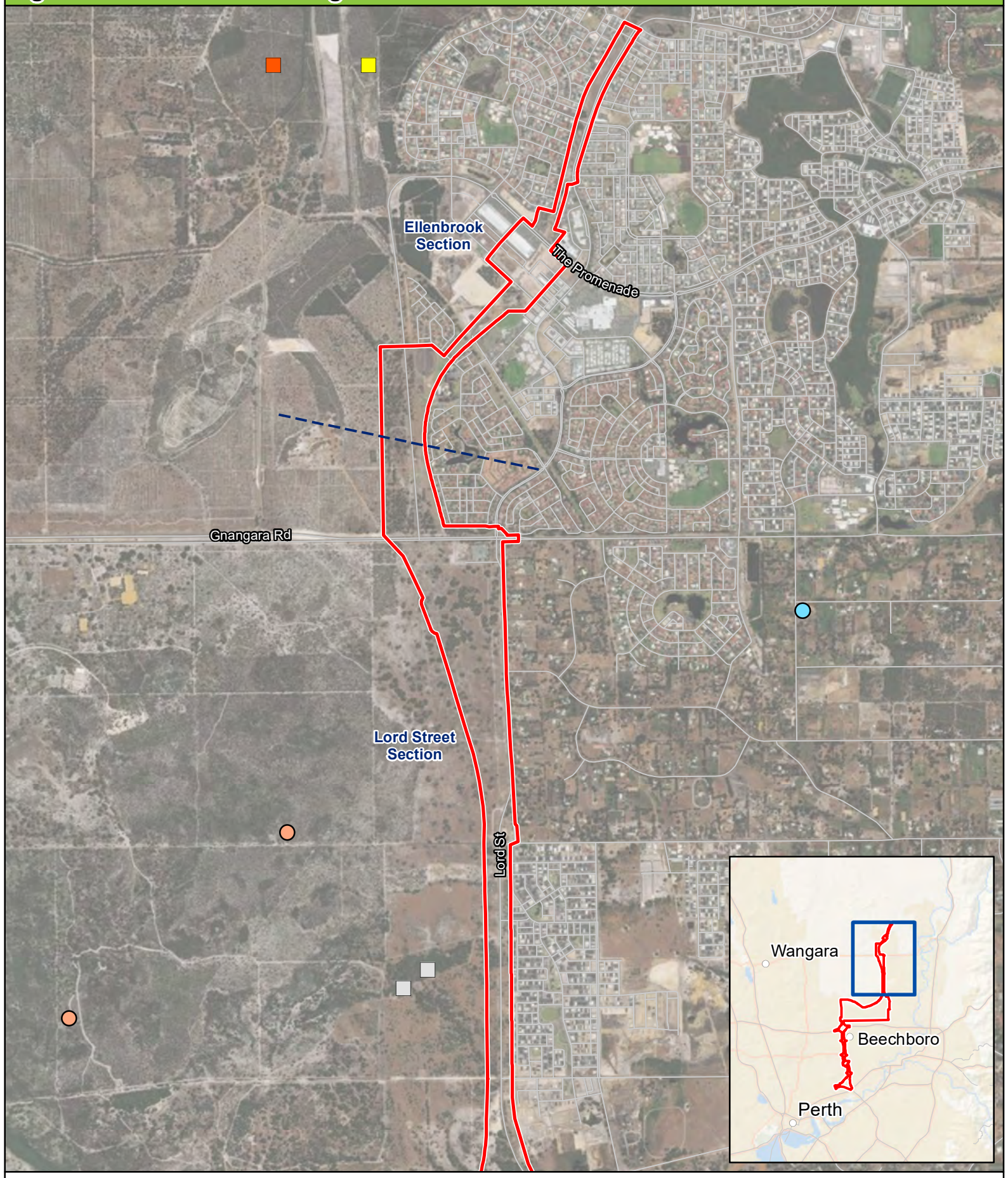
Some flora species may also be of conservation value even if not formally recognised as Threatened or Priority species. Flora taxa may have a high conservation significance if they are confined to scarce or refugial habitats, form uncommon, regionally significant populations, have significant geographical ranges and undescribed taxonomic entities (EPA 2016a). RPS (2019a) recorded six flora taxa of 'other' conservation significance within their study area, and the reason for their conservation significance as follows:

- *Aotus cordifolia* – the taxon is poorly reserved and is associated with a conservation significant ecological community (FCTs17).
- *Burchardia bairdiae* – the population is at the limit of its known geographic range.
- *Conostephium minus* – the taxon is poorly reserved and is endemic to the SCP.
- *Conostylis aculeata* subsp. *cygnorum* – the taxon is endemic to the SCP.
- *Dielsia stenostachya* – the taxon is endemic to the SCP.
- *Verticordia nitens* – the population is at the limit of its known geographic range.

Conostylis aculeata subsp. *cygnorum* and *Dielsia stenostachya* were recorded from three or more quadrats within the study area (RPS 2019a).

Cyathochaeta teretifolia (P3) also has high conservation value due to the taxon being poorly reserved.

Figure 2-3a: Conservation significant flora



Legend

- Environmental review boundary

Conservation significant flora (Coffey 2016)

- *Anigozanthos humilis* subsp. *chrysanthus*, P4
- *Hypolaena robusta*, P4

Conservation significant flora (RPS 2019)

- *Cyathochaeta teretifolia*, P3

Historical Records (DBCA)

- *Stachystemon* sp. *Keysbrook*, P1
- *Verticordia lindleyi* subsp. *lindleyi*, P4

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

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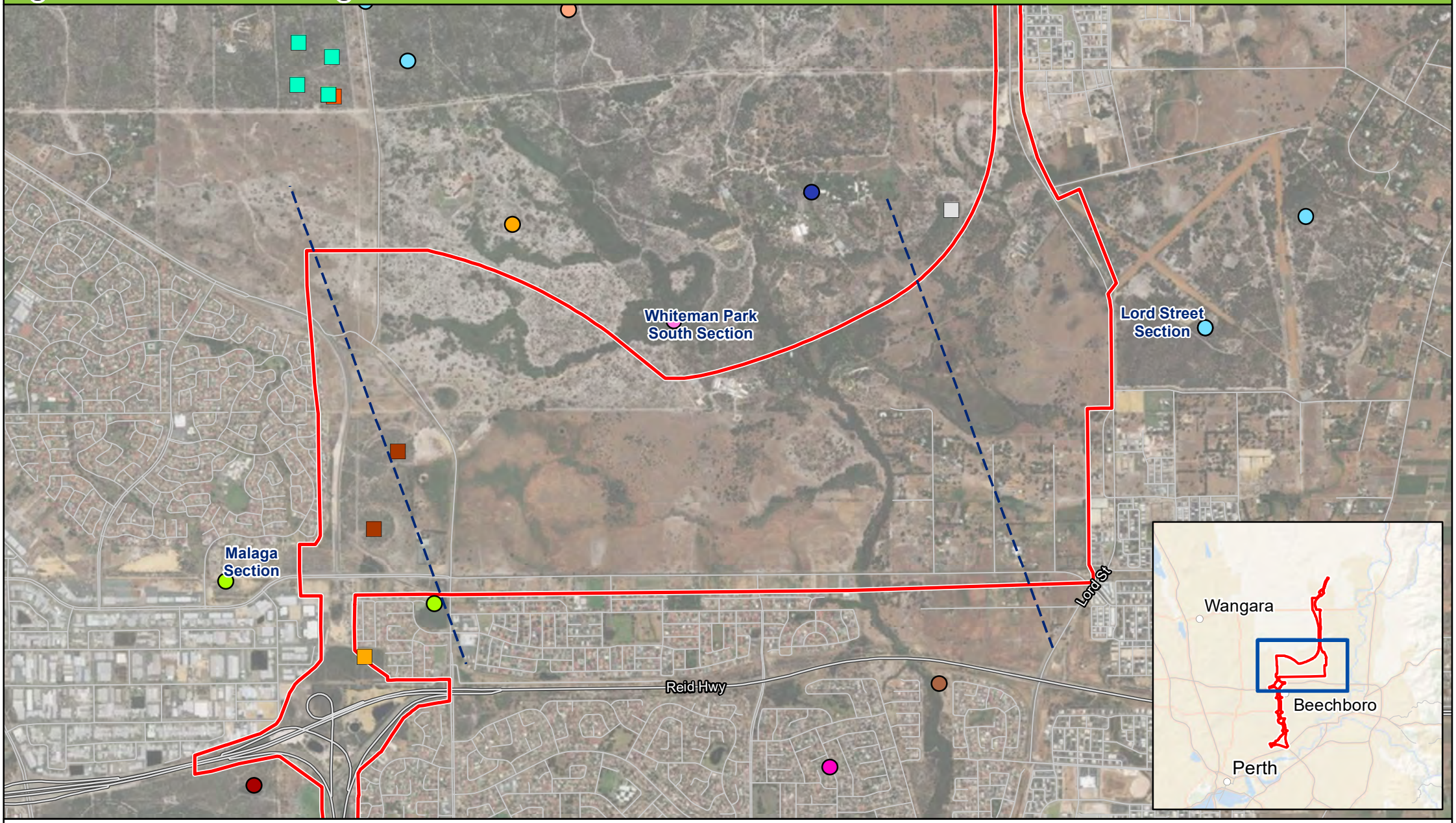
Figure 2-3b: Conservation significant flora



Legend

Environmental review boundary

Conservation significant flora (Coffey 2016)

- *Anigozanthos humilis* subsp. *chrysanthus*, P4
- *Cyathochaeta teretifolia*, P3
- *Hypolaena robusta*, P4
- *Millotia tenuifolia* var. *laevis*, P2

Conservation significant flora (RPS 2019)

- *Cyathochaeta teretifolia*, P3
- *Anigozanthos humilis subsp. chrysanthus*, P4

Historical Records (DBCA)

- *Caladenia huegelii*, T
- *Cyathochaeta teretifolia*, P3
- *Drosera occidentalis* subsp. *occidentalis*, P4
- *Stylidium longitubum*, P4
- *Acacia benthamii*, P2
- *Amanita carneiphylla*, P2
- *Amanita fibrillopes*, P3
- *Stachystemon* sp. *Keysbrook*, P1
- *Verticordia lindleyi* subsp. *lindleyi*, P4

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Metres

Datum/Projection:
GDA 1994 MGA Zone 50

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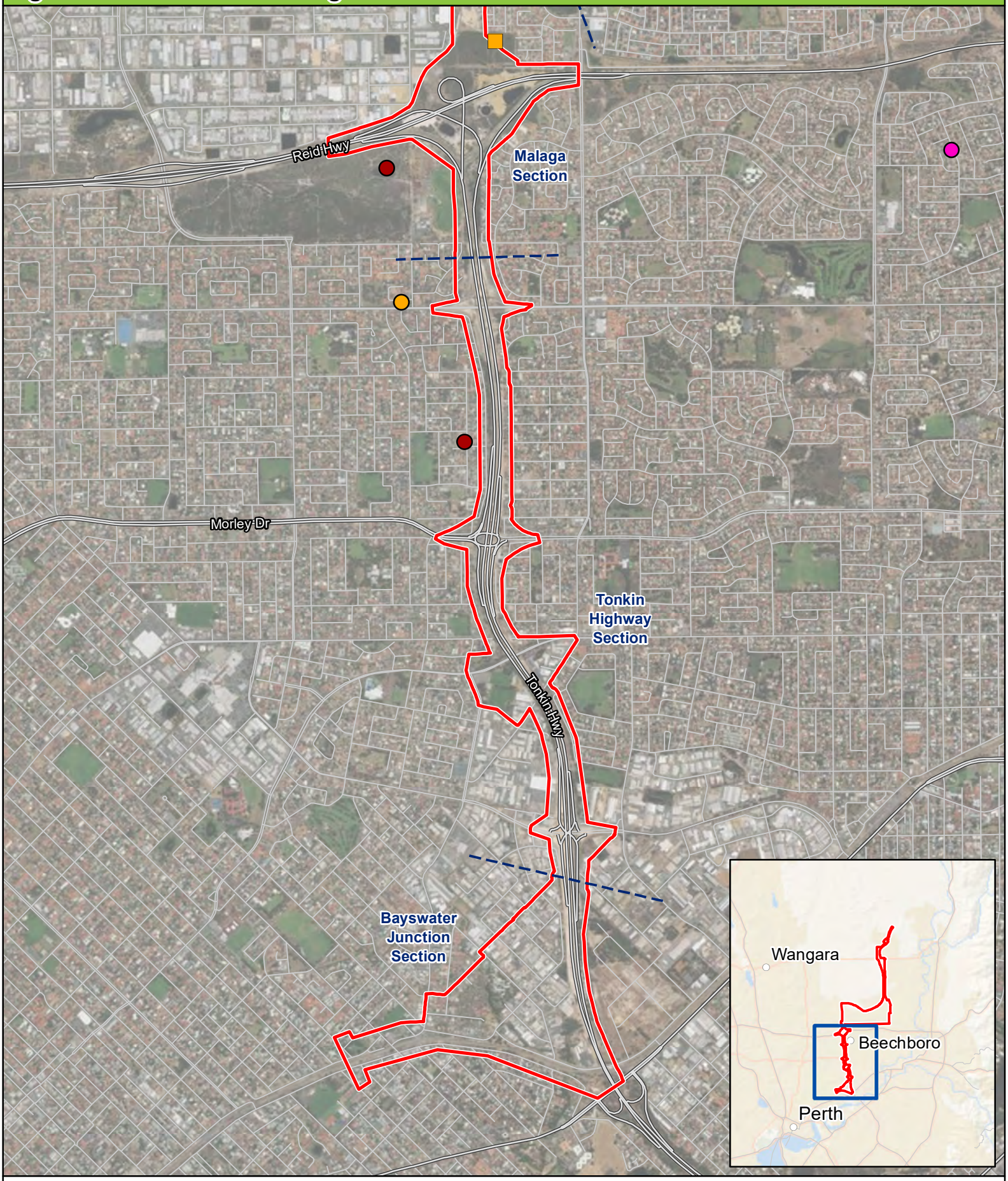
Figure 2-3c: Conservation significant flora



Legend

Environmental review boundary

Conservation significant flora (Coffey 2016)

- *Cyathochaeta teretifolia*, P3

Historical Records (DBCA)

- *Caladenia huegelii*, T
- *Cyathochaeta teretifolia*, P3
- *Amanita carneiphylla*, P2

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Metres
Datum/Projection:
GDA 1994 MGA Zone 50

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2.3.6 Introduced flora

RPS (2019a) recorded a total of 65 introduced flora species. From these 65 species, two are declared pests under Section 22(2) of the BAM Act; *Zantedeschia aethiopica* (Arum Lily) and *Moraea flaccida* (Cape Tulip). None of the weeds recorded were listed as Weeds of National Significance (WONS).

2.3.7 Phytophthora dieback

Limited assessments of the prevalence of *Phytophthora* dieback within the ERB are currently available. Terratree (2014) assessed the vegetation within and adjacent to PDNH which covers parts of the Malaga section of the ERB. This survey identified areas surrounding Hepburn Avenue in Whiteman Park as 'infested' with most other areas considered to be 'excluded' due to lack of vegetation in Good or better condition – as required to provide adequate numbers of disease indicator species to sample. Historical records of the extent of *Phytophthora* dieback have been recorded within Whiteman Park itself, in its northern parts (Coffey 2015b).

2.3.8 Bush Forever

Bush Forever identifies regionally significant bushland for protection within the Swan Coastal Plain portion of the Perth metropolitan region. Bush Forever sites have been identified on the basis of criteria relating to their conservation value and a target of protecting at least 10% of each vegetation complex, which is representative of regional ecosystems and habitats (Government of Western Australia 2000a). Bush Forever aims to protect a comprehensive representation of all ecological communities originally occurring in the region (Government of Western Australia 2000a).

There are eight Bush Forever sites located within one kilometre of the ERB. Five of these sites are located within the ERB, three of which overlap the boundary only slightly (Table 2-11) (Figure 2-4).

Table 2-11: Bush Forever Sites within the ERB

Site number	Site name	Location relative to ERB
200	Caversham Airbase Bushland, West Swan / Whiteman	Adjoins the ERB east of Lord Street section
304	Whiteman Park, Whiteman/West Swan	Intersects the Lord Street and Whiteman Park South sections
305	Bennett Brook Reserve	Adjoins the ERB south of Whiteman Park South section
307	Lightning Swamp and adjacent bushland, Noranda	Adjoins the ERB southwest of Tonkin Highway section
480	Victoria Road Bushland, Malaga/Beechboro	Within the Tonkin Highway section (Tonkin Highway and Reid Interchange)

Bush Forever sites 304 and 480 are the two sites which have large portions within the ERB. Bush Forever site 480 is completely within the Tonkin Highway and Reid Interchange and as such will have been mostly cleared for the PDNH project. Approximately 600 ha of Bush Forever site 304 is within the ERB (within the Whiteman Park South and Lord Street sections) however only a portion of this is expected to represent regionally significant vegetation. Measures in State Planning Policy 2.8 *Bushland Policy for the Perth Metropolitan Region* relate only to bushland within a Bush Forever site meeting the criteria for regionally significant vegetation.

2.3.9 DBCA managed lands

Gnangara-Moore River State Forest is the only DBCA managed land that intersects the ERB, in the Ellenbrook section west of Drumpellier Drive.

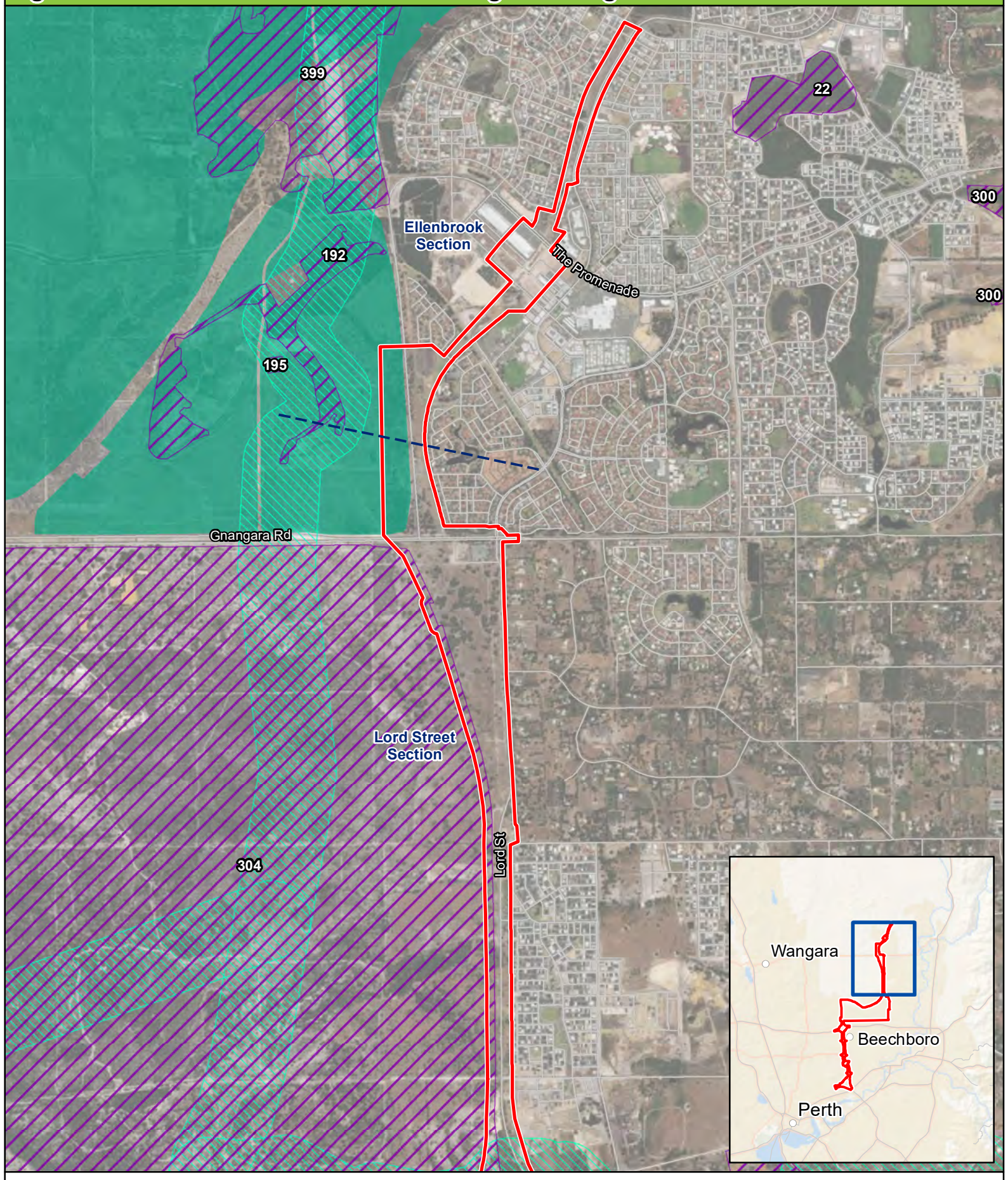
2.3.10 Ecological corridors/linkages

The historic clearing of the Perth IBRA subregion has increased the importance of remaining native vegetation. Ensuring linkages are maintained is critical to allow for ecological movement and connectivity between areas of refugial habitat for flora and fauna species (RPS 2018, Coffey 2015a).

The Regional Ecological Linkage Network plan's aim is to link protected regionally significance natural areas through the retention of the local natural areas in the best condition, so they can act as linkage corridors to enable flora and fauna dispersal between regionally significant areas (WALGA 2004). The ERB intersects three of these ecological linkage corridors, as shown in Figure 2-4. The ERB intersects the following ecological linkages:

- A north-south corridor connecting Gnangara-Moore River State Forest, Whiteman Park and remnant vegetation along Bennett Brook. The linkage is relatively unbroken, although southern parts are increasingly surrounded by urbanisation. The ERB crosses this linkage at Bennett Brook in the Whiteman Park South section.
- An east-west corridor following the Reid Highway road reserve. This linkage connects to Bennett Brook at its eastern end and is reliant upon vegetation within the road reserve, which has been increasingly cleared for road upgrades and projects. The ERB crosses this linkage in the Malaga section at Reid Highway.
- Another east-west corridor connecting Whiteman Park to vegetation on the eastern side of Lord Street, such as the former Caversham airbase, and ultimately to Ellen Brook. This linkage is increasingly affected by urban development. The ERB crosses this linkage in the Lord Street section adjacent to Youle-Dean Road.

Figure 2-4a: Conservation areas and ecological linkages



Legend

- Environmental review boundary
- Bush Forever sites (site number displayed)
- Regional ecological linkages
- DBCA Managed Areas (parks and reserves)

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

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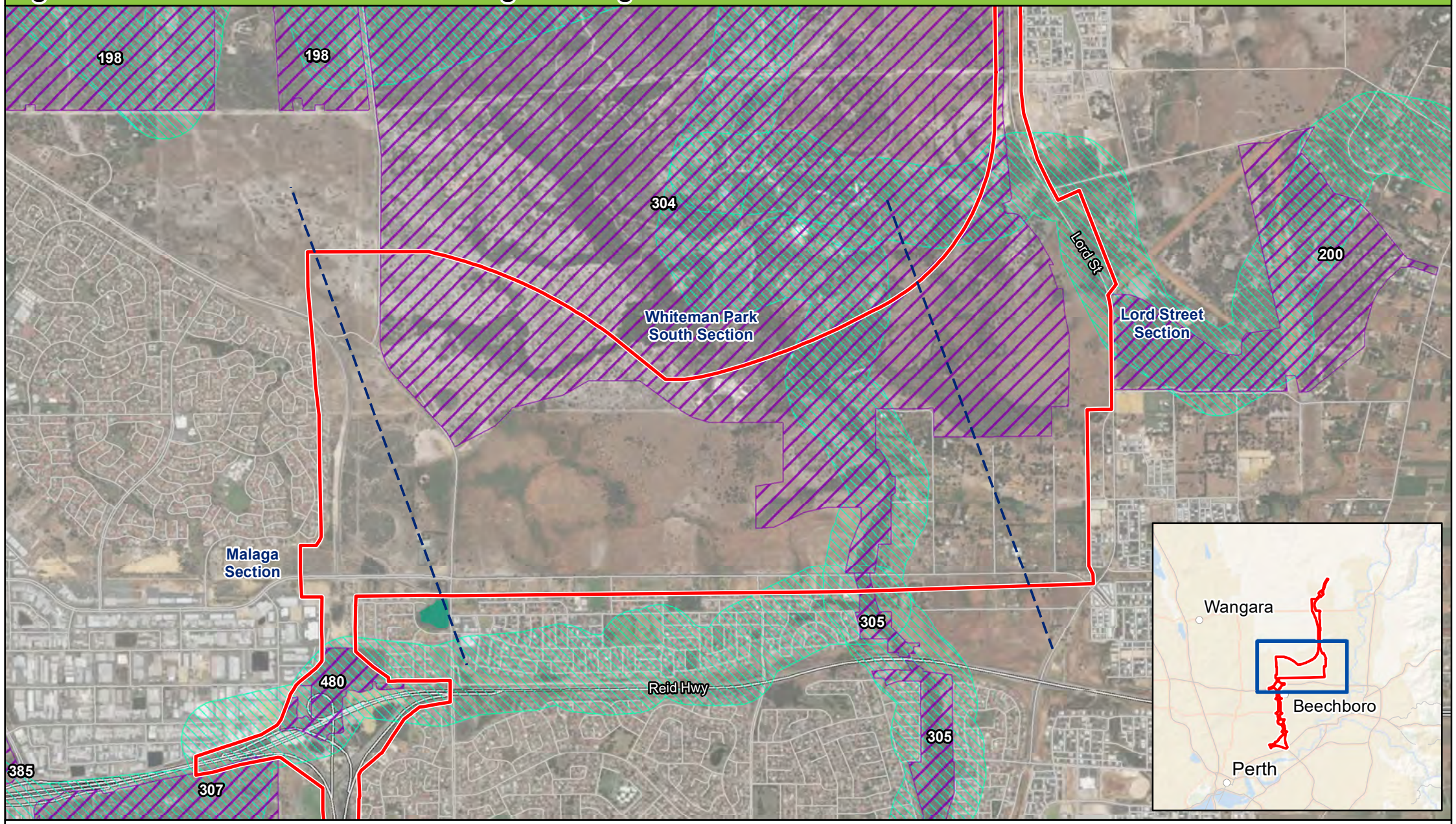
Figure 2-4b: Conservation areas and ecological linkages



Legend

- Environmental review boundary
- Bush Forever sites (site number displayed)
- Regional ecological linkages
- DBCA Managed Areas (parks and reserves)

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

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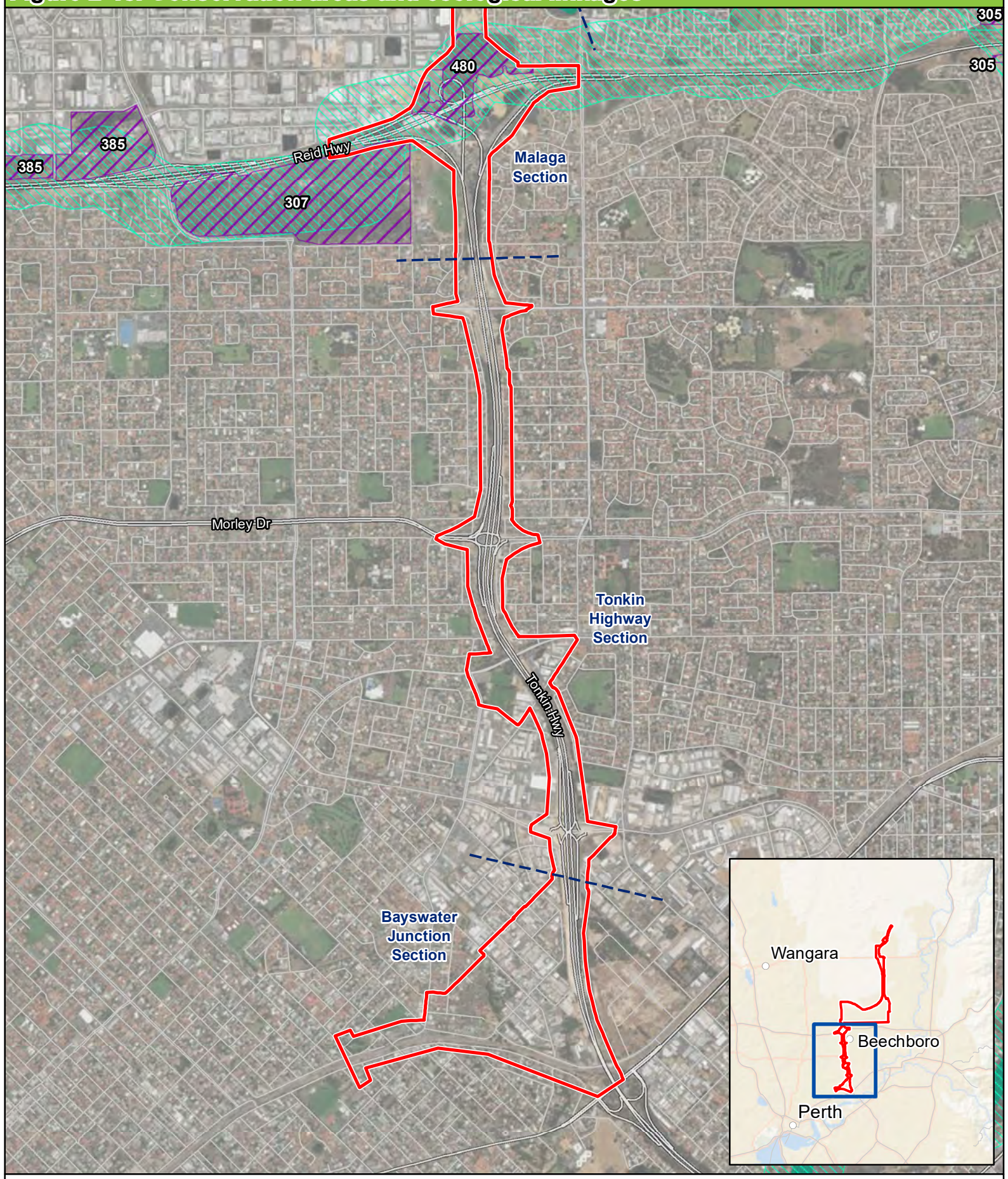
Figure 2-4c: Conservation areas and ecological linkages



Legend

- Environmental review boundary
- Bush Forever sites (site number displayed)
- Regional ecological linkages
- DBCA Managed Areas (parks and reserves)

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

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2.3.11 Riparian areas

Riparian vegetation along Bennett Brook was assessed in 1999 by the Water and Rivers Commission and concluded the condition of the vegetation and banks of the Brook to be in Moderate to Very Poor condition (WRC 1999). This assessment looked at the bank stability, foreshore vegetation, stream cover, habitat diversity and overall stream condition with only the bank stability near Mussel Pool receiving a Moderate classification. Foreshore vegetation along sections of Bennett Brook was found to be highly modified, with areas of overstorey species completely absent or present for a few metres from the bank only. This lack of foreshore vegetation resulted in erosion of the banks, minimal stream cover and reduced habitat diversity. No further information was available for this study to assess if the condition of riparian vegetation along Bennett Brook has changed in the intervening period.

RPS (2019a) described two broad wetland vegetation types comprising 11 vegetation units:

- Melaleuca wetland / dampland. This vegetation type consists of seven vegetation units dominated by *Melaleuca preissiana* and occurring through floodplains, palusplains, sumplands and damplands. Within the ERB, it occurs predominantly around the northern Malaga section and western Whiteman Park South sections. Vegetation condition is generally degraded to completely degraded.
- Eucalyptus rudis wetland / dampland / creekline. This vegetation type consists of four vegetation units associated with the banks and floodplains of Bennett Brook, extending onto the palusplains. Vegetation condition was very good within the parts of Bennett Brook closer to Whiteman Park. However, vegetation condition worsened with distance from Bennett Brook and Whiteman Park, decreasing to degraded at the southern boundary of the ERB. Vegetation within Horse Swamp was considered degraded, though fringing vegetation was in good to degraded condition. Other patches of vegetation associated with wetlands in the eastern Whiteman Park South section and southern Lord Street section were generally mapped as good to degraded or degraded.

A management plan for Horse Swamp (Cook 2011) also defines vegetation type and condition, though this plan is now reasonably outdated.

2.4 Potential constraints

Analysis of information currently available has identified the following flora and vegetation values as potential constraints to the MEL project:

- One EPBC Act-listed TEC: Banksia Woodland of the Swan Coastal Plain ecological community – Endangered.
- Two State listed TEC buffers:
  - Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain) – Critically Endangered (unlikely to occur within the ERB).
  - SCP20a (unlikely to occur within the ERB).
- One State listed PEC:
  - Banksia dominated woodlands of the Swan Coastal Plain IBRA region (P3)
- Three State listed Priority flora species:

  - *Cyathochaeta teretifolia* (P3)
  - *Anigozanthos humilis* subsp. *chrysanthus* (P4)
  - *Conostylis bracteata* (P3)
- Regionally significant vegetation within five Bush Forever sites
- Gnangara-Moore River State Forest
- Groundwater dependent ecosystems
- Three ecological linkages.

The Banksia Woodlands of the Swan Coastal Plain TEC was recorded by RPS (2019a) within the Malaga and Whiteman Park South sections, between Hepburn Avenue and Beechboro Road North, as well as south of Gnangara road within the Lord Street section (Figure 2-2). The state-listed Banksia dominated woodlands of the SCP IBRA region PEC is closely associated with the EPBC Act-listed TEC and was also recorded in the same location as the TEC (Coffey 2015a).

Priority flora species *Conostylis bracteata* (P3) and *Anigozanthos humilis* subsp. *chrysanthus* (P4) were recorded within the ERB in remnant bushland between Hepburn Avenue, Marshall Road and Beechboro Road North. *Cyathochaeta teretifolia* (P3) was recorded immediately adjacent to the ERB between Park Street and Woollcott Avenue.

Five Bush Forever sites are located within the ERB (three of which overlap the boundary only slightly). Bush Forever sites 304 and 480 are the two sites which have large portions within the ERB. Bush Forever 480 (Victoria Road Bushland) is completely within the Tonkin Highway and Reid Highway interchange and as such will have been mostly cleared for the PDNH project and therefore will not be a constraint. Approximately 600 ha of Bush Forever 304 (Whiteman Park) is within the ERB within the Whiteman Park South and Lord Street sections. The vegetation condition within Bush Forever 304 ranges from Completely Degraded to Very Good (RPS 2019a). The MEL project may impact on intact native vegetation by direct clearing or indirect impacts such as introduction of weeds. Depending on how much of Bush Forever site 304 is required for clearing this could be a constraint.

Several occurrences of GDEs have been mapped along the PDNH alignment and within the ERB. Based on the likely similarity of vegetation extending beyond the PDNH study area and into the ERB, as well as the presence of extensive wetland systems and shallow groundwater tables throughout the South Whiteman Park section, it is expected that GDEs and/or species dependent to some extent on groundwater are also present more broadly within the ERB.

While the flora and vegetation of the ERB is relatively well characterised, further information is likely to be required to support future impact assessment of the MEL with regard to flora and vegetation, particularly to address several spatial areas for which no data is currently available. Some additional work is likely to be required to ensure a comprehensive knowledge base that adequately covers relevant technical guidelines.

3. Terrestrial fauna

3.1 Relevant guidance

The EPA's objective for terrestrial fauna is "to protect terrestrial fauna so that biological diversity and ecological integrity are maintained" (EPA 2016c).

The following policies and guidance are relevant to the terrestrial fauna factor:

- Environmental Factor Guideline: Terrestrial Fauna (EPA 2016c);
- Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna (EPA 2016d);
- Technical Guidance: Terrestrial Fauna Surveys (EPA 2016e);
- Technical Guidance: Sampling of short range endemic invertebrate fauna (EPA 2016f);
- Revised Draft Referral Guideline for three threatened Black Cockatoo species: Carnaby's Cockatoo, Baudin's Cockatoo and the Forest Red-tailed Black Cockatoo (DotEE 2017); and
- EPBC Act Referral Guidelines for three threatened black cockatoo species: Carnaby's cockatoo (endangered) *Calyptorhynchus latirostris,* Baudin's cockatoo (vulnerable) *Calyptorhynchus baudinii,* and Forest red-tailed black cockatoo (vulnerable) *Calyptorhynchus banksii naso* (DSEWPAC 2012).

3.2 Information Sources

3.2.1 Databases searches

The following database searches were undertaken to support this analysis:

- DBCA Threatened and Priority Fauna Database; and
- DotEE EPBC Act Protected Matters Search Tool Database.

3.2.2 Reports provided by PTA or publicly available

Eight terrestrial fauna surveys have been undertaken in areas intersecting the ERB (Table 3-1; PGV Environmental 2014a;b, Terrestrial Ecosystems 2018 , Coffey 2014, 360 Environmental 2013a, GHD 2014, Coffey 2015a and AECOM 2016). The surveys varied between level 1, level 2, reconnaissance, detailed and targeted surveys, and Black Cockatoo assessments, as defined by the changing requirements of survey guidance, including *Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna* (EPA 2016d), *Technical Guidance: Terrestrial Fauna Surveys* (EPA 2016e), and *EPBC Act Referral Guidelines for three threatened Black Cockatoo species* (DSEWPAC 2012). In addition, one aquatic fauna survey has previously been undertaken within part of Bennett Brook which intersects the ERB: A Freshwater Fish Survey of Bennett Brook (North Metro Catchment Group 2006).

Two other surveys have been undertaken relevant to the ERB (Table 3-1) including: a baseline study of the flora and fauna values of Bennett Brook (Success Hill Action Group Inc. 1999) and an investigation on kangaroo populations (PGV Environmental 2014c). The study areas for these surveys fall outside, but in proximity to, the ERB.

An additional 14 desktop assessments or other documents with relevant fauna related information for areas intersecting or adjacent to the ERB have also been reviewed.

All surveys and reports are listed in Table 3-1.

Table 3-1: Key reports reviewed relevant to fauna surveys

Title	Author	Year	Summary of scope
Field Surveys			
Waterbirds assessment	RPS	2018	Survey of waterbirds in wetland areas within and near to the ERB alignment. Preliminary findings from November 2018. A follow-up survey to inform the 'waterbird survey and habitat assessment' has been scheduled for early Spring 2019.
Level 1 Fauna Risk Assessment and Black-Cockatoo Habitat Assessment for the alternative Ellenbrook Rail Line Alignments of Metronet	Terrestrial Ecosystems	2018	Level 1 fauna risk assessment to identify threatened or priority vertebrate fauna likely to be in the Study Area. Included a Black Cockatoo habitat assessment.
Ellenbrook Bus Rapid Transit Biological Assessment	AECOM	2016	Level 1 fauna assessment including assessment of relevant matters of national environmental significance. Included a Black Cockatoo habitat assessment.
NorthLink WA Level 2 Targeted Fauna Assessment Perth-Darwin National Highway	Coffey	2015	Level 2 fauna assessment to identify and assess ecological values and significance, including fauna movement survey and a Black Cockatoo habitat assessment.
Public Transport Authority Forrestfield Airport Link Environmental investigation	GHD	2014	Level 1 fauna assessment to evaluate of the major environmental constraints in the Study Area. Included a Black Cockatoo habitat assessment.
Memorandum: Tonkin Grade Separations – Flora, Vegetation and Fauna Habitat Mapping Gaps Analysis	Coffey	2014	Level 1 fauna assessment to ground-truth desktop information presented in 360 Environmental report (2013b).
Lot 800 Youle-Dean Road, Brabham – Black Cockatoo Habitat Assessment	PGV Environmental	2014	Black Cockatoo habitat assessment to update methodology and information provided in a 2007 ATA Environmental Carnaby's Cockatoo assessment.
Brabham LSP 3 Area – Black Cockatoo Habitat Assessment	PGV Environmental	2014	Black Cockatoo habitat assessment of foraging and breeding habitat.
Black-Cockatoo Assessment – Tonkin Highway	360 Environmental	2013	Black Cockatoo habitat assessment of foraging and breeding habitat.
Lot 800 Youle-Dean Road, Brabham – Kangaroo Population and Management	PGV Environmental	2014	Baseline kangaroo survey to outline approximate kangaroos present on site and their potential management prior to development.
Freshwater Fish Survey of Bennett Brook	North Metro Catchment Group	2006	Freshwater fish survey of Bennett Brook.
Bennett Brook Baseline Study of Flora and Fauna	Success Hill Action Group Inc.	1999	A baseline survey to investigate flora and vertebrate fauna values of the Bennett Brook area south of Benara Road in Caversham, to monitor the quality of water flow into

Title	Author	Year	Summary of scope
			Bennett Brook and the Swan River and to make recommendations for a management plan to preserve, protect and lead to the restoration of flora and fauna within the study area.
Desktop Assessments			
Bennett Springs East Structure Plan	RPS	2017	Desktop review of the remaining habitat within Bennett Springs East including database searches.
Ellenbrook Bus Rapid Transit Environmental Impact Assessment and Environmental Management Plan	Aurecon	2016	Desktop review of existing information including a recent biological survey by AECOM (2016).
Roads and Wildlife A Review of Purpose-Built Fauna Underpasses	Bamford Consulting Ecologists	2011	Desktop review of the effectiveness of purpose-built fauna underpasses for to the construction of a new section of road (Keane Road).
Public Environmental Review	Coffey	2015	Public Environmental Review for the Perth-Darwin National Highway (Swan Valley section). Desktop review of previous surveys and database searches.
Condition Environmental Management Plan Fauna – Construction	Coffey	2017	Management Plan for the Perth-Darwin National Highway (Swan Valley section). Desktop review of level 2 fauna survey (Coffey 2015c) and database searches.
Infrastructure Plan	Coffey	2017	Pre-construction Infrastructure Plan for the Perth-Darwin National Highway (Swan Valley section). Desktop review of fauna underpasses, bridges and fencing for habitat connectivity.
Tonkin Highway Expansion between Reid Highway and Guildford Road – Preliminary Environmental Impact Assessment	360 Environmental	2013	Preliminary Environmental Impact Assessment Report for the expansion of Tonkin Highway between Guildford Road and Reid Highway. Desktop review of previous surveys and database searches.
Lot 800 Youle-Dean Road, Brabham – Environmental Gap Analysis	PGV Environmental	2014	Desktop review of previous surveys and database searches. Gap analysis undertaken to determine information required.
Youle-Dean Road Upgrade and Realignment, Brabham – Environmental Assessment	PGV Environmental	2018	Desktop review of previous surveys for widening a road reserve and clearing of native vegetation.
Whiteman Park Conservation and Environmental Management Plan (CEMP)	Whiteman Park	2018	CEMP to provide a strategic plan for the management of Whiteman Park's environment. Desktop review of database searches.
Environmental Assessment Lots 346 & 347 Woollcott Avenue Brabham	Aurora Environmental	2013	Desktop review to consider the potential environmental impacts associated with the development site.

Title	Author	Year	Summary of scope
Environmental Assessment and Management Strategy Whiteman Edge LSP 1C	Emerge Associates	2014	Desktop review to consider the environmental values and attributes of the development sites.
Horse Swamp Environmental Management Plan	Michael Cook	2011	Environmental Management Plan to inform Whiteman Park about environmental issues and recommend sustainable management strategies.
Bennett Brook South Management Plan	Whiteman Park	2012	Management Plan to inform Whiteman Park of ecological issues including fauna protection and monitoring within the reserve.

3.2.3 Information coverage

Several fauna field surveys have been undertaken in areas overlapping the ERB in relation to the following projects:

- Forrestfield Airport Link – Level 1 Fauna Assessment (GHD 2014);
- Tonkin Grade Separations – Level 1 Fauna Assessment (Coffey 2014, 360 Environmental 2013a);
- Perth-Darwin National Highway – Level 2 Fauna Assessment (Coffey 2015c);
- Ellenbrook Bus Rapid Transit – Level 1 Fauna Assessment (AECOM 2016);
- Morley-Ellenbrook Line – Level 1 Fauna Risk Assessment (Terrestrial Ecosystems 2018); and
- The Bennett Brook Fish Survey Project – Freshwater Fish Survey of Bennett Brook (North Metro Catchment Group 2006).

The study areas of the fauna field surveys listed in Table 3-1 are displayed in Figure 3-1.

The GHD (2014) study for FAL generally covers the Bayswater Junction section of the MEL, the southernmost section of the ERB. The study does not cover the western extent of the ERB around Bayswater Station. In the zone between the existing Midland Line to Tonkin Highway, south of the Collier Road intersection, the GHD study area is limited to the industrial and vegetated areas between Clavering Road, Bassendean Road and Tonkin Highway. Parts of the ERB not covered by GHD (2014) are mostly residential, commercial and industrial land uses; however, there are a small number of public open space or road reserves with vegetation.

The 360 Environmental (2013a) and Coffey (2014) studies for the Tonkin Grade Separations generally cover the ERB in the Tonkin Highway section.

The Coffey (2015c) study for the PDNH overlaps with parts of the Malaga section of the MEL. It covers the Tonkin Highway and Reid Highway road reserves as well parts of Hepburn Avenue and Beechboro Road North. Unlike the flora and vegetation assessment for the PDNH (Coffey 2015a), the fauna study is largely limited to the PDNH footprint without including surrounding areas. This study is therefore expected to be of limited value to this analysis, particularly if construction of PDNH has resulted in removal of most permanent fauna values identified.

The AECOM (2016) study for the ERBT project generally corresponds to the Lord Street and Ellenbrook sections of the MEL. The study area runs in a narrow strip parallel to and west of Lord Street south of Marshall Road, intersects Lord Street at Youle-Dean Road, follows Drumpellier Drive and ends at The

Promenade in Ellenbrook. Parts of the ERB not covered by AECOM (2016) include the section north of The Promenade and a narrow strip west of Drumpellier Drive.

The Terrestrial Ecosystems (2018) study for the MEL considered ten areas in total. Six of the areas are within the Whiteman Park South and Lord Street section of the ERB:

1. A patch of vegetation on the northeast corner of Hepburn Avenue and Marshall Road.
2. A patch of vegetation associated with a Conservation Category Wetland approximately 500 m north of the intersection of Marshall Road and Silver Swan Road.
3. Bennett Brook and an adjoining area to the west, immediately south of Whiteman Park.
4. Horse Swamp.
5. An area north of Horse Swamp, west of Lord Street and south of Woollcott Avenue.
6. An area north of Woollcott Avenue and west of Lord Street.

The remaining four areas considered an alternative route from Malaga to Ellenbrook via the PDNH alignment, though this is not part of the ERB. Terrestrial Ecosystems (2018) is the primary source of information for the Whiteman Park South section, which includes the Marshall Road paddock. However, this study does not include the portion of the ERB south of Marshall Road beneath Western Power's 330 kV transmission lines, nor does it consider the fauna values of the semi-rural residential area of Bennett Springs north of Marshall Road (e.g. near Dulwich, Cheltenham and Rugby Streets).

The North Metro Catchment Group freshwater fish survey (2006) is the only recent aquatic fauna survey undertaken for the Bennett Brook catchment. Sampling was undertaken throughout the entire brook system from the headwaters in Whiteman Park to the mouth of the brook where it joins the Swan River. The study area included the Whiteman Park South section of the ERB.

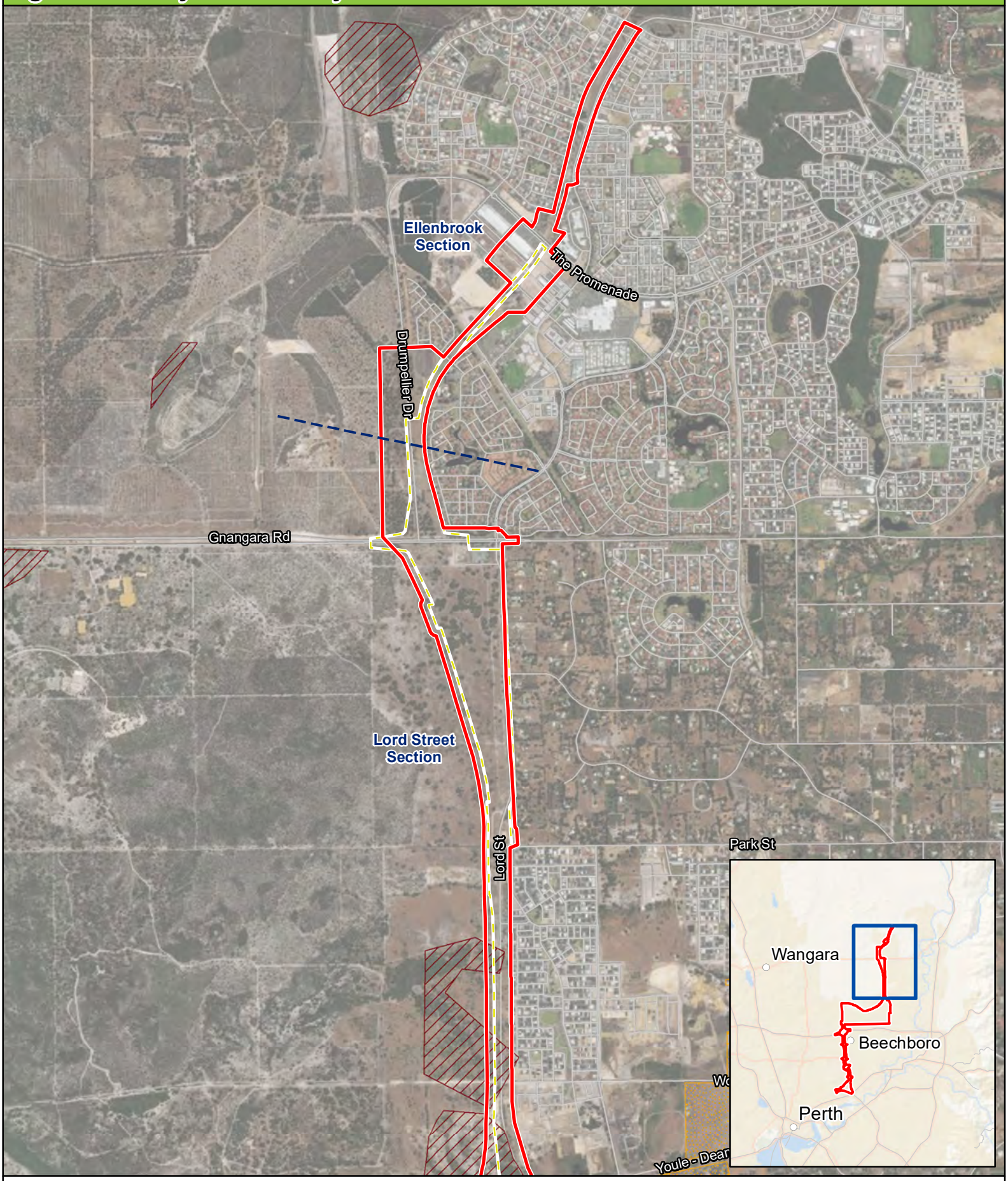
Given the recent nature of the majority of these projects (2013 to 2018), the information within the reports is considered by ELA to be generally sufficient for the identification of key values relating to the fauna within the ERB. Although the fish fauna survey at Bennett Brook is much older (2006), the information provided in it is considered sufficient for the identification of potential values relating to aquatic fauna within the ERB. Additional surveys would be required to confirm the currency of the findings from this survey. It should be noted that while previous reports/surveys have indicated the presence of an environmental value, as a result of the project's implementation, these values may no longer be present. Further verification of presence/absence of values may be required at a later date.

The ERB includes some areas that have not been considered in the abovementioned surveys, namely:

- The southwest corner of Whiteman Park, east of Beechboro Road North; and
- The southeast corner of Whiteman Park between Whiteman Drive East, Mussel Pool Road and Horse Swamp.

No information is available regarding Short-range Endemic (SRE) invertebrate fauna.

Figure 3-1a: Key fauna survey areas



Legend

- Environmental review boundary

Fauna survey boundaries

- Black Cockatoo habitat assessmetnt & kangaroo survey (PGV Environmental 2014)
- Level 1 fauna assessment (AECOM 2016)
- Level 1 fauna assessment (Terrestrial Ecosystems 2018)

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

N

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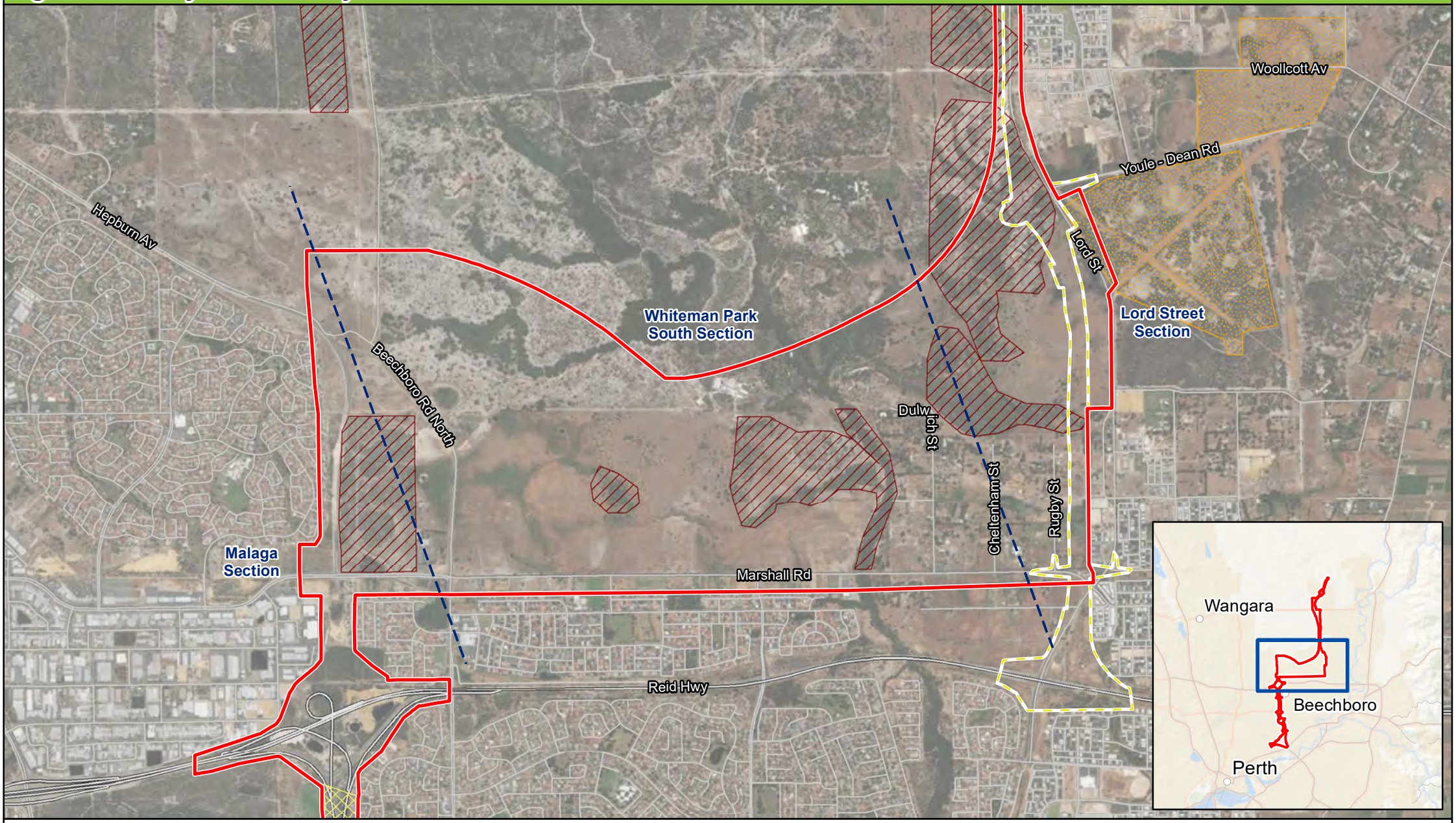
Figure 3-1b: Key fauna survey areas



Legend

- Environmental review boundary

Fauna survey boundaries

- Black Cockatoo habitat assessmetnt & kangaroo survey (PGV Environmental 2014)
- Level 2 fauna assessment (Coffey 2015)
- Level 1 fauna assessment (AECOM 2016)
- Level 1 fauna assessment (Terrestrial Ecosystems 2018)

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

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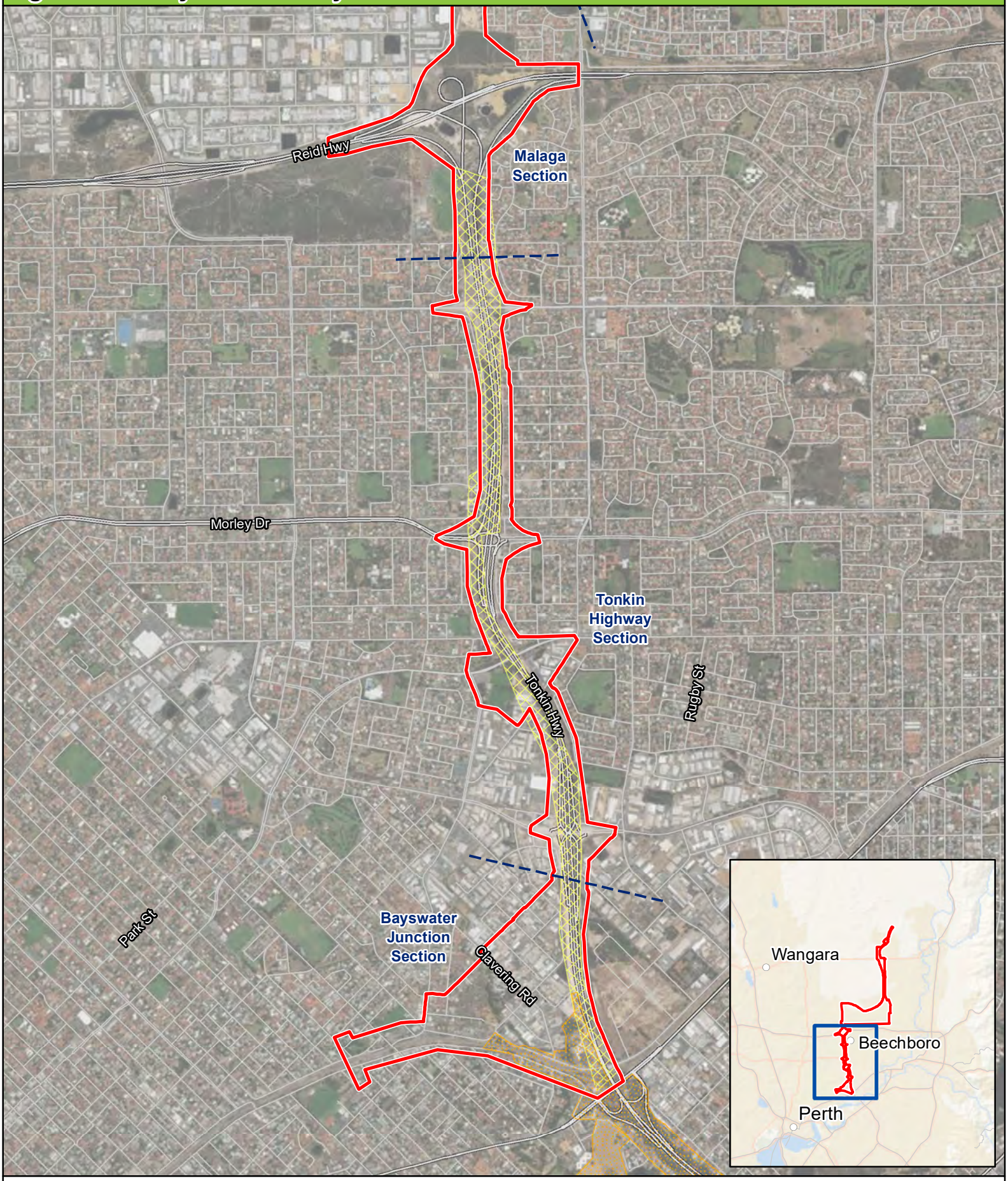
Figure 3-1c: Key fauna survey areas



Legend

Environmental review boundary

Fauna survey boundaries

Level 2 fauna assessment (Coffey 2015)

Level 1 fauna assessment (GHD 2014)

0 250 500 1,000

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

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3.3 Description of relevant environmental values

3.3.1 Fauna habitat

Broad habitat types and associated fauna values based on those described by Coffey (2015c) have been used to compile a description of fauna habitat using compiled information from various studies conducted within the ERB (Table 3-2). A total of eight fauna habitat types were described overlapping the ERB (Malaga and Lord street section) including four natural fauna habitat types: Banksia woodland, Eucalypt/Corymbia woodland, Dampland, and Wetland habitats; and four secondary fauna habitat types: modified vegetation, paddock, pine plantation and cleared areas (Table 3-2; Coffey 2015c; AECOM 2016; Terrestrial Ecosystems 2018).

The habitat types present in the ERB have variable quality from cleared areas and infrastructure to intact native vegetation of good quality (Terrestrial Ecosystems 2018). The Ellenbrook section (where mapped) is described as cleared (AECOM 2016), with the majority of the mapped fauna habitat within the Lord Street section described as Eucalypt/Corymbia woodland (open Jarrah/Marri woodland) (AECOM 2016, Terrestrial Ecosystems (2018). Mapped habitat within the Whiteman Park South section is described as a mixture of Eucalypt/Corymbia woodland (open Jarrah/Marri), Dampland (Melaleuca around inundated areas) and Banksia woodlands (Terrestrial Ecosystems 2018). Modified vegetation is the predominant habitat type within the Malaga section (Coffey 2015c).

Table 3-2: Broad fauna habitat types

Habitat types	Mapped extent	Habitat value
Banksia woodland	Limited mapped extent alongside Lightning Swamp and around Gnangara Road. RPS and Coffey flora and vegetation surveys also noted Banksia woodland within the north-eastern part of the Malaga section. This was not reflected in the Terrestrial Ecosystems survey report which mapped the area as Eucalypt/Corymbia woodland and grasstrees.	Moderate value. Potential foraging habitat for black cockatoos.
Eucalypt/Corymbia woodland	Limited mapped extent surrounding areas of Dampland vegetation and southeast side of the Reid Highway/Tonkin Highway intersection. Also mapped by Terrestrial Ecosystems in the north-eastern part of the Malaga section.	High value. Microhabitats provide potential foraging, shelter and breeding habitat.
Dampland (seasonally waterlogged)	Limited mapped extent north of the Reid Highway/Tonkin Highway intersection, throughout the Whiteman Park South section, between Charlton Way and Woollcott Avenue in the Lord Street section and adjacent to Youle-Dean Road in the Lord Street section.	Moderate value, particularly for amphibians and Quenda, where thick understorey is present.
Wetland (open water areas)	Limited mapped extent within the Malaga and Whiteman Park South sections.	Moderate value. Provides habitat for waterbirds (including migratory), amphibians and other aquatic species, and an important water source for local fauna.

Habitat types	Mapped extent	Habitat value
Modified vegetation- significantly altered structure, sporadic cover or roadside rehabilitation	Some mapped extent within Malaga section and adjacent to urban development in the Lord Street section.	Low value.
Paddock- may have scattered mature remnant trees	Present along Lord Street. Also evident from assessment of aerial photography throughout the Whiteman Park South section.	Low value.
Pine plantation	Present north of Gnangara Road in northern extent of Lord Street Section.	Important food source and roosting habitat for Black Cockatoos. Otherwise low value to other species.
Infrastructure/Cleared	Most prevalent within the ERB, including: • north of Reid Highway/Tonkin Highway intersection; • between Gnangara Road and Charlton Way in the Lord Street section; and • surrounding Youle-Dean Road in the Lord Street section. Based on assessment of aerial photography this also described the majority of the Bayswater Junction and Tonkin Highway sections of the alignment.	No value.

Note: 'limited' habitat may be because of limited information availability and/or limited actual on-ground availability of the habitat.

3.3.2 Species diversity

Species diversity from the previous fauna field surveys that overlap the ERB are shown in Table 3-3. These numbers include seven introduced species which have been recorded within the ERB including (AECOM 2016; Coffey 2015c; GHD 2014):

- European Cattle (*Bos taurus*);
- Red Fox (*Vulpes vulpes*);
- Feral Cat (*Felis catus*);
- European Rabbit (*Oryctolagus cuniculus*);
- House Mouse (*Mus musculus*);
- Dog (*Canis lupus familiaris*); and
- Mosquito Fish (*Gambusia holbrookii*).

Table 3-3: Species richness from previous surveys

Reference	Study Area Size (ha)	Birds	Mammals	Reptiles	Amphibians	Fish	Total
AECOM 2016	190.22	33	6	3	0	0	**42**
Coffey 2015c	987.1	62	9	19	6	1	**97**
GHD 2014	153	35	4	2	1	0	**42**
North Metro Catchment Group 2006	N/A	0	0	0	5	4	**9**

PGV Environmental (2014c) identified a large population of *Macropus fuliginosus* (Western grey kangaroo) as being of concern for other developments close to the ERB. The highest number recorded was 275 individuals in a 100 ha area slightly overlapping the southern part of the Lord Street section, with kangaroos observed grazing on grass in cleared paddocks. The Western grey kangaroo was the most abundant native mammal recorded in two other fauna surveys overlapping the ERB (AECOM 2016, Coffey 2015c).

A recent waterbird survey was undertaken within the ERB in November 2018 by RPS, with a follow up survey planned for early spring 2019 (RPS in prep.). The initial survey undertaken in November 2018 identified 21 waterbird species, one of which is listed as migratory under the EPBC Act and is addressed below. The remaining species are not of conservation significance. All 21 species were recorded at Horse Swamp, and four or fewer species recorded at Bennett Brook, Mussel Pool, seasonal wetlands and dams.

3.3.3 Conservation significant fauna

Based on the previous fauna surveys outlined in Section 3.3.2 and database searches (DotEE 2019a; DBCA 2007-2019; DBCA 2019b), a total of 15 fauna species of conservation significance were either recorded or determined to be likely to occur within the ERB. Table 3-4 outlines these species, their conservation status (both at a Commonwealth and State level) and distribution and habitat. It should be noted that oceanic or pelagic species identified in the database searches have been excluded from this assessment given that they do not occur within the ERB.

Four conservation significant fauna species have previously been recorded within the ERB including:

- *Calyptorhynchus latirostris* (Carnaby's Cockatoo);
- *Calyptorhynchus banksii naso* (Forest Red-tailed Black Cockatoo);
- *Plegadis falcinellus* (Glossy Ibis); and
- *Isoodon obesulus* subsp. *fusciventer* (Quenda).

Nine conservation significant fauna species are considered likely (or with potential) to occur within the ERB, given the proximity of nearby records and/or availability of suitable habitat including:

- *Apus pacificus* (Fork-tailed Swift);
- *Ardea modesta* (Eastern Great Egret);
- *Calyptorhynchus baudinii* (Baudin's Cockatoo);
- *Macropus irma* (Western brush wallaby);
- *Hydromys chrysogaster* (Water rat);
- *Neelaps calonotos* (Black-striped Snake);

- *Ctenotus gemmula* (Jewelled Sandplain Ctenotus);
- *Galaxiella nigrostriata* (Black-stripe minnow); and
- *Synemon gratiosa* (Graceful Sun-moth).

The remaining species listed in Table 3-4 are considered unlikely to occur.

The Critically Endangered Western Swamp Tortoise (*Pseudemydura umbrina*) was also identified from database searches as possibly occurring (DBCA 2019b). The Western Swamp Tortoise is known from three locations including Ellen Brook Nature Reserve, Twin Swamps Nature Reserve and Mogumber Nature Reserve. The closest known occurrence of this species is within the Twin Swamps Nature Reserve which is approximately 7 km east of the Ellenbrook section of the ERB. It is considered unlikely to occur within the ERB itself and based on current knowledge of likely project implementation, indirect impacts are considered unlikely due to the distance. This species is therefore not considered further.

Table 3-4: Conservation significant species potentially occurring the ERB

Species	Conservation status		Distribution and habitat	Likelihood of occurrence within the ERB[3]
	EPBC Act[1]	BC Act[2]		
Birds				
Carnaby's Cockatoo (*Calyptorhynchus latirostris*)	EN	EN	Carnaby's Cockatoo is endemic to southwest WA with populations extending from the Murchison River to Esperance, and inland to Coorow, Kellerberrin and Lake Cronin (DotEE 2019b, DSEWPAC 2012). Carnaby's Cockatoo foraging habitat includes native shrubland, kwongan heathland and woodland dominated by proteaceous plant species including Banksia, Hakea and Grevillea, and pine plantations (DSEWPAC 2012, DPaW 2013).	**Recorded.** Carnaby's Cockatoo have been observed foraging in previous fauna surveys overlapping the ERB (Terrestrial Ecosystems 2018, Coffey 2015c, GHD 2014). 50% of individual fauna records provided from the DBCA database search were Carnaby's Cockatoo.
Baudin's Cockatoo (*Calyptorhynchus baudinii*)	EN	VU	Baudin's Cockatoo is found in southwest WA with populations extending from Albany northward to Gidgegannup and Mundaring (east of Perth), and inland to the Stirling Ranges and near Kojonup (DotEE 2019b, DSEWPAC 2012). Baudin's Cockatoo foraging habitat includes Eucalyptus woodlands and forest, and proteaceous woodland and heath (DSEWPAC 2012).	**Potential to occur – vagrant**. Baudin's Cockatoo may infrequently be seen foraging in the project area but would typically return to the hills to roost at night. They are highly unlikely to breed or roost in the MEL proposal ERB.
Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)	VU	VU	Forest Red-tailed Black Cockatoo is found in southwest WA with populations extending north to Perth and east to Wundowie, Mount Helena, Christmas Tree Well, North Bannister, Mount Saddleback, Rocky Gully and the upper King River (DSEWPAC 2012). Forest Red-tailed Black Cockatoo foraging habitat includes jarrah and marri woodlands and forests.	**Recorded.** Forest Red-tailed Black Cockatoo have been observed foraging in previous fauna surveys overlapping the ERB (Terrestrial Ecosystems 2018, AECOM 2016, Coffey 2015c, GHD 2014).
Australian Painted Snipe (*Rostratula benghalensis australis)*	EN	EN	The Australian Painted Snipe has been recorded at wetlands in all states of Australia, however it is most common in eastern Australia (DotEE 2019b). This species generally inhabits shallow terrestrial freshwater wetlands, including temporary and permanent lakes, swamps and claypans, sometimes utilising areas that are lined with trees, or that have some scattered fallen or washed-up timber (DotEE 2019b).	**Unlikely.** Australian Painted Snipe are most common in Eastern Australia and are rarely recorded in Western Australia.
Fork-tailed Swift (*Apus pacificus*)	Mi	–	The Fork-tailed Swift is a non-breeding visitor to all states and territories of Australia. In Western Australia there are widespread but scattered records of the Fork-tailed Swift along much of the coastline, with some sparsely scattered inland records, especially in the Wheatbelt (DotEE 2019b). They are almost exclusively aerial, and are most commonly found over inland plains, but sometimes above foothills or in coastal areas (DotEE 2019b).	**Likely.** Suitable habitat is present in the ERB.

Species	Conservation status		Distribution and habitat	Likelihood of occurrence within the ERB[3]
	EPBC Act[1]	BC Act[2]		
Glossy Ibis (*Plegadis falcinellus*)	Mi	Mi	The Glossy Ibis is widespread throughout the world, with the exception of southeast Asia, where it is scarce. In Australia it is generally located east of the Kimberley in Western Australia and the Eyre Peninsula in South Australia (DotEE 2019b).	**Recorded.** The Glossy Ibis was recorded at Horse Swamp (RPS in prep.).
Cattle Egret (*Ardea ibis*)	Mi	–	The Cattle Egret is native to Africa, southwest Europe and Asia. In Australia, it is widespread and common and in Western Australia, the Cattle Egret is most common in the north east from Wyndham through to Arnhem Land, in the NT. In the non-breeding season, it can occur in far south-west coastal areas of Western Australia.	**Unlikely.** The ERB is located outside of the predominant distribution in Western Australia.
Eastern Great Egret (*Ardea modesta*)	Mi	–	The Eastern Great Egrets occurs across Australia including in south-west Western Australia, where it utilises a wide range of wetland habitats.	**Likely.** Suitable habitats are available within the ERB.
Mammals				
Woylie (*Bettongia penicillata ogilbyi*)	EN	CR	Woylies prefer patches of dense undergrowth, that provide continuous canopy and therefore refuges against introduced predators. Scattered Woylie populations may be found throughout the jarrah forest in the south-west corner of Western Australia (DEC 2012c).	**Unlikely.** There are translocated populations of Woylies within fenced enclosures in Whiteman Park (AECOM 2016, DEC 2012c) but this species is considered unlikely to occur within the ERB outside this area.
Chuditch (*Dasyurus geoffroii*)	VU	VU	Chuditch currently only occurs in areas dominated by sclerophyll forest or drier woodland, heath and mallee shrubland and require adequate numbers of suitable den and refuge sites and sufficient prey biomass to survive (DEC 2012a). The majority of records are found in the contiguous Jarrah forests of the south west of Western Australia.	**Unlikely.** There are no known established populations within the Greater Perth metropolitan area.
Western Brush Wallaby (*Macropus irma*)	–	P4	The Western Brush Wallaby is distributed across the south-west of Western Australia from north of Kalbarri to Cape Arid. This species optimum habitat is open forest or woodland, seasonally wet flats with low grasses and open thickets (DotEE 2019b).	**Likely.** DBCA (2019b) have recorded several individuals surrounding the ERB, with the most recent record 4 km north of the Whiteman Park South section in 2016. Western Brush Wallaby have also been confirmed in Whiteman Park from the annual trapping survey (AECOM 2016).

Species	Conservation status		Distribution and habitat	Likelihood of occurrence within the ERB[3]
	EPBC Act[1]	BC Act[2]		
Quenda (*Isoodon obesulus* subsp. *fusciventer*)	–	P4	Quenda are widely but patchily distributed through south-western WA, from around Guilderton to east of Esperance and inland to Hyden. This species prefers low, dense vegetation such as heath and swampy habitat and is often associated with forests, woodland, shrubland and riparian areas (DEC 2012b).	**Recorded.** Quenda have been found at the intersection of Reid and Tonkin Highways (Coffey 2015c); adjacent to the Tonkin Highway in revegetation (GHD 2014); and from numerous potential diggings (AECOM 2016). DBCA (2019b) have recorded over 300 individuals overlapping and surrounding the ERB.
Water Rat (*Hydromys chrysogaster*)	–	P4	The water rat inhabits lakes, dams, beaches, mangroves and offshore islands. Swan River and riparian vegetation provides suitable habitat.	**Likely.** DBCA (2019b) have recorded several individuals surrounding the ERB, with the most recent record in 2011. Water rat are likely to be present in the swampy areas, therefore the Wetland habitat.
Reptiles				
Black-striped Snake (*Neelaps calonotos*)	–	P3	The Black-striped Snake occurs only along the Swan Coastal Plain with the bulk of this species' known distribution occurring in the Perth region, however there have been recent records of this species further north near Dongara and Eneabba suggesting it has a broader distribution (Bush et al. 2010).	**Likely.** DBCA (2019b) have recorded two individuals in the Bayswater Junction section and Lord Street section of the ERB. The Black-striped Snake are likely to utilise the Banksia woodland habitat.
Jewelled Sandplain Ctenotus (*Ctenotus gemmula*)	–	P3	The Jewelled Sandplain Ctenotus is scarce on the Swan Coastal Plain as it is the northern extent of its range (Bush et al. 2010).	**Likely.** DBCA (2019b) have recorded two individuals 4 km north-east of the Ellenbrook section of the ERB. The Jewelled Sandplain Ctenotus may utilise the Banksia woodland habitat.

Species	Conservation status		Distribution and habitat	Likelihood of occurrence within the ERB[3]
	EPBC Act[1]	BC Act[2]		
Fish				
Black-stripe minnow, (*Galaxiella nigrostriata*)	EN	EN	The Black-striped minnow is restricted to the ephemeral peat wetlands of south western Australia where it has a distribution ranging from Lake Chandala, north of Muchea, south to Augusta and along the south western coastline to the west of Albany (TSSC 2018). This species is believed to have once inhabited Bennett Brook and has more recently been recorded nearby in Ellen Brook (North Metro Catchment Group 2006).	**Potential.** This species has been recorded approximately 4.2 km east of the ERB in Ellen Brook. Suitable habitat is present in Bennett Brook although it was not recorded during aquatic fauna surveys in 1997-98 or 2006 (North Metro Catchment Group 2006).
Invertebrates				
Graceful Sun-moth (*Synemon gratiosa*)	–	P4	Habitat for sun moth is in the Swan Coastal Plain (Banksia woodland on Spearwood and Bassendean dunes, where the second known host plant *Lomandra hermaphrodita* is widespread.	**Likely.** DBCA (2019b) have recorded several individuals surrounding the ERB in 2011. Sun moth may occur in Bayswater Junction section in woodland habitats adjoining Tonkin Highway (GHD 2014) or Whiteman Park South section.

[1] Species listed under the EPBC Act
CR = listed as Critically Endangered under the EPBC Act.
EN = listed as Endangered under the EPBC Act.
VU = listed as Vulnerable under the EPBC Act.
[2] Species listed in Western Australia under the *Biodiversity Conservation Act 2016* (BC Act) or by the Department of Biodiversity, Conservation and Attractions (DBCA)
CR = Schedule 1: Fauna that is rare or is likely to become extinct as critically endangered flora (CR) under the BC Act.
EN = Schedule 2: Fauna that is rare or is likely to become extinct as endangered flora (EN) under the BC Act.
VU = Schedule 3: Fauna that is rare or is likely to become extinct as vulnerable flora (VU) under the BC Act.
Mi = Schedule 5: Migratory birds protected under an international agreement. A subset of the migratory animals, that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species under the BC Act.
P1 = Priority 1: Poorly-known species – species that are known from one or a few locations (generally five or less) which are potentially at risk (DBCA).
P2 = Priority 2: Poorly-known species – species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation (DBCA).
P3 = Priority 3: Poorly-known species – species that are known from several locations, and the species does not appear to be under imminent threat (DBCA).
P4 = Priority 4: Rare, Near Threatened and other species in need of monitoring (DBCA).
[3] Likelihood of occurrence criteria
Known to occur: Recorded from the study area, through database search results and/or from previous surveys of the study area (<20 years)
Likely to occur: The study area is within the species current distribution and contains suitable habitat for the species, however; the species utilises seasonal habitat or has a large home range, so is not always present/visible in the study area; and/or Survey limitations identified.

Potential to occur: The study area is within the species current distribution and contains habitat, however (at least two of below);

- The study area is located on the edge of the species range or it has a patchy distribution; and/or
- Survey limitations identified; and/or
- Habitat is less suitable; and/or
- Species is cryptic, and/or difficult to record utilising traditional survey methods.

Potential to occur – vagrant: Species has the potential to occur on a vagrant, or transient, basis only in that:

- May occasionally occur within the site;
- May occasionally fly or forage over the site (aerial species only);
- Are unlikely to utilise the site for foraging, breeding or nesting; and
- Are unlikely to utilise the site on an ongoing or permanent basis.

Unlikely to occur: The study area is within the species current distribution and either:

- Contains habitat, was adequately surveyed (including for seasonal, migratory and cryptic species and fauna species with large home ranges) and did not record the species; or
- The habitat is modified and unlikely to support the species and survey limitations identified.

3.3.4 Black cockatoo habitat assessment

A number of surveys have been undertaken within, or in proximity, to the ERB to assess foraging, roosting and breeding habitat for Black Cockatoos.

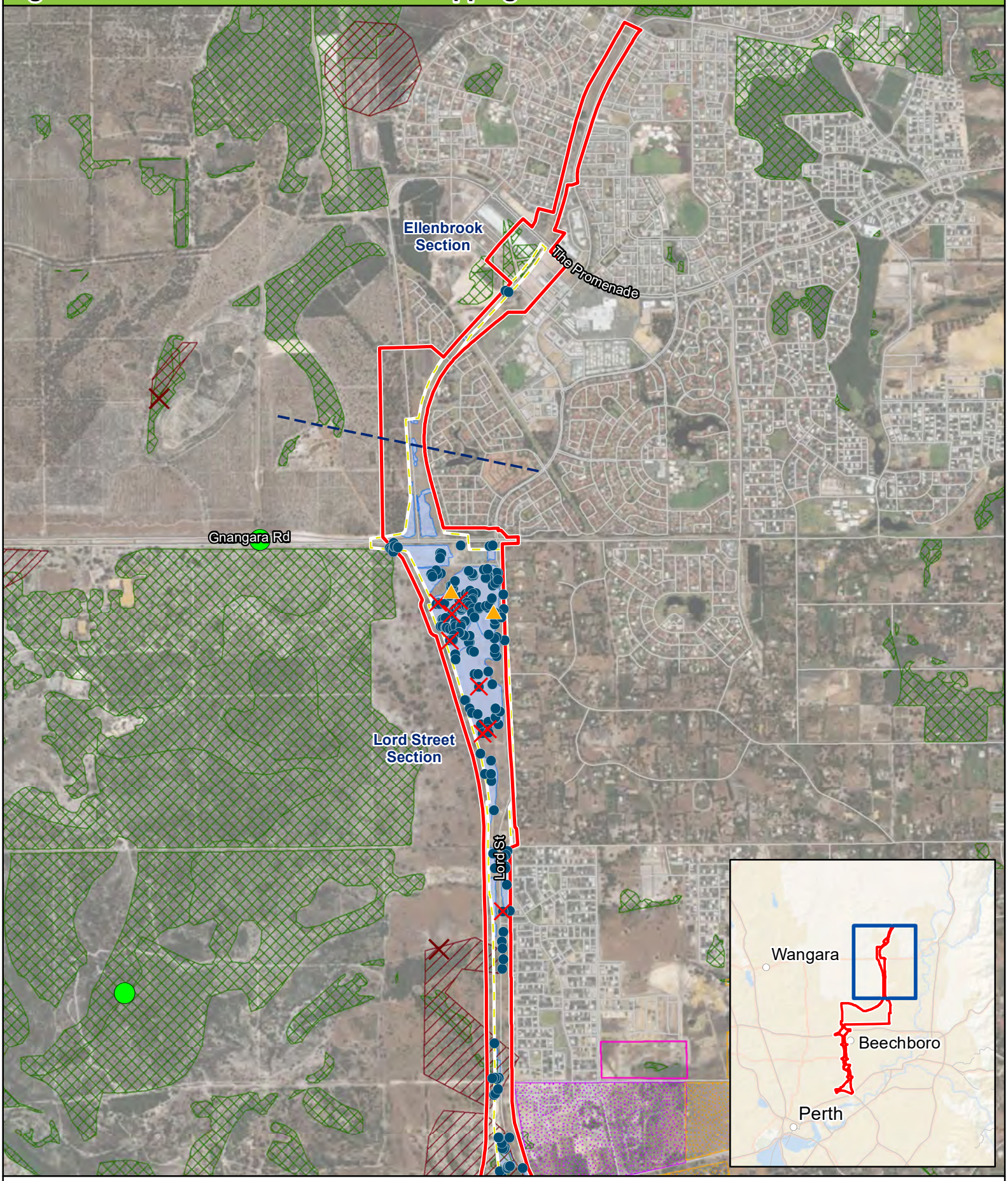
A summary of these surveys is provided in Table 3-5. Note that the extents of habitat are not mutually exclusive between surveys and do not directly represent the extents of habitat found in the ERB. Key study areas and available mapping of habitat values are presented in Figure 3-2.

Table 3-5: Black cockatoo assessments from previous surveys

Reference	Study area size* (ha)	Description of location of study area	Potential foraging habitat* (ha)	Potential breeding trees* (individuals)
Terrestrial Ecosystems 2018	406.7	Malaga, Lord Street and Ellenbrook sections of the MEL proposal ERB and an additional alignment option along PDNH route from Reid Highway to Gnangara Road.	153.3	10
AECOM 2016	190.2	Ellenbrook Bus Rapid Transit route, constituting the Lord Street section of the MEL proposal ERB.	63.1	291
Aurecon 2016 (utilising data from AECOM 2016	56.8	Ellenbrook Bus Rapid Transit route, constituting the Lord Street section of the MEL proposal ERB.	10.0	106
Coffey 2015c	987.1	Perth-Darwin National Highway, constituting the Bayswater Junction, Tonkin Highway and Malaga sections of the MEL proposal ERB.	253.5	1061
GHD 2014	153	Forrestfield Airport Link, constituting the Bayswater Junction of the MEL proposal ERB.	19.5	125
PGV Environmental 2014a	110	Lot 800 Youle-Dean Road constituting the southern extent of the Lord Street section of the MEL proposal ERB.	38.2	163
PGV Environmental 2014b	Not specified	Expanse of land in-between Youle-Dean Road in the south, Paterson Road in the north, Partridge Street in the west and Murray Road in the east. Does not intersect the MEL ERB, but lies adjacent to the southern extent of the Lord Street section of the MEL proposal ERB.	1.4	65
360 Environmental 2013a	99	Study area comprised the Malaga Section of the ERB from the Reid Highway south to the Bayswater Junction section.	17.3	148
Coffey 2014	N/A	The study area comprises a different alignment to the ERB but does cover part of the Malaga section of the ERB.	253.5	1061

*Some of the study areas, foraging habitat and breeding trees occur outside the ERB. Location of foraging and breeding habitats are shown in Figure 3-2.

Figure 3-2a: Black Cockatoo habitat mapping



Legend

Environmental review boundary

DBCA dataset

Carnaby's Cockatoo - Confirmed roost location

Carnaby's Cockatoo foraging areas on the Swan Coastal Plain (investigation required)

MNES survey boundaries

Black Cockatoo habitat assessmetnt & kangaroo survey (PGV Environmental 2014)

Desktop assessment (Aurora Environmental 2013)

Desktop assessment (Emerge Associates 2014)

Level 1 fauna assessment (Terrestrial Ecosystems 2018)

Terrestrial Ecosystems (2018)

Potential black cockatoo breeding tree

AECOM (2016)

Level 1 fauna assessment

Potential foraging habitat

Potential black cockatoo breeding tree

Hollows present

Direct observation of Forest Red-tailed Black Cockatoo

0 250 500 1,000

Metres

Datum/Projection:
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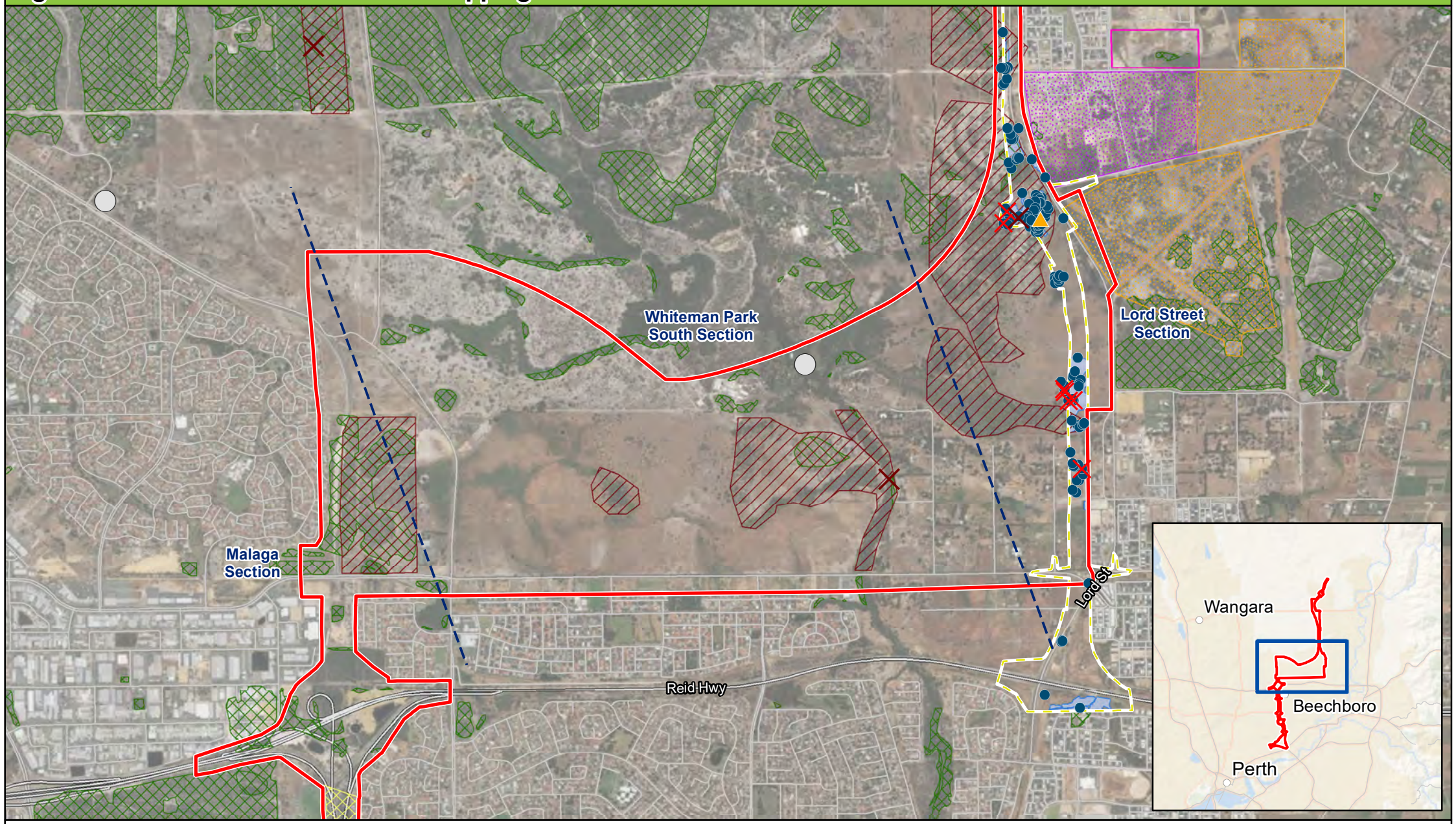
Figure 3-2b: Black Cockatoo habitat mapping



Legend

Environmental review boundary

DBCA dataset

Carnaby's Cockatoo - Unconfirmed roost location

Carnaby's Cockatoo foraging areas on the Swan Coastal Plain (investigation required)

MNES survey boundaries

Black Cockatoo habitat assessmetnt & kangaroo survey (PGV Environmental 2014)

Desktop assessment (Aurora Environmental 2013)

Desktop assessment (Emerge Associates 2014)

Level 2 fauna assessment (Coffey 2015)

Level 1 fauna assessment (Terrestrial Ecosystems 2018)

AECOM (2016)

Level 1 fauna assessment

Potential foraging habitat

Hollows present

Potential black cockatoo breeding tree

Direct observation of Forest Red-tailed Black Cockatoo

Terrestrial Ecosystems (2018)

Hollows present

0 250 500 1,000

Metres

Datum/Projection: GDA 1994 MGA Zone 50

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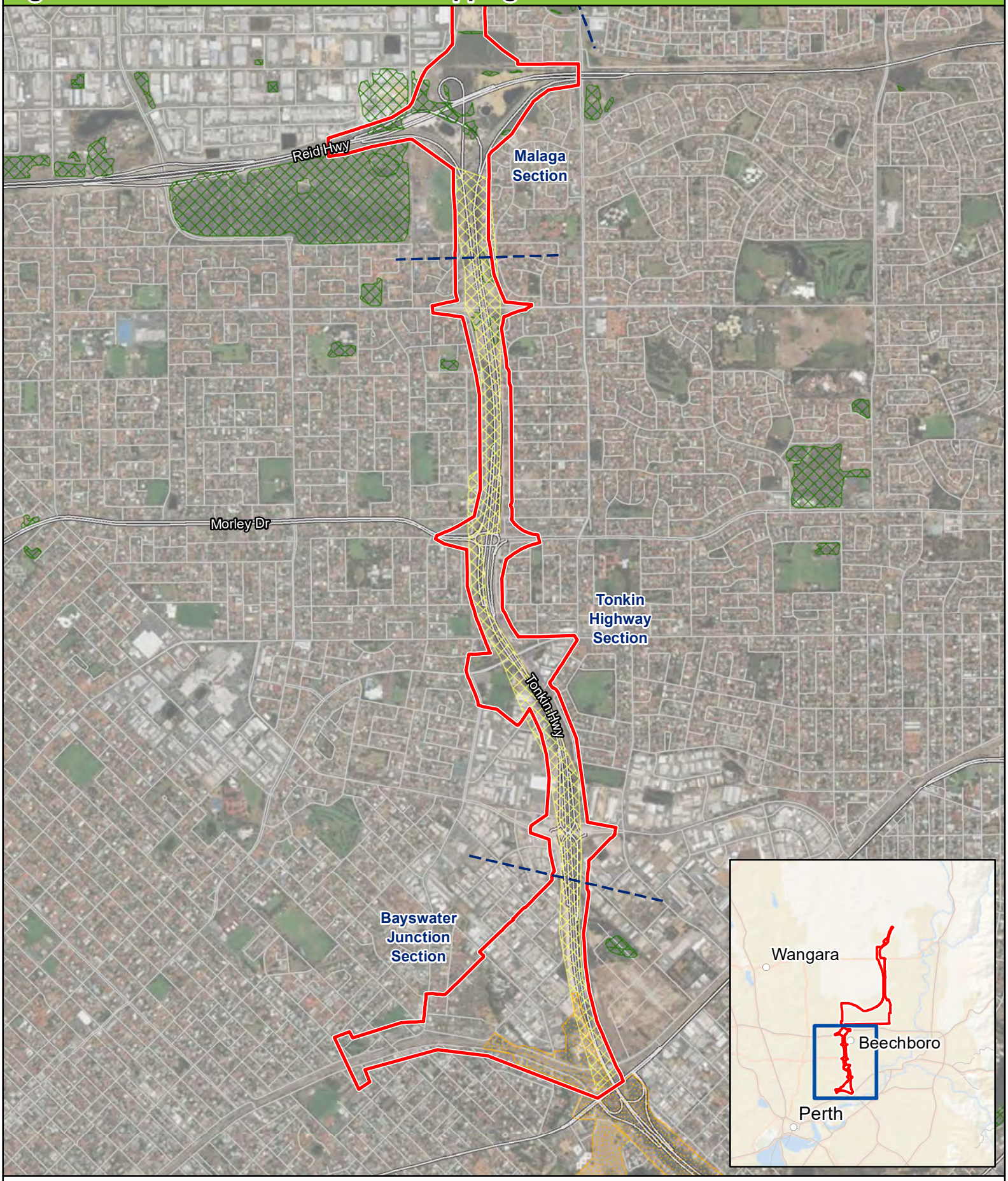
Figure 3-2c: Black Cockatoo habitat mapping



Legend

Environmental review boundary

DBCA dataset

Carnaby's Cockatoo foraging areas on the Swan Coastal Plain (investigation required)

MNES survey boundaries

Level 2 fauna assessment (Coffey 2015)

Level 1 fauna assessment (GHD 2014)

0 250 500 1,000

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

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3.3.4.1 Black cockatoos

The EPBC Act referral guidelines for three threatened black cockatoo species (DSEWPAC 2012) and the Species Profile and Threats Database provides detailed information on the ecology and modelled distributions of black cockatoos within Western Australia.

BAUDIN'S COCKATOO

Baudin's Cockatoo is known to occur in the southwest of Western Australia in an area generally bound by the 750 mm isohyet which extends from Albany north to Gidgegannup and Mundaring, and inland to the Stirling Ranges and near Kojonup. The species range varies between the breeding and non-breeding seasons and it breeds almost exclusively in the Jarrah, Marri and Karri forests of the far southwest of Western Australia. During the non-breeding season, the species range expands (DotEE 2019c). Foraging is determined by the presence of Marri and, where unavailable, Banksia and Hakea species (DotEE 2019c).

The ERB lies outside the known breeding and foraging range of the species (DSEWPAC 2012). However, the species has historically been recorded within Whiteman Park and as such, is considered to potentially occur (360 Environmental (2014b; Terrestrial Ecosystems 2018). While the species has the potential to forage and roost within areas of Eucalypt/Corymbia woodland, it is (at most) expected to only be an occasional visitor, especially given the lack of breeding habitat available.

FOREST RED-TAILED BLACK COCKATOO

The Forest Red-tailed Black Cockatoo (FRTBC) is endemic to the southwest of Western Australia. The species is most common in the dense Jarrah, Karri and Marri forests receiving more than 600 mm of rainfall annually, and in the northern Darling range where it inhabits fairly continuous habitat. FRTBC nests predominantly in very old Marri, in deep hollows. Since the 1990s, the species has been found on the Swan Coastal Plain where it forages on exotic vegetation including Cape Lilac and has also been recorded breeding (DotEE 2019d). The FRTBC has recently been recorded breeding on the Swan Coastal Plain, at Murdoch University approximately 17 km south of the ERB (Birdlife 2015).

The species has been recorded foraging within or in proximity to the ERB or flying over the ERB in GHD (2014), Coffey (2015c), Terrestrial Ecosystems (2018) and AECOM (2016). The species was also recorded foraging on Cape Lilac in GHD (2014) and evidence of foraging activity in the form of chewed marri nuts was observed in AECOM (2016), GHD (2014) and Terrestrial Ecosystems (2018).

CARNABY'S COCKATOO

Carnaby's Cockatoo is endemic and widespread across the southwest of Western Australia, in areas receiving between 300 mm and 750 mm rainfall annually, ranging from the Wheatbelt to the extreme southwest and the Swan Coastal Plain and to Kalbarri in the north (DotEE 2019e). The species is known to forage and roost across the Perth metropolitan region throughout the year where it feeds on native shrubland, kwongan heathland, native proteaceous plant species such as banksia, large eucalypts such as marri and jarrah, as well as exotic species such as pine, pecan, almond, liquid amber and canola crops.

Breeding is predominantly confined to the Wheatbelt from the Stirling Ranges north west to near Three Springs. Breeding usually occurs in large hollows in Wandoo and Salmon Gum; however, Carnaby's Cockatoo has also been recorded breeding in Red Morrel, York Gum, Tuart, Flooded Gum, Swamp Yate

and Marri Eucalypt woodland. Suitable hollows can take up to 120 to 150 years to develop in these tree species.

Whilst breeding preferentially occurs in the Wheatbelt, Carnaby's Cockatoos have recently been recorded breeding within the Perth metropolitan region, approximately 18 km north west of the ERB at Joondalup Campus (Birdlife 2015).

Carnaby's Cockatoo have previously been recorded foraging or flying over the ERB and in nearby areas in GHD (2014), Coffey (2015c), Terrestrial Ecosystems (2018). Evidence of foraging activity in the form of chewed banksia cones was also observed by Coffey (2015c).

3.3.4.2 Foraging habitat assessment

Foraging habitat is defined as plants of species known to support foraging within the range of each of the species (DotEE 2017). For Baudin's and Forest Red-tailed Black Cockatoos this generally includes seeds of marri and jarrah in woodlands and forest, and the seeds of native proteaceous plant species. Foraging for Carnaby's Cockatoo includes native shrubland, kwongan heathland, native proteaceous plant species and introduced species including *Pinus* spp.

Foraging habitat for black cockatoos was recorded within the Tonkin Highway section of the ERB by 360 Environmental (2013a). Approximately 17.30 ha of suitable foraging habitat was identified; however, no indirect evidence of foraging (i.e. chewed marri nuts or banksia cones) was observed. FRTBC were observed foraging on introduced Cape Lilac trees in the 360 Environmental study area centred on the Tonkin Highway road reserve (360 Environmental 2013a).

Some small areas of foraging habitat were identified around the Bayswater section of the ERB by GHD (2014). In addition, recent and historic foraging evidence (e.g. chewed marri nuts) was recorded during this survey in all woodland habitats within the GHD study area.

Foraging habitat has been recorded within the Malaga section of the ERB by Coffey (2015c). The majority of this habitat was assessed as being low quality; however, some small areas south of the Reid Highway, East of the Tonkin Highway and around Micro Gardens Park were assessed as being high quality foraging habitat as they contain foraging, roosting and breeding habitat for black cockatoos.

AECOM (2016) mapped black cockatoo habitat across the Ellenbrook Rapid Bus Transit route along Lord Street, and concluded these areas did not possess a high diversity or density of foraging species for black cockatoos. A number of pine plantations were mapped during this survey. Pine plantation are an important food source for Carnaby's Cockatoo and Baudin's Cockatoo and also offer potential roosting habitat although this was not assessed during this survey.

Foraging habitat was mapped in a number of small sections of the ERB by Terrestrial Ecosystems (2018). Approximately 64.5ha of foraging habitat was rated as 1 (i.e. contained a few plants that would occasionally provide a food source for Black-Cockatoos), 81.1ha rated as 2 (i.e. contained plants that are a preferred food source for Black-Cockatoos) and 7.7 ha rated as 3 (contained an abundance of plants that are a preferred food source for Black-Cockatoos). Areas with a foraging habitat rating of 2 or higher occurred in the Lord Street section of the ERB and in areas outside the ERB. A pine plantation was recorded just north of Drumpellier Drive; however, this area was outside the current ERB. This pine

plantation provides suitable foraging habitat and potential roosting for black cockatoos (Terrestrial Ecosystems 2018).

3.3.4.3 Roosting habitat assessment

Potential roosting habitat is defined as a suitable tree (generally the tallest) or group of tall trees, native or introduced, usually close to an important water source, and within an area of quality foraging habitat; however, black cockatoos will also favour roost sites in proximity (within 12 km) to foraging and water resources (DotEE 2017). A known roosting site is defined as a group or larger scattering of trees, where there are records or recent evidence of night roosting such as scats or feathers (DotEE 2017).

While no known roosting sites occur within the ERB, known roost sites occur nearby along Gnangara Road (approximately 800 m west of the ERB), within Whiteman Park (approximately 1.8 km west of the ERB) and within the Gnangara Pine Plantation (approximately 7.6 km west of the ERB) (Peck et al. 2017) (Figure 3-2). A potential roosting site is recorded by DBCA in Whiteman Park near Mussel Pool, within the ERB. Suitable roosting habitat for all three species of black cockatoo occurs within the Eucalypt/Corymbia woodland, Wetland and Pine Plantation habitat types within (or in proximity to) the ERB (Terrestrial Ecosystems 2018; Coffey (2014; 2015c); PGV Environmental (2014a, 2014b). Potential roosting habitat was identified within the Bayswater, Malaga and Lord Street sections of the ERB. Whilst potential roosting habitat was identified in a number of surveys, no evidence of roosting such as scats or feathers were recorded during any of the surveys.

AECOM (2016) and 360 Environmental (2013a) did not survey for black cockatoo roosting habitats.

3.3.4.4 Breeding habitat assessment

Breeding habitat is defined as species of trees known to support breeding within the range of the species which either have a suitable nest hollow or are of a suitable diameter at breast height (DBH) to develop a nest hollow (DotEE 2017). The breeding requirements vary considerably between the three species. Based on the modelled distributions and known breeding habits, ELA considers it unlikely that Baudin's Cockatoo breeds within the ERB.

Both FRTBC and Carnaby's Cockatoo occur more commonly in the Perth metropolitan area and the Swan Coastal Plain and have previously been recorded within the ERB. A number of trees in the ERB are considered to represent potential breeding trees for these species due to suitable nest hollows or suitable DBH (which is over 500 mm for most trees; DSEWPAC 2012). The estimated number of potential breeding trees recorded during the surveys are shown in Table 3-5 and Figure 3-2. These trees occur predominantly within Eucalypt/Corymbia woodland and wetland habitats in the Tonkin Highway, Malaga, Lord Street and Ellenbrook sections of the ERB (Figure 3-2). A small number of potential breeding trees also occur in the Bayswater section of the ERB (Figure 3-2).

3.3.5 Conservation areas

Conservation areas, such as Bush Forever sites and CCWs, are discussed in Sections 2.3.8 and 4.4.2 and are shown in Figure 2-4 and Figure 4-1. Several conservation areas which are important for the long-term protection of fauna habitat occur within, or directly adjacent to, the ERB. These are summarised below.

Whiteman Park (Bush Forever site 304) consists of 1,548 ha of bushland, of which some overlaps the ERB in the Whiteman Park South section (Government of Western Australia 2000b). Nearly half is

retained for the conservation of wildlife and provides a protected habitat for a wealth of native fauna (Whiteman Park 2018). The Banksia woodlands of the Swan Coastal Plain TEC occurs within Whiteman Park and is known to support a rich and diverse array of native fauna.

CCWs within Whiteman Park South section of the ERB include Horse Swamp, Mussel Pool and Bennett Brook (Figure 4-1). These areas act as a refuge for waterbirds in the winter months; with some birds constructing their nests on the man-made islands around Horse Swamp that provide safe refuge from predators (Whiteman Park 2018). The presence of smaller native mammals, such as Quenda, is restricted by the lack of undergrowth and predation by feral foxes and cats in some of these areas (Cook 2011). Bennett Brook (Bush Forever site 305) lies south of Whiteman Park, is classified as a CCW and lies adjacent to the corner of the Whiteman Park South and Lord Street section of the ERB (Government of Western Australia 2000b; Figure 2-4). This site comprises 120 ha of bushland associated with seasonal and permanent wetlands and provides an ecological link to Whiteman Park (RPS 2017, Whiteman Park 2012, North Metro Catchment Group 2006).

Lightning Swamp and Adjacent Bushland (Bush Forever site 307) is comprised of 135 ha and occurs south of the Malaga section outside the ERB (Government of Western Australia 2000b; Figure 2-4). The bushland provides habitat to over 125 native fauna and avian species, which visit the corridor due to its healthy and diverse vegetation (Urban Bushland Council WA 2019).

Victoria Road Bushland (Bush Forever site 480) occurs within the Malaga section of the ERB and comprises 20.6 ha of shrublands, low lying woodland and seasonal wetlands (Government of Western Australia 2000b). This site occurs in a highly urbanised area and forms ecological linkages to the north, east and west (Figure 2-4). Victoria Road Swamp (a CCW) also occurs within this site (Figure 4-1).

Beechboro Road (Cullacabardee) Bushland (Bush Forever site 198) is 431 ha and occurs approximately 2 km north of the Whiteman Park South section of the ERB. This bushland forms part of an ecological linkage with the greater Whiteman Park Nature Reserve (Government of Western Australia 2000b, Coffey 2015c).

Caversham Airbase Bushland (Bush Forever site 200) lies directly adjacent to the Lord Street section of the ERB (Figure 2-4). This site comprises approximately 97 ha of dense shrublands, woodlands and wetlands (Government of Western Australia 2000b) and forms ecological linkages with areas to the east and Whiteman Park to the west.

3.3.6 Habitat connectivity

Habitat connectivity is crucial for ground-dwelling fauna species, such as Quenda, to move through the landscape. Previous fauna surveys (AECOM 2016, Coffey 2015c, GHD 2014) and assessment of the Perth regional ecological linkages (Government of Western Australia 2000b) have been used to identify areas of importance in regard to ecological linkages (see Figure 2-4). This section discusses the ecological linkages identified in Chapter 2.3.10 in terms of their value to fauna.

The ERB occurs in a highly modified landscape, therefore any remaining vegetation is likely to be important habitat for fauna. Regionally significant bushland and wetland linkages overlapping and surrounding the ERB include Beechboro Road (Cullacabardee) bushland, Bennett Brook and Horse Swamp as part of the Whiteman Park Bush Forever site (detailed in Section 3.3.5).

The main ecological linkage in the ERB follows Bennett Brook, which runs through the Whiteman Park South section north to south, adjacent to Horse Swamp before flowing into the Swan River. High amounts of Quenda diggings have been observed at Marshall Road along Bennett Brook, in the intersection of Marshall Road and Bennett Brook, along the Bennett Brook corridor, south of Benara Road, and in Clarry Small Park (Whiteman Park 2012, 2018; DBCA 2019b). Riparian zones, such as Bennett Brook, often act as wildlife corridors facilitating the movement of wildlife in this case, especially for ground-dwelling fauna (Bamford Consulting Ecologists 2011, GHD 2014).

Terrestrial Ecosystems (2018) identified an ecological linkage from Whiteman Park to the Caversham Airbase (Bush Forever site 200). Using this linkage, fauna movement could occur from the Whiteman Park South section east to the Lord Street section of the ERB; however, there are limited linkage opportunities for ground-dwelling fauna (such as reptiles) due to the absence of connecting vegetation.

To the north (outside) of the ERB, Coffey (2015c) undertook fauna movement surveys of Beechboro Road (Cullacabardee) bushland and Maralla Road bushland for their potential to provide ecological linkages and encourage safe fauna movement. Using ARC GIS Hot Spot analysis, a total of 354 fauna crossings were recorded over six consecutive nights, with the highest proportion of records being the Western Grey Kangaroo. Tracks also belonged to introduced species such as foxes, cats and rabbits.

The Swan River is 1 km south of the Bayswater Junction section of the ERB. The Swan River and associated riparian vegetation is fragmented; however, provides an important corridor connecting parklands and reserves located along the Swan River foreshore (GHD 2014). Fauna utilising this area include aquatic species, amphibians and waterbirds.

3.4 Potential constraints

Analysis of all information currently available relating to the MEL project has identified the following as known terrestrial and aquatic fauna constraints to the MEL project:

- Various fauna habitat types, some of which have the potential to support conservation significant fauna.
- Black cockatoo habitat:
  - Known foraging habitat for Carnaby's Cockatoo and Forest Red-tailed Black Cockatoo, and potential foraging habitat for Baudin's Cockatoo, which may visit irregularly and infrequently;
  - Potential roosting habitat for all three species of black cockatoo; and
  - Potential breeding habitat for Carnaby's Cockatoo and FRTBC.
- Confirmed occurrence of four terrestrial fauna species of conservation significance including:
  - Carnaby's Cockatoo
  - FRTBC
  - Quenda; and
  - Glossy Ibis
- Likely or potential occurrence of nine other terrestrial fauna species of conservation significance including:
  - Fork-tailed Swift;
  - Eastern Great Egret;
  - Baudin's Cockatoo;
  - Western brush wallaby;
  - Water rat;
  - Black-striped Snake;
  - Jewelled Sandplain Ctenotus;
  - Black-stripe minnow; and
  - Graceful Sun-moth.
- Conservation areas with importance for fauna habitat and connectivity values including Bush Forever sites, wetlands and other surface water features.
- Management of the kangaroo population in and around Whiteman Park.

Although the fauna of the Swan Coastal Plain has been well documented with numerous surveys completed in recent history, fauna occurs in a highly modified landscape that is continuously changing. This includes fauna habitat within the ERB, which has been preliminarily characterised into a variety of habitat types including modified vegetation and cleared areas. The current status of fauna habitat may need to be further determined and refined to provide a high degree of confidence in determining potential impacts on fauna and fauna habitat by the MEL project.

The ERB potentially supports a minimum of 62 birds, 9 mammals, 19 reptiles, six amphibian and four fish species. These include a number of conservation significant species. No information is available regarding SRE invertebrate fauna, which may require further assessment.

Black cockatoo habitat has been assessed and recorded within or in proximity to the ERB. Carnaby's Cockatoo and FRTBC have both been recorded foraging in, or in proximity to, and/or flying over n the

ERB. The ERB contains foraging, roosting and breeding habitat for Carnaby's Cockatoo and FRTBC. The ERB also contains suitable foraging habitat for Baudin's Cockatoo which potentially occur within the area as an infrequent visitor. Pine plantations are also present within the ERB which provide an important foraging source for Carnaby's Cockatoo on the Swan Coastal Plain. The ERB also contains suitable breeding and roosting habitat for Carnaby's Cockatoo and FRTBC. A number of trees in the ERB are considered potential breeding trees, due to the presence of suitable nest hollows or suitable DBH. Further work will be required to ensure black cockatoo habitat assessments are complete and follow relevant technical guidelines so that habitat type and quality can be adequately assessed.

Other conservation significant species such as Quenda were recorded in the ERB, and an additional 11 conservation significant species were determined likely (or with potential) to occur. Further specific surveys targeting these species may be required to ensure a comprehensive understanding of these values relevant to the MEL project, particularly for any conservation significant fauna species at high risk of impact.

Conservation areas of significance to fauna include bushlands and wetlands in Bush Forever sites including Whiteman Park, Horse Swamp, Bennett Brook, Beechboro Road bushland, Victoria Road Bushland (Bush Forever site 480), Caversham Airbase Bushland (Bush Forever site 200) and Lightning Swamp. These areas are important for the long-term protection of fauna habitat as well as ecological linkages throughout the landscape, particularly in an increasingly urbanised environment.