Southern Link Road Stage 3 Environmental Approvals TEC and Native Bee Survey

City of Canning

ecoscape

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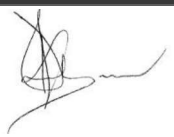
Draft rev0	Lyn Atkins	 David Kaesehagen Managing Director	 David Kaesehagen Managing Director	31/01/2019
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SUMMARY

The City of Canning is proposing to locate part of the Southern Link Road on a portion of the Grose Avenue/Lake Street Wetland (also known as Cannington Swamp and Carousel Swamp) in Cannington. This wetland is largely considered to represent the EPBC-listed endangered *Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain* TEC, and a critically endangered short-tongued native bee species (*Leioproctus douglasiellus*) has previously been recorded from the site and another species (*Neopasiphae simplicior*) considered likely to occur. The wetland has previously been subject to a flora, vegetation and fauna (including invertebrates) survey by Natural Area Holdings in 2016. NAH did not attempt to clarify TEC mapping, and no threatened bee species were recorded during its survey.

The City appointed Ecoscape to conduct a flora and vegetation survey to clearly define the boundaries of the TEC and therefore the area of impact; Ecoscape's survey area was restricted to the proposed development area and 20 m buffer and did not encompass the entire wetland. Ecoscape engaged a native bee expert to conduct surveys for the threatened bees.

Ecoscape established seven floristic quadrats and assessed and mapped vegetation type and condition. Three native vegetation types were recorded, although one was in entirely Degraded condition. One, characterised by *Melaleuca lateritia*, was considered to represent conservation significant vegetation; it occupied 0.12 ha within the proposed development area (2.10% of the extent of the TEC as mapped by DBCA, noting that the unrefined DBCA mapping included 0.16 ha within the TEC). Two Priority-listed flora species were recorded; *Aponogeton hexatepalus* and *Schoenus natans* (both P4).

Floristic analysis and comparison with available species data indicates that the *Melaleuca lateritia* shrubland was more similar to the EPBC-listed *Clay Pans of the Swan Coastal Plain* TEC than the Muchea Limestone TEC. However, both are listed for protection under the EPBC Act.

Seven native bee surveys were conducted during November and December 2018 and January and February 2019 by native bee specialist Kit Prendegast. Although a high diversity of native bees was documented, some of which are regionally rare and undescribed, neither of the target bee species were recorded from the 47 bee species and morphospecies identified from the wetland.

Addendum

In order to minimise clearing in the TEC, the City has developed three road construction options that are under consideration. The extent that each option corresponds with the TEC is detailed, with the option having the most clearing intercepting with the 0.17 ha of TEC (DBCA mapping) or 0.10 ha (Ecoscape mapping).

1 INTRODUCTION

1.1 BACKGROUND

The City of Canning City Centre Activity Plan was approved by the Western Australian Planning Commission on 24 October 2017 and guides development in the Canning City Centre as a Strategic Metropolitan Regional Centre under State Planning Policy 4.2 – Activity Centres for Perth and Peel. A key component of the development of the City Centre is the completion of the construction of the Southern Link Road from Albany Highway to Gerard Street. The road intersects a small portion of the Grose Avenue/Lake Street Wetland.

This report documents the significant environmental attributes of the wetland associated with the Southern Link Road from Grey Street to Jameson Street.

The proposed road alignment impacts approximately 0.37 hectares of native vegetation including 0.16 hectares of the endangered *Shrublands and Woodlands on Muchea Limestone* ('Muchea Limestone TEC'), listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Part of the site is a listed Conservation Category Wetland.

In order to forward the required environmental approvals (if required) and guide planning around the development, the City of Canning ('the City') commissioned a flora, vegetation and fauna survey of the site. The findings of this are summarised in **Section 2.4.1** that follows.

In 2016 the City met with the Environmental Protection Authority (EPA) together with the Department of Parks and Wildlife (DPaW, now Department of Biodiversity Conservation and Attractions [DBCA]). Representatives from the Threatened Species and Communities Unit and Wetlands Branch advised that in order for the Department to assess the City's proposal to construct the Southern Link Road on the proposed alignment, it would need to, in addition of the flora and fauna survey, undertaken hydrological monitoring of the wetland and demonstrate that the proposed road would have minimum impact of the Threatened Ecological Community and Conservation Category Wetland. The City engaged Urbaqua to undertake this study, which are summarised in **Section 2.5.1**.

In 2018, the City appointed Ecoscape to undertake additional works aimed at further refining the boundaries of the Muchea Limestone TEC and confirming the presence of two critically endangered native bees that had previously been recorded at the wetland.

This document provides the results of the above TEC and native bee assessments. Summaries of the findings of previous surveys and other relevant documents are also included.

Addendum

In order to minimise the impact on the TEC, the City worked with its civil engineers to reduce the development footprint of the proposed road, resulting in three options being under consideration. Potential impacts of these are presented in the discussion (**Section 5.3**) in this document.

1.2 LOCATION

The survey area is located in Cannington, in the City of Canning, approximately 10.5 km south of the Perth CBD. The site is located between Grose Avenue, Lake Street, Bent Street and Franklin Avenue, adjacent to the Cannington Greyhound Track and a Western Power substation. The wetland is known variously as Grose Avenue/Lake Street Wetland, Cannington Swamp and Carousel Swamp.

The survey area is indicated on **Figure 1**.

Figure 1: Location

1.3 STATUTORY FRAMEWORK

These environmental assessments were conducted in accordance with Commonwealth and State legislation and guidelines:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- Western Australian *Environmental Protection Act 1986* (EP Act)
- Western Australian *Biodiversity Conservation Act 2016* (BC Act, partly enacted)
- Department of Environment Water Heritage and the Arts (DEWHA 2009) *Matters of National Environmental Significance. Significant impact guidelines 1.1 - Environment Protection and Biodiversity Conservation Act 1999.*

In addition, the Minister for the Environment has published lists of fauna and flora species in need of special protection because they are considered rare, likely to become extinct, or are presumed extinct. The current listings were published in the *Government Gazette* on 16 January 2018 (Government of Western Australia 2018b) and was taken into account.

As well as those listed above, the assessment complied with EPA requirements for environmental survey and reporting in Western Australia, as outlined in:

- EPA (2016a) *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment*, known as the *Flora and Vegetation Technical Guidance*
- EPA (2016b) *Technical Guidance - Terrestrial Fauna Surveys*, known as the *Fauna Technical Guidance.*

1.3.1 WESTERN AUSTRALIAN BIODIVERSITY CONSERVATION ACT 2016

The Western Australian BC Act provides for the conservation, protection and ecologically sustainable use of biodiversity and biodiversity components in Western Australia. It came into effect in January 2019.

Threatened species (both flora and fauna) that meet the categories listed within the BC Act are highly protected and require authorisation by the Minister to take or disturb. These are known as Threatened Flora and Threatened Fauna. The conservation categories of critically endangered, endangered and vulnerable have been aligned with those detailed in the EPBC Act, as below.

Flora and fauna species may be listed as being of special conservation interest if they have a naturally low population, restricted natural range, are subject to or recovering from a significant population decline or reduction of range or are of special interest, and the Minister considers that taking may result in depletion of the species. Migratory species and those subject to international agreement are also listed under the Act. These are known as specially protected species in the BC Act.

Threatened Ecological Communities are also protected under the BC Act and are categorised using the same criteria as threatened species.

1.3.2 COMMONWEALTH ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

At a Commonwealth level, Threatened taxa are protected under the EPBC Act, which lists species that are considered critically endangered, endangered, vulnerable, conservation dependant, extinct, or extinct in the wild (detailed in **Table 6** in **Appendix One**).

1.3.3 THREATENED AND PRIORITY FLORA

Conservation significant flora species are those that are listed as TF (Threatened Flora) and (within Western Australia) as PF (Priority Flora). TF species are listed as threatened by the Western Australian DBCA and protected under the provisions of the BC Act. Some State-listed TF are provided with additional protection as they are also listed under the Commonwealth EPBC Act.

Flora are listed as PF where populations are geographically restricted or threatened by local processes, or where there is insufficient information to formally assign them to TF categories. Whilst PF are not specifically listed in the BC Act, some may qualify as being of special conservation interest and these have a greater level of protection than unlisted species.

There are eight categories covering State-listed TF and PF species (DBCA 2017) which are outlined in **Table 7** in **Appendix One** (noting that the definitions for TF included in the BC Act have been aligned with those in the EPBC Act). PF for Western Australia are regularly reviewed by the DBCA whenever new information becomes available, with species status altered or removed from the list when data indicates that they no longer meet the requirements outlined in **Table 7**.

1.3.4 OTHER SIGNIFICANT FLORA

According to the *Flora and Vegetation Technical Guidance* (EPA 2016a) other than being listed as Threatened or Priority Flora, a species can be considered as significant if it is considered to be:

- locally endemic or association with a restricted habitat type (e.g. Groundwater Dependent Ecosystems, Sheet Flow Dependent Vegetation)
- a new species or has anomalous features that indicate a potential new species
- at the extremes of range, recently discovered range extensions (generally considered greater than 100 km or in a different bioregion), or isolated outliers of the main range)
- unusual species, including restricted subspecies, varieties or naturally occurring hybrids
- relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

Some of these are known as specially protected species under the BC Act (see **Section 0** above).

1.3.5 INTRODUCED FLORA

Introduced plant species, known as weeds, are plants that are not indigenous to an area and have been introduced either directly or indirectly (unintentionally) through human activity. Species are regarded as introduced if they are listed as 'alien' on *FloraBase* (Western Australian Herbarium [WAH] 1998-2018).

1.3.5.1 Declared Pest Plants

The Western Australian Organism List (WAOL) details organisms listed as Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act). Under the BAM Act, Declared Pests are listed as one of the three categories, or exempt:

- C1 (exclusion), that applies to pests not established in Western Australia; control measures are to be taken to prevent their entry and establishment
- C2 (eradication), that applies to pests that are present in Western Australia but in low numbers or in limited areas where eradication is still a possibility
- C3 (management), that applies to established pests where it is not feasible or desirable to manage them in order to limit their damage
- exempt (no category).

1.3.5.2 Weeds of National Significance (WONS)

At a national level there are thirty-two weed species listed as Weeds of National Significance (WONS) (Australian Government & DotEE 2018; Weeds Australia 2012). The Commonwealth *National Weeds Strategy: A Strategic Approach to Weed Problems of National Significance* (2012c) describes broad goals and objectives to manage these species.

1.3.6 THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

1.3.6.1 Nationally Listed Threatened Ecological Communities

Ecological communities are naturally occurring biological assemblages associated with a particular type of habitat (Government of Western Australia 2016). At Commonwealth level, Threatened Ecological Communities (TECs) are protected under the Commonwealth EPBC Act. An ecological community may be categorised into one of the three sub-categories:

- critically endangered, if it is facing an extremely high risk of extinction in the wild in the immediate future
- endangered, if it is not critically endangered and is facing a very high risk of extinction in the wild in the near future
- vulnerable, if it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future.

1.3.6.2 State Listed Threatened Ecological Communities

The Western Australian DBCA also maintains a list of TECs which are further categorised into three subcategories much like those of the EPBC Act. The full details of DBCA criteria are shown in **Table 8** in **Appendix One**.

1.3.6.3 State Listed Priority Ecological Communities

DBCA maintains a list of Priority Ecological Communities (PECs). PECs include potential TECs that do not meet survey criteria, or that are not adequately defined.

1.3.7 THREATENED AND PRIORITY FAUNA

Certain fauna species are listed in conservation categories under the Commonwealth EPBC Act (outlined in **Table 6** in **Appendix One** and/or Western Australian BC Act. In addition to these statutory listings, DBCA maintains a list of 'Priority' species (P1-P4) that are also of conservation interest, outlined in **Table 7** in **Appendix One** It is a requirement of fauna survey for environmental impact assessment that potential for presence of these species, and for impact due to the proposed action, are investigated using all appropriate sources of information.

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

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

1.3.8 ENVIRONMENTALLY SENSITIVE AREAS

There are a number of areas around Western Australia identified as being of environmental significance within which the exemptions to the Native Vegetation Clearing Regulations do not apply. These are referred to as Environmentally Sensitive Areas (ESAs), and are declared under section 51B of the EP Act and described in the Environmental Protection (Environmentally Sensitive Areas) Notice (Government of Western Australia 2005).

1.3.9 CONSERVATION ESTATE

The National Reserve System is a network of protected areas managed for conservation under international guidelines. The objective of placing areas of bushland into the Conservation Estate is to achieve and maintain a comprehensive, adequate and representative reserve system for Western Australia. The Conservation and Parks Commission is the vesting body for conservation lands, forest and marine reserves that are managed by DBCA (Government of Western Australia 2018a).

2 EXISTING ENVIRONMENT

Documents, largely supplied by the City, that are relevant to this assessment are summarised below, including those detailing environmental and hydrological surveys that have been conducted at, or are relevant to, the site.

2.1 MUCHEA LIMESTONE TEC

2.1.1 APPROVED CONSERVATION ADVICE

The *Approved Conservation Advice for Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain* (Department of the Environment and Energy [DotEE] 2017) ('Muchea Limestone TEC') describes the TEC as:

> *… occurs on the heavy soils of the eastern side of the Swan Coastal Plain. Known patches include wetland and well-drained habitats, in a variety of landforms (Tauss & Weston 2010). It is defined on the basis of rare limestone-influenced substrates. Where the best developed limestone occurs, near Gingin, the plant community is located on shallow black clay or sandy clay soils on limestone. Typical and common native species in areas of best developed limestone are the tree Casuarina obesa, the mallees Eucalyptus decipiens and Eucalyptus foecunda and the shrubs Melaleuca huegelii, Alyogyne huegelii var. huegelii, Grevillea curviloba ssp. incurva, Grevillea curviloba ssp. curviloba, Grevillea evanescens, Melaleuca acerosa, and the herb Thysanotus arenarius. Where the limestone substrate is less well developed and limestone may occur as nodules or chunks, the flora assemblages can be influenced by other characteristics of the substrate, such as clay content, with the presence of calcicoles such as Alyogyne sp. Rockingham, Alyogyne hakeifolia, Carex thecata, Hibbertia spicata subsp. spicata, Lechenaultia linarioides, Thysanotus arenarius, Gahnia trifida, Eremophila glabra and Melaleuca brevifolia providing evidence of the limestone influence.*
>
> *Melaleuca huegelii shrublands, Eucalyptus decipiens mallee, Casuarina obesa woodlands, and Melaleuca brevifolia, M. systena, or M. viminea shrublands is recorded on Muchea Limestone (Tauss & Weston 2010).; however, the full range of vegetation on the Muchea Limestone substrate is not well documented. Floristic analysis can link calcicole species in Muchea Limestone sites with floristic community types on Tamala Limestone in Spearwood dunes or floristic community type 18 shrublands on calcareous silts (Tauss & Weston 2010).*

Aspects relevant to and of potential significance for defining the TEC, as detailed in the *Approved Conservation Advice*, are:

- the TEC is listed as endangered under the EPBC Act
- some of the flora species are generally coastal species that do not generally occur further inland (linked to Gibson *et al.* (1994) floristic community type (FCT) 18)
- there are 16 known occurrences of the TEC (as at April 2017) including Carousel Swamp
- the required substrate is aeolian sandplain with residual deposits of limestone or Muchea Limestone or Plain limestone deposits
- the critical habitat is the area of occupancy, substrate, freshwater superficial groundwater and/or surface waters and local catchments
- no condition threshold has been set for this community due to its very restricted distribution.

2.1.2 INTERIM RECOVERY PLAN 2000-2003

The 2000-2003 *Interim Recovery Plan* for the Western Australian-listed *Shrublands and Woodlands on Muchea Limestone* TEC (English & Blyth 2000) includes much of the information included in *Approved Conservation Advice* for the later Commonwealth listing of the similarly named TEC (DotEE 2017, above), however, in Western Australia the community is considered to be critically endangered. At the time of writing only four occurrences of the TEC had been identified, all in the Gingin/Muchea/Vines areas (although this is contradicted by a later listing in Appendix 2 of an occurrence in Gosnells), and it was considered that

no floristic quadrats representing the TEC had been included in the Gibson *et al.* (1994) *Floristic Survey of the Southern Swan Coastal Plain*.

As well as the information also included in the Commonwealth *Approved Conservation Advice*, a species list of typical and common species regularly associated with Muchea Limestone soils (and therefore, presumably, the TEC although this is not specifically stated) was provided, as below.

Trees:	*Casuarina obesa*	
Mallees	*Eucalyptus decipiens*	
	Eucalyptus foecunda	
Shrubs:	*Acacia leptospermoides* ssp. *leptospermoides*	
	Allocasuarina lehmanniana	
	Alyogyne huegelii var. *huegelii*	
	Baeckea robusta	
	Comesperma integerrimum	
	Darwinia sp 'Muchea' (now *Darwinia foetida*)	
	Diplopeltis huegelii	
	Dodonaea aptera	
	Exocarpos sparteus	
	Grevillea curviloba ssp. *curviloba*	CR
	Grevillea curviloba ssp. *incurva*	CR
	Grevillea evanescens	P1
	Hibbertia spicata ssp. *spicata*	
	Lechenaultia linarioides	
	Melaleuca acerosa (now *Melaleuca systena*)	
	Melaleuca huegelii	
	Pimelea ferruginea	
	Stylobasium australe	
Herbs:	*Apium annum*	
	Conostylis candicans	
	Haloragis aculeolata	P2
	Senecio lautus ssp. *dissectifolius*	
	Thysanotus arenarius	
	Wilsonia humilis	
Grasses:	*Stipa flavescens*	
	Poa ?porphyroclados	

Major structural formations of the Muchea Limestone plant community were also provided, as follows.

Where the Muchea Limestone is best developed

On rises with outcropping limestone:

- *Eucalyptus decipiens* mallee over heath often dominated by *Melaleuca huegelii*
- *Melaleuca huegelii* heath or shrubland over *Grevillea evanescens* and *Xanthorrhoea preissii*

On wet flats:

- Scattered *Casuarina obesa* over *Melaleuca lateriflora*[1], *Grevillea evanescens* and *Melaleuca viminea* shrubland and herbs
- *Melaleuca huegelii*, *Grevillea evanescens* and *Melaleuca* species shrubland and herbs
- *Casuarina obesa* open woodland over *Poa* grassland and herbs

[1] *Melaleuca lateriflora* is not known from the Swan Coastal Plain IBRA region (*FloraBase*, Western Australian Herbarium 1998). Presumably this should be *M. lateritia*.

Creekline:

- *Eucalyptus rudis* open forest over *Melaleuca rhaphiophylla* open low forest over shrubland over tall sedgeland and grassland

Where the limestone appears to be at greater depth, is more remote or the limestone area is geographically isolated from other limestone areas:

On sand dunes (often yellow or orange):

- Banksia woodlands over heath
- *Acacia saligna* shrubland over herbs
- *Eucalyptus decipiens* mallee

On damper sands over limestone:

- Open Marri woodland over mixed shrublands usually containing *Melaleuca huegelii*, *Acacia saligna*, *Grevillea curviloba* and *Regelia ciliata*.

2.1.3 PLANT COMMUNITIES ON IRONSTONE & MUCHEA LIMESTONE (POSTER)

The Department of Conservation and Land Management (DCALM, now DBCA) Species and Communities Branch produced an undated poster describing the *Plant Communities on Ironstone & Muchea Limestone* to describe the Muchea Limestone TEC (DCALM, last updated 2013).

Characteristics of these plant communities noted in this document are:

- they are characterised by masses of everlastings (*Rhodanthe* spp.)
- floristic analysis links these pant communities to 'herb rich shrublands in clay pans'
- *Melaleuca huegelii* and *Eucalyptus decipiens* are characteristic of the best condition Muchea Limestones.

2.2 CLAY PANS OF THE SWAN COASTAL PLAIN TEC

2.2.1 APPROVED CONSERVATION ADVICE

The *Clay Pans of the Swan Coastal Plain* TEC was endorsed as a critically endangered EPBC-listed TEC in 2012. The *Approved Conservation Advice* for the TEC (DSEWPaC 2012a) ('Clay pans' TEC) describes the TEC as:

> *… occurs in Western Australia where clay soils form an impermeable layer close to the landscape surface, and wetlands form that rely solely on rainfall to fill and then dry to impervious pans in summer.*
>
> *The ecological community generally occurs as a shrubland (less commonly as a low, open woodland) over a ground layer of geophytes, herbs and sedges which are characteristic of the wetter parts of the sites. There are no dominant species which characterise the entire ecological community. The ecological community, however, shows similar landform and vegetation structural features across its range.*
>
> *A distinctive feature of these clay pan wetlands is the suite of geophytes and annual flora that germinates, grows and flowers sequentially as these areas dry over summer, producing a floral display for over three months. The clay pans have very high species richness, a number of local endemics and are the most floristically diverse of the Swan Coastal Plain wetlands.*
>
> *The seasonally inundated clays that support this ecological community are relatively productive agricultural soils and many were cleared and drained soon after European settlement. Others were mined for clay for brick and tile manufacture. Those that remained intact were largely located on the Swan Coastal Plain in close proximity to metropolitan Perth. In more recent years large areas have disappeared under urban development and today the plant communities of the clay pan wetlands are amongst the most threatened in Western Australia.*

This advice, and the DBCA *Interim Recovery Plan* (DPaW 2015), identify that this TEC consists of a combination of Western Australian-listed TECs and one PEC:

- *Herb rich saline shrublands in clay pans* (Community Type 7 (SCP07)) – vulnerable

- *Herb rich shrublands in clay pans* (Community Type 8 (SCP08)) – vulnerable
- *Dense shrublands on clay pans* (Community Type 9 (SCP09)) – vulnerable
- *Shrublands on dry clay flats* (Community Type 10a (SCP10a)) – endangered
- *Clay pans with shrubs over herbs* (Community Type 117) – P1 PEC, also known as *Clay pans with mid dense shrublands of Melaleuca lateritia over herbs* (DPaW 2015).

The DBCA *Interim Recovery Plan* (DPaW 2015) lists characteristic taxa for each of the component Western Australian TECs and PEC.

2.3 CRITICALLY ENDANGERED SHORT-TONGUED NATIVE BEES

Two EPBC-listed critically endangered short-tongued native bee species have been identified as occurring, or potentially occurring, in the wetland. The Approved Conservation Advice applicable to these species are summarised below.

2.3.1 LEIOPROCTUS DOUGLASIELLUS

2.3.1.1 Approved Conservation Advice

The *Approved Conservation Advice for Leioproctus douglasiellus (a short-tongued bee)* (Department of Sustainability Environment Water Population and Communities [DSEWPaC] 2013) includes the following advice that is relevant to this assessment:

- *Leioproctus douglasiellus*, Family Colletidae: females are 8 mm in length, with a wing length of almost 5 mm
- it is listed as critically endangered under the EPBC Act and Schedule 1 (fauna that is rare or likely to become extinct) under the Western Australian *Wildlife Conservation Act 1950* (which has since been superseded by the BC Act)
- as at 2013 it was thought to occur in three locations within the Perth metropolitan area ranging from Cannington to Forrestdale, with an extent of occurrence of 24.3 km^2 and area of occupancy of 0.2 km^2
- it has been collected on two plant species: *Goodenia filiformis*[2] and *Anthotium junciforme*, both previously listed as Priority species.

This advice suggests, but does not implicitly state, that this species has been recorded in the subject wetland.

2.3.1.2 Presence in Grose Avenue/Lake Street Wetland

Leioproctus douglasiellus was reported as having been recently been found 'near Carousel in Cannington' during a Department of Environment and Conservation survey (Swan Catchment Council 2007). The vegetation was described as *areas of heath on flowering Goodenia filiformis & G. pulchella (perennial herbs, yellow flowers), Lobelia tenuior (annual herb, blue flowers) and Anthotium junciforme (perennial herb, blue/violet flowers)*. *Neopasiphae simplicior* was not reported as having been found but was targeted during the survey.

2.3.1.3 Identification Factsheet

The relevant factsheet available on the Pest and Disease Image Library (PaDIL) website was used as a reference (Walker 2010a).

2.3.2 NEOPASIPHAE SIMPLICIOR

2.3.2.1 Approved Conservation Advice

The *Approved Conservation Advice for Neopasiphae simplicior (a short-tongued bee)* (DEWHA 2009) includes the following advice that is relevant to this assessment:

- *Neopasiphae simplicior*, Family Colletidae, is smaller and has less modified antennae and legs than other species belonging to the same genus. Males are 7 mm in length, with a wing length of 5 mm.

[2] *Goodenia filiformis* only occurs in far southern parts of Western Australia (Western Australian Herbarium 1998-2019, accessed 5 March 2019) and appears to have been erroneously listed for both bee species. The relevant host species are known to be *G. pulchella* and *G. micrantha* (K. Prendergast *pers. comm.*).

- it is listed as critically endangered under the EPBC Act and Schedule 1 (fauna that is rare or likely to become extinct) under the Western Australian *Wildlife Conservation Act 1950* (which has since been superseded by the BC Act)
- as at 2009 it was known from a single location at Forrestdale Lake, with an extent of occurrence and area of occupancy estimated at 1 km^2
- it has only been collected at flowers of Thread-leaved Goodenia (*Goodenia filiformis*), a perennial herb; Slender Lobelia (*Lobelia tenuior*), an annual herb; *Angianthus preissianus* (males only), an annual herb; and *Velleia* sp.

2.3.2.2 Presence in Grose Avenue/Lake Street Wetland

Neopasiphae simplicior was first described in 1954 at 'Cannington' from a single male specimen (Houston & Western Australian Museum 2010). The location accuracy attributed to this record is 10-50 km (Geocode precision 4) thus may not have been from this wetland.

2.3.2.3 Identification Factsheet

The relevant factsheet available on the PaDIL website was used as a reference (Walker 2010b).

2.4 ENVIRONMENTAL SURVEYS

2.4.1 NAH 2015 FLORA, VEGETATION AND FAUNA SURVEY

In 2015 the City appointed Natural Area Holdings Pty Ltd (NAH) to undertake a Level 2 Flora and Vegetation Survey and Level 2 Fauna Survey at the Grose Avenue/Lake Street Wetland site (Natural Area Consulting Management Services 2016). This incorporated a desktop assessment and field surveys which were conducted during September, October, November and December 2015.

The field assessment included:

- revisiting and reassessing four 10 m x 10 m floristic quadrats established by Woodman Environmental in 2004 and installation of four additional floristic quadrats
- assessing and mapping of vegetation condition; weed presence, type and density; vegetation types
- searches for and mapping presence of significant flora species, including targeted searches for conservation significant flora
- collection of a flora inventory
- installation of six fauna traplines incorporating funnel and pitfall traps, and six Elliot traps, and installation of two motion activated cameras
- recording opportunistic fauna sightings and a nocturnal survey.

The key findings of the survey were:

- 111 vascular flora species; 57 native species and 54 introduced species
- two conservation significant flora species: *Eremophila glabra* subsp. *chlorella* (TF) and *Ornduffia submersa* (P4) although none were in areas anticipated to correspond with the proposed road
- nine vegetation types
- presence of the Muchea Limestone TEC, which was not defined in the report by vegetation types nor any analysis conducted to confirm its presence
- the vegetation condition ranged from Excellent to Completely Degraded but was largely in Completely Degraded condition
- three mammal species (all introduced), 15 birds, five reptiles, four amphibians, 42 invertebrates
- no fauna of conservation significance including no conservation significant native bees.

NAH concluded that the proposed Southern Link Road would require clearing of 0.16 ha of the 5.8 ha Muchea Limestone TEC, of which 0.09 ha was in Good or Very Good condition.

NAH did not record any of the flora species considered to be associated with the two critically endangered native bees included in the current assessment.

2.4.2 DOE 2004 CAROUSEL SWAMP FLORA AND VEGETATION PRELIMINARY ASSESSMENT

Keighery and Hyder-Griffiths (2004) conducted a preliminary flora and vegetation survey of the wetland in May. The key findings of this assessment were:

- most of the site was considered to be wetland, with only one portion considered as upland vegetation
- the vegetation was highly variable, forming a mosaic of units
- it was representative of wetlands on heavy soils on the eastern side of the Swan Coastal Plain
- it was associated with Muchea Limestone soils and patches of ironstone
- was considered representative of FCT 7 (or FCT 7, 8 or 9), but required a spring survey to accurately determine which FCT/s were present.

2.4.3 SHORT-TONGUED NATIVE BEE SURVEYS

Aside from the survey noted in **Section 2.3.1.2** above, no additional surveys are known to have been conducted for *Leioproctus douglasiellus* or *Neopasiphae simplicior* in the wetland. Whilst invertebrates were targeted in the NAH survey (**Section 2.4.1**), these bees were not specifically targeted and the fauna survey was largely conducted outside of the period that would be considered optimal to detect them.

2.5 HYDROLOGICAL STUDIES

2.5.1 URBAQUA 2017 HYDROLOGICAL STUDIES

Urbaqua (2018a) undertook a hydrological study to:

- assess the existing condition of the Muchea Limestone TEC and supporting wetlands
- determine the potential impacts of construction of the proposed road and infrastructure
- prepare a preliminary management plan.

Eight groundwater monitoring bores (four installed by Urbaqua in 2017; two JDA bores from 2012 and two Parsons Brinkerhoff bores from 2005) were monitored monthly (July 2017-January 2018). This report (Urbaqua 2018a), and the updated report (Urbaqua 2018b) that reported on a part of the road alignment but included the same hydrological data, also reported that:

- depths to groundwater ranged from 2.28 m to 4.14 m during the monitoring period, with surface water present above one of the bores during August, September and October
- pH was within the guideline range for wetlands, nitrogen levels were relatively low, elevated total nitrogen concentration was recorded for two bores, and total phosphorus and ammonia levels exceeded the wetland criteria in all bores
- superficial groundwater is considered as Fresh
- there is no upstream catchment or surface runoff feeding into the swamp, with recharge from rainfall
- no specific data discussing the hydrological condition of the TEC was presented.

2.5.2 PARSONS BRINCKERHOFF WOODMAN 2005 SOIL AND HYDROGEOLOGICAL INVESTIGATIONS

In 2005, Parsons Brinckerhoff conducted a soil and hydrogeological investigation for Woodman Environmental Consulting (2005) on behalf of Western Power which was planning on expanding the Cannington substation, including powerline upgrades that were anticipated to require excavation into the swamp surface. The investigation included determining the presence and extent of any Muchea Limestone soils.

Eight boreholes were drilled during phase 1 in February 2005 and 11 boreholes drilled during phase 2 in May 2005. Limestone gravel was occasionally encountered at approximately 1-4.5 m depth at four locations. It was determined that the limestone gravel was not formed in-situ but may have been deposited during flood events. Surficial ferricrete was inferred over part of the site and thin lenses of iron cemented sands identified, however, extensive ferricrete layers were not encountered.

Parsons Brinckerhoff determined that soils matching the description of Muchea Limestone were not intersected during its investigation.

3 METHODS

3.1 TEC ASSESSMENT

The City appointed Ecoscape to conduct a flora and vegetation survey to further refine the boundaries of the TEC, in order to determine areas of impact by the proposed works.

The flora and vegetation survey was conducted in accordance with relevant sections of the *Flora and Vegetation Technical Guidance* (EPA 2016a).

The assessment was conducted only in areas close to the mapped TEC, within and close to the proposed works area and buffer of the proposed works area. Other areas within the greater wetland were not assessed and are noted as such when providing extents.

3.1.1 FLORISTIC QUADRATS

Floristic quadrat ('quadrat') locations were selected using aerial photography, environmental values and field observations to represent the vegetation values existing at the site, and were recorded in areas of Good or better condition vegetation.

The unmarked quadrats were 10 m x 10 m in dimension as required according to the *Flora and Vegetation Technical Guidance*.

The following information was collected from within each quadrat:

- observer
- date
- quadrat/site number
- GPS location (GDA94) of the northwest corner
- digital photograph (spatially referenced with a reference number), taken from the northwest corner, looking diagonally across the quadrat
- soil type and colour
- topography
- list of flora species recorded with the average height and total cover within the quadrat for each species
- vegetation description (as per below)
- vegetation condition.

Descriptions of vegetation types used the nomenclature of the National Vegetation Information System (NVIS) at Level V (Executive Steering Committee for Australian Vegetation Information [ESCAVI] 2003). Up to three dominant and characteristic species from the three main strata informed the vegetation type description.

The data from the floristic quadrats was used for floristic analysis to determine if the vegetation types, as observed in the field, are also floristic units.

3.1.2 VEGETATION TYPE MAPPING

In order to accurately define the TEC boundaries, the previous NAH mapping (Natural Area Consulting Management Services 2016) within and adjacent to the proposed works area was groundthruthed and only altered if the mapping was considered inaccurate, could be refined or has changed since the survey e.g. if fire has affected the vegetation or vegetation condition has altered significantly.

3.1.3 FLORA INVENTORY

A flora inventory was collected from quadrat data. Addition flora survey was not been identified as being required.

Plants were collected for expert identification by Ecoscape taxonomists if they are unknown to the field botanist or have potential to be of conservation significance, and were processed according to Western

Australian Herbarium protocols, including being submitted to the Herbarium as a voucher specimen if they meet the appropriate criteria.

3.1.4 VEGETATION CONDITION AND MAPPING

The vegetation condition was assessed at each quadrat and additional notes regarding variation to vegetation condition taken opportunistically during traverses within the survey area. Vegetation condition was assessed using the scale included in the *Flora and Vegetation Technical Guidance* (**Table 11** in **Appendix One**).

Vegetation condition may be a significant factor in identifying the extent of the TEC as Degraded or Completely Degraded vegetation that has few or no native species is frequently considered to not represent extant native vegetation. However, it is noted in the *Approved Conservation Advice* (DotEE 2017) that no condition thresholds have been set for this TEC.

3.1.5 STATISTICAL ANALYSIS

3.1.5.1 Multivariate Floristic Analysis

PATN© software (Belbin & Collins 2006) was used to undertake statistical analysis to generate floristic groups using the data collected from the quadrats and relevés, in order to better understand local significance of floristic units. PATN analysis has been used for several local floristic analyses including Gibson *et al.* (1994) for the Swan Coastal Plain.

PATN is a multivariate analysis tool that generates estimates of association (resemblance, affinity, distance) between sets of objects described by a suite of variables (attributes), and classifies the objects into groups and condenses the information and displays the patterns in the data graphically. It offers a choice of data transformations prior to multivariate analysis.

Floristic groups, identified using a dendrogram output of the analysis, are used as a tool to inform vegetation type groups at various levels and scales.

For this analysis, the Kulczynski similarity coefficient using presence/absence data was the most appropriate association to use; this provides a good estimation of association for ecological applications (Belbin & Collins 2006). This was followed by Flexible UPMGA (Un-weighted Pair Group Using Arithmetic Averaging) fusion to produce clusters of related objects (species); these are the floristic groups that are displayed as a dendrogram.

Interpretation of these purely floristic groups into recognisable and mappable on-ground units is a tool used to identify broad vegetation types. Generally, quadrats or relevés that are closely floristically related on the dendrogram form identifiable vegetation units, however interpretation is frequently required for imperfect results. Vegetation types are therefore determined as a combination of floristic analysis and on-ground interpretation using dominant and characteristic species.

In this case, both Ecoscape's 2018 and NAH's 2016 data was compared.

3.1.5.2 Floristic Analysis to Compare with Swan Coastal Plain FCTs

Floristic Community Types (FCTs) are groups of co-occurring plant species, identified by floristic analysis from over 500 10 m x 10 m quadrats located on the southern Swan Coastal Plain (SCP) between Seabird and the foothills of the Whicher Range by Gibson *et al.* (1994). This floristic analysis defined 43 community types and subtypes. The major correlations with the floristic classification were seasonal moisture regime and geomorphology; however there was poor correlation with vegetation structure and mapped vegetation units. Despite the poor correlation with mapped vegetation units, DBCA defines many TECs and PECs on the SCP in terms of FCTs, as identified from the Gibson *et al.* (1994) data.

The extent of an FCT is not mapped in the same way as vegetation complexes or vegetation units, thus their presence cannot be determined by desktop assessment.

Identification of the Most Similar FCTs

Affinities with FCTs are identified after analysis of field survey relevé data. There were three types of comparisons conducted:

1. Statistical analysis, discounting FCTs from different landforms or landscape positions.
2. Comparing dominant species to FCT descriptions.
3. Examining inferred FCT types and soil types of surrounding bushlands.

FCT analysis of the collected data is conducted using an in-house database program which compares the species list collected from the relevé data with the information in Table 12 of Gibson *et al.* (1994) and includes data from additional unpublished sites. The analysis produces a list of possible FCTs, with the output including:

- the number of FCT species in the quadrat/detailed relevé in relation to the defined FCT list
- the percentage of FCT species in the quadrat/detailed relevé in relation to the defined FCT list
- the total cumulative frequency (i.e. running total) of FCT species in the quadrat/detailed relevé for each defined FCT, which weights typical FCT species.

The output list of possible FCTs is compared with landform, landscape position, distribution, typical species and descriptions in Gibson *et al.* (1994) to indicate the best possible match with an FCT.

This analysis provides an objective and quantitative method for determining FCTs. Ecoscape appreciates that, as TECs on the SCP are generally described in terms of FCTs, DPaW may be required to confirm the presence of TECs if they are determined from FCT analysis.

Prior to conducting the analysis flora taxonomy is reconciled as much as possible to match 1994 taxonomy. The reconciliation included:

- reducing unrecognised subtaxa to the equivalent species
- excluding all taxa not identified to species level
- excluding all taxa not included in the Gibson *et al.* (1994) data i.e. they were not encountered in any of the quadrats
- renaming to recognise former taxonomy e.g. reinstating *Dryandra* spp. (now included in *Banksia*)
- synonymising taxa described after 1994 to (where identifiable) the taxon they would have been considered to represent in 1994 e.g. *Astartea affinis* (described 2006) included in *Astartea* aff. *fascicularis*.

3.2 NATIVE BEE SURVEY

The sampling methodology is considered to be optimal for sampling native bees based on previous evaluations of methods by Prendergast (2018) and were timed to coincide with the documented activity time of the target bee species, with *Leioproctus douglasiellus* having been previously recorded in October and November, and host plants of *Neopasiphae simplicior* flowering October to January (Adamson 2008; DEHWA 2008; Western Australian Herbarium 2018 - *Goodenia pulchella* description). Surveys were conducted over late spring to summer 2018/19 on 23 November, 20 December, 5 January, 16 January, 26 January, 5 February and 23 February. Surveys were 5 hrs in duration between 1000-1500 hrs.

Bees were collected using entomological sweepnets over the entire site, not just the portion subject to the TEC assessment. Sweepnetting was conducted using the random walk method to collect native bees, focussing on locations with host plants.

In addition, passive sampling was conducted using bee bowls (five yellow rectangular containers, five yellow bowls and 20 soufflé cups; 10 UV-reflective yellow and 10 UV-reflective blue) placed on bare open ground and filled with water plus a few drops of unscented surfactant. Bowl colours chosen were those known to attract native bees (Prendegast 2018), and also correspond to the colours of the host plants of the target species. Bee bowls were set-up prior to the surveys and in place for the duration of the site survey (5.5 hrs).

Insects were pinned, labelled with a unique code and survey information (date, location, GPS coordinates, flora host) and identified, with the name added to the label.

The field surveys were conducted by Kit Prendergast (B.Sc. Hons. Zoology and Conservation, PhD researcher and native bee scientist, Curtin University) and (in November) Dr Rob Manning (Australian Natural Biotechnology) and identified by Kit Prendergast.

4 RESULTS

4.1 TEC ASSESSMENT

The flora and vegetation survey was conducted on 22 November 2018 by Stephen Kern, Associate Environmental Scientist/Botanist (flora collecting permit SL012270).

4.1.1 FLORA

Seven floristic quadrats were recorded from within the area of and near the proposed works, as shown on **Map 1**.

Fifty four species were recorded, including 18 introduced species (weeds) none of which were Declared Pest plants or Weeds of National Significance. The full list of species, presented as a site by species table, is included in **Table 12** in **Appendix Two**. Quadrat datasheets are also included in this Appendix.

4.1.1.1 Conservation Significant Flora

No TF listed under the Commonwealth EPBC Act or Western Australian BC Act were recorded.

Two P4 PF species were recorded: *Aponogeton hexatepalus* (recorded opportunistically) and *Schoenus natans* (recorded from three quadrats and opportunistically, including one quadrat corresponding with the proposed development area); **Plate 1** and **Plate 2**; locations shown on **Map 1**. NAH (2016) did not record either species. *Schoenus natans* was observed to form mats under much of the **MIMS** vegetation type.

Plate 1: *Aponogeton hexatepalus*

Plate 2: *Schoenus natans*

4.1.2 VEGETATION TYPES

Three vegetation types were mapped as corresponding with the area that was assessed:

- **MIMS**: *Melaleuca lateritia* mid shrubland (**Table 1**)
- **VjTS**: *Viminaria juncea* tall shrubland (**Table 2**)
- **VjMrLW**: *Viminaria juncea* and *Melaleuca rhaphiophylla* low woodland (**Table** 3).

Melaleuca lateritia mid shrubland (**MIMS**) corresponds with part of the area mapped by DBCA as included in the Muchea Limestone TEC buffers. It also corresponds, although not entirely, with the vegetation mapped as *Melaleuca lateritia* Heathland by NAH (2016). Ecoscape's **VjTS** vegetation type largely corresponds with NAH's *Viminaria juncea* and *Melaleuca lateritia* Woodland vegetation type although no representative quadrats were recorded by NAH in the relevant section of the site. Ecoscape's **VjMrLW** vegetation type corresponds with an area mapped as 'degraded area with little to no natives present' by NAH (noting that Ecoscape concurs with the vegetation condition rating of Degraded for this area).

The above vegetation types are described in the tables that follow. The photograph is of the quadrat in **bold** font. Vegetation type extents are illustrated on **Map 1**.

Extents provided in the following tables refer only to the areas mapped during this assessment and do not include areas other than those indicated on **Map 1**. Areas included in the proposed works area/development area (road alignment) and 20 m buffer that were included in the overall site that did not have native vegetation (assessed as Completely Degraded, 'not native vegetation', 'rehab – Geraldton Wax' and 'not assessed' as it was not close to the mapped TEC) occupied 2.67 ha, 75.55% of the total intersecting area.

Table 1: Vegetation type MIMS

Vegetation Type MIMS		
Vegetation Description	**Quadrats**	**Representative photograph**
Melaleuca lateritia, *Astartea affinis* and *Viminaria juncea* mid shrubland over *Leptocarpus canus* and *Watsonia meriana* mid rushland/forbland NVIS M+ ^*Melaleuca lateritia*,^*Astartea affinis*,*Viminaria juncea*\^shrub\3\c;G ^*Leptocarpus canus*,^*Watsonia meriana*\^rush,forb\2\c	**SL1801** SL1802 SL1805 SL1806	
Other Characteristic Species		**Area and Extent of the Survey Area**
Cassytha racemosa forma *racemosa* *Eutaxia virgata* *Goodenia pulchella* subsp. Coastal Plain B (L.W. Sage 2336) *Gratiola pubescens* *Isolepis cernua* var. *setiformis* *Lachnagrostis filiformis* *Schoenus natans* *Schoenus tenellus* *Stylidium divaricatum* *Stylidium roseoalatum* **Cynodon dactylon*		**Proposed works area**: 0.12 ha (8.81%) **Buffer**: 0.13 ha (6.05%)

Table 2: Vegetation type VjTS

Vegetation Type VjTS		
Vegetation Description	**Quadrats**	**Representative photograph**
Viminaria juncea tall shrubland over *Watsonia meriana* mid dense forbland NVIS M+ ^*Viminaria juncea*\^shrub\4\c;G ^*Watsonia meriana*\^forb\2\d	SL1803 **SL1804**	
Other Characteristic Species		**Area and Extent of the Survey Area**
Chorizandra enodis *Gompholobium marginatum* *Haemodorum simplex* *Lepidosperma costale* *Melaleuca lateritia* *Opercularia vaginata* *Patersonia occidentalis* *Xanthorrhoea brunonis* **Briza minor* **Cenchrus setaceus* **Ehrharta calycina* **Eragrostis curvula* **Hyparrhenia hirta* **Lysimachia arvensis*		**Proposed works area**: 0.25 ha (18.62%) **Buffer**: 0.23 ha (10.42%)

Table 3: Vegetation type VjMrLW

Vegetation Type VjMrLW		
Vegetation Description	**Quadrats**	**Representative photograph**
Viminaria juncea and *Melaleuca rhaphiophylla* low woodland over *Watsonia meriana*, *Paspalum dilatatum* and *Lepidosperma costale* mid dense forbland/grassland/sedgeland NVIS U+ ^ *Viminaria juncea*,^ *Melaleuca rhaphiophylla*\^tree\6\c;G ^ ^ *Watsonia meriana*,*Paspalum dilatatum*,*Lepidosperma costale*\^forb,tussock grass,sedge\2\c	**SL1807**	
Other Characteristic Species		**Area (ha) and Extent (%) of the Survey Area**
Astartea scoparia *Leptocarpus canus* *Lomandra suaveolens* *Patersonia occidentalis* *Xanthorrhoea brunonis*	**Briza maxima* **Cynodon dactylon* **Romulea rosea* **Rumex crispus* **Sparaxis bulbifera*	**Proposed works area**: 0 **Buffer**: 0.10 ha (4.71%)

4.1.2.1 Multivariate Analysis

The floristic analysis dendrogram, produced using both Ecoscape 2018 and NAH 2016 data identified the groupings shown in **Figure 2** (noting that the colour change is arbitrary and is only used to differentiate broad floristic types). The letter code suffixes refer to the dominant highest stratum species and vegetation structural codes of the quadrat, not necessarily the vegetation type to which the quadrat has been mapped as).

The broad interpretations from the analysis are that:

- Ecoscape's interpretation of vegetation types is valid from both structural composition and floristics (noting that quadrat SL1806 was close to the mapped boundary, and potential transition, between two vegetation types and the boundary is not discrete)
- there is little floristic similarity between Ecoscape (prefixed by 'SL18') and NAH (prefixed by 'N') quadrats
- NAH's wettest quadrats (N1, N5, N7 and N8 characterised, in order, by *Casuarina obesa*, *Bolboschoenus caldwellii*, *Baumea juncea* and *Melaleuca rhaphiophylla*) form a discrete floristic group, with none of the Ecoscape quadrats floristically similar (noting that Ecoscape's survey was of a smaller area than NAH's, and this is entirely expected as Ecoscape did not survey in the wettest part of the wetland)
- Ecoscape's vegetation type dominated by *Melaleuca lateritia* (**MlS**) is only broadly floristically similar to NAH's equivalent (MlH).

Floristic differences may be due to the surveys being conducted at different times (NAH in late September, Ecoscape in late November), during different years, assessment by different botanists or, most likely, a combination. The overall interpretation of the floristic analysis is that there are a wide range of vegetation types within the wetland, and that Ecoscape's assessment of only a small portion of the site (close to the eastern edge) is reflected in the largely closer grouping of Ecoscape's quadrats than those of NAH.

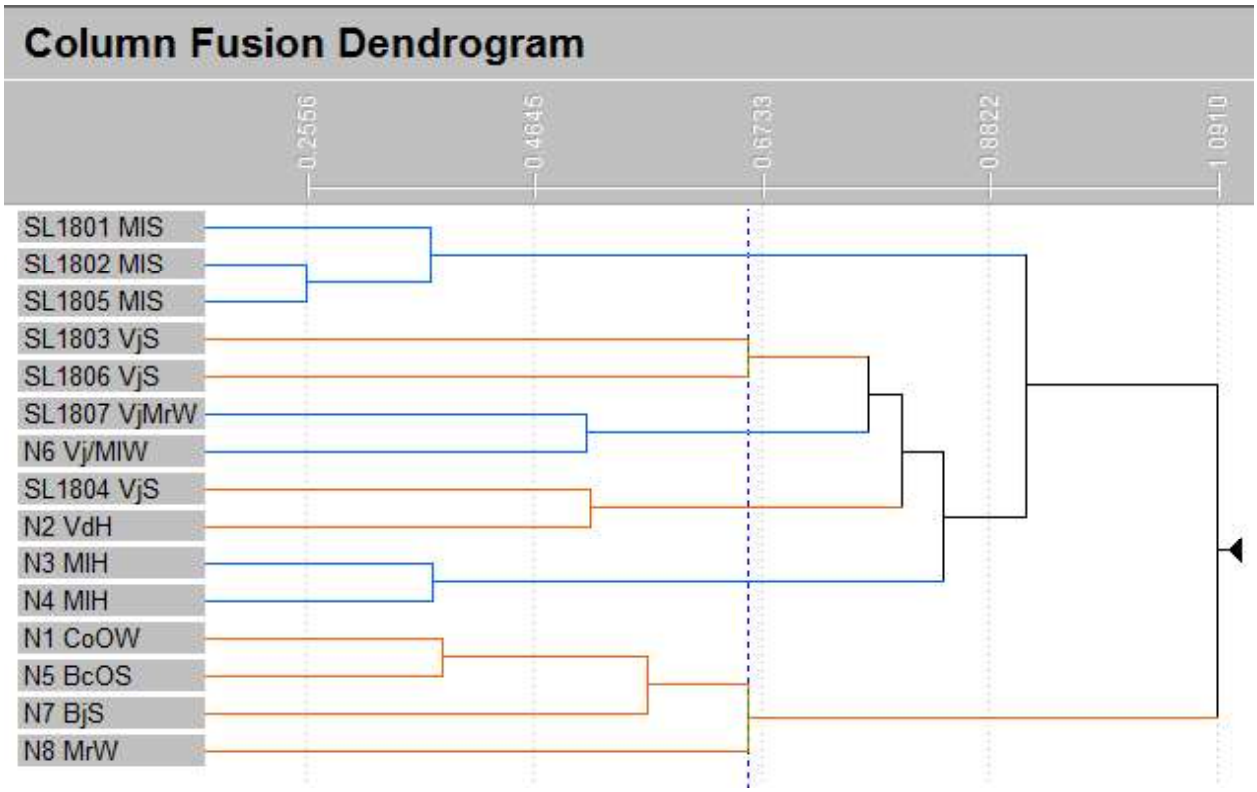


Figure 2: Multivariate analysis dendrogram

4.1.2.2 Floristic Analysis to Compare with Swan Coastal Plain FCTs

The raw FCT analyses results are included in **Appendix Three**. The most similar Gibson *et al.* (1994) Swan Coastal Plain (SCP) FCTs are highlighted, however, it should be noted that:

- the Muchea Limestone TEC is not defined in terms of the SCP FCT data as it was not recognised at the time of the Gibson *et al.* surveys (DCALM 2013; DotEE 2017)
- the 'Clay pans with mid dense shrublands of *Melaleuca lateritia* over herbs' component of the EPBC *Clay Pans of the Swan Coastal Plain* TEC is not identified by a Gibson *et al.* SCP FCT (DPaW 2015; DSEWPaC 2012a)
- due to the low floristic diversity in both the Ecoscape and NAH quadrats the results of the FCT analysis are indicative only and do not show strong associations with any particular SCP FCT, but rather with groups of FCTs. Quadrats with very low numbers of FCT species are not included in the analysis due to extremely low reliability of the analysis.

The main aim of the FCT analysis was to identify if the floristics of the wetland are allied to coastal FCTs (i.e. those with calcicoles; plants associated with limestone soils) or more inland types, not to clearly identify which FCT each quadrat was associated with.

The results of the FCT analyses indicate that the quadrats are most similar to SCP FCTs 7, 8, 9 and 13. The former three are Western Australian TECs incorporated (with others) into the EPBC-listed critically endangered *Clay Pans of the Swan Coastal Plain* TEC. SCP FCT 13 has no specific conservation significance.

The FCT analysis did not indicate that there were any limestone influences on the vegetation of the site.

4.1.2.3 Floristic Interpretation

Due to the inclusive FCT analysis above that broadly allied the quadrats recorded with clay pan FCTs representative of the Clay Pans TEC rather than the Muchea Limestone TEC, species list comparisons were made with available lists for each of the TECs (Clay Pans TEC, DPaW 2015 Appendix 2; Muchea Limestone TEC, English & Blyth 2000 Appendix 1 and characteristic species in Appendix 2).

All quadrats (both Ecoscape and NAH; **Table 14** in **Appendix Three**) have more species listed for inclusion in the Clay Pans TEC than the Muchea Limestone TEC.

4.1.3 VEGETATION CONDITION

The vegetation condition ranged from Very Good to Completely Degraded. The condition of the area considered by DBCA to represent the Muchea Limestone TEC ranged from Very Good to Degraded.

The southern portion of the TEC, inclusive of the locations of quadrats SL1803 and SL1804, has been assessed as being in Degraded condition due to the extensive weed cover, largely *Watsonia meriana*, and lack of native species. Quadrat data sheets, included in **Appendix Two**, should be viewed for additional detail.

Vegetation condition extents are shown on **Map 1**.

4.2 NATIVE BEE SURVEY

Bee surveys were conducted on 23 November, 20 December 2018, and 5 January, 16 January, 26 January, 4 February and 23 February 2019 by Kit Prendergast and, in November, with Dr Rob Manning. All surveys were conducted under warm, sunny conditions with low wind speed and cloud cover.

Host plants for the target bee species (*Goodenia pulchella*) were in bloom throughout the survey periods; prolifically during November and December, declining in January and sparse during the last three surveys.

Forty seven species have been recorded in total. Many are undescribed and have been given a morphospecies identifier. The total number of specimens and species richness per survey is in **Table 4**.

Table 4: Bees collected per survey

Date	Total No.	Species richness
23 November	51	5
20 December	32	12
5 January	33	7
16 January	12	5
26 January	148	31
4 February	77	21
23 February	10	4

The bee species and numbers per survey are shown in **Table 15** in **Appendix Four**.

The two target bee species, *Leioproctus douglasiellus* and *Neopasiphae simplicior*, have not been recorded.

5 DISCUSSION

5.1 TEC ASSESSMENT

No flora species listed for protection under the Commonwealth EPBC Act of Western Australian BC Act were recorded from the area assessed by Ecoscape in 2018, although two P4 species (*Aponogeton hexatepalus* and *Schoenus natans*) were recorded. Neither were recorded within the overall site by NAH (2016).

Part of the site (0.16 ha corresponding with the proposed road) has been considered to represent the Muchea Limestone TEC on the basis of DBCA's assessment, for which complete details that would describe how this conclusion was reached have not been sighted.

Nineteen bore holes were drilled and assessed by Parsons Brinckerhoff in 2005 (Woodman Environmental Consulting Pty Ltd 2005) and did not identify the requisite TEC soil conditions of Muchea Limestone and/or significant ironstone. However, some transported limestone was recorded thus limestone considered as Plains limestone may occur, thus not entirely precluding the Muchea Limestone TEC from occurring (based on soil type requirements).

Comparison of the flora species of the site (current survey and NAH 2016 survey), shown in **Table 14** in **Appendix Three**, with those listed in the *Interim Recovery Plan* for the Muchea Limestone TEC (English & Blyth 2000), using the species listed in Appendix 1 and those definitive of the vegetation (major structural formations) in Appendix 2, identified only three species in common (four if the identification of *Melaleuca lateriflora* in the *Interim Recovery Plan* should be *Melaleuca lateritia*): *Acacia saligna* (from one Ecoscape quadrat), *Casuarina obesa* (from one NAH quadrat), *Melaleuca rhaphiophylla* (from two quadrats and one each from Ecoscape and NAH) and *Melaleuca lateritia* (five from Ecoscape and three from NAH).

None of these species are particularly associated with limestone soils (WAH 1998), and a significant number of species listed for inclusion in the Clay Pans TEC with 23 species listed for inclusion in the *Clay pans with shrubs* PEC component of the Clay Pans TEC.

Further comparison of quadrat data and Swan Coastal Plain FCTs (Gibson *et al*. 1994), analysed using the method described in **Section 3.1.5.2** (with raw results in **Table 13** in **Appendix Three**) show that all quadrats with sufficient FCT species for meaningful analysis were aligned with FCTs largely on the eastern Swan Coastal Plain (Pinjarra Plain landform), and most frequently with FCTs associated with seasonal wetlands of clay soils (FCTs 7-13, but mostly FCTs 7-9). FCTs 7-10 are all Western Australian TECs, combined (with a Western Australian PEC), into the EPBC-listed critically endangered Clay Pans TEC. No quadrats showed any affinity with any of the more coastal, limestone-influenced FCTs which is definitive of the Muchea Limestone TEC.

On the basis of the field survey and floristic analysis and data comparison conducted using both Ecoscape's and NAH's (2016) quadrat data, combined with the hydrogeological data (Woodman Environmental Consulting Pty Ltd 2005), it is Ecoscape's opinion that the wetland, in particular the area mapped as vegetation type **MIMS** (and, by NAH as MlH), is more likely to represent the *Clay Pans of the Swan Coastal Plain* TEC, specifically the *Clay pans with shrubs over herbs* DBCA P1 PEC component, than the *Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain* TEC. However, both Commonwealth TECs are listed for protection under the EPBC Act This finding concurs with the preliminary Keighery and Hyder-Griffiths (2004) assessment that the wetland corresponds with one of the FCTs of the Clay Pans TEC, most likely FCT 7.

The EPBC-listed endangered Muchea Limestone TEC has 16 known occurrences, including the Carousel Swamp (DotEE 2017). The indicatively mapped distribution (Environment Australia 2003), now outdated, indicates that the bulk of the community occurs north of Perth at the Vines (Upper Swan), Bullsbrook, Muchea and Beermullah. As such, the subject wetland is a geographical outlier. The range of the TEC, when including this wetland, is approximately 95 km north-south.

The EPBC-listed critically endangered Clay Pans TEC has 114 known occurrences in 50 separate locations (DPaW 2015). The indicatively mapped distribution (DSEWPaC 2012b) is from north of Lancelin to south of

Busselton, and extending east of the Swan Coastal Plain with a north-south distribution of over 300 km. Occurrences include at the Brixton Street (and other) Wetlands over various sites in Kenwick, approximately 2.8 km to the east. However, the Western Australian components of the Commonwealth TEC are either listed as vulnerable (SCP FCTs 7-9, which are the most similar to the communities on the site) or as a PEC (*Clay pans with shrubs over herbs*, characterised by *Melaleuca lateritia*, which is the most similar to the vegetation of the site).

However, despite which EPBC-listed TEC occurs on site, development will require environmental approvals and management according to its protection under the Commonwealth EPBC Act. According to Ecoscape's 2018 assessment that refined the boundary of the TEC, 0.12 ha of the proposed development area (proposed road) corresponds with a TEC (2.10% of the 5.71 ha DBCA mapped extent). According to unrefined DBCA mapping 0.16 ha of the TEC was included in the proposed development area.

5.2 NATIVE BEE SURVEY

Neither of the target short-tongued native bee species (*Leioproctus douglasiellus* and *Neopasiphae simplicior*) have been recorded during seven survey periods that corresponded with optimal timing to find them i.e. suitable season, suitable weather and prolific flowering of suitable host species.

It is unlikely that either currently occur, particularly *Neopasiphae simplicior* that may never have been recorded from the site. A significant number of the bee species recorded from the site have not been formally described and, as such, it is possible that some may be uncommon or meet the criteria to be considered as threatened. However, removing a small portion of the potential habitat for the proposed Southern Link Road, while reducing the amount of available habitat, is unlikely to be significant in terms of the threatening processes that operate on small urban remnants of native bushland e.g. weed invasion, fire, disease, changed hydrology, human disturbance, climate change.

5.3 POTENTIAL IMPACT (ADDENDUM)

In order to reduce the road footprint, the City's engineers have developed three construction options that are currently under consideration:

- Option 1: using a retaining wall along the boundary line
- Option 2: 1:4 batter bottom line offset 4 m from the boundary line
- Option 3: 1:2 cobbled batter line offset 2 m from the boundary line.

Each of these options is assuming an estimated backfill to 1 m maximum. Cross sections of these options and their impact on the TEC, as mapped by DBCA and as refined by Ecoscape, are presented in **Figure 4** and **Map 2** respectively.

The extents that each option intersect with the TEC as mapped by DBCA and refined by Ecoscape are presented in **Table 5**. The colours in this table correspond with the colours used in the map.

Table 5: Impacts on the TEC per road construction option

	DBCA mapping		Ecoscape mapping	
Options	**ha**	**m^2**	**ha**	**m^2**
Option 1	0.13	1,276.19	0.08	777.78
Option 3	0.15	1,484.65	0.09	893.99
Option 2	0.17	1,717.37	0.10	1,012.80

Option 1: Vertical Wall – This option has the least ground footprint within the TEC area and would require the least clearing also. As the wall is a vertical option it will have nil impact to stormwater movements and the potential for scour on the outer edges of the treatment with the road reserve side of the geometry draining back within the road. This feature will provide nothing in the way of landscape buffering between the road reserve and the TEC, however the addition of a fence line which will act as a "Trash Screen" and also

prevent errant pedestrians from falling down the embankment. This option will limit the movement of fauna between the Road Reserve to the TEC due to the presence of the fence.

Option 2: This option will have the greatest ground footprint impact of the 3 presented (by area) within the TEC. It will however have the most natural appearance of the options presented and provide the opportunity to remove the requirement for the fence line (as desired) and introduce vegetation to the batter as a means to control both scour as well as stabilize the batter. With the embankment height varying across the length of the project the impacts of this batter will vary with regards to footprint however if incorporated into an outer edge revegetation/restoration its impact could be minimised due to the reduced compactive effort required.

Option 3: This option presents the second least impact of the 3 options presented from a ground footprint perspective. This option would require engineering stabilisation of the batter via rock or concreting similar to the treatment which exists closer to the Gerard St Bridge (**Figure 3**). This option will require more compactive effort to the fringe to ensure the batter segments are embedded and the "armour" does not fail.

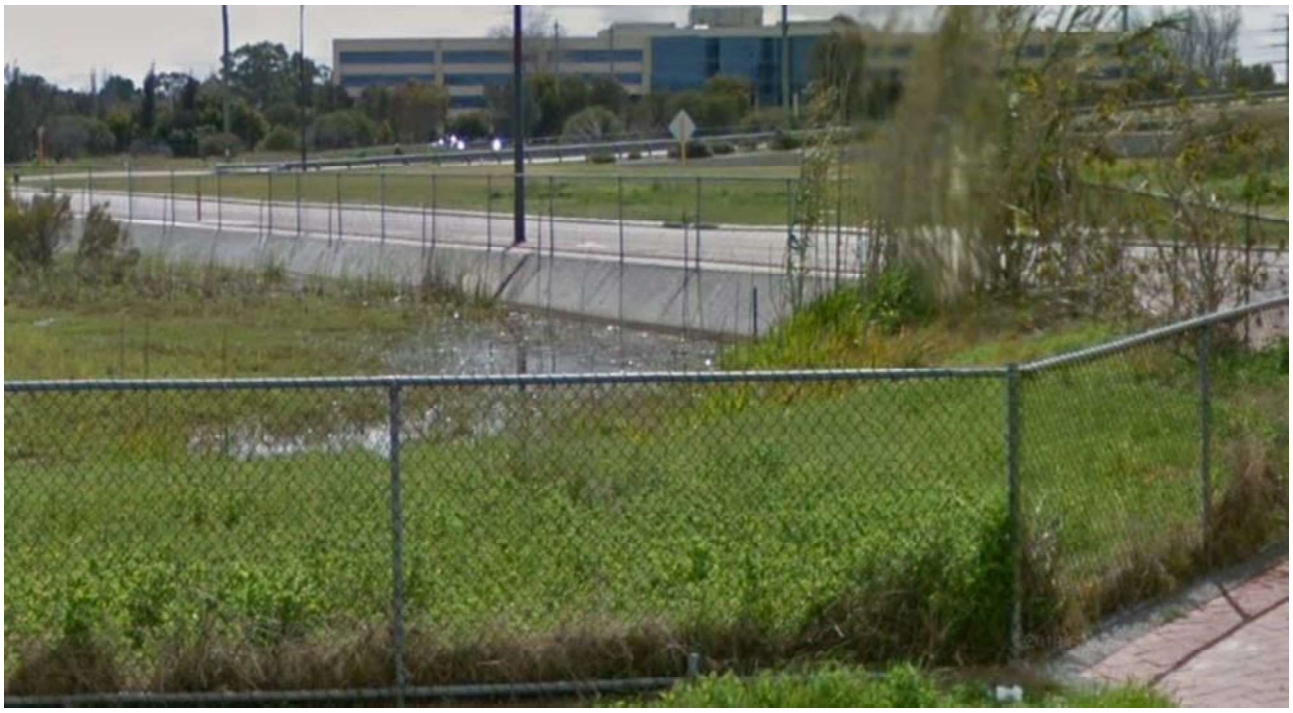
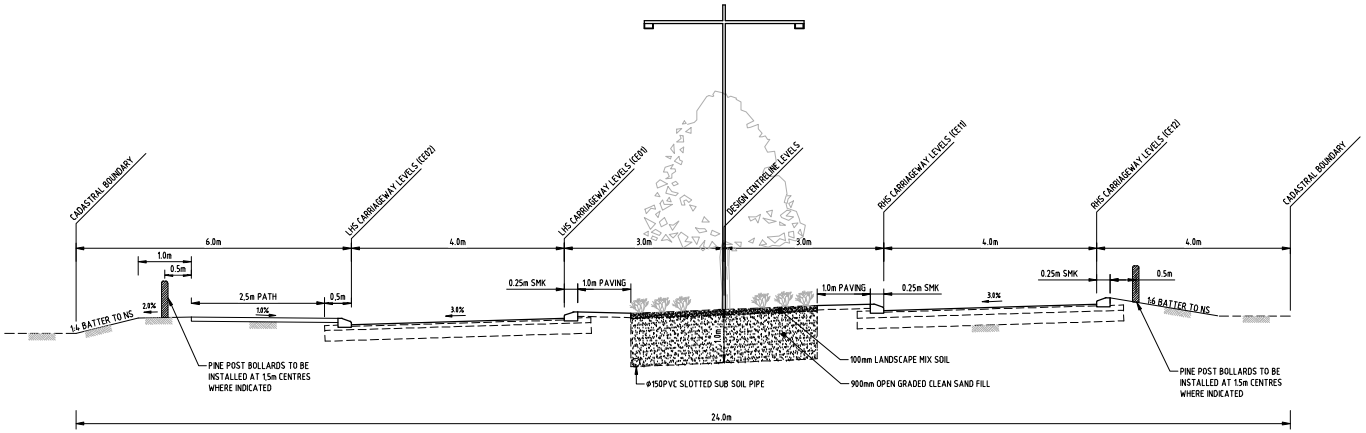


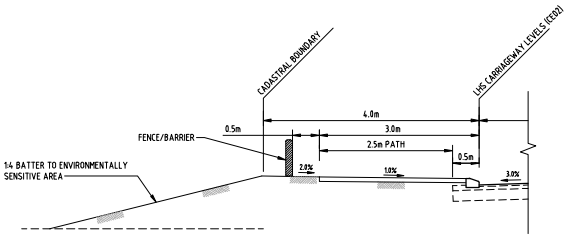
Figure 3: Gerard Street Bridge.

There is a greater potential for scour to the edge with this treatment also due to stormwater discharge running down the face of the wall. This treatment will offer consistency in appearance to the surrounding treatment and again offer the fence line to act as a "trash screen "preventing the movement of waste into the reserve and also preventing errant pedestrians from falling down the embankment. This option will limit the movement of fauna between the Road Reserve to the TEC due to the presence of the fence.

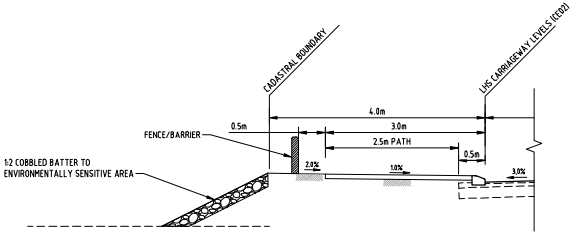
The City is also investigating clearing offset options in the form of management and restoration of the wetland.



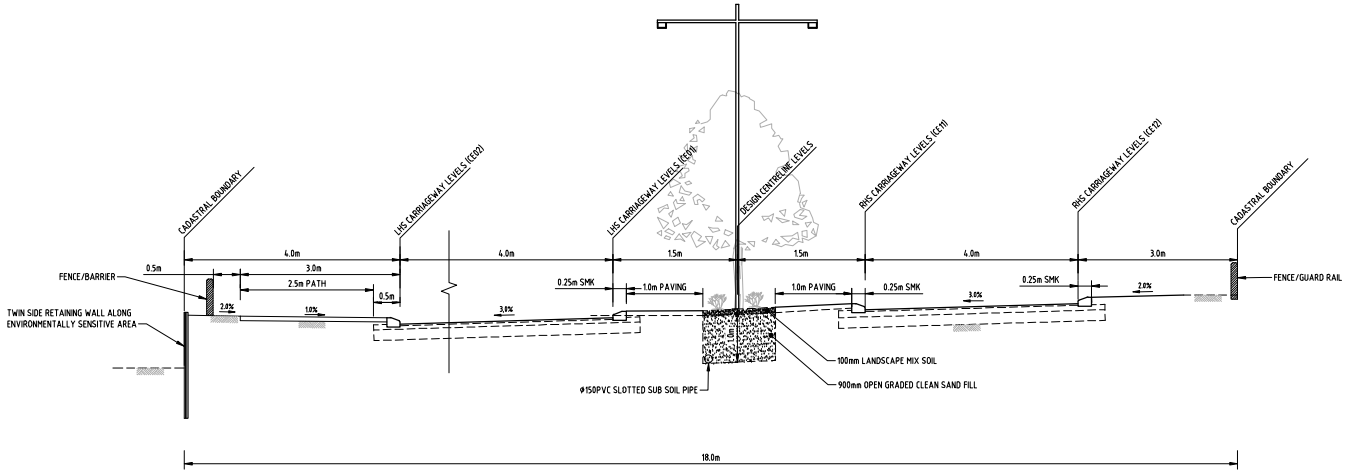
TYPICAL CROSS SECTION (A-A)
NTS



1:4 BATTER TO ENVIRONMENTALLY SENSITIVE AREA (OPTION 2)
NTS



1:2 COBBLED BATTER TO ENVIRONMENTALLY SENSITIVE AREA (OPTION 3)
NTS



TWIN SIDE RETAINING WALL (OPTION 1) TYPICAL SECTION ENVIRONMENTALLY SENSITIVE AREA (B-B)
NTS

PROJECT:
SOUTHERN LINK ROAD CANNINGTON

No.	DATE	REVISION	BY
D	15-4-2019	BLOCK RET WAALL REMOVED. 3 OPTIONS ADDED, TWIN SIDE, 14, 12.	MJV
C	22-3-2019	UPDATED TO 24m ROAD RESERVE.	MJV
B	21-3-2019	25m AND 18m ROAD RESREVE AREAS NOTED.	MJV
A	14-2-2019	PRELIMINARY PLOT FOR DISCUSSION	MJV

Porter Consulting Engineers
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Email office@porterseng.com.au
www.porterseng.com.au
TUSAS Pty Ltd ACN 070 091 168 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 76 606 396 385

CLIENT:
CITY OF CANNING

DRAWING:
TYPICAL CROSS SECTIONS

STATUS: **FOR COMMENT**

SCALE	NTS
DATE	FEB 2019
DESIGN	ELW
DRAWN	MJV
CHECK	
APP'D	

DRAWING No. **18-7-100/800**
REV No. **D**
ORIGINAL DRAWING SIZE **A1**
FILE NAME \\192.168.101.102\Data\ACTIVE PROJECTS\18-07-100\ACAD\18T800-D.dwg

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MAPS

LEGEND

- Vegetation Quadrats

Conservation Significant Flora

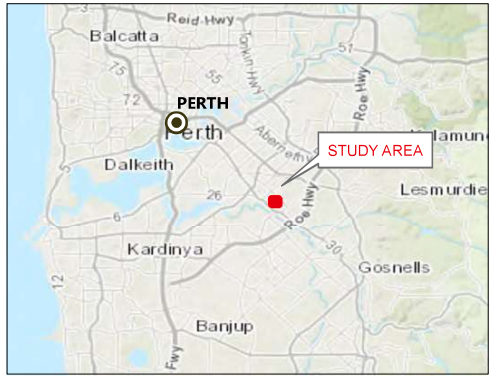
- A *Aponogeton hexatepalus*
- S *Schoenus natans*
- Development Area
- 20 m buffer
- Canning Swamp (DBCA)

Vegetation

- MIMS: *Melaleuca lateritia* mid shrubland
- VjMrLw: *Viminaria juncea* and *Melaleuca rhaphiopylla* low woodland
- VjTS: *Viminaria juncea* tall shrubland
- Rehab - Geraldton Wax
- Completely Degraded
- Not Native Vegetation
- Not Assessed

Vegetation Condition

- Very Good
- Good
- Degraded
- Completely Degraded



DATA SOURCES
SOURCE DATA:
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SERVICE LAYERS: SOURCES: ESRI, HERE, DELORME, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, MAPMYINDIA, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

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SOUTHERN LINK ROAD ENVIRONMENTAL APPROVAL FLORA AND VEGETATION

City of CANNING

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

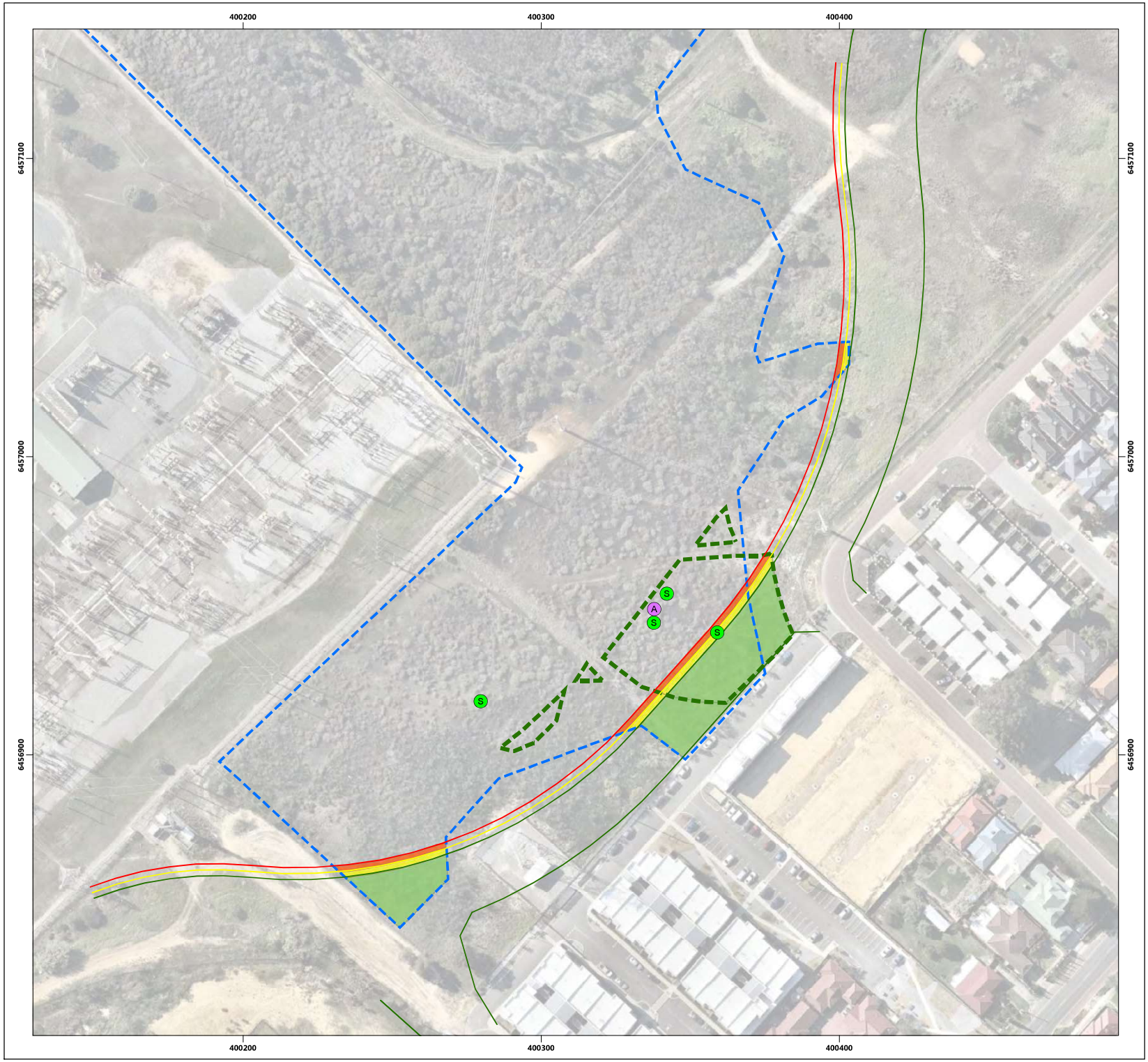
SCALE: 1:1,750 @ A3

0 10 20 30 40 50 m

PROJECT NO: 4267-18

REV	AUTHOR	APPROVED	DATE
0	SB	SK	18/12/2018
1	SB	LA	29/01/2019

MAP 01



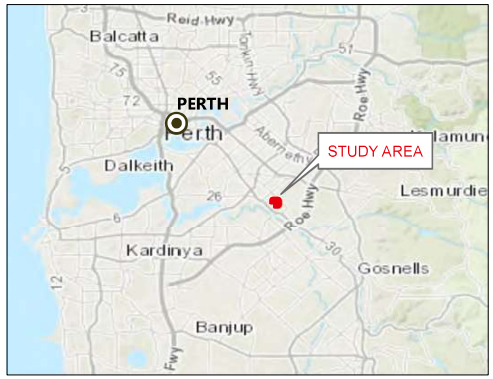
LEGEND

Conservation Significant Flora

- A Aponogeton hexatepalus
- S Schoenus natans
- Option 2
- Option 3
- Option 1
- TEC Boundary (Ecoscape 2018)
- TEC Canning Swamp (DBCA 2018)

Options intersecting with the TEC boundaries

- Option 1
- Option 3
- Option 2



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SOUTHERN LINK ROAD ENVIRONMENTAL APPROVAL DEVELOPMENT OPTIONS

City of CANNING

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

N

SCALE: 1:1,250 @ A3

0 10 20 30 40 50 m

PROJECT NO: 4267-18

REV	AUTHOR	APPROVED	DATE
0	SB	LA	22/05/2019
0	SB	LA	04/07/2019

MAP 02

APPENDIX ONE DEFINITIONS AND CATEGORIES

Table 6: EPBC Act categories for flora and fauna

EPBC ACT 1999 category	Definition
Extinct	A native species is eligible to be included in the extinct category at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
Extinct in the wild	A native species is eligible to be included in the extinct in the wild category at a particular time if, at that time: (a) it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered (CE)	A native species is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered (EN)	A native species is eligible to be included in the endangered category at a particular time if, at that time: (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable (VU)	A native species is eligible to be included in the vulnerable category at a particular time if, at that time: (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.
Conservation Dependent	A native species is eligible to be included in the conservation dependent category at a particular time if, at that time: (a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory; (iv) cessation of the plan of management would adversely affect the conservation status of the species.

Table 7: Conservation codes for Western Australian flora and fauna (DBCA 2019)

Conservation Codes for Western Australian Flora and Fauna	
Threatened, Extinct and Specially Protected fauna or flora[1] are species[2] which have been adequately searched for and are deemed to be, in the wild, threatened, extinct or in need of special protection, and have been gazetted as such. **The *Wildlife Conservation (Specially Protected Fauna) Notice 2018* and the *Wildlife Conservation (Rare Flora) Notice 2018* have been transitioned under regulations 170, 171 and 172 of the *Biodiversity Conservation Regulations 2018* to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the *Biodiversity Conservation Act 2016*.** Categories of Threatened, Extinct and Specially Protected fauna and flora are:	
T	**Threatened species** Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as threatened species under section 26(2) of the *Biodiversity Conservation Act 2016* (BC Act). Threatened fauna is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for Threatened Fauna. Threatened flora is that subset of 'Rare Flora' listed under schedules 1 to 3of the *Wildlife Conservation (Rare Flora) Notice 2018* for Threatened Flora. The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.
CR	**Critically endangered species** Threatened species considered to be "*facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines*". Listed as critically endangered undersection 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines. Published under schedule 1 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for critically endangered fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for critically endangered flora.
EN	**Endangered species** Threatened species considered to be "*facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines*". Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under schedule 2 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for endangered fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for endangered flora.
VU	**Vulnerable species** Threatened species considered to be "*facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines*". Listed as vulnerable undersection 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines. Published under schedule 3of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for vulnerable fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for vulnerable flora.
Extinct species Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild.	
EX	**Extinct species** Species where "*there is no reasonable doubt that the last member of the species has died*", and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act). Published as presumed extinct under schedule 4of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for extinct fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for extinct flora.
EW	Extinct in the wild species Species that "*is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form*", and listing is otherwise in accordance with the ministerial guidelines (section 25of the BC Act). Currently there are no threatened fauna or threatened flora species listed as extinct in the wild. If listing of a species as extinct in the wild occurs, then a schedule will be added to the applicable notice.
Specially protected species Listed by order of the Minister as specially protected under section 13(1) of the BC Act. Meeting one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection. Species that are listed as threatened species (critically endangered, endangered or vulnerable) or extinct species under the BC Act cannot also be listed as Specially Protected species.	

Conservation Codes for Western Australian Flora and Fauna	
MI	**Migratory species** Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15of the BC Act). Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the *Convention on the Conservation of Migratory Species of Wild Animals* (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are 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. Published as migratory birds protected under an international agreement under schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.
CD	**Species of special conservation interest (conservation dependent fauna)** Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14of the BC Act). Published as conservation dependent fauna under schedule 6 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018.*
OS	**Other specially protected species** Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18of the BC Act). Published as other specially protected fauna under schedule 7of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018.*
P	**Priority species** Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna or flora. Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.
1	**Priority 1: Poorly-known species** Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
2	**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, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
3	**Priority 3: Poorly-known species** Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.
4	**Priority 4: Rare, Near Threatened and other species in need of monitoring** (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

[1] The definition of flora includes algae, fungi and lichens.
[2] Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).

Table 8: DBCA definitions and criteria for TECs and PECs (DEC 2013)

Criteria	Definition
Threatened Ecological Communities	
Presumed Totally Destroyed (PD)	An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies (A or B): A. Records within the last 50 years have not been confirmed despite thorough searches of known or likely habitats or B. All occurrences recorded within the last 50 years have since been destroyed
Critically Endangered (CR)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C): A. The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and either or both of the following apply (i or ii): i. geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 10 years); ii. modification throughout its range is continuing such that in the immediate future (within approximately 10 years) the community is unlikely to be capable of being substantially rehabilitated. B. Current distribution is limited, and one or more of the following apply (i, ii or iii): i. geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 10 years); ii. there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes; iii. there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes. C. The ecological community exists only as highly modified occurrences that may be capable of being rehabilitated if such work begins in the immediate future (within approximately 10 years).
Endangered (EN)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B, or C): A. The geographic range, and/or total area occupied, and/or number of discrete occurrences have been reduced by at least 70% since European settlement and either or both of the following apply (i or ii): i. the estimated geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term future (within approximately 20 years); ii. modification throughout its range is continuing such that in the short term future (within approximately 20 years) the community is unlikely to be capable of being substantially restored or rehabilitated. B. Current distribution is limited, and one or more of the following apply (i, ii or iii): i. geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 20 years); ii. there are few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes; iii. there may be many occurrences but total area is small and all or most occurrences are small and/or isolated and very vulnerable to known threatening processes. The ecological community exists only as very modified occurrences that may be capable of being substantially restored or rehabilitated if such work begins in the short-term future (within approximately 20 years).

Criteria	Definition
Vulnerable (VU)	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B or C): A. The ecological community exists largely as modified occurrences that are likely to be capable of being substantially restored or rehabilitated. B. The ecological community may already be modified and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations. C. The ecological community may be still widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.
Priority ecological communities	
Priority One	*Poorly known ecological communities* Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority Two	*Poorly known ecological communities* Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, state forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities, but do not meet adequacy of survey requirements, and / or are not well defined, and appear to be under threat from known threatening processes.
Priority Three	*Poorly known ecological communities* i. Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or; ii. Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; iii. Communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities, but do not meet adequacy of survey requirements and / or are not well defined, and known threatening processes exist that could affect them.
Priority Four	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring. i. Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change These communities are usually represented on conservation lands. ii. Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. iii. Ecological communities that have been removed from the list of threatened communities during the past five years.
Priority Five	*Conservation Dependent Ecological Communities* Ecological Communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Table 9: NVIS structural formation terminology, terrestrial vegetation (ESCAVI 2003)

	Cover characteristics							
	Foliage cover *	70-100	30-70	10-30	<10	» 0 (scattered)	0-5 (clumped)	unknown
	Cover code	d	c	i	r	bi	bc	unknown
Growth Form	**Height Ranges (m)**	**Structural Formation Classes**						
tree, palm	<10,10-30, >30	closed forest	open forest	woodland	open woodland	isolated trees	isolated clumps of trees	tree, palm
tree mallee	<3, <10, 10-30	closed mallee forest	open mallee forest	mallee woodland	open mallee woodland	isolated mallee trees	isolated clumps of mallee trees	tree mallee
shrub, cycad, grass-tree, tree-fern	<1,1-2,>2	closed shrubland	shrubland	open shrubland	sparse shrubland	isolated shrubs	isolated clumps of shrubs	shrub, cycad, grass-tree, tree-fern
mallee shrub	<3, <10, 10-30	closed mallee shrubland	mallee shrubland	open mallee shrubland	sparse mallee shrubland	isolated mallee shrubs	isolated clumps of mallee shrubs	mallee shrub
heath shrub	<1,1-2,>2	closed heathland	heathland	open heathland	sparse heathland	isolated heath shrubs	isolated clumps of heath shrubs	heath shrub
chenopod shrub	<1,1-2,>2	closed chenopod shrubland	chenopod shrubland	open chenopod shrubland	sparse chenopod shrubland	isolated chenopod shrubs	isolated clumps of chenopod shrubs	chenopod shrub
samphire shrub	<0.5,>0.5	closed samphire shrubland	samphire shrubland	open samphire shrubland	sparse samphire shrubland	isolated samphire shrubs	isolated clumps of samphire shrubs	samphire shrub
hummock grass	<2,>2	closed hummock grassland	hummock grassland	open hummock grassland	sparse hummock grassland	isolated hummock grasses	isolated clumps of hummock grasses	hummock grass
tussock grass	<0.5,>0.5	closed tussock grassland	tussock grassland	open tussock grassland	sparse tussock grassland	isolated tussock grasses	isolated clumps of tussock grasses	tussock grass
other grass	<0.5,>0.5	closed grassland	grassland	open grassland	sparse grassland	isolated grasses	isolated clumps of grasses	other grass
sedge	<0.5,>0.5	closed sedgeland	sedgeland	open sedgeland	sparse sedgeland	isolated sedges	isolated clumps of sedges	sedge
rush	<0.5,>0.5	closed rushland	rushland	open rushland	sparse rushland	isolated rushes	isolated clumps of rushes	rush
herb	<0.5,>0.5	closed herbland	herbland	open herbland	sparse herbland	isolated herbs	isolated clumps of herbs	herb
fern	<1,1-2,>2	closed fernland	fernland	open fernland	sparse fernland	isolated ferns	isolated clumps of ferns	fern
bryophyte	<0.5	closed bryophyte-land	bryophyte-land	open bryophyteland	sparse bryophyteland	isolated bryophytes	isolated clumps of bryophytes	bryophyte
lichen	<0.5	closed lichenland	lichenland	open lichenland	sparse lichenland	isolated lichens	isolated clumps of lichens	lichen
vine	<10,10-30, >30	closed vineland	vineland	open vineland	sparse vineland	isolated vines	isolated clumps of vines	vine

Table 10: NVIS height classes (ESCAVI 2003)

Height		Growth form				
Height Class	**Height Range (m)**	**Tree, vine (M & U), palm (single-stemmed)**	**Shrub, heath shrub, chenopod shrub, ferns, samphire shrub, cycad, tree-fern, grass-tree, palm (multi-stemmed)**	**Tree mallee, mallee shrub**	**Tussock grass, hummock grass, other grass, sedge, rush, forbs, vine (G)**	**Bryophyte, lichen, seagrass, aquatic**
8	>30	tall	NA	NA	NA	NA
7	10-30	mid	NA	tall	NA	NA
6	<10	low	NA	mid	NA	NA
5	<3	NA	NA	low	NA	NA
4	>2	NA	tall	NA	tall	NA
3	1-2	NA	mid	NA	tall	NA
2	0.5-1	NA	low	NA	mid	tall
1	<0.5	NA	low	NA	low	low

Source: (based on Walker & Hopkins 1990)

Table 11: Vegetation Condition Scale for the South West and Interzone Botanical Provinces (EPA 2016a)

Condition rating	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance or damage caused by human activities since European settlement.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species. Damage to trees caused by fire, the presence of non-aggressive weeds and occasional vehicle tracks.
Very Good	Vegetation structure altered, obvious signs of disturbance. Disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds at high density, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees and shrubs.

APPENDIX TWO FLORA INVENTORY/QUADRAT DATA

Table 12: Site x species

Family	Name	Introduced	Cons. Code	SL1801	SL1802	SL1803	SL1804	SL1805	SL1806	SL1807	Opp.
Apiaceae	*Schoenolaena juncea*							X			
Aponogetonaceae	*Aponogeton hexatepalus*		P4								X
Asparagaceae	*Lomandra suaveolens*									X	
Centrolepidaceae	*Centrolepis aristata*				X						
Colchicaceae	*Burchardia bairdiae*				X						
Cyperaceae	*Chorizandra enodis*			X			X				
	Cyperus tenellus	*		X							
	Isolepis cernua var. *setiformis*			X	X			X			
	Lepidosperma costale					X				X	
	Schoenus natans		P4	X	X			X			
	Schoenus tenellus			X	X			X			
Fabaceae	*Acacia saligna*								X		
	Eutaxia virgata			X	X						
	Gompholobium marginatum						X				
	Viminaria juncea			X		X	X		X	X	
Goodeniaceae	*Goodenia pulchella* subsp. Coastal Plain B (L.W. Sage 2336)			X				X	X		
Haemodoraceae	*Haemodorum simplex*						X				
INDETERMINANT	Indeterminant spp.			X	X						
Iridaceae	*Patersonia occidentalis*						X			X	
	Romulea rosea	*								X	
	Sparaxis bulbifera	*		X						X	
	Watsonia meriana	*		X	X	X	X	X	X	X	
Juncaceae	*Juncus bufonius*	*		X							
Juncaginaceae	Juncaginaceae sp.			X	X			X			
Lauraceae	*Cassytha racemosa* forma *racemosa*			X	X			X			
Lythraceae	*Lythrum hyssopifolia*	*		X							
Myrtaceae	*Astartea affinis*			X	X				X		
	Astartea scoparia									X	
	Melaleuca lateritia			X	X		X	X		X	
	Melaleuca rhaphiophylla									X	
	Verticordia densiflora var. *densiflora*						X				
Orchidaceae	*Microtis media* subsp. *media*			X							
Plantaginaceae	*Gratiola pubescens*			X	X			X			
Poaceae	*Avena barbata*	*							X		
	Briza maxima	*								X	
	Briza minor	*					X				
	Cenchrus clandestinus	*							X		
	Cenchrus setaceus	*				X					
	Cynodon dactylon	*		X	X					X	

Family	Name	Introduced	Cons. Code	SL1801	SL1802	SL1803	SL1804	SL1805	SL1806	SL1807	Opp.
Poaceae cont'	*Ehrharta calycina*	*				X					
	Eragrostis curvula	*					X				
	Hyparrhenia hirta	*				X	X				
	Lachnagrostis filiformis			X	X			X	X		
	Paspalum dilatatum	*								X	
Polygonaceae	*Rumex crispus*	*								X	
Primulaceae	*Lysimachia arvensis*	*				X	X		X		
Restionaceae	*Leptocarpus canus*			X	2			2		X	
	Leptocarpus coangustatus			X							
Rubiaceae	*Opercularia vaginata*			X			X				
Stylidiaceae	*Stylidium divaricatum*				X				X		
	Stylidium roseoalatum				X			X			
Thymelaeaceae	*Pimelea imbricata* var. *major*								X		
Xanthorrhoeaceae	*Xanthorrhoea brunonis*						X		X	X	

Southern Link

SL1801

Staff SOK **Date** 22/11/2018 **Season** A

Revisit

Type Q 10 m x 10 m

Location

MGA Zone 50 400355 **mE** 6456941 **mN** **Lat.** -32.0193 **Long.** 115.9449

Habitat Flat

Aspect N/A **Slope** N/A

Soil Type Light grey clay

Rock Type Nil

Loose Rock 0 % cover **Litter** 5 % cover ; 0-3 cm in depth

Bare ground 50% cover **Weeds** 15 % cover

Vegetation M+ ^*Melaleuca lateritia*,^*Astartea affinis*\^shrub\3\i;G ^*Leptocarpus canus*,*Watsonia meriana*\^rush,forb\2\c

Veg. Condition Good

Disturbance Edge effects

Fire Age >10 years

Notes Parts would be seasonally inundated

Species	WA Cons.	Height (m)	Cover (%)	Count
Astartea affinis		1.5	10	
Cassytha racemosa forma *racemosa*		1.5	15	
Chorizandra enodis		0.5	1	
**Cynodon dactylon*		0.3	1	
**Cyperus tenellus*		0.1	<1	
Eutaxia virgata		0.8	5	

Goodenia pulchella subsp. *Coastal Plain B (L.W. Sage 2336)*		0.4	<1
Gratiola pubescens		0.1	<1
Indeterminant spp.		0.1	<1
Isolepis cernua var. *setiformis*		0.1	<1
Juncaginaceae sp.		0.2	<1
**Juncus bufonius*		0.1	<1
Lachnagrostis filiformis		0.2	<1
Leptocarpus canus		0.6	20
Leptocarpus coangustatus		0.5	<1
**Lythrum hyssopifolia*		0.2	<1
Melaleuca lateritia		1.5	15
Microtis media subsp. *media*		0.3	<1
Opercularia vaginata		0.5	2
Schoenus natans	P 4	0.1	<1
Schoenus tenellus		0.1	<1
**Sparaxis bulbifera*		0.3	<1
Viminaria juncea		3	4
**Watsonia meriana*		0.7	10

Southern Link

SL1802

Staff SOK **Date** 22/11/2018 **Season** A

Revisit

Type Q 10 m x 10 m

Location

MGA Zone 50 400338 **mE** 6456954 **mN** **Lat.** -32.0192 **Long.** 115.9447

Habitat Flat

Aspect N/A **Slope** N/A

Soil Type Light grey clay

Rock Type Nil

Loose Rock 0 % cover **Litter** 3 % cover ; 0-2 cm in depth

Bare ground 30% cover **Weeds** 3 % cover

Vegetation M+ ^*Melaleuca lateritia*,^*Astartea affinis*\^shrub\3\c;G ^*Leptocarpus canus*,^*Watsonia meriana*\^rush,forb\2\c

Veg. Condition Very Good

Disturbance Weeds

Fire Age >10 years

Notes Wet clay, seasonally inundated

Species	WA Cons.	Height (m)	Cover (%)	Count
Astartea affinis		1.5	2	
Burchardia bairdiae		1	<1	
Cassytha racemosa forma *racemosa*		1.5	8	
Centrolepis aristata		0.1	<1	
**Cynodon dactylon*		0.3	<1	
Eutaxia virgata		1	<1	

Southern Link

Gratiola pubescens		0.1	<1
Indeterminant spp.		0.02	<1
Isolepis cernua var. *setiformis*		0.1	4
Juncaginaceae sp.		0.2	2
Lachnagrostis filiformis		0.3	<1
Leptocarpus canus		0.6	30
Leptocarpus canus		0.6	3
Melaleuca lateritia		1.5	30
Schoenus natans	P 4	0.1	5
Schoenus tenellus		0.1	<1
Stylidium divaricatum		0.3	<1
Stylidium roseoalatum		0.1	<1
* *Watsonia meriana*		0.6	2

Southern Link

SL1803

Staff SOK **Date** 22/11/2018 **Season** A

Revisit

Type Q 10 m x 10 m

Location

MGA Zone 50 400260 **mE** 6456865 **mN** **Lat.** -32.0200 **Long.** 115.9439

Habitat Flat

Aspect N/A **Slope** N/A

Soil Type Light grey clay

Rock Type Nil

Loose Rock 0 % cover **Litter** 5 % cover ; 0-2 cm in depth

Bare ground 20 % cover **Weeds** 80 % cover

Vegetation M+ ^*Viminaria juncea*\^shrub\4\i;G ^*Watsonia meriana*\^forb\2\d

Veg. Condition Degraded

Disturbance Weeds, fire

Fire Age 3 years

Notes

Species	WA Cons.	Height (m)	Cover (%)	Count
**Cenchrus setaceus*		0.5	<1	
**Ehrharta calycina*		1	<1	
**Hyparrhenia hirta*		1	<1	
Lepidosperma costale		0.5	<1	
**Lysimachia arvensis*		0.3	<1	
Viminaria juncea		3.5	25	
**Watsonia meriana*		1	80	

Southern Link

SL1804

Staff SOK **Date** 22/11/2018 **Season** A

Revisit

Type Q 10 m x 10 m

Location

MGA Zone 50 400281 **mE** 6456890 **mN** **Lat.** -32.0197 **Long.** 115.9441

Habitat Flat

Aspect N/A **Slope** N/A

Soil Type Light grey clay

Rock Type Nil

Loose Rock 0 % cover **Litter** 5 % cover ; 0-2 cm in depth

Bare ground 5 % cover **Weeds** 80 % cover

Vegetation M+ ^*Viminaria juncea*\^shrub\4\c;G ^*Watsonia meriana*\^forb\2\d

Veg. Condition Degraded

Disturbance Weeds, fire

Fire Age 3 years

Notes

Species	WA Cons.	Height (m)	Cover (%)	Count
**Briza minor*		0.3	<1	
Chorizandra enodis		0.6	<1	
**Eragrostis curvula*		1	<1	
Gompholobium marginatum		0.2	<1	
Haemodorum simplex		0.5	<1	
**Hyparrhenia hirta*		1.5	<1	
**Lysimachia arvensis*		0.2	<1	

		Southern Link
Melaleuca lateritia	1.5	1
Opercularia vaginata	0.5	<1
Patersonia occidentalis	0.4	<1
Verticordia densiflora var. *densiflora*	0.8	<1
Viminaria juncea	3.5	35
* *Watsonia meriana*	1	80
Xanthorrhoea brunonis	0.8	<1

Southern Link

SL1805

Staff SOK **Date** 22/11/2018 **Season** A

Revisit

Type Q 10 m x 10 m

Location

MGA Zone 50 400275 **mE** 6456918 **mN** **Lat.** -32.0195 **Long.** 115.9440

Habitat Flat

Aspect **Slope**

Soil Type Light grey clay

Rock Type Nil

Loose Rock 0 % cover **Litter** 2 % cover ; 0-1 cm in depth

Bare ground 65 % cover **Weeds** <1 % cover

Vegetation M+ ^*Melaleuca lateritia*\^shrub\3\i;G ^*Leptocarpus canus*,^*Goodenia pulchella* subsp. *Coastal Plain B (L.W. Sage 2336)*\^rush,forb\1\i

Veg. Condition Very Good

Disturbance

Fire Age 3 years

Notes

Species	WA Cons.	Height (m)	Cover (%)	Count
Cassytha racemosa forma *racemosa*		1.5	5	
Goodenia pulchella subsp. *Coastal Plain B (L.W. Sage 2336)*		0.4	5	
Gratiola pubescens		0.1	<1	
Isolepis cernua var. *setiformis*		0.1	3	
Juncaginaceae sp.		0.1	<1	
Lachnagrostis filiformis		0.2	<1	

Southern Link

Leptocarpus canus		0.5	10
Leptocarpus canus		0.7	<1
Melaleuca lateritia		1.5	20
Schoenolaena juncea		0.4	1
Schoenus natans	P 4	0.1	1
Schoenus tenellus		0.1	<1
Stylidium roseoalatum		0.1	<1
* *Watsonia meriana*		0.5	<1

Southern Link

SL1806

Staff SOK **Date** 22/11/2018 **Season** A

Revisit

Type Q 10 m x 10 m

Location

MGA Zone 50 400329 **mE** 6456928 **mN** **Lat.** -32.0194 **Long.** 115.9446

Habitat Flat

Aspect N/A **Slope** N/A

Soil Type Light grey clay

Rock Type Nil

Loose Rock 0 % cover **Litter** 5 % cover ; 0-2 cm in depth

Bare ground 20% cover **Weeds** 70 % cover

Vegetation M+ ^*Viminaria juncea*,^*Acacia saligna*\^shrub\4\c;G ^*Watsonia meriana*\^forb\2\d

Veg. Condition Degraded

Disturbance Weeds, fire

Fire Age 3 years

Notes

Species	WA Cons.	Height (m)	Cover (%)	Count
Acacia saligna		3	5	
Astartea affinis		1	<1	
**Avena barbata*		1	<1	
**Cenchrus clandestinus*		0.3	2	
Goodenia pulchella subsp. *Coastal Plain B (L.W. Sage 2336)*		0.4	2	
Lachnagrostis filiformis		0.3	<1	
**Lysimachia arvensis*		0.2	<1	

Southern Link

Pimelea imbricata var. *major*	1	<1
Stylidium divaricatum	0.3	<1
Viminaria juncea	3	30
* *Watsonia meriana*	1	70
Xanthorrhoea brunonis	1	1

Southern Link

SL1807

Staff SOK **Date** 22/11/2018 **Season** A

Revisit

Type Q 10 m x 10 m

Location

MGA Zone 50 400378 **mE** 6457005 **mN** **Lat.** -32.0187 **Long.** 115.9451

Habitat Flat

Aspect N/A **Slope** N/A

Soil Type Grey clay

Rock Type Nil

Loose Rock 0 % cover **Litter** 10 % cover ; 0-2 cm in depth

Bare ground 10 % cover **Weeds** 70 % cover

Vegetation U+ ^ *Viminaria juncea*,^ *Melaleuca rhaphiophylla*\^tree\6\c;G ^ ^ *Watsonia meriana*,*Paspalum dilatatum*,*Lepidosperma costale*\^forb,tussock grass,sedge\2\c

Veg. Condition Degraded

Disturbance Weeds

Fire Age >5 years

Notes Unmarked quadrat, based on approximately 10 m x 10 m due to small area and degradation

Species	WA Cons.	Height (m)	Cover (%)	Count
Astartea scoparia		1	<1	
* *Briza maxima*		0.3	<1	
* *Cynodon dactylon*		0.4	5	
Lepidosperma costale		0.6	5	
Leptocarpus canus		0.5	<1	
Lomandra suaveolens		0.2	<1	

		Southern Link
Melaleuca lateritia	1.5	1
Melaleuca rhaphiophylla	5	15
**Paspalum dilatatum*	0.7	10
Patersonia occidentalis	0.3	<1
**Romulea rosea*	0.1	<1
**Rumex crispus*	1	<1
**Sparaxis bulbifera*	0.3	<1
Viminaria juncea	4	30
**Watsonia meriana*	1	30
Xanthorrhoea brunonis	0.5	2

APPENDIX THREE FLORISTIC COMMUNITY TYPE ANALYSIS AND TEC COMPARISON

Table 13: FCT analysis: comparison with Gibson *et al.* (1994) floristic community types

Note that NAH quadrats Q1, Q5, Q6, Q8 (NAH 2016) and Ecoscape quadrats SL1803, SL1806 that had only 2-3 FCT species are not included below as analysis was considered inconclusive. Blue highlighted FCT types and their EPBC listing are considered the most similar to the quadrats.

Quadrat	Quadrat Description	Mapped Vegetation Type	FCT No.	FCT Name	Typical Landform	No. spp. in quadrat.	Species Richness			WA Cons. code	Comm. TEC
							No. FCT spp.	% of FCT spp.	Cumulative Frequency		
SL1801	M+ ^*Melaleuca lateritia*,^*Astartea affinis*\^shrub\3\i;G ^*Leptocarpus canus,Watsonia meriana*\^rush,forb\2\c	**MIMS**	13	Deeper wetlands on heavy soils	Bassendean / Pinjarra Plain	24	10	57.47%	266		TEC
			8	Herb rich shrublands in clay pans	Pinjarra Plain		8	15.38%	425		TEC
			9	Dense shrublands on clay flats	Pinjarra Plain		7	19.72%	314		TEC
			10a	Shrublands on dry clay flats	Pinjarra Plain		5	9.65%	189		TEC
SL1802	M+ ^*Melaleuca lateritia*,^*Astartea affinis*\^shrub\3\c;G ^*Leptocarpus canus*,^*Watsonia meriana*\^rush,forb\2\c	**MIMS**	13	Deeper wetlands on heavy soils	Bassendean / Pinjarra Plain	17	5	28.74%	189		
			7	Herb rich saline shrublands in clay pans	Pinjarra Plain		5	10.78%	139		TEC
			8	Herb rich shrublands in clay pans	Pinjarra Plain		4	7.69%	210		TEC
SL1804	M+ ^*Viminaria juncea*\^shrub\4\cG ^*Watsonia meriana*\^forb\2\d	**VjTS**	8	Herb rich shrublands in clay pans	Pinjarra Plain	14	10	19.23%	411		TEC
			3a	E. calophylla-K. australis woodlands on heavy soils	Pinjarra Plain		9	15.28%	255		TEC
			3c	E. calophylla - X. preissii woodlands & shrublands	Pinjarra Plain		8	16.67%	230		TEC
SL1805	M+ ^*Melaleuca lateritia*\^shrub\3\i;G ^*Leptocarpus canus*,^*Goodenia pulchella* subsp. Coastal Plain B (L.W. Sage 2336)\^rush,forb\1\i	**MIMS**	7	Herb rich saline shrublands in clay pans	Pinjarra Plain	12	4	8.62%	89		TEC
			13	Deeper wetlands on heavy soils	Bassendean / Pinjarra Plain		4	22.99%	167		
			9	Dense shrublands on clay flats	Pinjarra Plain		3	8.45%	89		TEC
			8	Herb rich shrublands in clay pans	Pinjarra Plain		3	5.77%	115		TEC
SL1807	U+ ^*Viminaria juncea*,^*Melaleuca rhaphiophylla*\^tree\6\c;G ^^*Watsonia meriana,Paspalum dilatatum,Lepidosperma costale*\^forb,tussock grass,sedge\2\c	**VjMrW**	13	Deeper wetlands on heavy soils	Bassendean / Pinjarra Plain	16	7	40.23%	167		
			11	Wet forests and woodlands	Bassendean / Pinjarra Plain		6	22.06%	184		
			7	Herb rich saline shrublands in clay pans	Pinjarra Plain		6	12.93%	172		TEC
			8	Herb rich shrublands in clay pans	Pinjarra Plain		6	11.54%	334		TEC
NAH Q2	No quadrat description available	Not attributed (probably VdH)	8	Herb rich shrublands in clay pans	Pinjarra Plain	15	8	15.38%	434		TEC
			7	Herb rich saline shrublands in clay pans	Pinjarra Plain		7	15.09%	184		TEC
			10a	Shrublands on dry clay flats	Pinjarra Plain		6	11.58%	289		TEC

NAH Q3	No quadrat description available	Not attributed (probably MlH)	7	Herb rich saline shrublands in clay pans	Pinjarra Plain	16	7	15.09%	118		TEC
			8	Herb rich shrublands in clay pans	Pinjarra Plain		7	13.46%	182		TEC
			9	Dense shrublands on clay flats	Pinjarra Plain		6	16.90%	189		TEC
NAH Q4	No quadrat description available	Not attributed (probably MlH)	8	Herb rich shrublands in clay pans	Pinjarra Plain	13	5	9.62%	177		TEC
			9	Dense shrublands on clay flats	Pinjarra Plain		5	14.08%	139		TEC
			5	Mixed shrub damplands	Bassendean / Pinjarra Plain		5	13.02%	80		
			7	Herb rich saline shrublands in clay pans	Pinjarra Plain		5	10.78%	95		TEC
			13	Deeper wetlands on heavy soils	Bassendean / Pinjarra Plain		4	22.99%	133		
NAH Q7	No quadrat description available	Not attributed (probably BjS)	11	Wet forests and woodlands	Bassendean / Pinjarra Plain	11	4	14.71%	84		
			24	Northern Spearwood shrublands & woodlands	Spearwood		3	7.18%	60		
			7	Herb rich saline shrublands in clay pans	Pinjarra Plain		3	6.47%	111		TEC

Table 14: TEC species comparison

Blue highlighted species are representative of the Clay pans with shrubs over herbs TEC; gold highlighted are representative of the Muchea Limestone TEC); pink highlighted species is representative of both TECs (Clay Pans TEC, DPaW 2015 Appendix 2; Muchea Limestone TEC, English & Blyth 2000 Appendix 1 and characteristic species in Appendix 2)

Species	Muchea Limestone TEC	FCT7	FCT8	FCT9	FCT10a	Clay pans with shrubs	SL1801	SL1802	SL1803	SL1804	SL1805	SL1806	SL1807	NAH Q1	NAH Q2	NAH Q3	NAH Q4	NAH Q5	NAH Q6	NAH Q7	NAH Q8
Acacia saligna	Y											X									
Astartea affinis							X	X				X				X	X				
Astartea scoparia													X								
Asteraceae														X							
Avena barbata												X		X							
Baumea juncea																				X	
Briza maxima		Y	Y										X								
Briza minor		Y			Y					X					X					X	
Bolboschoenus caldwellii																		X			
Burchardia bairdiae								X													
Burchardia multiflora															X						
Cassytha flava																X	X		X		
Cassytha racemosa forma *racemosa*				Y			X	X			X										X
Casuarina obesa	Y													X							
Cenchrus clandestinus												X									
Cenchrus setaceus									X												
Centrolepis aristata		Y	Y		Y	Y		X													
Chorizandra enodis			Y			Y	X			X				X	X	X	X	X			
Cicendia filiformis		Y	Y		Y	Y													X		
Cynodon dactylon							X	X					X	X				X	X	X	X
Cyperaceae																	X				
Cyperus tenellus			Y		Y	Y	X														
Dischisma capitatum															X						
Drosera glanduligera																X	X				
Drosera menziesii			Y		Y	Y									X	X					
Ehrharta calycina									X												
Eleocharis acuta						Y								X				X			
Eragrostis curvula										X											
Euphorbia peplus														X				X		X	X
Euphorbia terracina																					X
Eutaxia virgata							X	X								X	X				
Gompholobium marginatum										X											
Goodenia pulchella subsp. Coastal Plain B (L.W. Sage 2336)					Y	Y	X				X	X					X		X		

Species	Muchea Limestone TEC	FCT7	FCT8	FCT9	FCT10a	Clay pans with shrubs	SL1801	SL1802	SL1803	SL1804	SL1805	SL1806	SL1807	NAH Q1	NAH Q2	NAH Q3	NAH Q4	NAH Q5	NAH Q6	NAH Q7	NAH Q8
Gratiola pubescens						Y	X	X			X										
Haemodorum simplex			Y							X					X						
Hyparrhenia hirta									X	X											
Hypochaeris radicata														X							
Indeterminant spp.							X	X													
Isolepis cernua var. *setiformis*						Y	X	X			X										
Juncaginaceae sp.							X	X			X										
Juncus bufonius						Y	X														
Lachnagrostis filiformis						Y	X	X			X	X									
Lepidosperma costale									X				X								
Lepidosperma longitudinale				Y												X					
Leptocarpus canus							X						X								
Leptocarpus coangustatus							X														
Lolium rigidum						Y								X		X		X		X	
Lolium x hybridum																					X
Lomandra suaveolens													X								
Lotus subbiflorus															X	X		X	X	X	X
Lysimachia arvensis									X	X		X				X					
Lythrum hyssopifolia						Y	X														
Meeboldina cana						Y								X		X	X				X
Meeboldina coangustata				Y		Y												X			X
Melaleuca lateritia	(Y)					Y	X	X		X	X		X			X	X		X		
Melaleuca rhaphiophylla	Y												X								X
Microtis media subsp. *media*						Y	X														
Opercularia vaginata							X			X					X						
Paspalum dilatatum													X						X		
Patersonia occidentalis										X			X		X						
Pimelea imbricata var. *major*												X			X						
Restionaceae																					X
Romulea rosea						Y							X		X						
Rumex crispus													X								
Schoenolaena juncea					Y						X										
Schoenus natans						Y	X	X			X										
Schoenus tenellus				Y		Y	X	X			X										
Senecio vulgaris														X				X		X	
Sonchus oleraceus						Y											X				

Species	Muchea Limestone TEC	FCT7	FCT8	FCT9	FCT10a	Clay pans with shrubs	SL1801	SL1802	SL1803	SL1804	SL1805	SL1806	SL1807	NAH Q1	NAH Q2	NAH Q3	NAH Q4	NAH Q5	NAH Q6	NAH Q7	NAH Q8
Sparaxis bulbifera							X						X						X		
Stylidium divaricatum								X				X				X	X				
Stylidium roseoalatum						Y		X			X										
Thysanotus manglesianus																X					
Thysanotus tenellus															X						
Triglochin mucronata														X				X			X
Triglochin sp.																				X	
Typha orientalis																				X	
Utricularia multifida						Y								X		X				X	
Verticordia densiflora var. *densiflora*					Y					X					X						
Verticordia huegelii															X						
Viminaria juncea			Y				X		X	X		X	X						X		
Watsonia meriana							X	X	X	X	X	X	X		X	X	X		X	X	
Watsonia suaveolens																	1				
Xanthorrhoea brunonis										X		X	X								
No sp in FCT	4	4	8	4	8	23															

APPENDIX FOUR NATIVE BEE SURVEY RESULTS

Table 15: Bee survey results

Species	Family	23 Nov	20 Dec	5 Jan	16 Jan	26 Jan	5 Feb	23 Feb
Thyreus waroonensis	Apidae	1	3					
Amegilla (Notomegilla) chlorocyanea	Apidae		1	observed			1	1
Lasioglossum (Chilalictus) castor	Halictidae	33	9	4	1	1		
Lasioglossum (Chilalictus) cf. bullatum	Halictidae	2	1	1				
Lasioglossum (Chilalictus) cognatum	Halictidae	12	8	15	6	3	4	3
Lasioglossum (Chilalictus) platychilum	Halictidae		1					
Lasioglossum (Chilalictus) hemichalceum	Halictidae					1	1	
Lasioglossum (Chilalictus) sp. 13	Halictidae					2		
Lasioglossum (Chilalictus) sp. 29	Halictidae		1		1	2	1	
Lasioglossum (Chilalictus) sp. 23	Halictidae		1					
Lasioglossum (Chilalictus) sp. 30	Halictidae			2				
Lasioglossum sp. 32 *Lasioglossum (Chilalictus) cf. melanopterum*	Halictidae					1		
Lipotriches (Austronomia) flavoviridis	Halictidae	2	2	1		6	2	1
Lipotriches sp. nov. Lipotriches sp. 6	Halictidae					1		
Homalictus (Homalictus) dotatus	Halictidae					23	9	
Megachile (Austrochile) remotula	Megachilidae		1					
Megachile (Eutricharaea) obtusa	Megachilidae		1		1	observed		
Megachile apicata	Megachilidae		1	2	2			5
Megachile speluncarum	Megachilidae		2					
Megachile "houstoni" M306/F367	Megachilidae			1				
Megachile callura	Megachilidae			3				
Megachile tosticauda	Megachilidae					1		
Megachile (Eutricharaea) chrysopyga	Megachilidae					2		
Megachile (Hackeriapis) oblonga	Megachilidae					1	2	
Megachilidae (Hackeriapis) sp. 62	Megachilidae				1			
Megachile (Schizomegachile) monstrosa	Megachilidae					1		
Euryglossina (Euryglossina) sp. 52	Colletidae					7	2	
Euryglossina (Microdontura) mellea	Colletidae					14	7	
Euryglossina (Turnerella) argocephala	Colletidae					10	3	

Species	Family	23 Nov	20 Dec	5 Jan	16 Jan	26 Jan	5 Feb	23 Feb
Euryglossina (Euryglossina) narifera	Colletidae					7	6	
Euryglossina (Turnerella) glauerti	Colletidae					4		
Euryglossina (Euryglossina) hypochroma	Colletidae					10		
Euryglossinae Euryglossula sp. 4	Colletidae					2		
Hylaeus (Prosopisteron) sp. 26	Colletidae					3		
Euryglossinae Euryglossula sp. 4	Colletidae						1	
Euryglossula fultoni	Colletidae						1	
Hylaeus (Gnathoprosopis) euxanthus	Colletidae					3		
Hylaeus (Euprosopis) violaceus	Colletidae					1		
Hylaeus (Euprosopoides) ruficeps kalamundae	Colletidae					4	3	
Hylaeus (Gnathoprosopis) amiculus	Colletidae					2	1	
Hylaeus (Prosopisteron) aralis	Colletidae					11	7	
Hylaeus (Euprosopis) elegans	Colletidae					23	11	
Hylaeus (Prosperisteron) "curviscapatus"	Colletidae					1		
Hylaeus (Rhodohylaeus) proximus	Colletidae					1		
Hylaeus (Prosopisteron) "breviscapatus"	Colletidae						3	
Hylaeus (Macrohylaeus) alcyoneus	Colletidae						1	
Leioproctus (Leioproctus) clarki	Colletidae					6	4	
Leioproctus (Leioproctus) plumosus	Colletidae					3		

APPENDIX 8

SOUTHERN LINK ROAD NATIVE BEE SURVEY
(Source: Prendergast 2019)

Southern Link Road Native Bee Surveys

Kit Prendergast (PhD researcher, native bee scientist, BSc Zoology and Conservation Biology, First Class Honours) on behalf of Ecoscape

Female *Lasioglossum* on *Goodenia pulchella.* Credit: Kit Prendergast

Executive Summary

The City of Canning appointed Ecoscape to conduct investigations, including native bee surveys, at the Cannington Claypan where the proposed Southern Link Road is to be constructed. Kit Prendergast was appointed by Ecoscape on a short-term contract to conduct the bee investigations.

Cannington is historically known to be habitat for the only two native bee species in Australia that are listed as threatened on the EPBC Act list of threatened species - *Leioproctus (Andrenopsis) douglasiellus* (Colletidae) that has previously been collected from the site and *Neopasiphae simplicior* (Colletidae) that is known to at least historically occur in the vicinity; consequently, these species were the focus of survey efforts.

Seven surveys were conducted from late November to the end of February. Despite the host plant being present and flowering, and recording a diverse assemblage of native bees, no observations of either of the two target threatened species were made.

The survey identified 47 species and morphospecies of native bees, ranging from 4-32 species per survey. The survey effort and high species yields indicate that the survey effort was sufficient to identify if the target bees were present over the months that surveys were conducted.

Cannington Claypan provides valuable foraging and nesting habitat for a high diversity of native bees, including some that are locally uncommon and are currently undescribed.

Table of Contents

1.0 Introduction

The City of Canning appointed Ecoscape to conduct investigations, including native bee surveys, at the Cannington Claypan where the proposed Southern Link Road is to be constructed. Kit Prendergast was appointed by Ecoscape on a short-term contract to conduct the bee investigations.

The surveys were conducted to document the assemblage of native bees that occupied the Cannington Claypan site. A particular emphasis was placed on searching for two native bees that have been listed as critically endangered and threatened with extinction: *Leioproctus (Andrenopsis) douglasiellus* (Colletidae) and *Neopasiphae simplicior* (Colletidae) (Appendix 3 and Appendix 4, respectively).

This report outlines:

- Background on native bees and the target bee species
- Survey aims and objectives
- Methodology
- Survey results
- Discussion of results

1.1 Scope of Work

The scope of the work undertaken by Kit Prendergast, on behalf of Ecoscape, associated with the surveys included:

- Undertaking comprehensive native bee surveying across the Cannington Claypan site
- Searching for the two Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) bee species listed as threatened, one of which has historically been recorded from the site: *Leioproctus (Andrenopsis) douglasiellus* (Colletidae), and *Neopasiphae simplicior* (Colletidae) that has been recorded from the area although not specifically from the site
- Taxonomic identification of the specimens collected
- Documenting the results of the surveys in terms of the presence/absence of the target threatened species, and the species richness of the bee assemblages recorded during the surveys of Cannington Claypan.

1.2 Background

Bees are keystone pollinators and the ecosystem service of pollination they perform is vital to the persistence of plant populations, and thus the health and functioning of ecosystems, both natural and anthropogenic (Potts *et al*., 2016). Urban expansion is recognised as a key threat to the abundance, diversity, and functional integrity of native bee assemblages (Cane, Johnson, & Klemens, 2005). In particular, loss and fragmentation of native vegetation has a detrimental impact on native bees (Prendergast, thesis, *in prep.,* Brown & Paxton, 2009). In Australia, many native bees have co-evolved with the native flowers, such that they are reliant upon native flowering resources in remnant vegetation in urban areas and cannot simply switch to forage on introduced species (Prendergast*,* thesis, *in prep.*, Batley & Hogendoorn, 2009). Co-evolution also means that loss of either mutualistic partner can in turn cause the extinction of the other (e.g. Pauw, 2007). Australia has approximately 2,000 native bees, many of which are undescribed (Houston, 2018).

1.2.1 Listed Threatened Native Bee Species

Leioproctus douglasiellus is a native bee that is listed as critically endangered under the Commonwealth EPBC Act, and as endangered on the Department of Biodiversity, Conservation and Attractions' Threatened and Priority Fauna List under the *Biodiversity Conservation Act 2016* (Department of Biodiversity, Conservation and Attractions, 2019).

L. douglasiellus has been recorded from only three locations ranging from Cannington (this site) to Forrestdale during the 2006-2008 Department of Environment and Conservation's (DEC) Rare Native Bee Surveys (Adamson, 2008). It has a restricted geographic distribution (24.3 km^2, with an area of occupancy of only 0.2 km^2). Since the first surveys documenting this species in 1954, much of its suitable habitat has declined due to large swaths of the Swan Coastal Plain being significantly altered for urban development (Threatened Species Scientific Committee, 2013). Moreover, *L. douglasiellus* appears to be highly specialised to collect pollen only from Goodeniaceae, and specimens have only been collected on two plant species: *Goodenia pulchella* (misnamed as *G. filiformis* in the *Approved Conservation Advice*) and *Anthotium junciforme* (Adamson, 2008; Threatened Species Scientific Committee, 2013).

No recovery plan or threat abatement plan is in place to ensure the persistence of this species (Department of the Environment, 2018a), and despite its clear threatened status, monitoring of this species has not occurred following the DEC Rare Native Bee Survey.

Neophasiphae simplicior is also listed as critically endangered under the EPBC Act (Department of the Environment, 2018b; Threatened Species Scientific Committee, 2008), listed as endangered on the Department of Biodiversity, Conservation and Attractions' Threatened and Priority Fauna List under the *Biodiversity Conservation Act 2016* (Department of Biodiversity, Conservation and Attractions, 2019), and as endangered (under IUCN redlist criteria) by the Western Australian Government (Threatened Species Scientific Committee, 2008). *N. simplicior* has undergone major declines in its geographic distribution and is believed to be only be found at a single location within the Forrestdale Lake Nature Reserve, having an extent and area of occupancy of only 1 km^2. It was previously known from the region of the proposed Southern Link Road development as the holotype was collected in Cannington (Walker, 2010). The only record of this species from Cannington was the1954 holotype collection by Dr Terry Houston (Houston, 1994), although *NatureMap* (Department of Parks and Wildlife 2007-2019) indicates eight more recent collections from between Port Gregory and Cape Arid.

Clearing of bushland for residential and industrial development is considered to be a main threat to *N. simplicior* (Threatened Species Scientific Committee, 2008). *N. simplicior* has a limited number of flowering species that it visits, having been collected only from the perennial herbs Thread-leaved Goodenia *Goodenia pulchella* and *Velleia* sp. (Goodeniaceae), and the annual herbs Slender Lobelia *Lobelia tenuior* (Campanulaceae) and *Angianthus preissianus* (Asteraceae) (only males recorded on this species, and thus is unlikely to serve as a pollen source) (Houston, 2000).

As is the case for many invertebrate taxonomic groups, the conservation status of native bees is unknown as most have not been assessed nor subject to monitoring. These two species are the sole native bees listed as threatened in Australia. There are an estimated 2,000 Australian native bees (Australian Government Department of the Environment and Energy, 2018). Given the specialisation of many, their restricted distribution, and being subjected to habitat loss, fragmentation and

degradation (Batley & Hogendoorn, 2009), it is possible that other species may meet the criteria for listing, however, are currently considered to be data deficient.

The only known systematic survey of native bees in the Perth metropolitan region was conducted in 2016-18 by Kit Prendergast, as part of her PhD thesis (*in prep*.). Prendergast's surveys revealed an exceptionally high diversity of species present in the region, emphasising the conservation value of urban areas as habitat for native bees (Prendergast, 2018). In particular, bushland remnants, such as the Clayton Claypan (although not specifically included), were found to be significant for conserving the full suite of native bees, with a significantly greater abundance, species richness and diversity, and number of rare species occurring in bushland remnants compared with residential gardens (Prendergast, 2018).

Prendergast's comprehensive surveys for her PhD (Prendergast, thesis, *in prep.)* did not include the Cannington Claypan, with the closest sites geographically being Maniana Reserve in Queens Park, and a residential garden in Wilson. None of her PhD survey sites included claypan areas.

1.3 Cannington Claypan Site Description

The Cannington Claypan is a Conservation Category Wetland and Threatened Ecological Community (TEC) covering 6.71 ha. The *Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain* TEC occupies 5.8 ha (Natural Area Holdings Pty Ltd, 2016), and is listed as endangered by the Department of the Environment under the EPBC Act (Department of the Environment, 2018c).

It is an important patch of remnant bushland embedded within an urban matrix, surrounded by the Western Power facility near Carousel Shopping Centre. A survey conducted in 2015 on the flora and fauna recorded 111 plant species (57 native and 54 introduced flora species were present) (Natural Area Holdings Pty Ltd, 2016). Although 42 invertebrates were recorded, none of these were bees, however this is likely due to inappropriate sampling.

2.0 Methodology

Surveys were conducted over late spring to summer 2018/19 in late November (23rd), late December (20th), in early, mid and late January (5th, 16th and 26th), and early and late February (5th and 23rd). Months of surveys were timed to coincide with the documented activity time of the target bee species (with *Leioproctus douglasiellus* having previously been recorded October-November, and how the host plants of *Neopasiphae simplicior* flower October-January (Adamson, 2008; Hollister & Thiele, 2018; Threatened Species Scientific Committee, 2008). Each survey commenced at approx. 1000h and ended at approx. 1500h.

Although the Southern Link Road extension is not proposed to go through the whole site as bees are mobile the whole site was surveyed.

The survey on 23 November 2018 was conducted by Kit Prendergast (PhD researcher, native bee expert), and Dr Rob Manning (honeybee expert). All other surveys were conducted by Kit Prendergast.

Both sweepnetting with an entomological sweepnet, and passive collections using bee bowls, were used to sample bees. Sweepnetting involved using the random walk method to collect native bees, with a focus on areas where host plants were. Bee bowls consisted of four types: fluorescent blue soufflé cups (10), fluorescent yellow soufflé cups (10), yellow party bowls (10) and yellow rectangular take-away containers (10). Each bowl was filled two-thirds with water, with a few drops of unscented detergent to reduce surface tension. Bowls were placed on the ground in open, bare patches not obscured by vegetation, with distances between bowls of at least 10 m. The bowls were set out at the start of the survey, and collected at the end of each survey day (approximately 5.5 hours).

Sampling methodology chosen was optimal for sampling native bees based on previous evaluations of methods by Prendergast (thesis, *in prep*.). Bowl colours chosen are those known to attract native bees (Prendergast, thesis, *in prep*.), and also correspond to the colours of the host plants of the target native bee species.

3.0 Native Bee Survey Results

3.1. November 23rd 2018 Survey

Summary:

Despite extensive surveying across the whole site there were no observations or specimens of the target species, *Leioproctus douglasiellus* (Colletidae).

All observations of foraging native bees occurred on *Goodenia pulchella* (Goodeniaceae). The survey yielded a low species diversity. A total of 51 specimens were collected belonging to five species (Table 1). Except for the cuckoo bee, *Thyreus waroonensis,* all were collected whilst foraging. *T. waroonensis* was collected whilst traversing the ground, most likely looking for a nest of its host, bees in the genus *Amegilla.* An *Amegilla* species was observed but evaded capture.

Bees in the genus *Lasioglossum* were extremely abundant, with hundreds of individuals being recorded. Both male and females were present, and nesting activity of females was observed (this is a ground-nesting species).

No cavity-nesting species were observed, despite megachilids being a dominant component of the urban southwest Western Australia (SWWA) bee fauna (Prendergast, thesis, *in prep*.), and flora they have observed to visit (*Viminaria juncea* and *Goodenia pulchella*) being present at high abundances.

Honeybees were present at the site, and unlike the native bees, foraged on most flora present, including; *Viminaria juncea, Goodenia pulchella, Verticordia densiflora, Pimelea imbricata* var. *major, Beaufortia sparsa,* and *Astartea affinis.* Although also using the host plant of the native bees including the target species *Leioproctus douglasiellus,* this was not their main foraging resources, and only 39 honeybees were observed on *Goodenia pulchella* with the majority observed on *Astartea affinis.*

The presence of *Thyreus waroonensis* suggests that Cannington Claypan is home to a healthy population of the host, *Amegilla*. Indeed, parasitoid species have been advocated to be bioindicators for the health of a habitat (Anderson *et al.,* 2011).

Weather conditions: sunny weather, minimal cloud cover. Gentle wind, increasing from 1400 h. Temperature 20-25^{o}C.

Table 1. Native bee specimens collected 23rd November 2018

Species	Family	Number
Thyreus waroonensis	Apidae	1
Lasioglossum (Chilalictus) castor	Halictidae	33
Lasioglossum (Chilalictus) cf. bullatum	Halictidae	2
Lasioglossum (Chilalictus) cognatum	Halictidae	12
Lipotriches (Austronomia) flavoviridis	Halictidae	2

Bee bowls yielded 7 native bees, as well as other invertebrates (Table 2).

Table 2. Specimens caught in bee bowls on 23rd November 2018

Taxonomic group	Small UV-fluorescent yellow	Small UV-fluorescent blue	Large round yellow bowls	Large rectangular yellow trays
Native bees	1	6	7	3
Honeybees			2	
Beetles	5		4	5
Orthoptera	1		3	4
Ants				5
Wasps			2	
Diptera			1	

3.2 December 20th 2018 Survey

Summary:

Leioproctus douglasiellus was not observed, nor was *Neopasiphae simplicior.* The host plant *Goodenia pulchella* was still blooming prolifically across the site. Thirty-two specimens comprising 13 species were collected (Table 3).

A higher species richness of native bees were observed in this survey than the November survey. The most common species was *Lasioglossum (Chilalictus) castor* which dominated the native bee fauna in November, however, this species was far less abundant than in November. Four *Thyreus waroonensis*, kleptoparasites of *Amegilla,* as well as two *Amegilla,* were observed, all foraging on *Goodenia*. The high numbers of *Thyreus*, which by virtue of their life-history strategy, are rare, indicates a healthy population present at this site, and of their host as well. Despite *Viminaria juncea* flowers being abundant in the previous November survey, no *Megachile* were observed - a taxon known to favour this genera. Interestingly, despite only a few plants remaining in flower, *Megachile* were observed foraging on them. *Megachile* were also observed foraging on *Goodenia.* Another new record was *Lasioglossum (Chilalictus) platychilum*, of which only a single individual was recorded, foraging on *Goodenia*. Although this species has a broad distribution, it is infrequently encountered in the Perth region: Prendergast has only recorded it once out of her 143 surveys, at Alison Baird Reserve, also foraging on *Goodenia.*

All native bee taxa were foraging on *Goodenia,* except for male *Homalictus*, which foraged on *Astartea affinis,* and *Megachile speluncarum*, foraging on *Viminaria juncea*. Honeybees were at low abundances (13 observed), with six foraging on *Goodenia,* one on *Verticordia densiflora,* four on *Beaufortia sparsa,* and two on *Astartea affinis.*

Weather conditions: 32°C, light breeze, hot and dry.

Table 3. Native bee specimens collected 20th December 2018

Species	Family	N
Amegilla (Notomegilla) chlorocyanea	Apidae	1
Thyreus waroonensis	Apidae	3
Lasioglossum (Chilalictus) castor	Halictidae	9
Lasioglossum (Chilalictus) cf. bullatum	Halictidae	1
Lasioglossum (Chilalictus) cognatum	Halictidae	8
Lipotriches (Austronomia) flavoviridis	Halictidae	2
Lasioglossum (Chilalictus) platychilum	Halictidae	1
Lasioglossum (Chilalictus) sp. 29	Halictidae	1
Lasioglossum (Chilalictus) sp. 23	Halictidae	1
Megachile (Austrochile) remotula	Megachilidae	1
Megachile (Eutricharaea) obtusa	Megachilidae	1
Megachile apicata	Megachilidae	1
Megachile speluncarum	Megachilidae	2

Bee bowls yielded only four native bees, as well as other invertebrates (Table 4).

Table 4. Specimens caught in bee bowls 20th December 2018

Taxonomic group	Small UV-fluorescent yellow	Small UV-fluorescent blue	Large round yellow bowls	Large rectangular yellow trays
Native bees		3 (halictids)		1 (*Megachile*)
Beetles		2		1
Orthoptera				1
Ants			20	
Wasps				1
Hemiptera		1		

3.3 January 5th 2019 Survey

Summary:

Leioproctus douglasiellus and *Neopasiphae simplicior* were not observed. Thirty-three specimens belonging to seven species were collected (Table 5).

Both host plants of *L. douglasiellus* were present, including for the first time *Anthotium junciforme. Goodenia pulchella* was again the dominant flowering plant, but was reduced in abundance compared with previous surveys. Floral diversity was low, and the vegetation and substrate dry due to high temperatures over the last few weeks. A female *Lipotriches (Austronomia) flavoviridis* was captured on *Anthotium junciforme*, and four *Megachile* were observed foraging on the same host, of which one specimen was captured. The main visitors to *Anthotium junciforme*, however, were bombyliids, which also were common visitors to *Goodenia.* The high density of bombyliids may represent a threat and potential explanation to the absence of the threatened native bee species. Bombyliids are parasitoids of native bees (Prendergast & David, 2018), and if they have generalist host preferences, they may be able to limit recruitment of hosts that are already at low abundances.

Lasioglossum (Chilalictus) spp. were again the most abundant native bee taxa present. Small *Megachile* were at greater abundances in this survey than previous surveys. No large megachilids were observed, as their host plant (*Viminaria juncea*) had ceased flowering. All native bees were foraging on *Goodenia pulchella* except for the four megachilids mentioned previously, three *Lasioglossum* sp. that were foraging on *Cassytha glabella* and two *Amegilla (Notomegilla) chlorocyanea* foraging on *Beaufortia sparsa*. In addition to the two *Amegilla (Notomegilla) chlorocyanea*, a further three were observed foraging on *Goodenia pulchella*, however, no specimens were collected. A *Thyreus waroonensis* was collected, and another observed, both on *Goodenia pulchella.* The presence of this cleptoparasitic species again reveals that this site has a healthy nesting population of *Amegilla.* A female *Lasioglossum (Chilalictus) castor* was observed entering a nesting hole, confirming Cannington Claypan is a nesting site for this species, and provides both food and nesting resources.

As with previous surveys the introduced *Apis mellifera* was at low abundances: one was observed in flight, four on *Beaufortia sparsa*, and three on *Goodenia pulchella.* This indicates competition by honeybees is unlikely at this site.

Weather conditions: 32^{o}C, light breeze, hot and dry.

Table 5. Native bee specimens collected January 5th 2019

Species	Family	N
Lasioglossum (Chilalictus) castor	Halictidae	4
Lasioglossum (Chilalictus) cf. bullatum	Halictidae	1
Lasioglossum (Chilalictus) cognatum	Halictidae	17
Lipotriches (Austronomia) flavoviridis	Halictidae	1
Megachile apicata	Megachilidae	2
Megachile "houstoni" M306/F367	Megachilidae	1
Megachile callura	Megachilidae	3

Bee bowls catch rate was low. Only a single native bee was caught in the bee bowls. The majority of insects caught were wasps (Table 6).

Table 6. Specimens caught in bee bowls January 5th 2019

Taxonomic group	Small UV-fluorescent yellow	Small UV-fluorescent blue	Large round yellow bowls	Large rectangular yellow trays
Native bees		1 *Lasioglossum*		
Orthoptera			1	
Ants				1
Wasps		1	2	4
Hemiptera				2

3.4 January 16th 2019 Survey

Summary:

The target rare native bee species were not observed. Twelve specimens belonging to six species were collected (Table 7).

Bee activity was lower than previous surveys. This is likely due to how flowering resources were much lower – *Goodenia pulchella* was now sparse. Few other plants were in flower, with *Anthotium junciforme* and *Cassytha glabella* being the only other plants in flower, but also flowering sparsely. Small megachilids and *Lasioglossum* were the only taxa present – no *Amegilla* or *Thyreus* were observed. All native bees were foraging on *Goodenia pulchella*, except for one female *Lasioglossum* and a male *Megachile* which were foraging on *Anthotium junciforme.* Only a single honeybee was observed. Bombyliid activity and activity of wasps, especially sphecids, was high. A megachilid specimen (male) [specimen ID: Megachilidae (Hackeriapis) 62 M CanningtonClaypan, 0127] was collected that had not been collected previously in any of the Cannington Claypan surveys, nor the extensive surveys of native bees across the Perth Metropolitan region, covering 14 sites over two years, by Prendergast (thesis, *in prep*.).

Weather conditions: 29°C, clear skies. Light breeze, increasing to more windy conditions midday.

Table 7. Native bee specimens collected January 16th 2019

Species	Family	N
Lasioglossum (Chilalictus) castor	Halictidae	1
Lasioglossum (Chilalictus) cognatum	Halictidae	6
Lasioglossum (Chilalictus) sp. 29	Halictidae	1
Megachile (Eutricharaea) obtusa	Megachilidae	1
Megachile apicata	Megachilidae	2
Megachilidae (Hackeriapis) sp. 62	Megachilidae	1

Bee bowls catch rate was very low, and no native bees were collected (Table 8).

Table 8. Specimens caught in bee bowls January 16th 2019

Taxonomic group	Small UV-fluorescent yellow	Small UV-fluorescent blue	Large round yellow bowls	Large rectangular yellow trays
Flies				1
Wasps				1

3.5 January 26th 2019 Survey

Summary:

There were no observations of *Leioproctus douglasiellus* and *Neopasiphae simplicior*.

However, 32 species of native bee were observed. A total of 148 specimens, comprising 31 species were collected, including a *Lipotriches* species that is undescribed and may be new to science. The host plants *Goodenia and Anthotium* were few and scattered. Only two native bees were observed foraging on *Goodenia* (both *Lasioglossum* females, one collected). The claypan was dry, despite some rain two days earlier, making the ground unsuitable for nesting. The vast majority of native bees were foraging on a single *Eucalyptus* sp. on the edge of the site, which hosted an extremely high diversity of native bees. *Lasioglossum* were also observed foraging on *Andersonia gracilis* (threatened flora), of which specimens were collected, and *Megachile (Eutricharaea) obtusa*, both males and females, were observed foraging on a single *Comesperma* plant (*Comesperma aff. polygaloides* (C. Tauss 4160) (no *M. obtusa* specimens were collected, but this species was collected in the previous survey). The activity on the mallee was extremely high, with thousands of native bees, as well as many wasps, honeybees and beetles foraging. A jewel beetle (*Castiarina*) was also collected.

Weather conditions: 32°C, sunny. Some rain two days prior. Cloudless. Light breeze.

Table 9. Native bee specimens collected January 26th 2019

Species	Family	N
Lasioglossum (Chilalictus) castor	Halictidae	1
Lasioglossum (Chilalictus) cognatum	Halictidae	3
Lasioglossum (Chilalictus) hemichalceum	Halictidae	1
Lasioglossum (Chilalictus) sp. 13	Halictidae	2
Lasioglossum (Chilalictus) sp. 29	Halictidae	2
Lasioglossum sp. 32 Lasioglossum (Chilalictus) cf. melanopterum	Halictidae	1
Lipotriches (Austronomia) flavoviridis	Halictidae	6
Lipotriches sp. nov. Lipotriches sp. 6	Halictidae	1
Homalictus (Homalictus) dotatus	Halictidae	23
Megachile tosticauda	Megachilidae	1
Megachile (Eutricharaea) chrysopyga	Megachilidae	2
Megachile (Hackeriapis) oblonga	Megachilidae	1
Megachile (Schizomegachile) monstrosa	Megachilidae	1
Euryglossina (Euryglossina) 52	Colletidae	7
Euryglossina (Microdontura) mellea	Colletidae	14
Euryglossina (Turnerella) argocephala	Colletidae	10
Euryglossina (Euryglossina) narifera	Colletidae	7
Euryglossina (Turnerella) glauerti	Colletidae	4
Euryglossina (Euryglossina) hypochroma	Colletidae	10
Euryglossinae Euryglossula sp. 4	Colletidae	2
Hylaeus (Prosopisteron) sp. 26	Colletidae	3
Hylaeus (Gnathoprosopis) euxanthus	Colletidae	3
Hylaeus (Euprosopis) violaceus	Colletidae	1
Hylaeus (Euprosopoides) ruficeps kalamundae	Colletidae	4
Hylaeus (Gnathoprosopis) amiculus	Colletidae	2
Hylaeus (Prosopisteron) aralis	Colletidae	11
Hylaeus (Euprosopis) elegans	Colletidae	23

Species	Family	N
Hylaeus (Prosperisteron) "curviscapatus"	Colletidae	1
Hylaeus (Rhodohylaeus) proximus	Colletidae	1
Leioproctus (Leioproctus) clarki	Colletidae	6
Leioproctus (Leioproctus) plumosus	Colletidae	3
Megachile (Schizomegachile) monstrosa	Megachilidae	1
Euryglossina (Euryglossina) 52	Colletidae	7
Euryglossina (Microdontura) mellea	Colletidae	14
Euryglossina (Turnerella) argocephala	Colletidae	10
Euryglossina (Euryglossina) narifera	Colletidae	7
Euryglossina (Turnerella) glauerti	Colletidae	4
Euryglossina (Euryglossina) hypochroma	Colletidae	10
Euryglossinae Euryglossula sp. 4	Colletidae	2
Hylaeus (Prosopisteron) sp. 26	Colletidae	3
Hylaeus (Gnathoprosopis) euxanthus	Colletidae	3
Hylaeus (Euprosopis) violaceus	Colletidae	1
Hylaeus (Euprosopoides) ruficeps kalamundae	Colletidae	4
Hylaeus (Gnathoprosopis) amiculus	Colletidae	2
Hylaeus (Prosopisteron) aralis	Colletidae	11
Hylaeus (Euprosopis) elegans	Colletidae	23
Hylaeus (Prosperisteron) "curviscapatus"	Colletidae	1
Hylaeus (Rhodohylaeus) proximus	Colletidae	1
Leioproctus (Leioproctus) clarki	Colletidae	6
Leioproctus (Leioproctus) plumosus	Colletidae	3

Bee bowl catch rates were low, with only one native bee caught, in a fluorescent blue bee bowl (Table 10).

Table 10. Specimens caught in bee bowls January 16th 2019

Taxonomic group	Small UV-fluorescent yellow	Small UV-fluorescent blue	Large round yellow bowls	Large rectangular yellow trays
Flies				3
Wasps	3		1	6
Native bee (*Lasioglossum* sp. Female)		1		
Honeybee				1
Spider				1

3.6 February 5th Survey

Summary:

The target rare native bee species were not observed.

A total of 77 specimens were collected, representing 21 species, including two not previously recorded (Table 11). Both host plants of *L. douglasiellus* had largely ceased flowering. The only plant species in flower were *Eucalyptus* sp. on the edge of the site, that hosted a high diversity of native bees, as well as honeybees and wasps; *Andersonia gracilis*, from which *Lasioglossum* were also observed foraging on; and a single *Comesperma* plant (*Comesperma aff. polygaloides* (C. Tauss 4160), which a *Megachile obtusa* was observed foraging on (but not collected). Conditions were very dry.

Amegilla chlorocynea was collected in a bee bowl but not observed. Bee bowl catch rates overall were low (Table 12).

Weather: 32°C, sunny. Cloudless, light breeze.

Table 11. Native bee specimens collected February 5th 2019

Species	Family	N
Amegilla (Notomegilla) chlorocyanea	Apidae	1
Lasioglossum (Chilalictus) cognatum	Halictidae	4
Lasioglossum (Chilalictus) hemichalceum	Halictidae	1
Lasioglossum (Chilalictus) sp. 29	Halictidae	1
Lipotriches (Austronomia) flavoviridis	Halictidae	2
Homalictus (Homalictus) dotatus	Halictidae	9
Megachile (Hackeriapis) oblonga	Megachilidae	2
Euryglossina (Euryglossina) 52	Colletidae	2
Euryglossina (Microdontura) mellea	Colletidae	7
Euryglossina (Turnerella) argocephala	Colletidae	3
Euryglossina (Euryglossina) narifera	Colletidae	6
Euryglossina (Euryglossina) hypochroma	Colletidae	7
Euryglossula fultoni	Colletidae	1
Euryglossinae Euryglossina 33 F [var Euryglossina 22 (Euryglossina) cf. lynettae?]	Colletidae	1
Hylaeus (Euprosopoides) ruficeps kalamundae	Colletidae	3
Hylaeus (Gnathoprosopis) amiculus	Colletidae	1
Hylaeus (Prosopisteron) aralis	Colletidae	7
Hylaeus (Euprosopis) elegans	Colletidae	11
Hylaeus (Prosopisteron) "breviscapatus"	Colletidae	3
Hylaeus (Macrohylaeus) alcyoneus	Colletidae	1
Leioproctus (Leioproctus) clarki	Colletidae	4

Table 12. Specimens caught in bee bowls February 5th 2019

Taxonomic group	Small UV-fluorescent yellow	Small UV-fluorescent blue	Large round yellow bowls	Large rectangular yellow trays
Flies				1
Wasps				1
Native bee (*Amegilla chlorocyanea*)		1		

3.7 February 23rd Survey

Summary:

The target species were not observed.

Very few native bees present, attributable to the very low abundance and diversity of flowers. Only ten specimens belonging to four species were collected (Table 13). Only a few *Goodenia* were in bloom, and no *Anthotium* were in flower. The conditions were very dry, with no rain since before the previous survey on February 5th. The only flowers in bloom were a few patches of *Oenothera drummondii* (Onagraceae) – a weed, from which a single *Lasioglossum* was observed (captured), and 11 *Amegilla* (1 specimen collected); a few patches of *Andersonia gracilis*, from a couple of *Lasioglossum* and a *Lipotriches flavoviridis* were observed foraging on and collected; a single *Comesperma* plant from which a *Megachile* was collected from; and a small patch of *Goodenia pulchella* from which a few *Megachile* were foraging on (three collected). *Cassytha glabella* was the most abundant plant but no native bees were observed visiting it. A single *Megachile* was collected in a large yellow bee bowl; the only other bee bowl capture was an ant (Table 14). No honeybees were observed, likely driven by the very low floral resources.

Weather: 26°C, sunny, breeze

Table 13. Native bee specimens collected February 23rd 2019

Species	Family	N
Amegilla (Notomegilla) chlorocyanea	Apidae	1
Lasioglossum (Chilalictus) cognatum	Halictidae	3
Lipotriches (Austronomia) flavoviridis	Halictidae	1
Megachile apicata	Megachilidae	5

Table 14. Specimens caught in bee bowls February 23rd 2019

Taxonomic group	**Small UV-fluorescent yellow**	**Small UV-fluorescent blue**	**Large round yellow bowls**	**Large rectangular yellow trays**
Native bee (*Megachile*)			1	
Ant				1

4.0 Conclusions

Over the total 32 hours of surveying from late November to late February, *Leioproctus douglasiellus* and *Neopasiphae simplicior*, the native bees listed as threatened under the EPBC list, were not observed.

A total of 47 species/morphospecies were recorded overall, with total species richness per survey ranging from 4 – 31 species (Appendix 1, Table 15). Based on the bee survey experience of Prendergast (thesis, *in prep*.), the site is considered to have high value as native bee habitat, with observations indicating Cannington Claypan serves as both a foraging and nesting habitat for native bees.

Table 5. Number of specimens collected and number of species collected per survey

Date	Total N	Species richness
23-Nov-18	51	5
20-Dec-18	32	12
5-Jan-19	33	7
16-Jan-19	12	5
26-Jan-19	148	31
5-Feb-19	77	21
23-Feb-19	10	4

The comprehensive surveying supports the conclusion that the two target species were not present at the time of sampling.

The survey results indicate that *Leioproctus douglasiellus* was not present at the time of surveying, given that the whole site was comprehensively surveyed, focussing on its host plant. However, due to limited records, its adult activity period is not definitively known and earlier survey (September/October) would provide greater certainty.

The cause of the absence of *Leioproctus douglasiellus* is unclear, however, it may be that the population was already reduced such that negative effects of small population size have resulted in the extirpation of *Leioproctus douglasiellus* since it was last recorded at this site (last record unknown). The site is highly isolated, being surrounded by an electricity substation, shopping centre, greyhound track, parking and residential development that appears to have little in the way of native vegetation that could serve to connect the Cannington Claypan population with any other populations in the region.

The absence of *Neopasiphae simplicior*, however, can be taken as more conclusive evidence that this bee does not occur at the site, given that its entire flight season was covered. It has not been recorded in the vicinity for over 60 years and may never have occurred at the site as the holotype collection record from 'Cannington' is too broad to precisely identify the location (geocode precision 4, indicating location accuracy of 10-50 km).

Even though the two target native bee species were not recorded, Cannington Claypan boasts a high diversity of native bees. In a single survey (January 26th), a total of 32 species were recorded. Of the 140 x 3 hr-long surveys conducted by Prendergast (thesis, *in prep*.) across 14 sites in urbanised

southwest WA, the highest total species richness recorded was 35 species, with the average number of species being 10.2 (range: 1-35 species).

At Cannington Claypan, the range of species recorded per survey varied, from a minimum of 4 to a maximum of 35 species recorded. This is evidence of the shifting phenology of native bee species, and confirms that the survey design of multiple sampling events was appropriate to accurately identify the diversity and assemblage composition of native bees at the site.

Despite the high abundance of weeds, during the early months *Goodenia pulchella* dominated. Even during the final survey when most flora had ceased blooming, native bees were present, and two bee species included weeds in their diet. Hence, despite the high weed incursion, Cannington Claypan cannot be written off as poor habitat for bees because of this feature.

European honeybees were not hyper-abundant, and in most surveys were only a minor component of the bee fauna present. Moreover, European honeybees did not focus their foraging activity on the host plants of the targeted threatened bee species. This indicates that competition for resources is low, and the bee assemblages at this site are unlikely to suffer from adverse impacts of competition by the introduced honeybee. Although the evidence is mixed, there are concerns that high abundances of honeybees can have adverse impacts on native bees (Paini, 2004). The relatively low honeybee abundance observed is another aspect of the value of the Cannington Claypan site as habitat for native bees.

In a previous flora and fauna survey conducted by Natural Area Holdings Pty Ltd during November 17-26 2016, despite 42 invertebrate species being recorded, no native bees were listed. This cannot be due to the lack of native bees being present, given that in the single survey conducted on November 23rd hundreds of native bee individuals were observed, representing six species (of which five were collected). The discrepancy is likely due to lack of specific expertise and the sampling methodology being inappropriate for sampling native bees. Given that native bees are keystone species in ecosystems, and as the most important pollinators, are vital to the health of floral communities, surveying and monitoring native bee populations by a specialist should be a component of any environmental assessment (Potts *et al.*, 2016).

The proposed Southern Link Road expansion will go through habitat where many native bees were collected. Although native bees are mobile, most have small flight ranges (Gathmann & Tscharntke, 2002) and, being hemmed in on all sides by an inhospitable urban matrix, Cannington Claypan represents their sole local habitat. Prendergast's PhD research (thesis, *in prep*.) identifies a statistically significant positive correlation between native bee abundance and diversity with the area of a site. Removal of part of the bee habitat may have adverse effects on the native bees present due to loss of habitat, edge effects which further degrade the amount of available habitat, pollution, and road mortality which can have a significant toll on invertebrates (Baxter-Gilbert, Riley, Neufeld, Litzgus, & Lesbarrères, 2015; Muñoz, Torres, & Megías, 2015).

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Appendix 1. Native bee species list by survey

Species	Family	11/23/18	20/12/18	5/1/19	16/1/19	16/1/19	5/2/19	23/2/19
Thyreus waroonensis	Apidae	1	3					
Amegilla (Notomegilla) chlorocyanea	Apidae	x	1	*x*				1
Lasioglossum (Chilalictus) castor	Halictidae	33	9	6	1	1		
Lasioglossum (Chilalictus) cf. bullatum	Halictidae	2	1	1				
Lasioglossum (Chilalictus) cognatum	Halictidae	12	8	15	6	3	4	3
Lasioglossum (Chilalictus) platychilum	Halictidae		1					
Lasioglossum (Chilalictus) hemichalceum	Halictidae					1	1	
Lasioglossum (Chilalictus) sp. 13	Halictidae					2		
Lasioglossum (Chilalictus) sp. 29	Halictidae		1		1	2	1	
Lasioglossum (Chilalictus) sp. 23	Halictidae		1					
Lasioglossum sp. 32 Lasioglossum (Chilalictus) cf. melanopterum	Halictidae					1		
Lipotriches (Austronomia) flavoviridis	Halictidae	2	2	1		6	2	1
Lipotriches sp. nov. Lipotriches sp. 6	Halictidae					1		
Homalictus (Homalictus) dotatus	Halictidae					23	9	
Megachile (Austrochile) remotula	Megachilidae		1					
Megachile (Eutricharaea) obtusa	Megachilidae		1		1	x		
Megachile apicata	Megachilidae		1	2	2			5
Megachile speluncarum	Megachilidae		2					
Megachile "houstoni" M306/F367	Megachilidae			1				
Megachile callura	Megachilidae			3				
Megachile tosticauda	Megachilidae					1		
Megachile (Eutricharaea) chrysopyga	Megachilidae					2		
Megachile (Hackeriapis) oblonga	Megachilidae					1	2	
Megachilidae (Hackeriapis) sp. 62	Megachilidae				1			
Megachile (Schizomegachile) monstrosa	Megachilidae					1		
Euryglossina (Euryglossina) 52	Colletidae					7	2	

Species	Family	11/23/18	20/12/18	5/1/19	16/1/19	16/1/19	5/2/19	23/2/19
Euryglossina (Microdontura) mellea	Colletidae					14	7	
Euryglossina (Turnerella) argocephala	Colletidae					10	3	
Euryglossina (Euryglossina) narifera	Colletidae					7	6	
Euryglossina (Turnerella) glauerti	Colletidae					4		
Euryglossina (Euryglossina) hypochroma	Colletidae					10	7	
Euryglossinae Euryglossula sp. 4	Colletidae					2		
Euryglossula fultoni	Colletidae						1	
Euryglossinae Euryglossina 53 F [var Euryglossina 22 (Euryglossina) cf. lynettae?]	Colletidae						1	
Hylaeus (Prosopisteron) sp. 26	Colletidae					3		
Hylaeus (Gnathoprosopis) euxanthus	Colletidae					3		
Hylaeus (Euprosopis) violaceus	Colletidae					1		
Hylaeus (Euprosopoides) ruficeps kalamundae	Colletidae					4	3	
Hylaeus (Gnathoprosopis) amiculus	Colletidae					2	1	
Hylaeus (Prosopisteron) aralis	Colletidae					11	7	
Hylaeus (Euprosopis) elegans	Colletidae					23	11	
Hylaeus (Prosperisteron) "curviscapatus"	Colletidae					1		
Hylaeus (Rhodohylaeus) proximus	Colletidae					1		
Hylaeus (Prosopisteron) "breviscapatus"	Colletidae						3	
Hylaeus (Macrohylaeus) alcyoneus	Colletidae						1	
Leioproctus (Leioproctus) clarki	Colletidae					6	4	
Leioproctus (Leioproctus) plumosus	Colletidae					3		

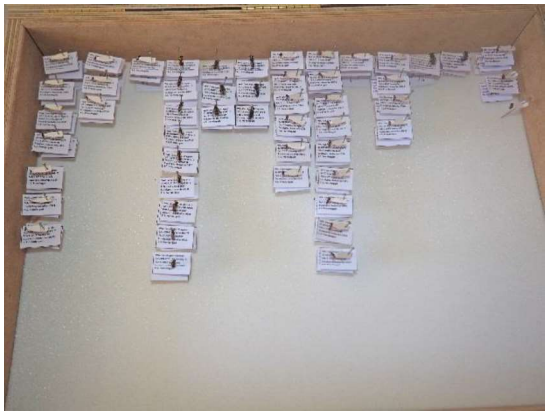
* X = seen, not collected

Appendix 2. Native bee photographs

Photograph credits: Kit Prendergast

Female *Lasioglossum (Chilalictus) cognatum*, the most common visitor to *Goodenia pulchella,* host plant of the two threatened bee species. Photographed during the survey conducted on November 23rd 2018.



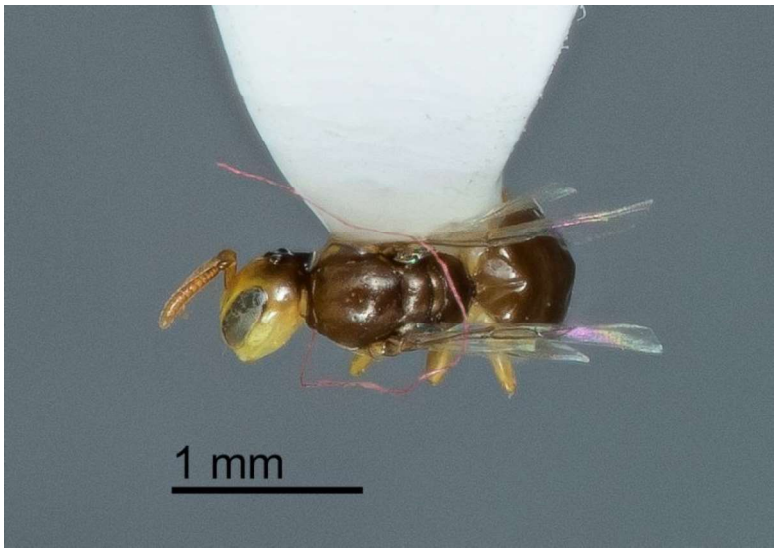



Specimen collection of native bees collected during the Cannington Claypan surveys

Thyreus waroonensis, female, kleptoparasite of *Amegilla*. This species was collected at Cannington Claypan, photographed by K. Prendergast at a different site.

Megachile (Shizomegachile) monstrosa, female, largest megachilid in Australia. This species was collected at Cannington Claypan, photographed by K. Prendergast at a different site.

Hylaeus (Euprosopis) elegans, female. One of the most common species during the latter surveys collected on *Eucalyptus*, otherwise rare in previous surveys conducted by K. Prendergast across the Perth metropolitan region. Males collected for the first time at this site. Photograph by K. Prendergast of specimen collected at another site.



Euryglossina (Microdontura) mellea male (above) and female (below). Smallest species collected. Monotypic for the subgenus. Photos of specimens collected by K. Prendergast at other sites.

Lasioglossum (Chilalictus) platychilum, female. Rarely observed across SWWA: one specimen collected at Cannington Claypan, and only collected once by K. Prendergast at Alison Baird Reserve, also on *Goodenia pulchella.* Specimen photographed by K. Prendergast collected at Alison Baird Reserve.

Appendix 3. PaDIL profile of Leioproctus (Andrenopsis) douglasiellus

Source: http://www.padil.gov.au/pollinators/pest/main/139407/51829

1. PaDIL Species Factsheet

Scientific Name:

Leioproctus (Andrenopsis) douglasiellus Michener, 1965
(Hymenoptera: Colletidae: Colletinae)

Common Name

Native douglasiellus colletid
Live link: http://www.padil.gov.au:80/pollinators/Pest/Main/139407

Image Library

Australian Pollinators
Live link: http://www.padil.gov.au:80/pollinators/

Partners for Australian Pollinators image library

Western Australian Museum
http://www.museum.wa.gov.au/

South Australian Museum
http://www.samuseum.sa.gov.au/

Museum Victoria
http://museumvictoria.com.au/

Australian Museum
http://australianmuseum.net.au/

2. Species Information

2.1. Details

Specimen Contact: Museum Victoria - discoverycentre@museum.vic.gov.au
Author: Walker, K.
Citation: Walker, K. (2010) Native douglasiellus colletid*(Leioproctus (Andrenopsis) douglasiellus)*Updated on 1/30/2015 Available online: PaDIL - http://www.padil.gov.au

2.2. URL

Live link: http://www.padil.gov.au:80/pollinators/Pest/Main/139407

2.3. Facets

Status: Native Australian Beneficial Species
Host Genera: Fresh Flowers
Bio-Region: Australasian - Oceanian
Host Family: Goodeniaceae

2.4. Diagnostic Notes

Leioproctus (Andrenopsis) douglasiellus Michener, 1965
Leioproctus (Andrenopsis) douglasiellus Michener, C.D. 1965. A classification of the bees of the Australian and South Pacific regions. Bulletin of the American Museum of Natural History 130: 1–362 [259].
Type data: Holotype WAM 54–128 ?, Pearce, WA.

3. Diagnostic Images

Clarence, Blue Mountains, NSW, 30 Dec 1993, N.W.Rodd
Dorsal Image - Female: M. Batley Australian Museum

3 km N Clarence, NSW, 22 Dec 2004, M. Batley
Dorsal Image - Male: M. Batley Australian Museum

Clarence, Blue Mountains, NSW, 30 Dec 1993, N.W.Rodd
Head Front Image - Female: M. Batley Australian Museum

3 km N Clarence, NSW, 22 Dec 2004, M. Batley
Head Front Image - Male: M. Batley Australian Museum

Clarence, Blue Mountains, NSW, 30 Dec 1993, N.W.Rodd
Lateral Image - Female: M. Batley Australian Museum

3 km N Clarence, NSW, 22 Dec 2004, M. Batley
Lateral Image - Male: M. Batley Australian Museum

Results Generated:

Monday, March 25, 2019

Appendix 4. PaDIL profile of Neopasiphae simplicior

Source: **http://www.padil.gov.au/pollinators/pest/main/139572**

1. PaDIL Species Factsheet

Scientific Name:

Neopasiphae simplicior Michener, 1965
(Hymenoptera: Colletidae: Colletinae)

Common Name

Native simplicior colletine
Live link: http://www.padil.gov.au:80/pollinators/Pest/Main/139572

Image Library

Australian Pollinators
Live link: http://www.padil.gov.au:80/pollinators/

Partners for Australian Pollinators image library

Western Australian Museum
http://www.museum.wa.gov.au/

South Australian Museum
http://www.samuseum.sa.gov.au/

Museum Victoria
http://museumvictoria.com.au/

Australian Museum
http://australianmuseum.net.au/

2. Species Information

2.1. Details

Specimen Contact: Museum Victoria - discoverycentre@museum.vic.gov.au
Author: Walker, K.
Citation: Walker, K. (2010) Native simplicior colletine*(Neopasiphae simplicior)*Updated on 10/1/2011 Available online: PaDIL - http://www.padil.gov.au

2.2. URL

Live link: http://www.padil.gov.au:80/pollinators/Pest/Main/139572

2.3. Facets

Status: Native Australian Beneficial Species
Host Genera: Fresh Flowers
Bio-Region: Australasian - Oceanian
Host Family: Asteraceae, Goodeniaceae, Lobeliaceae

2.4. Diagnostic Notes

Neopasiphae simplicior Michener, 1965

Neopasiphae simplicior Michener, C.D. 1965. A classification of the bees of the Australian and South Pacific regions. Bulletin of the American Museum of Natural History 130: 1–362 [262].

Type data: Holotype WAM 65–726, Cannington (as Camington), WA.

3. Diagnostic Images

WA, 0.5 km E Forest-Dale Lake. 25 km West of Perth. 28 October 1987. T. F. Houston on flowers of Goodenia filiformis
Dorsal Image - Female: Clare McLellan Museum Victoria

WA, 0.5 km E Forest-Dale Lake. 25 km West of Perth. 28 October 1987. T. F. Houston
Dorsal Image - Male: Clare McLellan Museum Victoria

WA, 0.5 km E Forest-Dale Lake. 25 km West of Perth. 28 October 1987. T. F. Houston
Gaster Ventral Image - Male: Clare McLellan Museum Victoria

WA, 0.5 km E Forest-Dale Lake. 25 km West of Perth. 28 October 1987. T. F. Houston on flowers of Goodenia filiformis
Head Front Image - Female: Clare McLellan Museum Victoria

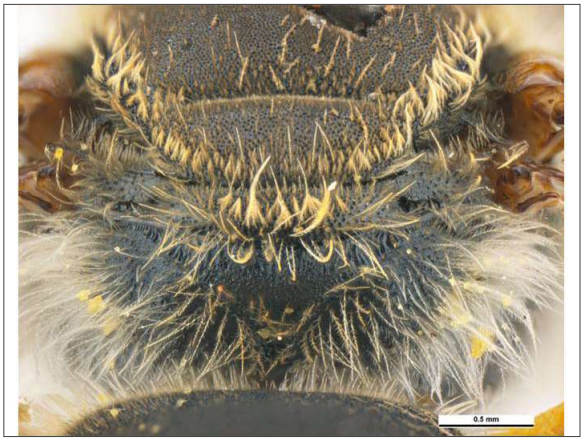
WA, 0.5 km E Forest-Dale Lake. 25 km West of Perth. 28 October 1987. T. F. Houston
Head Front Image - Male: Clare McLellan Museum Victoria

WA, 0.5 km E Forest-Dale Lake. 25 km West of Perth. 28 October 1987. T. F. Houston on flowers of Goodenia filiformis
Lateral Image - Female: Clare McLellan Museum Victoria

WA, 0.5 km E Forest-Dale Lake. 25 km West of Perth. 28 October 1987. T. F. Houston
Lateral Image - Male: Clare McLellan Museum Victoria

WA, 0.5 km E Forest-Dale Lake. 25 km West of Perth. 28 October 1987. T. F. Houston on flowers of Goodenia filiformis
Mesoscutum Image - Female: Clare Museum Victoria

WA, 0.5 km E Forest-Dale Lake. 25 km West of Perth. 28 October 1987. T. F. Houston on flowers of Goodenia filiformis
Metasoma Image - Female: Clare McLellan Museum Victoria



WA, 0.5 km E Forest-Dale Lake. 25 km West of Perth. 28 October 1987. T. F. Houston on flowers of Goodenia filiformis
Propodeum Image - Female: Clare McLellan Museum Victoria

Results Generated:

Monday, March 25, 2019