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27 October 2017

Native Vegetation Conservation Branch
Department of Water and Environmental
Regulation
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Dear Sir/Madam

Yanchep Rail Extension Geotechnical and UXO Investigations – Native Vegetation Clearing Permit Application

1. Background

The State Government as part of its METRONET plan has committed to extend the existing Joondalup railway line from Butler to Yanchep, to provide essential transportation services to Perth's rapidly expanding northern suburbs. The Yanchep Rail Extension (YRE) project will cater for the significant planned (and already underway) urban growth in the region, and provide an alternative travel option to help mitigate against congestion on the road network. The Public Transport Authority (PTA) is the responsible agency and subsequently the proponent with regards to the implementation of the project.

The YRE proposal is located within the City of Wanneroo, which is situated about 26 kilometres (km) north of Perth's Central Business District. The proposal lies between the suburbs of Butler and Yanchep and includes the suburbs of Alkimos and Eglinton. The YRE Proposal footprint or Clearing Boundary Footprint is shown in **Figure 1**. The area of the Clearing Boundary Footprint is 105 hectares (ha).

As part of the planning and design for the YRE proposal, additional investigations are required to define the geotechnical conditions and determine the risk of unexploded ordnance (UXO) presence along the entire YRE alignment. These investigations are separate to the implementation of the proposal, and involve targeted investigative works with clearing of native vegetation at scattered locations within the proposal footprint. For the geotechnical investigations, a number of boreholes will be drilled and cone penetration tests undertaken, as well as clearing to provide temporary access to the test locations. The clearing required for each borehole and cone penetration test is approximately 10m², plus 3.5 metre (m) wide access tracks. For the UXO survey, a 2.5m wide track is required to be cleared and mulched.

The Anticipated Clearing Area for all of these investigations is shown in **Figure 2**. It should be noted that the final area to be cleared is subject to minor deviations from that shown to accommodate ground conditions. Based on this, the clearing permit application is for the clearing of up to 5.07ha within the larger Clearing Boundary Footprint (Anticipated Clearing Area).

The PTA discussed the timing of the YRE proposal and the geotechnical and UXO investigations with Department of Water and Environment Regulation (DWER) and officers from the Environmental Protection Authority (EPA) Infrastructure Assessments and Native Vegetation Conservation Branches on 02 October 2017. It was agreed that the geotechnical and UXO investigations were separate from the YRE proposal and therefore a Native Vegetation Clearing Permit Application under Part V of the *Environmental Protection Act 1986* could be submitted to the DWER prior to the PTA submission of a referral to the EPA under Part IV of the Act. Section 3.4.1 of the *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016* states:

“Decision-making authorities may approve investigation work necessary to inform the EPA’s decision to assess a proposal or its assessment of a proposal, or to inform the design or planning that does not involve implementing of a proposal, if it is not likely to have a significant impact on the environment.”

This letter provides a summary of the relevant background information associated with the attached application for a Native Vegetation Clearing Permit.

2. Native Vegetation

The geotechnical and UXO investigations for the YRE proposal will require the clearing of native vegetation. The Anticipated Clearing Area of the YRE proposal is 5.07 ha within the larger Clearing Boundary Footprint, including 5m corridors for any tracks that are considered likely to be required to enable access to the YRE corridor (**Figure 2**). It should be noted that the locations provided may be subject to minor amendments to work around site constraints such as large trees or high mounds.

The PTA commissioned a Level 2 dual season flora survey and targeted Black Cockatoo survey of the YRE proposal area to identify the flora, vegetation and fauna values. This survey report is attached as **Attachment 1**.

The following information was extrapolated from the survey results for the Anticipated Clearing Area. The 5.07 ha of native vegetation comprises 13 vegetation associations:

- *Acacia saligna* and *Xanthorrhoea preissii* tall shrubland
- *Banksia sessilis* and *Melaleuca systema* mid-shrubland

- *Banksia sessilis* and *Spyridium globulosum* tall shrubland
- *Banksia attenuata*, *B. menziesii* low woodland
- *Lomandra* sp. Herbland
- *Eucalyptus gomphocephala* tall woodland
- *Eucalyptus* sp., *Agonis flexuosa* woodland
- *Melaleuca huegelii* and *M. systena* shrubland
- *Banksia attenuata* woodland
- *Xanthorrhoea preissii* shrubland
- *Eucalyptus decipiens* woodland
- Planted
- Scattered Natives

The remaining areas comprise of cleared areas devoid of native vegetation.

The vegetation condition within the Anticipated Clearing Area was rated as Excellent to Completely Degraded in condition. The extents of the vegetation condition ratings mapped within the Anticipated Clearing Area are detailed in **Table 1**.

The area defined as unclassified includes the proposed access tracks that are outside the extents of the flora and fauna survey, however are within the Clearing Boundary Footprint for the overall YRE proposal. The access tracks have been located on existing tracks, where possible, but included in the Anticipated Clearing Area to necessitate any widening that may be required to enable vehicle access.

Table 1 Vegetation Condition within the Anticipated Clearing Area

Vegetation Condition	Extent in Anticipated Clearing Area (ha)
Excellent	1.26
Very Good	0.62
Good	0.68
Good - Degraded	0.48
Degraded	0.73
Unclassified	1.32
Cleared	0.03
Total	5.07

The vegetation within the Anticipated Clearing Area aligned with two Priority Ecological Communities (PECs) and one Threatened Ecological Communities (TEC):

- *Banksia* Woodlands of the Swan Coastal Plain (SCP) TEC, which is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *Banksia* dominated woodlands of the SCP Interim Biogeographic Regionalisation for Australia (IBRA) region PEC, which is listed at Priority 3 by Department of Biodiversity Conservation and Attractions (DBCA).
- Northern Spearwood shrublands and woodlands (24), PEC, listed as a Priority 3 by DBCA

These ecological communities are mapped in **Figure 3**.

There is 0.88 ha of the *Banksia* Woodlands of the SCP TEC within the Anticipated Clearing Area, which also aligns with the *Banksia* dominated woodlands of the SCP IBRA region PEC present. There is 1.26 ha of Northern Spearwood shrublands and woodlands PEC present within the Anticipated Clearing Area.

No EPBC Act or *Wildlife Conservation Act 1950* listed flora taxa were recorded within the Anticipated Clearing Area, however, one DBCA-listed Priority 3 taxon, *Hibberfia spicata* subsp. *leptotheca* was recorded during the field survey adjacent to the Anticipated Clearing Area. In addition, no wetlands or watercourses occur within the Anticipated Clearing Area.

3. Minimisation and Avoidance

Prior to this point, numerous measures have been undertaken to avoid and minimise the need to clear vegetation for the purposes of the geotechnical and UXO investigations. These include undertaking a thorough desktop review of previous information, including studies undertaken previously by PTA and surrounding land developers, locating the investigation points along tracks, in cleared areas or outside of known conservation significant ecological communities as well as utilising less intensive clearing methods.

For example, the primary clearing method undertaken will be vegetation slashing, and in some locations grubbing. Access tracks will be constructed via a scrub rolling methodology. These methods will minimise the amount of vegetation cleared for the investigations, and will facilitate the regrowth of native vegetation. In this way, these methods will allow for the clearing of native vegetation to be reversible through either regrowth or rehabilitation, should the YRE proposal not proceed.

4. EPBC Referral

An assessment was undertaken to determine whether the native vegetation clearing required for these investigations would have potential impacts on any Matters of National Environmental Significance (MNES). The two key MNES identified were the Banksia Woodlands of the SCP TEC and Black Cockatoo habitat. Given that the investigations will involve clearing of up to 0.88 ha of the Banksia Woodlands of the SCP TEC, this is considered unlikely to have a significant impact. In addition, clearing of 2.14 ha of potential Black Cockatoo foraging habitat is considered unlikely to have a significant impact, due to the scattered nature of the clearing areas.

As a result, the investigation project has not been referred to the Department of the Environment and Energy under the EPBC Act.

5. Native Vegetation Clearing Permit

As per the attached *application for a clearing permit (purpose permit)* Form C2, the PTA seeks permission to clear up to 5.07 ha of native vegetation within the Clearing Boundary Footprint for the Yanchep Rail Extension Geotechnical and UXO Investigations (**Attachment 2**). The Anticipated Clearing Area is also shown on Attachment 2, noting however that the final area to be cleared is subject to minor deviations from that shown to accommodate ground conditions.

See **Attachment 3** for an assessment of this clearing against the 10 Clearing Principles, which found that the clearing is not at variance to any of the Principles.

As per this application, the PTA does not currently own the parcels of land covered by the clearing permit. However, the PTA will become the owner of the rail reserve should the YRE proposal proceed. The PTA currently has authority to enter land under Section 82 of the *Public Works Act 1902* for the purposes of conducting surveys and investigations for the YRE proposal, subject to giving notice in writing to the owner or occupier of the land of the intention to enter.

The *application for a clearing permit (purpose permit)* is enclosed for your consideration. Please contact Chrissie Harwood, Environmental Planner METRONET, on 6551 7153 should you have any queries.

Yours sincerely



Owen Thomas
EXECUTIVE DIRECTOR
INFRASTRUCTURE PLANNING AND LAND SERVICES

Figures

Figure 1: Clearing Boundary Footprint

Figure 2: Anticipated Clearing Area

Figure 3: Clearing Boundary Footprint and Conservation Significant Ecological Communities

Attachments

Attachment 1: Yanchep Rail Extension Biological Assessment (GHD, 2017)

Attachment 2: Application for Clearing Permit (Form C2)

Attachment 3: 10 Clearing Principles Assessment

Attachment 4: Credit Card Payment (Form C3)



Figure 1: Yanhep Rail Extension - Clearing Boundary Footprint

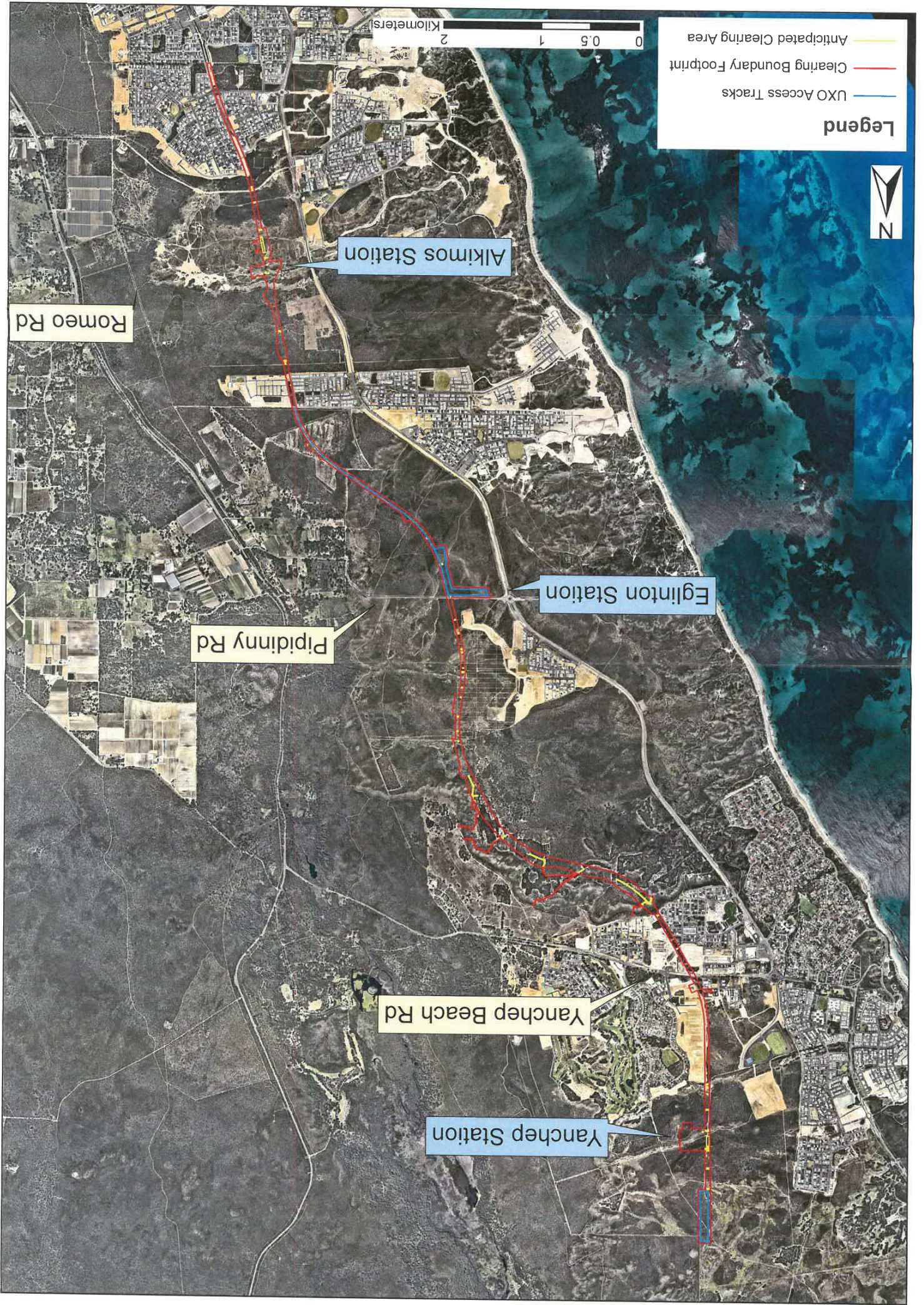
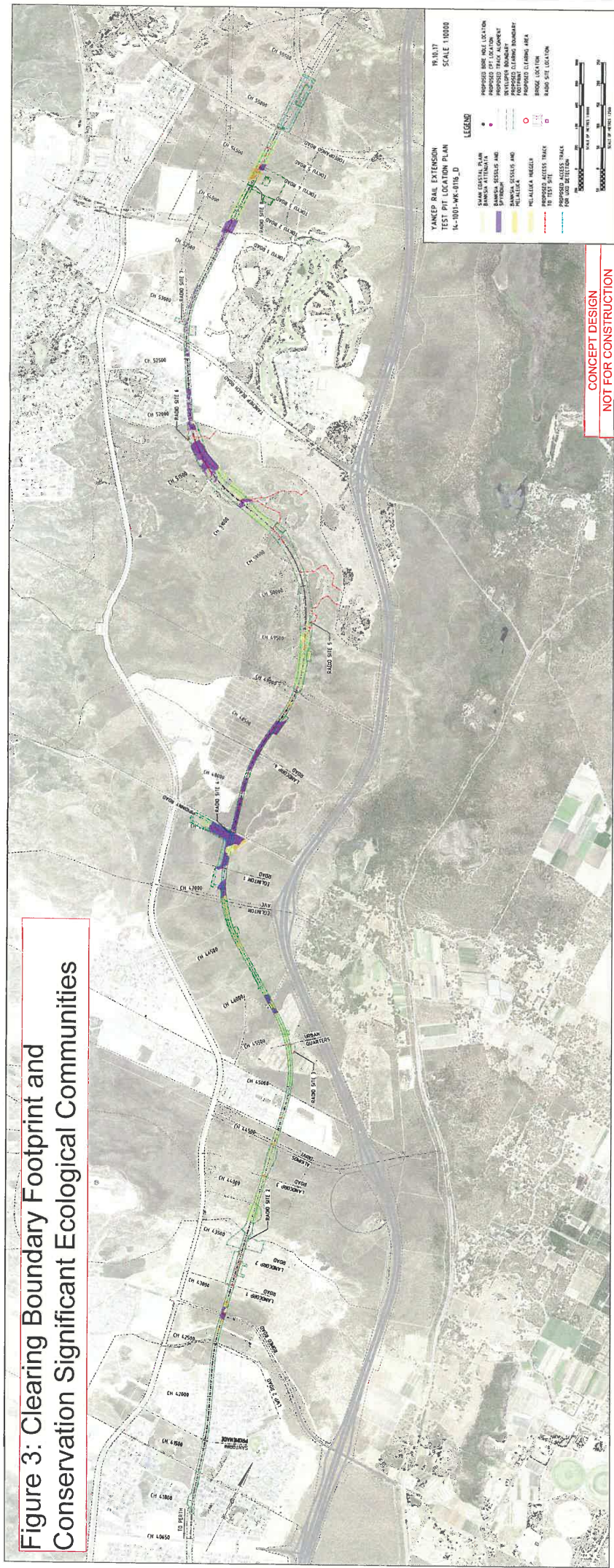
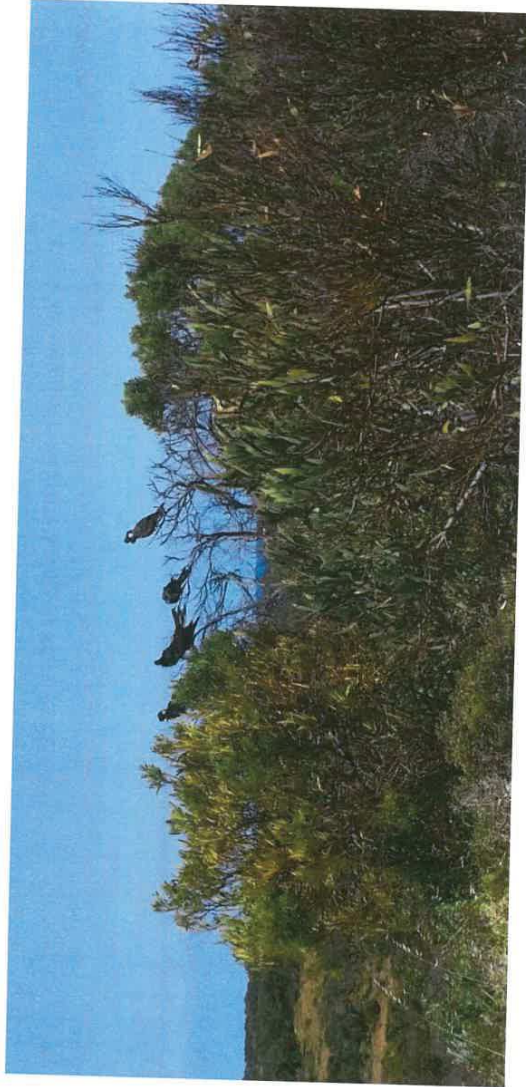


Figure 2: Yanchep Rail Extension - Anticipated Clearing Area

Figure 3: Clearing Boundary Footprint and Conservation Significant Ecological Communities



**CONCEPT DESIGN
NOT FOR CONSTRUCTION**



Public Transport Authority

Yanchep Rail Extension
Biological Assessment

August 2017

Executive summary

The Public Transport Authority (PTA) is in the planning stage for the extension of the northern suburbs passenger railway from Butler (Romeo Road) to Yanchep. The alignment extends from Romeo Road to the proposed Yanchep Railway Station, a distance of approximately 15.4 kilometres (km).

The PTA has commissioned GHD to undertake a dual season detailed vegetation and flora survey (a spring and out of season survey) and Level 1 fauna survey covering the whole of the newly refined alignment. The results of this assessment will be used to assess the ecological impact of the project and inform the environmental approvals process.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.6 and the assumptions and qualifications contained throughout this report.

Key findings

Vegetation

Regional vegetation mapped by Heddlie *et al.* (1980) indicates three vegetation complexes occur within the survey area. One of these, the Cottesloe central and south complex has 9.07% of its pre-European extent remaining within the Swan Coastal Plain (SCP) IBRA bioregion. When there is less than 30% of the pre-European extent remaining of an ecological community biodiversity, failure of ecosystem processes and the ability for long term viability is lost exponentially (ANZECC 2000). However, within the City of Wanneroo the Cottesloe complex – central and south has 41 % of its pre-European extent remaining.

The desktop study revealed no Department of Biodiversity, Conservation and Attractions (DBCAs)-managed conservation areas located within the survey area. Bush Forever site 289 (Ningana Bushland, Yanchep/Eglington) intersects the middle of the survey area and Bush Forever site 288 (Yanchep National Park and Adjacent Bushland) intersects the northern extent of the survey area. The majority of the survey area is an Environmentally Sensitive Area (ESA). This is related to the three Threatened Ecological Communities (TECs) that intersect the survey area at various locations. These were:

- Seven occurrences of the Aquatic Root Mat Community in Caves of the SCP (Caves SCP01) (TEC)
- One occurrence of Woodlands over sedgelands in Holocene dune swales of the southern SCP (SCP19b) (TEC)
- One occurrence of *Melaleuca huegellii* – *M. acerosa* (*M. systema*) shrublands on limestone ridges (SCP26a) (TEC)

Thirteen vegetation types were identified within the survey area; eleven of these were remnant native vegetation, and two were dominated by planted taxa and non-native species. The majority of the survey area was rated Excellent to Very Good in condition with the vegetation structure largely intact with some herbaceous and grassy weeds present (37.16 % of the survey area). Areas rated Degraded and Completely Degraded have been historically cleared or impacted by grazing and are dominated by introduced species.

A statistical analysis identified the possible presence of two conservation significant ecological communities within the survey area:

- Southern *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands (25) Priority 3 PEC

- Northern Spearwood shrublands and woodlands (24) Priority 3 PEC.

Field observations identified a further three conservation significant ecological communities likely to occur within the survey area:

- *Melaleuca huegelii* – *M. acerosa* [*M. systemaj*] shrublands on limestone ridges (26a) Endangered TEC
- Banksia dominated woodlands of the SCP IBRA region PEC
- Banksia Woodlands of the SCP TEC.

The Northern Spearwood shrublands and woodlands PEC is likely to occur within the survey area and is aligned with GHD VT02 and VT03. Field observations inferred two vegetation types (VT04 and VT09) met the key diagnostic characteristics for the Banksia Woodlands of the SCP TEC, as outlined in DoEE (2016c). The field assessment also identified the presence of the Banksia dominated woodlands of the SCP IBRA region PEC, listed as Priority 3 by DBCA. This PEC differs from the TEC in that it has no minimum condition and patch size thresholds. GHD VT08 is inferred to align with 26a TEC based on the statistical analysis, landform, vegetation structure and species composition.

The *Eucalyptus gomphocephala* (Tuart) vegetation units could not be confidently aligned with the Southern *Eucalyptus gomphocephala* and/or *Agoris flexuosa* woodlands PEC and is unlikely to occur within the survey area. However, Tuarts represent 'other significant vegetation'. Therefore any Tuart trees within the survey area should be avoided and retained where possible.

Flora

Two hundred and ten (210) flora taxa (including subspecies and varieties) were recorded during the field assessments. This comprised of 156 native taxa, 54 introduced flora taxa. No *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or *Wildlife Conservation Act 1950* (WC Act) listed flora were recorded within the survey area. One DBCA Priority-listed flora taxon was recorded; *Hibbertia spicata* subsp. *leptotheca* (P3), it was recorded in quadrat 8, in VT08.

Of the introduced taxa, three are listed as Declared Pests under the *Biosecurity and Management Act 2007* and/or as a Weeds of National Significance (WONS); **Gomphocarpus fruticosus* (narrowleaf cottonbush) and * *Solanum linnaeanum* (Apple of Sodom) are Declared Pests and **Lantana camara* (common lantana) is classed as Declared Pest and a WONS.

Fauna

Seven main fauna habitat types are present within the survey area: Eucalyptus woodland, *Banksia sessilis* over low mixed shrubland, mixed Banksia woodland, mixed tall shrubland, Lomandra herb lands on secondary dunes, planted Eucalypt woodland and highly disturbed areas. Four of these habitat types provide high value habitat for fauna. These four habitat types cover approximately 75% of the total survey area demonstrating the overall high value of the area. The remaining 25% includes medium to low value habitat for fauna.

The fauna surveys recorded 60 vertebrate fauna species, including 44 birds, eight reptiles and eight mammals. Three species of conservation significance were recorded during the survey, Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*) – listed as Endangered under EPBC Act and WC Act, Western Brush Wallaby (*Macropus irma*) listed as Priority 4 under the WC Act and Rainbow Bee-eater (*Merops ornatus*) listed as IA under the WC Act.

A further five conservation significant species were considered likely to occur within the survey area, including:

- Southern Brown Bandicoot / Quenda (*Isodon obesulus subsp. fusciventer*) – Priority 4 listed by DBCA
 - Peregrine Falcon (*Falco peregrinus*) – Listed as other specially protected fauna by DBCA
 - Western Quoll (*Dasyurus geoffroii*) – Listed as Vulnerable by the EPBC Act and DBCA
 - Jewelled South West Ctenotus (*Ctenotus gemmula*) – Listed as Priority 3 by DBCA
 - Black Striped Snake (*Neelaps calonotus*) – Listed as Priority 3 by DBCA
- A Black Cockatoo assessment identified 90.80 ha of suitable foraging habitat and 25 potential breeding trees were recorded. Of these, none had evidence of being previously used for nesting and none had suitable hollows for current breeding. The 25 potential breeding trees had a DBH of >500 mm which means they may be suitable for breeding in the future.

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Appendix B – Relevant legislation, conservation codes and background information

Appendix C – Database searches

Appendix D – Flora data

Appendix E – Fauna data

1. Introduction

1.1 Project background

The Public Transport Authority (PTA) is in the planning stage for the extension of the northern suburbs passenger railway, the Yanchep Rail Extension (the project). The proposed alignment extends from Romeo Road in Butler to the proposed Yanchep Railway Station, a distance of approximately 15.4 kilometres (km).

An initial environmental investigation including a desktop and field survey was completed by GHD Pty Ltd (GHD) in spring 2010 (GHD 2011). Subsequent alignment alterations resulted in an additional field survey of two new areas completed by GHD in spring 2012 (GHD 2012). Since the 2010 and 2012 surveys the alignment has been further refined and requires additional biological investigations.

1.2 Purpose of the report

The PTA commissioned GHD to undertake a dual season detailed vegetation and flora survey and Level 1 fauna survey of the survey area. The results of the assessment will be used to assess the ecological impact of the project and inform the environmental approvals process.

1.3 Project location

1.3.1 Survey area

The survey area is located between Butler and Yanchep, extending from Romeo Road in Butler to the proposed Yanchep Railway Station. The survey area is approximately 15.4 km long, covers 109.23 hectares (ha) and includes two components:

- The original alignment: approximately 13.7 km long and 40 metres (m) wide, increasing width at some station locations and other areas as required. The original alignment covers 87.39 ha.
- The extension: includes an additional 1.7 km section north of the original alignment and a 10 m buffer of the original alignment within Bush Forever site 289. The additional areas covers approximately 21.84 ha.

The original alignment and extension (referred to as the 'survey area') is mapped in Figure 1, Appendix A.

1.3.2 Study area

A study area was defined for the desktop based searches of the assessment and includes a 10 km buffer of the survey area.

1.4 Scope of works

The scope of works for the detailed flora and fauna survey included:

- A desktop review of publicly available information and relevant reports commissioned by the PTA was completed to determine the environmental values of the study area.
- A dual season biological survey was undertaken during spring 2016 and an out-of-season survey of the survey area to identify:
 - The presence or potential presence of any Threatened or Priority Flora

- Vegetation community types present, including presence of any Threatened or Priority Ecological Communities (PECs or TECs).
 - Vegetation condition, including the location of any Weeds of National Significance (WONS) or Declared Weeds
 - Flora species recorded including introduced species
 - Vegetation growing in association with wetlands or watercourses
 - The presence or potential presence of any Threatened or Priority fauna
 - Fauna habitat types, with a targeted Black Cockatoo habitat survey
 - Fauna species recorded including introduced species
- Preparation of a biological survey report (this document) that:
 - Documents the results of the desktop assessment and field survey, including mapping
 - Identifies and discusses potentially occurring significant flora, vegetation and fauna species and their habitat (including identifying potential breeding or feeding habitat for Black Cockatoos)
 - Assesses the project clearing against the 10 Clearing Principles, as outlined in Schedule 5 of the *Environmental Protection Act 1986*
 - Provides general advice with respect to environmental approvals as the final alignment and disturbance footprint for the project are yet to be finalised
 - Provision of spatial files in GIS format

1.5 Relevant legislation, conservation codes and background information

In Western Australia (WA) significant communities, and flora and fauna are protected under both Federal and State Government legislation. In addition, regulatory bodies also provide a range of guidance and information on expected standards and protocols for environmental surveys.

An overview of key legislation and guidelines, conservation codes and background information relevant to this Project are provided in Appendix B.

1.6 Limitations and assumptions

This report has been prepared by GHD for PTA and may only be used and relied on by PTA for the purpose agreed between GHD and PTA as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than PTA arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by PTA and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of infrastructure, access tracks and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions may change after the date of this report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

This report has assessed the flora and fauna values within the survey area, as shown in Figure 1. Appendix A. Should the survey area change or be refined, further assessment may be required.

2-

Methodology

2.1 Desktop assessment

Prior to the commencement of the field survey, a desktop assessment was undertaken to identify relevant environmental information pertaining to the study area and to assist in survey design. The desktop assessment involved a review of:

- Previous reports relevant to the study area including:
 - GHD 2011 *Northern Suburbs Railway Alignment from Romeo Rd (Alkimos) to Yanchep, Graceful Sun-moth Survey*
 - GHD 2012 *Northern Suburbs Railway Alignment Butler to Yanchep Environmental Investigation*
- The Department of the Environment and Energy (DoEE) Protected Matters Search Tool (PMST) to identify communities and species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) potentially occurring within the study area (DoEE 2016a) (Appendix C)
- The Department of Biodiversity, Conservation and Attractions (DBCA) TEC and PEC database to determine the potential for TECs or PECs to be present within the study area
- The DBCA *Nature/Map* database for flora and fauna species previously recorded within the study area (DBCA 2007-) (Appendix C)
- The DBCA Threatened (Declared Rare) and Priority Flora database (TPFL), Threatened and Priority Fauna database, and the WA Herbarium database (WAHERB) and for Threatened and Priority flora species listed under the *Wildlife Conservation Act 1950* (WC Act) and listed as priority by DBCA, previously recorded within the study area
- Existing datasets including previous vegetation mapping of the survey area (Beard 1979), aerial photography, geology/soils and hydrology information to provide background information on the variability of the environment, likely vegetation units and fauna habitats and to identify areas with potential to contain TECs, PECs, and Threatened and Priority listed flora and fauna species.

The environmental constraints identified in the desktop assessment are mapped in Figure 2 Appendix A.

2.2 Field survey

2.2.1 Vegetation and flora

GHD botanists (Gaynor Owen, SL012042, Mat Gannaway and Angela Benkovic, SL012111) completed a dual season detailed vegetation and flora assessment of the original alignment and a reconnaissance survey of the extension. The timing and survey efforts of each area are shown in Table 1.

Table 1 Flora and vegetation survey timing and effort

Date	Survey effort	Area
1-3 November 2016	Detailed survey Pt 1	Original alignment
3-5 May 2017	Detailed survey Pt 2	Original alignment
11-12 July 2017	Reconnaissance	Extension

The field surveys were undertaken to verify the results of the desktop assessment, identify and describe the dominant vegetation units, assess vegetation condition, and identify and record

vascular flora taxa present at the time of survey. Searches for conservation significant or other significant ecological communities and flora taxa were also undertaken during the field surveys.

The survey methodology employed by GHD was undertaken with reference to the Environmental Protection Authority (EPA) *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016a).

Data collection

Field survey methods involved a combination of sampling quadrats located in identified vegetation units and traversing the survey area by foot. Twenty-nine non-permanent quadrats were described throughout the survey area.

Quadrats (measuring 10 m x 10 m – area of 100 m²) were located within each identified vegetation unit. A minimum of two quadrats were located within each identified vegetation unit, where possible. Field data at each quadrat was recorded on a pro-forma data sheet and included the parameters detailed in Table 2. Quadrat data is provided in Appendix D.

Table 2 Data collected during the field survey

Aspect	Measurement
Collection attributes	Personnel/recorder, date, quadrat dimensions, photograph of the quadrat.
Physical features	Aspect, soil attributes, ground surface cover, leaf and wood litter.
Location	Coordinates recorded in GDA94 datum using a hand-held Global Positioning System (GPS) tool to accuracy approximately ± 5 m.
Vegetation condition	Vegetation condition was assessed using the condition rating scale adapted by EPA (2016a) for the South West Botanical Province.
Disturbance	Level and nature of disturbances (e.g. weed presence, fire and time since last fire, impacts from grazing, exploration activities).
Flora	List of dominant flora from each structural layer. List of all species within the quadrat including average height and cover (using a modified Braun-Blanquet scale)

A flora inventory was compiled from taxa listed in described quadrats and from opportunistic floristic records throughout the survey area.

Vegetation units

Vegetation units were identified and boundaries delineated using a combination of aerial photography, topographical features and field data/observations.

Vegetation units were described based on structure, dominant taxa and cover characteristics as defined by quadrat data and field observations. Vegetation unit descriptions follow the National Vegetation Information System (NVIS) and are consistent with NVIS Level V (Association), and are grouped within NVIS Level III (Broad Floristic Formation). At Level V up to three taxa per stratum are used to describe the association (ESCAVI 2003).

Comparison of vegetation units with regional datasets

The most recent and detailed floristic analysis on the SCP was completed by Gibson *et al.* (1994). The Gibson *et al.* (1994) study established 509 standard area sites across the SCP; floristic data was recorded, and based on the presence or absence of individual species and multi-variant analysis techniques, used to define 30 floristic community types (FCTs). A further 13 subdivisions were evident within the 30 FCTs, making a total of 43 types. The work of Gibson *et al.* (1994), and other unpublished data collected as part of the System 6 and Part System 1 Update program and from various sources (e.g. Griffin 1994 and Keighery 1996 – collected to be directly comparable with Gibson *et al.* (1994)) was incorporated into Bush Forever (Government of WA (GoWA) 2000) (referred to in this report as the SCP dataset). Bush

Forever identified a further 23 FCTs, including 15 supplementary groups and reclassification a number of FCTs. In total 66 FCTs are recognised for the SCP. The categorisation of TECs and PECs on the SCP has been largely defined by FCTs.

Inference analysis

GHD quadrat data was compared to existing data (where available) for FCTs described on the SCP. Species that occur in greater than 50 per cent of quadrats within each FCT (listed in Table 3) were compared to recorded GHD species for each vegetation unit and inferences between FCTs and vegetation units made.

Statistical analysis

PRIMER v6 (Clarke and Gorley 2006) was used to compare the GHD quadrats to existing data (where available) for FCTs described on the SCP. PRIMER is limited in use for this purpose as analysis is based on all species recorded in quadrats, includes introduced species and does not take into account dominance of species. Further interpretation of statistical results, coupled with multiple field surveys and desktop information is needed to determine whether the vegetation units are representative of a certain FCT.

Information from the SCP dataset was extracted for each FCT described on Uplands centred on Spearwood and Quindalup Dunes, as well as those identified in the desktop searches (e.g. TEC and PEC searches). Representative quadrats from each FCT were selected for the analysis and are shown in Table 3.

Two FCTs identified in the desktop searches were removed from the analysis, these included the Aquatic Root Mat Community Number 1 of Caves of the SCP (Caves SCP01) TEC and Shrublands on clay flats (10a) TEC. There were no established caves or areas of clay flats present within the survey area.

Table 3 List of Gibson et al. (1994) quadrats used in PRIMER analysis

Floristic Community Type Name and ID	Status	Quadrats
Sedgeland in Holocene dune swales (19a)	TEC	PB-1, PB-6, ricr01
Woodlands over sedgeland in Holocene dune swales (19b)	TEC	cool 09, cool14, cool15, xyan10
<i>Banksia illicifolia</i> woodlands (22)	PEC *	5F01, BANK-1, BNR27, BNR29, BNR32, DEJONG01, ELE18, ELE23, jand03, MELA-10, MELA-5, MPK02, MR11, pinj12, PLINE-6, raven05, WARB-2, WARB-4, white07, YAN-17, YAN-18, YAN-22, zBEER 01
SCP <i>Banksia aitenauata</i> – <i>B. menziesii</i> woodlands (23b)	PEC *	5A01, 5C02, 5C04, 5C06, 5D01, 5E01, BC3, BNR03, BNR19, BNR26, BNR30, BNR31, BNR33, ELDO-1, ELE01, ELE03, ELE08, ELE16, ELE17, ELE24, ELE28, MELA-2, MELA-3, MELA-6, MELA-7, MELA-8, MELA-9, MHR01, MILT-3, MILT-7, MILT-8, MIME 01, MNP01, MNP02, MOOR 05, MOOR 06, MOOR 07, MOOR 08, MOOR 09, MP01, MP04, MP05, MP06, MP08, MP09, MP10, MPK01, MPK03, MR05, MR09, MR10, MR12, MR13, mrip04, MUCK-1, MUJ01, MWR04, MWR08, MWR10, OYR01, PLINE-1, PLINE-2, RAAF-1, RAAF-2, RAAF-3, RGR01, RGR04, SF01, SF02, SINT-1, WN084CHE, WN086CHE, WN089CHE, WN090HED, WN093HED, WN100WNR, YAN-19, YAN-20, zBEER 04

Floristic Community Type Name and ID	Status	Quadrats
Northern Spearwood shrublands and woodlands (24)	PEC	bold07, bold09, bold12, bold13, bold14, bold23, BOLD-1, BOLD-2, BOLD-3, BOLD-4, buck01, CHIDPT-1, Hepb03, MI23, MTB-1, NEER-1, NEER-7, NEER-9, NEER-10, NEER-11, PTWALT-1, star01, star02, TRIG-5, TRIG-6, xbeer01
Southern <i>Eucalyptus gomphocephala</i> – <i>Agonis flexuosa</i> woodlands (25)	PEC **	bold16, bumb01, C71-4, colriv01, CORON-2, gelor01, GMaid01, GMaid03, KEME-1, ledad01, LYONS-2, MEAL-1, MINN-1, MINN-3, much04, MYALUP-2, NMAid05, PAGA-6, PAGA-8, tokyu01, vines01, yela03
<i>Melaleuca huegelii</i> – <i>M. acerosa</i> [<i>M. systena</i>] shrublands on Limestone ridges (26a)	TEC	CLIFT02, CLIFT03, SHE-4, SHE-5, SVH-1, WABL-1, YAN-2, YAN-12, YAN-13, YAN-15, YAN-24, ZYAN4, ZYAN5
Woodlands and mallees on Limestone (26b)		BW03, Guid05, Guid09, Hepb02, MEAL-2, NWIL-2, OYR02, SHE-1, SHE-3, SHE-6, tokyu02, tokyu05, WABL-2, WABL-3, WHILL-5, wilb04, wilb13, YALG-1, YALG-2, YALG-6, YALG-7, YAN-1, YAN-10, YAN-11, YAN-14, YAN-16, YAN-23, YAN-5
Species poor mallees and shrublands on Limestone (27)		bold18, bold22, BU03, PAR1, SVH-2, WHILL-3, WHILL-4, wilb05, YALG-3, YALG-4, YALG-5, YALG-8
Spearwood <i>Banksia attenuata</i> – <i>Eucalyptus</i> woodlands (28)		4M03, bee01, BULL-1, BULL-10, BULL-11, BULL-4, BULL-9, DEPOT-1, Guid08, HARRY-1, HARRY-2, Hepb01, KING-1, KING-2, ledad02, MILT-4, moore01, moore02, moore03, much01, much03, NEER-2, NEER-20, NEER-21, NEER-22, NEER-23, NEER-3, NEER-4, NEER-5, NEER-6, NEER-8, Pinn01, Pinn03, quinn02, sams01, sand01, SEAB-6, SHE-2, SHENT-1, star03, tokyu03, TRIG-3, TRIG-4, WABL-4, WARI-1, WARI-2, WATERRD1, wilb06, wilb07, wire01, wire02, WOODV-1, WOODV-2, YAN-25, YAN-3, YAN-4, YAN-6, YAN-8, YAN-9, yela01, Yuri02
Coastal shrublands on shallow sands [southern SCP] (29a)	PEC	BMAid02, BU01, BU02, BU04, BURN-1, BURN-2, GARD02, MI21, NAVB-2, NMAid01, NMAid03, Pinn02, PRES-1, rich02, rott2, SEAB-4, SEAB-5, SEAB-8, TRIG-2, wilb11
Acacia shrublands on taller dunes [southern SCP] (29b)	PEC	bold08, bold11, Guid01, Guid03, Guid04, Guid06, Guid10, MI01, MI02, MI06, MI07, MI09, MI18, NPRES-1, NWIL-1, NWIL-3, PB-2, PB-3, PB-4, PB-5, SEAB-2, SEAB-7, SW06, SW07, SW11, tokyu04, tokyu07, TRIG-1, WHILL-1, WHILL-2, wilb01, wilb08, wilb09, wilb12
<i>Callitris preissii</i> and/or <i>Melaleuca lanceolata</i> forests and woodlands (30a2)		bold05, GARD04, MHENRY-1, MHENRY-2, PEPGRV-1, PEPGRV-2, SEAB-1, WOODP-1, WOODP-2, xyan08
Quindalup <i>Eucalyptus gomphocephala</i> and/or <i>Agonis flexuosa</i> woodlands (30b)	PEC	LESCH-1, LESCH-2, LESCH-3, LESCH-4, LESCH-5, NMAid04, PERB-1, pip01, Possum3, Possum4
S11		bold05, m4601, m4602, MI04, MI05, MI08, rott01, SW05, SW08, SW09, SW10, TR06, TR07, TR08

Floristic Community Name and ID	Status	Quadrats
S12		MI11, MI12, MI17, MI19, MI22, SW02, SW03, SW04, TR03, TR04, TR05, wilb02
S14		MI10, MI13, MI14, MI15, MI16, MI20, SW01, TR01, TR02

* A component of the Endangered Banksia woodlands of the SCP EPBC listed TEC
 **Can form a component of the Endangered Banksia Woodlands of the SCP EPBC listed TEC

Multiple site analysis

The GHD and SCP dataset quadrat data was combined and presence/absence matrix created of all taxa (including perennials and annuals). The dissimilarity between quadrats was determined using the Bray-Curtis measure and the Resemblance function in PRIMER. A Cluster analysis (using Agglomerative Hierarchical Clustering technique) based on group average was undertaken using the Bray-Curtis similarity matrix and results presented as a dendrogram. In addition, a non-metric multi-dimensional analysis (MDS) was undertaken using the Bray-Curtis similarity matrix and results presented as a two dimensional scatter plot. A factor was added to the output to define sample groups by FCT. The outputs of the PRIMER analysis were used to inform decisions on vegetation units.

Single site insertion analysis

A single site insertion (SSI) analysis was conducted on GHD quadrats that were considered to align with FCT 26a. The SSI analysis involved analysing GHD quadrats Q08, Q21 and Q24 individually against the SCP dataset. This type of analyses is considered a more powerful method of grouping each quadrat with the SCP data and therefore enables a more robust result.

Vegetation condition

The vegetation condition was assessed and mapped in accordance with the vegetation condition rating scale for the South West and Interzone Botanical Provinces (devised by Keighery (1994) and adapted by EPA (2016a)). The scale recognises the intactness of vegetation and consists of six rating levels as outlined in (Table 4)

Table 4 Vegetation condition rating scale

Vegetation condition rating	South West and Interzone Botanical Provinces description
Pristine	Pristine or nearly so, no obvious signs of 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.
Degraded	Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing. 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 vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described

Flora identification and nomenclature

Species that were well known to the survey botanists were identified in the field; all other species were collected and assigned a unique collection number to facilitate tracking. All specimens collected during the field assessment were dried and processed in accordance with the requirements of the WA Herbarium. Species were identified by the use of taxonomic literature, electronic keys and online electronic databases.

The conservation status of all recorded flora was compared against the current lists available on FloraBase (WA Herbarium 1998-) and the EPBC Act Threatened species database provided by DotEE (2017).

Nomenclature used in this report follows that used by the WA Herbarium as reported on FloraBase (WA Herbarium 1998-).

Surveys for conservation significant flora

Prior to the field survey, information obtained from the desktop assessments (e.g. aerial photography, geology, soils and topography data, EPBC Act PMST, TPFL, NatureMap and the WAHERB databases search results) was reviewed to determine conservation significant flora taxa potentially present within the study area and locations. Additionally, ecological information (e.g. habitat, associated flora taxa and phenology) was sourced from FloraBase (WA Herbarium 1998-) and other relevant publications where available, to provide further details.

Potential habitats were searched by opportunistic sampling. Locations within the survey area with differing hydrology, fire or disturbance history to the surrounding areas were also searched where identified.

2.2.2 Fauna

GHD ecologists Glen Gaikhorst and Claudia Perry undertook a Level 1 fauna survey (reconnaissance survey) of the survey area from 1 – 2 November 2016. The subsequent surveys were undertaken by Claudia Perry on 3 – 5 May and 11 July 2017. The majority of the survey area was traversed on foot and by vehicle over the course of the surveys to identify and describe the dominant fauna habitat types present and their condition, assess habitat connectivity, and identify and record fauna species within the survey area. An assessment of the likelihood of conservation significant fauna and their habitats occurring within the survey area was also undertaken.

The survey methodology employed by GHD was undertaken with reference to the EPA *Technical Guidance – Terrestrial Fauna Surveys* (EPA 2016b).

Habitat assessment

A fauna habitat assessment was undertaken to document the type, condition and extent of habitats within the survey area. The following information was recorded:

- Habitat structure (e.g. vegetation type, presence/absence of structural layers such as ground cover and mid storey)
- Presence/absence of refuge including: density of ground covers, fallen timber (coarse woody debris), hollow-bearing trees and stags and rocks/boulder piles, and the type and extent of each refuge

- Presence/absence of waterways including type, extent and habitat quality within waterway
- Location of the habitat within the survey area in comparison to the habitat within the surrounding landscape
- Habitat connectivity and identification of wildlife corridors within and immediately adjacent to the survey area
- Current land use and disturbance history
- Evaluation of key habitat features and types identified during the desktop assessment relevant to fauna of conservation significance
- Evaluation of the likelihood of occurrence of conservation significant fauna within the habitat (based on presence of suitable habitat)
- A representative photograph of each habitat type

Opportunistic fauna searches

Opportunistic fauna searches were also conducted across the survey area. Opportunistic searches involved:

- Searching the survey area for tracks, scats, bones, diggings and feeding areas for both native and feral species
- Searching through microhabitats including turning over logs or rocks, turning over leaf litter and examining tree hollows and hollow logs
- Visual and aural surveys, which accounted for many bird species potentially utilising the survey area
- Recording GPS locations of any conservation significant fauna species

Black Cockatoos

A targeted survey for Black Cockatoo was conducted in accordance with the EPBC Act referral guidelines for three threatened black cockatoo species: Carnaby's Cockatoo (endangered) *Calyptorhynchus latirostris*, Baudin's Cockatoo (vulnerable) *Calyptorhynchus baudinii*, Forest Red-tailed Black Cockatoo (vulnerable) *Calyptorhynchus banksii naso*, (Department of Sustainability, Environment, Water, Populations, and Communities (DSEWPaC 2012). The assessment included:

- The identification and recording (via GPS) of the locations of potential and actual breeding habitat within the survey area (relevant tree species with a diameter at breast height (DBH) of >500 mm for Jarrah, Marri and Tuart or DBH of >300 mm for Wandoo or Salmon Gum
- Identifying, describing and recording the size of existing tree hollows and any evidence of use by Black Cockatoos within the survey area
- Identifying, describing and recording the (DBH) of trees with existing hollows within the survey area
- Identifying, recording and describing the locations of potential night roosting habitat
- Identifying, recording and describing the locations of potential foraging habitat

The survey distinguished between actual and potential breeding habitat as per the following:

- Actual nest trees: Evidenced as currently being used or have been used in the past
- Potential habitat: Trees with available hollows that do not show evidence of use now or in the past; trees with hollows that do not show evidence of use now or in the past where the hollow is not available (e.g. hollows are occupied by bees or galahs); and those trees

without hollows but which have the potential to develop hollows in the future, and which have DBH >600 mm or 300 mm for different species.

Fauna species identification

Identification of fauna species was made in the field using available field guides and electronic guides (e.g. Morcombe 2004). Where identification was not possible, photographs of specimens were collected to be later identified.

Nomenclature used in this report follows that used by the WA Museum and the DBCA NatureMap database (DBCA 2007–) with the exception of birds, where by Christidis and Boles (2008) was used.

2.3 Limitations

2.3.1 Desktop limitations

The EPBC Act PMST is based on bioclimatic modelling for the potential presence of species. As such, this does not represent actual records of the species within the area. The records from the DBCA searches of threatened flora and fauna provide more accurate information for the general area. However, some records of collections, sightings or trappings cannot be dated and often misrepresent the current range of threatened species.

New Wildlife Conservation (Rare Flora) and Wildlife Conservation (Specially Protected Fauna) Notices were gazetted February 2017. To date information contained in publically available databases such as *NatureMap* does not reflect these newly gazetted Notices. This report has been updated to reflect the conservation status of flora and fauna listed in these Notices. However, the outputs of database searches contained in this report such as *NatureMap*, does not reflect the conservation status of flora and fauna listed in these Notices.

2.3.2 Field survey limitations

The EPA (2016a) Technical Guide states that flora and fauna survey reports for environmental impact assessment in WA should contain a section describing the limitations of the survey methods used. The limitations and constraints associated with this field survey are discussed in Table 5. Based on this assessment, the present survey effort has not been subject to any constraints which affect the thoroughness of the assessment and the conclusions which have been formed.

Table 5 Field survey limitations

Aspect	Constraint	Comment
Sources of information and availability of contextual information.	Nil	Adequate information is available for the survey area, this includes: <ul style="list-style-type: none"> Broad scale (1:250,000) mapping by Beard (1978) and digitised by Shepherd <i>et al.</i> (2002) Regional biogeography (Mitchell <i>et al.</i> 2002)
Scope (what life forms were sampled etc.)	Nil	Vascular flora and terrestrial vertebrate fauna were sampled during the survey. Non-vascular flora, invertebrate and aquatic fauna were not surveyed.
Proportion of flora collected and identified (based on sampling, timing and intensity)	Minor	The detailed vegetation and flora survey was undertaken over two seasons, in spring 2016 and autumn 2017, and the reconnaissance survey was completed in winter 2017. The flora collected during the field survey is detailed in 4.1.5 and a full flora species list is provided in Appendix D. The portion of flora collected and identified was considered high, and it is likely the survey under-recorded some grass species (Poaceae), herbs and orchids due to poor flowering material during the field assessments. Grasses, annuals and orchids were observed during the spring assessment, however due to a lack of flowering and/or fruiting bodies were not identifiable, and as such, are likely to be underrepresented in the flora collected.
Proportion of fauna identified, recorded and/or collected		The fauna survey was undertaken in spring 2016, autumn 2017 and winter 2017, and were a reconnaissance survey. The fauna assessment sampled those species that can be easily seen, heard or have distinctive signs, such as tracks, scats, diggings, etc. Many cryptic species would not have been identified during the reconnaissance survey and seasonal variation within species often requires targeted surveys at a particular time of the year. Of the fauna species recorded during the survey, all species were identified to species level.
Flora determination	Minor	The fauna assessment was aimed at identifying habitat types and terrestrial vertebrate fauna utilising the survey area. No sampling for invertebrates or aquatic species occurred. The information available on the identification, distribution and conservation status of invertebrates is generally less extensive than that of vertebrate species. Flora determination was undertaken by GHD ecologists in the field and at the WA Herbarium. Three taxa could only be identified to family level only, 29 taxa could be identified to genus level only, and 1 taxon could be tentatively identified to species level, due to lack of flowering and/or fruiting material required for identification. Some species, particularly grasses, sedges and herbs, may have been overlooked due to lack of material. The taxonomy and conservation status of the WA flora is dynamic. This report was prepared with reliance on taxonomy and conservation status current at the time report development, but it should be noted this may change in response to ongoing research and review of International Union for Conservation Nature criteria.

Aspect	Constraint	Comment
Completeness and further work which might be needed (e.g. was the relevant area fully surveyed)?	Minor	The majority of the survey area was accessed on foot or traversed by vehicle. The access tracks created as a result of infrastructure development (roads, water and electrical services) allowed access to the majority of the survey area. Information gained from the survey was extrapolated across those sections of the survey area not accessed on foot during the field survey to assist with determining the vegetation and habitat types for the entire survey area.
Mapping reliability	Minor	The vegetation was mapped at a scale of 1:6,000 using high-resolution ESRI aerial imagery obtained from Landgate, topographical features, previous broad scale mapping (Beard 1979) and field data. Data was recorded in the field using hand-held GPS tools (e.g. Nomad Juno and Garmin GP-5). Certain atmospheric factors and other sources of error can affect the accuracy of GPS receivers. The Garmin GPS units used for this survey are accurate to within 25 metres on average. Therefore the data points consisting of coordinates retrieved from the GPS may contain inaccuracies.
Timing/weather/season/cycle	Moderate	The field surveys were conducted during spring (1 – 4 November 2016), autumn (3 – 5 May 2017) and winter (11 – 12 July 2017). In the spring survey (August-October), the Gingham weather recording station (No. 009178, BoM 2017) recorded a total of 243.6 mm of rainfall. This total is approximately 10% higher than the long-term average for the same period (August – October: 226.1 mm) (BoM 2017). The weather conditions during the spring field survey included: <ul style="list-style-type: none"> • Daily maximum temperature ranging from 23.8 to 33.2 °C • Daily minimum temperature ranging from 7.9 to 14.0 °C • Daily rainfall 0 mm In the three months prior to the autumn survey (February-April), the Gingham weather recording station (No. 009178, BoM 2017) recorded a total of 165.0 mm of rainfall. This total is significantly higher than the average for this period, which is 65.9 mm (BoM 2017). The weather conditions during the autumn field survey included: <ul style="list-style-type: none"> • Daily maximum temperature ranging from 24.3 – 31.1 °C • Daily minimum temperature ranging from 9.5 – 16.1 °C • Daily rainfall: 0.0-3.0 mm In the three months prior to the winter survey (April-June), the Gingham weather recording station (No. 009178, BoM 2017) recorded a total of 117.8 mm of rainfall. This total is significantly lower than the average for this period, which is 214.5 mm (BoM 2017). The weather conditions during the winter field survey included: <ul style="list-style-type: none"> • Daily maximum temperature ranging from 18.7 – 20.8 °C • Daily minimum temperature ranging from 10.1 – 11.4 °C • Daily rainfall 0 mm

Aspect	Constraint	Comment
Disturbances (e.g. fire, flood, accidental human intervention)	Nil	The weather conditions recorded during the survey periods are considered unlikely to have impacted upon the vegetation and flora survey. The survey timings were considered appropriate for the flora and fauna field survey. Much of the survey area has been subjected to historical disturbance events (e.g. clearing, dumping), however, these disturbances did not impact the survey.
Intensity (in retrospect, adequate)	Nil	The vascular flora of the survey area was sampled in accordance with EPA (2016a) and terrestrial fauna sampled in accordance to EPA (2016b).
Resources	Nil	The survey area was sufficiently covered by GHD zoologists and botanists during the survey. Adequate resources were employed during the field survey. Twenty-five person days were spent undertaking the survey using two zoologists and three botanists.
Access restrictions	Nil	No access problems were encountered during the survey.
Experience levels	Nil	The zoologists and botanists who executed the survey are practitioners suitably qualified and experienced in their respective fields. Glen Gaikhorst (senior zoologist) has over 22 years' experience undertaking fauna surveys within WA. Claudia Perry (zoologist) has 3 years' experience undertaking fauna surveys in WA. Botanists Gaynor Owen, Mat Garinaway and Angela Benkovic all have over 10 years' experience undertaking flora surveys within WA.

3. Desktop assessment

3.1 Climate

The study area is located in the South Western Province of WA and experiences a temperate climate with distinctly dry, hot summers and cool, wet winters.

The BoM Gingin Aero station (site number 009178) is the nearest weather station to the study area with continuous long-term data (19.0 km from the study area). Climatic data from this site indicates the mean maximum temperature of the area ranges from 18.2 °C in July to 33.3 °C in February and the mean minimum temperature ranges from 6.0 °C in July to 17.1 °C in February. The mean annual rainfall is 666.9 mm with an average of 101 rain days per year (BoM 2017). Climate statistics for the region are summarised in Plate 1 (source: Weather Zone 2017)

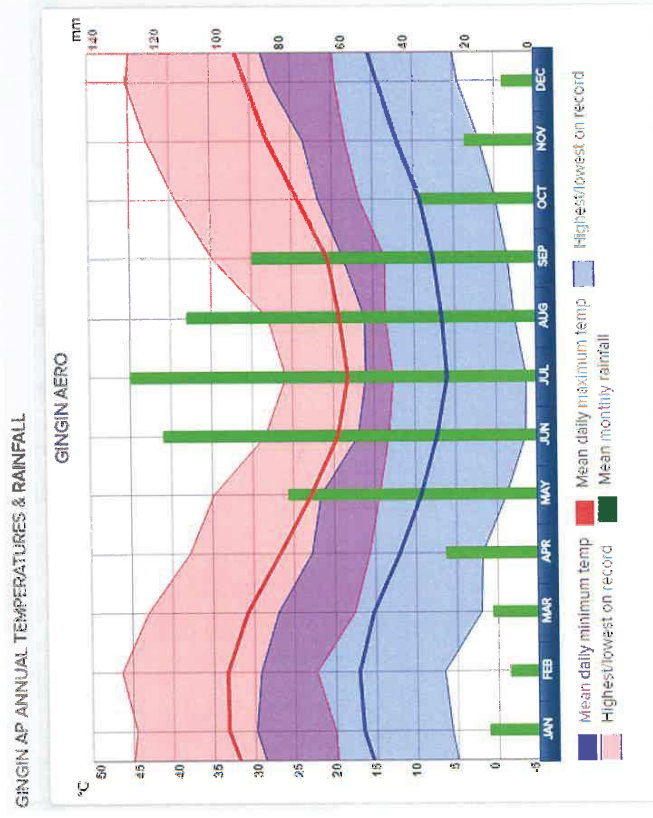


Plate 1 Mean climate statistics for Gingin Aero (Weather zone 2017)

3.2 Regional biogeography

The survey area is situated in the Southwest Botanical Province of WA (Beard 1990) within the SCP (SWA) bioregion and the Perth (SWAZ) subregion as described by the Interim Biogeographic Region of WA (IBRA) (DotEE 2016b).

The SCP bioregion is a low lying coastal plain, mainly covered with woodlands. The Perth subregion is composed of colluvial and aeolian sands, alluvial river flats and coastal limestone. Heath and/or Tuart woodlands occur on limestone. *Banksia* and *Jarrah-Banksia* woodlands on

Quaternary marine dunes of various ages and Marri on colluvial and alluvial soils. The subregion also includes a complex series of seasonal wetlands (Mitchell *et al.* 2002).

3.3 Landform and soils

Soil-landscape mapping of the South West of WA (DAFWA 2007) indicates that the survey area is located on the Quindalup Dunes and Spearwood Dunes landforms. The Quindalup Dunes comprises dunes and ridges generally oriented parallel to the present coast, composed of unconsolidated (calcareous) sands and shell fragments. The Spearwood Dunes lie landward of the Quindalup Dunes and consist of mainly brown and yellow sands of varying depths over limestone (Tamala Limestone). The DAFWA (2007) soil mapping indicates there are six different soil types within the survey area:

- Quindalup South Subsystem
 - Shallow calcareous sands over limestone and much rock outcrop (211Qu_Qs)
 - Calcareous sands with organic staining to about 30 cm, overlying pale brown sand with definite cementation below 1 m (211Qu_Q1)
 - Calcareous sands have organic staining to about 20 cm, passing into pale brown sand, some cementation below 1 m (211Qu_Q2)
 - Calcareous sands showing variable depths of surface darkening (211Qu_Qp)
- Spearwood Subsystem
 - Yellow deep sands (211Sp_Ky)
 - Bare limestone or shallow siliceous or calcareous sand over limestone (211Sp_Kls)

3.4 Hydrology

A search of the Department of Water and Environmental Regulation (DWER) Geographic Data Atlas (DWER 2016) indicates the survey area is within the DWER Swan-Avon Region. A summary of the Geographic Data Atlas queries for the survey area is provided in Table 6.

Table 6 Department of Water and Environmental Regulation Geographic data atlas queries for the project area

Aspect	Details	Result
Groundwater area	Groundwater areas proclaimed under the <i>Rights in Water and Irrigation Act 1914</i> (RIWI Act).	Perth groundwater area
Groundwater subareas	Groundwater subareas proclaimed under the RIWI Act.	Quinns, Eglinton and Yanchep subareas
Surface water areas	Surface water areas proclaimed under the RIWI Act.	None present
Irrigation district	Irrigation Districts proclaimed under the RIWI Act.	None present
Rivers	Rivers proclaimed under the RIWI Act.	None present
Public Drinking Water Source Areas (PDWSA)	PDWSAs is a collective term used for the description of Water Reserves, Catchment Areas and Underground Pollution Control Areas declared (gazetted) under the provisions of the <i>Metropolitan Water Supply, Sewage and Drainage Act 1909</i> or the <i>Country Area Water Supply Act 1947</i> .	Perth Coastal and Gwelup Underground Water Pollution Control Area
Waterway Management Areas	Areas proclaimed under the <i>Waterway Conservation Act 1976</i> .	None present

3.4.1 Watercourses

There are no drainage lines within or adjacent to the survey area.

3.4.2 Wetlands

The EPBC Act PMST did not identify any International significant listed wetland within 10 km of the survey area. However, one nationally important wetland is located within 10 km of the survey area, the Loch McNess System (Yancheep Lake). The Loch McNess System occurs approximately 1.5 km east of the survey area within Yancheep National Park (Figure 2, Appendix A).

The Geomorphic Wetlands SCP dataset (Hill *et al.* 1996) identified nine wetlands within 5 km of the survey area (Table 7). These included five Conservation Category Wetlands (CCW), three Resource Enhancement Wetlands (REW) and one Multiple Use Wetland (MUW).

Table 7 Geomorphic wetlands within study area

Name	Category
Loch McNess	CCW
Yonderup Lake	CCW
Wiggarup Lake	CCW
Pippidimny Swamp	CCW
Nowergup Lake	CCW
Beonaddy Swamp	REW
Coogee Swamp	REW
Carabooda Lake	REW
Mindarie Lake	MUW

3.5 Land use

3.5.1 DBCA managed lands

No DBCA-managed conservation areas are located within the survey area. The closest DBCA managed area is Yancheep National Park (R 9868, Class A) located adjacent (east) to the northern extent of the survey area (Figure 2, Appendix A).

3.5.2 Environmentally Sensitive Areas

The majority of the survey area lies with an Environmentally Sensitive Area (ESA). This ESA likely aligns with the presence of TECs and their buffer zones within the survey area (Figure 2, Appendix A).

3.5.3 Bush Forever

Bush Forever site 289 (Ningana Bushland, Yancheep/ Eglington) intersects the middle of the survey area and Bush Forever site 288 (Yancheep National Park and Adjacent Bushland) intersects the northern extent of the survey area (Figure 2, Appendix A).

3.6 Vegetation and flora

3.6.1 Broad vegetation mapping and extents

Broad scale (1:250,000) pre-European vegetation mapping of the area has been completed by Beard (1979) at an association level. The mapping indicates that two vegetation associations intersect the survey area:

- Low woodland; banksia (association 949)
 - Mosaic: Shrublands; *Acacia lasiocarpa* & *Melaleuca acerosa* [now *M. systera*] heath / Shrublands; *Acacia rostellifera* & *Acacia cyclops* thicket (association 1007).
- Regional vegetation has been mapped by Heddle *et al.* (1980) based on major geomorphic units on the SCP. The Heddle *et al.* (1980) mapping indicates that three vegetation complexes on Aeolian deposits of the SCP are present within the survey area:
- Quindalup complex: Coastal dune complex consisting mainly of two alliances- the strand and fore dune alliance and the mobile and stable dune alliance. Local variations include the low closed forest of *Melaleuca lanceolata* – *Callitris preissii* and the closed scrub of *Acacia rostellifera*.
 - Cottesloe complex – north: Predominantly low open forest and low woodland of *Banksia attenuata* – *B. menziesii* – *Eucalyptus todtiana*; closed heath on the limestone outcrops.
 - Cottesloe complex – central and south: Mosaic of woodland of *Eucalyptus gomphocephala* and open forest of *E. gomphocephala* – *E. marginata* – *Corymbia calophylla*; closed heath on the limestone outcrops.

The pre-European mapping has been adapted and digitised by Shepherd *et al.* (2002). The extent of the vegetation associations have been determined by the state-wide vegetation remaining extent calculations maintained by the DBCA (latest update October 2016 – Government of Australia (GoWA) 2016). As shown in Table 8, the current extents of vegetation associations 949 and 1007 are greater than 46% of their pre-European extents at all levels (State, IBRA bioregion, IBRA subregion and LGA), and are therefore above the 30 per cent threshold level¹.

The Local Biodiversity Program (2013) and GoWA (2017) have assessed the vegetation complexes mapped by Heddle *et al.* (1980) against presumed pre-European extents within the SCP IBRA bioregion (Table 9) and the City of Wanneroo (Table 10) respectively. The Quindalup and Cottesloe – north complexes have greater than 31% of their pre-European extents remaining within the SCP IBRA bioregion and in the City of Wanneroo. The Cottesloe – central and south complex has less than 10% of its pre-European extent remaining within the SCP IBRA bioregion and greater than 41% of its pre-European extent remaining within the City of Wanneroo.

3.6.2 Conservation significant ecological communities

A search of the EPBC Act PMST identified three EPBC Act-listed TECs potentially occurring within the study area. These TECs were also identified in a search of the DBCA TEC/PEC database, however, one is listed as a Priority 3 PEC by DBCA. A further two TECs and seven PECs were identified in the DBCA TEC/PEC database search. Details on all of these communities are provided in Table 11.

¹ The 30 per cent threshold level is the level below which species loss appears to accelerate exponentially at an ecosystem level (ANZECC 2000).

There are nine occurrences of TECs that intersect the survey area at various locations (Figure 2, Appendix A). The majority of the survey area overlays seven occurrences of the Aquatic Root Mat Community in Caves of the SCP (Caves SCP01) TEC. The middle section of the survey area intersects one occurrence of Woodlands over sedgelands in Holocene dune swales of the southern SCP (SCP19b) TEC, and the southern section of the survey area intersects one occurrence of the *Melaleuca huegelii* – *M. acerosa* (*M. systema*) shrublands on limestone ridges (SCP26a) TEC.

Table 8 Extents of vegetation associations mapped with the survey area (GoWA 2016)

Vegetation association	State	Pre-European extent (ha)	Current extent (ha)	Remaining (%)	% Current extent in all DBCA managed lands
SCP IBRA bioregion		1,501,221.93	580,697.31	38.68	37.35
Perth IBRA sub-region		1,117,757.03	467,145.63	41.79	38.06
1007	State WA	30,407.75	20,753.02	68.25	12.07
	IBRA bioregion: SCP (SWA)	30,109.89	20,741.41	68.89	8.32
	IBRA sub-region: Perth (SWA2)	30,109.89	20,741.41	68.89	8.32
	LGA: City of Wanneroo	8,058.91	4,865.20	60.37	1.93
949	State WA	215,193.94	123,036.57	56.39	24.42
	IBRA bioregion: SCP (SWA)	209,993.26	120,178.91	57.23	13.91
	IBRA sub-region: Perth (SWA2)	184,475.82	104,034.41	56.39	14.88
	LGA: City of Wanneroo	37,438.40	17,092.80	45.02	18.57

Table 9 Extents of vegetation complexes on the SCP mapped within the survey area (Heddie *et al.* 1980, Local Biodiversity Program 2013)

Vegetation complex	Pre-European extent (ha)	2013 extent (ha)	% of pre-European extent	% of pre-European extent with formal protection
Quindalup complex	38,503.00	21,322.64	55.38	14.40
Cottesloe complex - north	21,386.63	14,869.63	31.74	28.60
Cottesloe complex - central and south	49,786.04	11,905.85	9.07	4.69

Table 10 Extents of vegetation complexes within in City of Wanneroo mapped within the survey area (GoWA 2017)

Vegetation complex	Pre-European extent (ha)	Current extent (ha)	% of pre-European extent	Proportion of the vegetation complex within the LGA %
Quindalup complex	8,818	5,368.14	60.88	16.16
Cottesloe complex - north	8,715	5,955.20	68.33	20.05
Cottesloe complex - central and south	13,313	5,556.62	41.74	29.39

Table 11 Threatened and Priority Ecological Communities Identified in the desktop searches

Community Type	EPBC Act	DBCA	Description	Location
Aquatic Root Mat Community in Caves of the SCP (TEC) (Caves SCP21)	Endangered	Critically Endangered	At Yanchep and on the Leuwin Naturaliste Ridge, permanent streams and pools occur in caves and some support dense growths of root mats (from living Tuart trees). The root mats provide a constant and abundant primary food source for some of the richest aquatic cave communities known. Caves containing the aquatic root mat community at Yanchep occur where sandy soils underlie limestone karriks. The root mats are supported by the organic pools and streams. The community occurs in linear damplands and occasionally swamps, between Holocene dunes. Typical and common native species are the shrubs <i>Acacia rostellifera</i> , <i>A. saligna</i> , <i>Xanthorrhoea preissii</i> , the sedges <i>Baumea juncea</i> , <i>Ficinia nodosa</i> , <i>Lepidosperma glandatum</i> , and the grass <i>Poa corryvreckensis</i> . Several exotic weeds are found in this community but generally at low cover values. Two sub-groups identified: <ul style="list-style-type: none"> Community type 13a is termed 'sedgelands in Holocene dune swales' and generally occurs in the younger swales. Community type 13b is termed 'woodlands over sedgelands in Holocene dune swales' and tends to occur in older swales. This subgroup has an overstorey of woodlands including <i>Eucalyptus gomphocephala</i>, <i>Melaleuca mitchelliana</i> and <i>Banksia littoralis</i>. 	Intersects the majority of the survey area
Sedgelands in Holocene dune swales of the southern SCP (TEC) (SCP19)	Endangered	Critically Endangered	Species rich thickets, heaths or scrubs dominated by <i>Melaleuca huegelii</i> , <i>M. systena</i> (previously <i>M. acerosa</i>), <i>Banksia sessilis</i> or <i>Allocasuarina preissii</i> , <i>Acacia rostellifera</i> , <i>Opuntia</i> spp. and <i>Phyllanthus</i> spp. occur on the limestone ridges. Broadly occurs on the southern limestone ridges. A distinctive feature of the particular clay pan wetlands that comprise the ecological community 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 SCP wetlands.	Intersects the southern section of the survey area
<i>Melaleuca huegelii</i> - <i>M. acerosa</i> (<i>M. systena</i>) shrublands on limestone ridges (TEC) (SCP26a)	Endangered	Endangered	Occurs approximately 9 km east of the survey area	
Shrublands on dry clay flats (TEC) (10a)	Critically Endangered	Endangered		

Community type	EPBC Act	DBC-A	Description	Location
SCP <i>Banksia attenuata</i> - <i>B. menziesii</i> woodlands (PEC) (SCP23b)	Endangered TEC (part)	Priority 3	(A component of the Endangered Banksia Woodlands of the SCP EPBC listed TEC) Endangered TEC (part) These woodlands occur in the Bassendean system, from Melaleuca Park to Groggin. Occurs in reasonably extensive Banksia woodlands north of Perth.	Occurs approximately 7 km east of the survey area
<i>Banksia ilicifolia</i> woodlands (PEC) (SCP22)	Endangered TEC (part)	Priority 3	(A component of the Endangered Banksia Woodlands of the SCP EPBC listed TEC) Endangered TEC (part) Low lying sites generally consisting of <i>Banksia ilicifolia</i> - <i>B. attenuata</i> woodlands, but <i>Melaleuca praesertina</i> woodlands and scrubs are also recorded. Occurs on Bassendean and Spearwood systems in the central SCP north of Rockingham. Typically has very open understorey, and sites are likely to be seasonally waterlogged.	Occurs approximately 7 km east of the survey area
Quindalup <i>Eucalyptus gomphocephala</i> and/or <i>Agonis flexuosa</i> woodlands (PEC) (SCP30b)		Priority 3	This community is dominated by either <i>Eucalyptus gomphocephala</i> or <i>Agonis flexuosa</i> . The presence of <i>Hibbertia cuneiformis</i> , <i>Geranium renersum</i> and <i>Dichondra repens</i> differentiate this group from other Quindalup community types. The type is found from the Leschenault Peninsula south to Busselton.	Occurs approximately 2 km east of the survey area
Southern <i>Eucalyptus scopulorum</i> and/or <i>Agonis flexuosa</i> woodlands (PEC) (SCP25)	Endangered TEC (part)	Priority 3	Can be a component of the Endangered Banksia Woodlands of the SCP EPBC listed TEC. Occurs in the Bassendean system south of Woodman Point. Recorded from the Karakatta, Coffees and Vasse units. Dominants other than tuart were occasionally recorded, including <i>Corymbia calophylla</i> at Paganoni block and <i>Eucalyptus decipiens</i> at Kemerton, however tuarts are emergent nearby. Banksias found in this community include <i>Banksia attenuata</i> , <i>B. grandis</i> and <i>B. littoralis</i> . However, Tuart formed the overstorey nearby.	Occurs approximately 7 km north of the survey area
Northern Spearwood shrublands and woodlands (PEC) (SCP24)	Endangered TEC (part)	Priority 3	(Can be a component of the Endangered Banksia Woodlands of the SCP EPBC listed TEC) Endangered TEC (part) Heaths with scattered <i>Eucalyptus gomphocephala</i> occurring on deeper soils north from Woodman Point. Most sites occur on the Cottlesloe unit of the Spearwood system. The heathlands in this group typically include <i>Dryandra sessilis</i> (now <i>Banksia sessilis</i>), <i>Calothamnus quadrifidus</i> , and <i>Chloeris granitiorius</i> .	Occurs approximately 2 km south east of the survey area
<i>Acacia</i> shrublands on taller dunes (PEC) (SCP29b)		Priority 3	Community is dominated by <i>Acacia</i> shrublands or mixed heaths on the higher dunes. Any sites from Sealup to south of Mandurah. No consistent overstorey but scattered <i>Acacia</i> species, <i>rostellifera</i> , <i>Acacia lasocarpa</i> , and <i>Melaleuca eucrocea</i> (now <i>M. systena</i>) were important.	Occurs approximately 7 km north and 7 km south of the survey area

Community Type	EPBC Act	DBCA ¹	Description	Location
Coastal shrublands on shallow sands (PEC), SCP29a)		Priority 3	Mostly heaths on shallow sands over limestone close to the coast. No single dominant but important species include <i>Spyridium globulosum</i> , <i>Rhagodia baccata</i> , and <i>Cleora axillaris</i>	Occurs approximately 8 km south of the survey area
Banksia woodlands of the SCP (TEC) Banksia dominated woodlands of the SCP IBRA region (PEC)	Endangered	Priority 3	The ecological community is a woodland associated with the SCP of southwest WA. A key diagnostic feature is a prominent tree layer of <i>Banksia</i> with scattered eucalypts and other tree species often present among or emerging above the <i>Banksia</i> canopy. The understorey is a species rich mix of sclerophyllous shrubs, graminoids and forbs. The ecological community is characterised by a high endemism and considerable localised variation in species composition across its range.	Community considered likely to occur within the study area

3.6.3 Flora diversity

The *NatureMap* database search identified 957 plant taxa, representing 134 families that have been recorded within the study area. This total comprises 789 native flora taxa and 168 introduced flora taxa. Dominant families recorded within the study area include Fabaceae (86 taxa), Myrtaceae (70 taxa) and Asteraceae (67 taxa). The *NatureMap* database search is provided in Appendix C.

3.6.4 Conservation significant flora

Desktop searches of the EPBC Act PMST database, *NatureMap* database, DBCA TPFL and WAHERB databases identified the presence/potential presence of 49 conservation significant flora taxa within the study area. The desktop searches recorded:

- Eight taxa listed under the EPBC Act and/or as Threatened under the WC Act
- Six Priority 1 taxa
- Seven Priority 2 taxa
- Seventeen Priority 3 taxa
- Eleven Priority 4 taxa

The locations of conservation significant flora registered on the DBCA databases are mapped in Figure 2, Appendix A.

3.7 Fauna

3.7.1 Fauna diversity

The *NatureMap* database search identified 602 fauna species previously recorded within the study area. This total included 209 birds, 61 reptiles, nine amphibians and 43 mammals. The remainder of species are marine fish and invertebrates and were not considered as part of this survey (except for conservation-listed invertebrates that were recorded opportunistically).

3.7.2 Conservation significant fauna

The EPBC Act PMST and *NatureMap* database identified the presence, or potential presence of 21 conservation significant fauna species, excluding marine or migratory/marine as no marine habitat was present within the survey. In addition to the 21 species identified by the database searches, 12 additional species were considered for this assessment as a result of a review of the species listed under Schedules 1–4 of the WC Act (revised February 2017).

3.8 Previous survey results

Two previously field survey have been completed in November 2010 (GHD 2011) and October 2012 (GHD 2012), to identify the environmental values of a similar alignment to the current survey area.

Vegetation and flora

The previous surveys did not identify any TECs or PECs within the survey area. Additionally no Threatened flora were located, although three Priority flora were recorded; *Conostylis pauciflora* subsp. *euryrhipis* (P4), *C. pauciflora* subsp. *pauciflora* (P4) and *Beyeria cinerea* subsp. *cinerea* (P3). The surveys recorded 193 plant taxa, comprising of 153 natives and 40 introduced species.

Fauna

The previous surveys for a similar alignment identified 35 vertebrate fauna species including 25 birds, six reptile and four mammal species in the survey area. Of these, four species were introduced including the Laughing Kookaburra, Red Fox, Cat and European Rabbit.

Three species of conservation significance were recorded in 2012 including Carnaby's Black Cockatoo, Graceful Sunmoth and a ground cricket (*Pachysaga murggai* or *strobila*). Carnaby's Black Cockatoo is listed as Endangered under the EPBC Act and WC Act. The Graceful Sunmoth is list Priority 4 under DBCA. The ground cricket could not be identified to species level and was either *P. murggai* or *P. strobila*, which are listed as P3 or P1 respectively.

4. Field survey results

4.1 Vegetation and flora

4.1.1 Vegetation types

Thirteen vegetation types were identified and described for the survey area (Table 12 and Figure 3, Appendix A). Eleven of the vegetation types comprised remnant native vegetation. The remaining two vegetation types were dominated by planted taxa and scattered native species.




The vegetation types were distributed in a mosaic like pattern along the survey area as the soil landscapes and dune landforms changed. *Banksia sessilis* and *Spyridium globulosum* tall shrubland (VT03) was the dominant vegetation type within the survey area (21.97 ha) occurring in patches along the entire alignment. *Eucalyptus* sp. and *Agonis flexuosa* woodland (VT07) and *Eucalyptus decipiens* woodland (VT11) were the most restricted vegetation types within the survey area, occupying 0.30 ha and 0.26 ha respectively.




Areas identified as cleared are devoid of native vegetation. These areas primarily occur within newly established housing estates and infrastructure corridors.




A floristic analysis was used to compare the GHD quadrats to existing data (where available) for FCTs described and surveyed by Gibson *et al.* (1994) on uplands centred on Spearwood and Quindalup Dunes. The cluster analysis and resulting dendrogram showed a clear separation of quadrats from FCTs s14, 22 and 23b; other FCTs had quadrats on multiple clades. The GHD quadrats clustered on one clade separate to all other FCT quadrats (Appendix D). This preliminary analysis indicates that, statistically, the vegetation recorded in the GHD quadrats does not have strong affinities to any TECs or PECs known from the area.




A MDS scatter plot was also produced and largely reflected the dendrogram. FCT s14, 22 and 23b showed the most discrete grouping. However, the scatter plot illustrates some GHD quadrats having affinities to FCTs 24, 25, 26a and 28 (Appendix D). The statistical outputs indicate partial statistical alignment between the GHD vegetation types and the previously described Gibson *et al.* (1994) FCTs based on taxa present or absence. However, limitations with the data analysis include no consideration of dominant taxa within each vegetation type.



Table 12 Recorded vegetation types

Vegetation type	Vegetation Type Description	Landform and Substrate	Extent (ha)	Vegetation Association/FCT alignment & quadrat reference	Photograph
<i>Acacia saligna</i> and <i>Xanthorrhoea preissii</i> tall shrubland (VT01)	<i>Acacia saligna</i> , <i>Xanthorrhoea preissii</i> tall shrubland over mixed introduced sparse herbland/grassland	Slopes of dunes with brown sandy soils	11.46 ha	Quadrat: 1, 826	
<i>Banksia sessilis</i> and <i>Banksia spinulosa</i> shrubland (VT02)	<i>Banksia sessilis</i> , <i>Meibomia stricta</i> , <i>Cochlospermum quadrifidus</i> , <i>Hakea issorcarpha</i> midshrubland over <i>Hitzleria hypericoides</i> low open shrubland over mixed sparse herbland	Slopes of dunes with yellow sandy soils	3.98 ha	FCT 24 (PEC) Quadrats 2, 20 & 23	
<i>Banksia sessilis</i> and <i>Spyritium globulosum</i> tall shrubland (VT03)	<i>Banksia sessilis</i> , <i>Spyritium globulosum</i> tall shrubland over <i>Calcharrimus quadrifidus</i> , <i>Meibomia systena</i> low shrubland over open sedgeland <i>Mesomelaena pauciflora</i> , <i>Desmodium flexuosum</i>	Dune swales with brown sandy soils	21.97 ha	FCT 24 (PEC) Quadrats 3, 13 & 16	

Vegetation type	Vegetation Type Description	Landform and Substrate	Extent (ha)	Vegetation Association/CT alignment & quadrat	Photograph
<i>Banksia attenuata</i> , <i>B. menziesii</i> low woodland (VT04)	<i>Banksia attenuata</i> , <i>B. menziesii</i> low woodland over shrubland <i>Calothamnus quadrifidus</i> , <i>Halimolobos</i> , <i>Xanthorrhoea preissii</i> over sparse sedge/land, <i>Mesomelaena pseudostylgia</i> , <i>Desmocladius flexuosus</i> .	Undulating plain with brown-yellow sandy soils.	19.34 ha	Association 045 Banksia woodlands TEC/ woodlands PEC Quadrats: 4, 18, 19, 22, 29	
<i>Lomandra</i> sp. herbland (VT05)	<i>Melaleuca systena</i> , <i>Hibbertia hypericoides</i> isolated shrubs over <i>Lomandra</i> sp., <i>Carosyllis candidensis</i> , <i>Kenmedia prostrata</i> herbland.	Dunes ridges with white to brown sandy soils.	7.42 ha	Quadrats 5, 9 & 12	
<i>Eucalyptus gomphocephala</i> tall woodland (VT06)	<i>Eucalyptus gomphocephala</i> tall woodland over <i>Spyridium globulosum</i> tall sparse shrubland	Slopes of dunes with brown sandy soils.	3.11 ha	Quadrats 6, 25 & 27	

Vegetation type	Vegetation Type Description	Landform and Substrate	Extent (ha)	Vegetation Association/FCT alignment & quadrat reference	Photograph
<i>Eucalyptus</i> sp. <i>Aprais flexuosa</i> woodland (VT07)	<i>Eucalyptus</i> sp. <i>Aprais flexuosa</i> woodland over <i>Sporycium globulosum</i> sparse shrubland.	Slopes of dunes with brown, sandy soils.	0.30 ha	Quadrat: 7	
<i>Melealeuca huegelii</i> and <i>M. systena</i> sparse herbland <i>Peroboloborgia campochiana</i> shrubland (VT08)	<i>Melealeuca huegelii</i> , <i>M. systena</i> <i>Cheelea pressii</i> shrubland over sparse herbland <i>Peroboloborgia campochiana</i>	Upper slopes and ridge of dunes with brown, sandy soils and numerous limestone outcroppings.	0.69 ha	FCT 26a (TEC) Quadrats 6, 21 & 24	
<i>Banksia attenuata</i> woodland (VT09)	<i>Banksia attenuata</i> low woodland over <i>Melealeuca systena</i> , <i>Spyridium globulosum</i> , <i>Xanthorrhoea pressii</i> shrubland over sparse mixed sedgeland.	Undulating plain and dune swales with brown sandy soils.	7.73 ha	Association 949 <i>Banksia</i> woodland TEC/ <i>Banksia</i> dominated woodland PEC Quadrats 11, 14 & 15	

Vegetation type	Vegetation Type Description	Landform and Substrate	Extent (ha)	Vegetation Association/CT alignment & quadrat reference	Photograph
Xanthorrhoea premissa shrubland (VT10)	Xanthorrhoea premissa tall shrubland over Jacksonia calycina, Hakea prostrata, Banksia dallanneyi low open shrubland over Lomandra sp., Conostylis spp. open herbland	Slopes of dunes with brown sandy soils.	1.74 ha	Quadrat 13 & 28	
Eucalyptus decipiens woodland (VT11)	Eucalyptus decipiens woodland over Banksia sessilis, Hibbertia hypericoides, Xanthorrhoea premissa shrubland over Conostylis pseudostylis, Dacrydium flexuosum sparse herbland	Undulating plain with brown sandy soils	0.26 ha	Quadrat: 17	
Planted (VT12)	Areas with planted shrubs and trees of both native and introduced species. Understorey is generally comprised of introduced herbs and grasses.	Undulating plain and dunes slopes with sandy soils	8.53 ha	-	

Vegetation type	Vegetation Type Description	Landform and Substrate	Extent (ha)	Vegetation Association/CT	Photograph
Scattered Natives (VT13)	Areas with isolated native shrubs. Primary grasses and introduced grasses and herbs.	Undulating plain and dunes slopes with sandy soils	12.38 ha	-	
Cleared	Areas devoid of native vegetation that have been cleared for housing and infrastructure.	-	12.32 ha	-	

4.1.2 Vegetation condition

The vegetation condition within the survey area was rated as Pristine to Completely Degraded in condition. The extents of the vegetation condition ratings mapped within the survey area are detailed in Table 13 and mapped in Figure 4, Appendix A.

The small area rated as Pristine comprised vegetation within the centre of the survey area that was a very thick *Banksia sessilis* community, the thickness of the vegetation inhibits the growth of weeds and reduced the presence of motorcycle tracks. Much of the survey area was rated as Excellent to Very Good in condition with the vegetation structure largely intact and some herbaceous and grassy weeds present (37.17% of the survey area). The survey area is intersected by a large number of tracks that are utilised by the local residents resulting in some areas affected by soil erosion and becoming infested with weeds. The Degraded and Completely Degraded areas have been historically cleared or impacted by grazing and are dominated by introduced species. The cleared areas are devoid of native vegetation and are associated with cleared areas for housing and infrastructure (9.45% of the survey area).

Table 13 Extent of vegetation condition ratings mapped within the survey area

Vegetation Condition	Extent in survey area (ha)
Pristine	1.30
Excellent	19.95
Very Good	20.65
Very Good - Good	1.00
Good	17.90
Good - Degraded	1.42
Degraded	14.84
Completely Degraded	21.85
Not rated – cleared	10.32
Total	109.23 ha

4.1.3 Conservation significant ecological communities

The statistical analysis identified the possible presence of two conservation significant ecological communities within the survey area:

- Southern *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands (25) Priority 3 PEC²
 - Northern Spearwood shrublands and woodlands (24) Priority 3 PEC².
- Additionally, assessing the vegetation types described at a broad level, based on dominant species, landform features and field observations a further three conservation significant ecological communities were identified as likely to occur within the survey area:
- *Melaleuca huegelii* – *M. acerosa* [*M. systema*] shrublands on limestone ridges (26a) Endangered TEC
 - *Banksia* dominated woodlands of the SCP IBRA region PEC²
 - *Banksia* Woodlands of the SCP TEC.

² Community is also recognised as part of the *Banksia* Woodlands of the Swan Coastal Plain TEC, which is listed as Endangered under the EPBC Act.

Statistically some GHD quadrats showed affinity to FCT 25. Statistics and field observations aligned the quadrats of GHD VT02 and VT03 to FCT 24. Field observations also found GHD VT08 aligned closely with 26a and GHD VT04 and VT09 aligned with the *Banksia* dominated woodlands of the SCP IBRA region PEC. A number of areas of GHD VT04 and VT09 also met the key diagnostic characteristics of the Banksia Woodlands of the SCP TEC. A description of each conservation significant ecological community and its possible occurrence within the survey area is described below.

Southern *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands PEC

The Southern *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands (SCP 25) PEC is generally found south of Woodman Point. The community is characterised by *Eucalyptus gomphocephala* (Tuart), with other dominants, occasionally records include *Corymbia calophylla* and *E. decipiens*. Other common species are *Agonis flexuosa*, *Hibbertia hypericoides*, *Maczamia riedlei*, *Acacia willdenowiana* and *Hardenbergia comptoniana*. One occurrence of this PEC was recorded approximately 7 km north of the survey area (DBCA TEC/PEC database).

The flora assessment conducted by GHD recorded *Eucalyptus gomphocephala* and *Agonis flexuosa* dominated communities (VT06 and VT07 respectively) within the survey area. However, the GHD quadrats that represented these communities did not align statistically with SCP 25, nor do the vegetation types contain most/all the key indicator species present in this PEC. The GHD quadrats that clustered more closely with SCP 25 were identified as *Banksia* spp. dominated woodland communities. The Southern *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands PEC is recognised as a component of the Banksia Woodlands of the SCP EPBC Act listed TEC (where a *Banksia* canopy is present), and this may explain the statistical results.

It is considered that Southern *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands PEC is unlikely to occur within the survey area.

Northern Spearwood shrublands and woodlands PEC

The Northern Spearwood shrublands and woodlands (24) PEC occurs as heaths or heaths with scattered *Eucalyptus gomphocephala* occurring on deeper soils north from Woodman Point. *Banksias* found in this community include *Banksia attenuata* and *B. menziesii*. The heathlands in this group typically include *Dryandra sessilis* (now *Banksia sessilis*), *Calothamnus quadrifidus* and *Schoenus grandiflorus*, with other common species including *Hardenbergia comptoniana*, *Melaleuca acerosa* and *Xanthorrhoea preissii*.

The GHD vegetation types that were statistically representative of the Northern Spearwood shrublands and woodlands PEC were VT02 and VT03. Field observations also confirmed the similarities. The key characteristics of Northern Spearwood shrublands and woodlands PEC met by VT02 and VT03, were:

- Occurs on the western SCP on the Cottesloe units of the Spearwood system
- The vegetation types includes occurrences of *Banksia attenuata* and *B. menziesii*
- The heath community may consist of *Banksia sessilis*, *Calothamnus quadrifidus*, *Melaleuca systena*, *Xanthorrhoea preissii*, *Lepidosperma squamatum*, *Hardenbergia comptoniana*, *Phyllanthus calycinus*, *Conostylis aculeata*, *Dianella revoluta*, *Lomandra maritima*, *Schoenus grandiflorus*, *Desmodium flexuosa* and *Austrostipa flavescens*

It is considered the Northern Spearwood shrublands and woodlands PEC is likely to occur within the survey area and is aligned with GHD VT02 (3.98 ha) and VT03 (21.97 ha). A

breakdown of the PEC areas within the survey area is detailed in Table 14 with the PEC extent mapped in Figure 5, Appendix A.

Table 14 Extent of Northern Spearwood shrublands and woodlands PEC within the survey area

Vegetation type	Vegetation condition	Extent (ha)
VT02	Excellent	3.10
	Very Good	0.31
	Good	0.57
	Pristine	1.30
VT03	Excellent	6.88
	Very Good	4.24
	Very Good - Good	1.00
	Good	4.56
	Good - Degraded	0.67
	Degraded	3.11
	Completely Degraded	0.21
Total		25.95

Banksia Woodlands of the SCP TEC

The Banksia Woodlands of the SCP TEC is restricted to the SCP IBRA bioregion and immediately adjacent areas, including the Dandaragan Plateau, from Jurien Bay in the north, to Dunsborough in the south, and northwest on the Whicher and Darling escarpments (DotEE 2016c). The ecological community typically occurs on well drained, low nutrient soils on sandplain landforms, particularly deep Bassendean and Spearwood sands and occasionally on Quindalup sands (DotEE 2016c).

During the field survey two vegetation types were assessed as meeting the key diagnostic characteristics for the Banksia Woodlands of the SCP TEC, as outlined in DotEE (2016c). Specifically:

- The survey area occurs in the SCP IBRA bioregion
 - The survey area occurs on sandplain landform, notably Spearwood and Quindalup sands
 - The vegetation types have a low woodland structure and the upper sclerophyllous layer is dominated or co-dominated by *Banksia attenuata* and/or *B. menziesii*. The understorey consists of a mid-ground sclerophyllous shrub layer and/or a herbaceous ground layer of cord rushes, sedges and perennial and ephemeral forbs that sometimes includes grasses
- Furthermore, the mapped areas meet the minimum condition and patch size criteria outlined by DotEE (2016c) necessary to be considered as part of the TEC. A breakdown of the TEC areas within the survey area is detailed in Table 15 with the TEC extent mapped in Figure 5, Appendix A.

Table 15 Extent of Banksia Woodlands of the SCP TEC within the survey area

Condition rating	Minimum patch size	Vegetation type and extent
Excellent	0.5 ha	VT04: 5.59 ha
Very Good	1 ha	VT04: 5.59 ha VT09: 6.39 ha
Good	2 ha	VT04: 4.88 ha VT09: 0.39 ha
Total		22.84 ha

***Banksia* dominated woodlands of the SCP IBRA region PEC**

The field assessment also confirmed the presence of the Banksia dominated woodlands of the SCP IBRA region PEC, listed as Priority 3 by DBCA. This PEC differs from the TEC in that it has no minimum condition and patch size thresholds. There is 27.07 ha of the PEC present within the survey area (this total includes 22.84 ha which also aligns with the Banksia Woodlands of the SCP TEC). A breakdown of the PEC is detailed in Table 16 with the TEC extent mapped in Figure 5, Appendix A.

Table 16 Extent of Banksia dominated woodlands of the SCP IBRA region PEC within the survey area

Vegetation type	Vegetation condition	Extent (ha)
VT04	Excellent	5.59
	Very Good	5.59
	Good	4.88
	Degraded	3.09
VT09	Completely Degraded	0.19
	Very Good	6.39
	Good	0.39
	Degraded	0.86
Total	Completely Degraded	0.08
		27.07

Melaleuca huegeli-Melaleuca systema shrublands of limestone ridges TEC

The *Melaleuca huegeli-Melaleuca systema* shrublands of limestone ridges TEC occurs on skeletal soils on ridge slopes and ridge tops with limestone outcropping. The community is described as comprising of species rich thickets, heaths or scrubs dominated by *Melaleuca huegeli*, *M. systema*, *Banksia sessilis* over *Grevillea preissii*, *Acacia lasiocarpa* and *Spyridium globulosum* (community 26a as described by Gibson *et al.* 1994). The community is highly restricted and known from massive limestone ridges around Yanchep north of Perth, and south of Perth near Lake Clifton.

Field observations inferred GHD VT08 may align with TEC 26a, but the multiple site analysis was inconclusive. Therefore, a SSI analysis using quadrats represented by VT08 (Q08, Q21 and Q24) was performed. Three two-dimensional MDS scatter plots were produced and are provided in Appendix D. The statistical outputs indicate the following:

- Q08 – showed affinities to FCTs 24, 26a and 29
- Q21 – showed affinities to FCTs 24, 26a, 26b and 27
- Q24 – showed affinities to FCTs 26a and 29b

Each quadrat represented by GHD VT08 showed affinities with variable FCTs. However, all showed affinities to FCT 26a.

GHD VT08 is inferred to align with *Melaleuca huegelii-Melaleuca systena* shrublands of limestone ridges TEC based on landform, vegetation structure and species composition. The vegetation type contained many of the key species outlined in the community description (e.g. *Melaleuca huegelii*, *M. systena* and *Grevillea praeisii*) and generally was in Very Good to Excellent condition. There is 0.69 ha of this TEC present within the survey area, restricted to three small patches within the survey area. A breakdown of the TEC is detailed in Table 17 with the TEC extent mapped in (Figure 5, Appendix A).

Table 17 Extent of *Melaleuca huegelii-Melaleuca systena* shrublands of limestone ridges TEC within the survey area

Vegetation-type	Vegetation condition	Extent (ha)
VT08	Excellent	0.61
	Very Good	0.08
Total		0.69

4.1.4 Other significant vegetation

Tuart is endemic to the SCP extending from Jurien Bay to Busselton and being largely confined to the Quindalup and Spearwood Dune systems (GoWA 2000). It is estimated prior to European settlement that Tuart woodlands covered more than 11,600 ha. However, recent estimations indicate that only 35 per cent remains with large amounts cleared for agricultural and urban development (GoWA 2000).

Although the VT06 could not be confidently aligned with the Southern *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands PEC, it represents 'other significant vegetation' as the community has a restricted distribution, large degree of historical impact from threatening processes and may represent a refuge for native fauna. Therefore any Tuart trees within the survey area should be avoided and retained where possible.

4.1.5 Flora diversity

Two hundred and ten (210) flora taxa (including subspecies and varieties) representing 53 families and 141 genera were recorded from the survey area during the field survey. This total comprised of 156 native taxa, 54 introduced flora taxa.

Dominant families recorded from the survey area included:

- Fabaceae (23 taxa)
- Poaceae (22 taxa)
- Proteaceae (18 taxa).

The number of native species typically recorded in 100 m² within the Quindalup and Spearwood Dune systems ranges from 9-35 and 37-55 respectively (GoWA 2000). Based on described quadrats, species diversity ranged from 12 to 57 (average 34) taxa per 100 m². The survey area is considered representative of the floristic diversity in the area. The highest floristic diversity was recorded in VT02.

4.1.6 Conservation significant flora

No EPBC Act or WC Act listed flora were recorded within the survey area, however, one DBCA Priority-listed flora species was recorded within the survey area during the field survey,

Hibbertia spicata subsp. *leptotheca* (P3). The species is described as an erect or spreading shrub, approximately 0.2-0.5 m high with yellow flowers. *Hibbertia spicata* subsp. *leptotheca* is recorded in the SCP IBRA bioregion where it grows near coastal limestone ridges, outcrops and cliffs (WA Herbarium 1998—).

Hibbertia spicata subsp. *leptotheca* was recorded in quadrat 8, VT08 – *Melaleuca huegelii* and *M. systena* shrubland. Within this quadrat one plant was recorded (Figure 5, Appendix A).

Likelihood of occurrence

A likelihood of occurrence assessment was conducted post-field survey for all conservation significant flora taxa identified in the desktop assessment (Appendix D). This assessment took into account previous records, habitat requirements, efficacy of the survey, intensity of the survey, flowering times and the cryptic nature of species.

The likelihood of occurrence assessment post-field survey concluded that one taxon is known to occur (*Hibbertia spicata* subsp. *leptotheca*), three taxa are likely to occur, 13 taxa may possibly occur and the remaining 32 taxa are unlikely or highly unlikely to occur within the survey area. The three taxa likely to occur have previously been recorded within the study area and the field survey was undertaken outside their reported flowering periods.

4.1.7 Introduced flora

Fifty-four (54) introduced flora taxa were recorded in the survey area. Of the introduced taxa, three are listed as Declared Pests under the *Biosecurity and Management Act 2007* and/or as a WONS:

- **Gomphocarpus fruticosus* (Narrowleaf Cottonbush) – Declared Pest
- **Solanum linnaeanum* (Apple of Sodom) – Declared Pest
- **Lantana camara* (Common Lantana) – Declared Pest and WONS.

The remaining introduced taxa are considered environmental weeds and all have been previously recorded on the SCP. The locations of **Gomphocarpus fruticosus*, **Solanum linnaeanum* and **Lantana camara* within the survey area are mapped in Figure 4, Appendix A.

4.2 Fauna

4.2.1 Fauna habitats

The survey identified seven fauna habitat types within the survey area. These habitat types are closely aligned to the vegetation types described in Section 4.1.1 and are presented below in Table 18. They consist of:

- Eucalyptus woodland
- *Banksia sessilis* over low mixed shrubland
- Mixed *Banksia* woodland
- Mixed tall shrubland
- Lomandra herb lands on secondary dunes
- Limestone ridge lines
- Planted Eucalypt woodland
- Highly disturbed.




4.2.2 Fauna habitat connectivity and disturbance




The survey area is a mosaic of intact remnant and previously disturbed areas. Much of the region is designated for residential development and many areas show evidence of clearing since the 2012 surveys. Although bisected by roads and residential suburbs connectivity is currently present north and south via a thin strip of natural vegetation. Parts of the survey area have been affected by varying degrees of disturbance. Dumping was present throughout the majority of the survey area in particular adjacent to tracks and roads which are easily accessible to the public. Weeds were also present throughout the majority of the survey area in varying degrees. Weed species increased adjacent to tracks and roads due to edge effects.

4.2.3 Habitat quality

The fauna habitat value is largely high with several areas of medium quality, however the overall habitat value is considered to be high.

Table 18 Fauna habitat types within survey area

Habitat type	Indicative photograph
<p>Eucalypts woodland 3.11 ha</p> <p>This habitat incorporates vegetation types VT06</p> <p>This habitat type is dominated by Tuart with a mixed under story of shrubs and weed understorey. The vegetation varies slightly in species composition and density throughout the survey area depending on the amount of disturbance but is always dominated by Tuart. This habitat had deep sandy soils with litter and woody debris associated to Tuarts and shrub layers. Some of the woody debris areas were very thick able to provide refuge areas for ground dwelling mammals and reptiles. Few large logs were present in this habitat which is likely an artefact of historical fire activity, although little fire activity was recorded during the survey. This woodland provides excellent cover for small bush birds and mammals with numerous aerial species recorded in this habitat type.</p> <p>Conservation significant species:</p> <p>One species of conservation significance was recorded in this habitat type, Carnaby's Black Cockatoo (<i>Calyptrornis albosus</i>). The Carnaby's Black Cockatoo was recorded resting in the habitat type however is likely to also utilise it for roosting. The Western Brush Wallaby (<i>Macropus irma</i>) (resident), Southern Brown Bandicoot (<i>Isodon obesulus/obesiventer</i>) (resident), Peregrine Falcon (<i>Falco peregrinus</i>) (foraging) and Chuditch (<i>Dasyurus geoffroyi</i>) (foraging) may all opportunistically use this habitat.</p> <p>Habitat Value - High</p>	 
<p>Banksia sessilis over low mixed shrubland 25.95 ha.</p> <p>This habitat incorporates vegetation types VT02, VT03.</p> <p>This habitat type is dominated by <i>Banksia sessilis</i> with sparse <i>Acacia</i>, <i>Hakea</i>, <i>Xanthorrhoea</i> and <i>Olearia</i> species over a low, native shrubland and weed understorey. The vegetation varies slightly in species composition throughout the survey area but it always dominated by <i>Banksia sessilis</i>. This habitat often had either heavy loam soils with limestone incursion or limestone capping. Some areas of limestone were extensive and may provide hide areas for fauna species. In some areas the limestone formed pinacles amongst the vegetation. This shrubland provides excellent cover for small bush birds and mammals with numerous aerial species recorded in this habitat type.</p>	

Habitat type	Indicative photograph
<p>Conservation significant species:</p> <p>One species of conservation significance was recorded in this habitat type, Carnaby's Black Cockatoo. The Carnaby's Black Cockatoo was recorded feeding in the habitat type throughout the survey area. The Western Brush Wallaby (resident), Southern Brown Bandicoot (resident), Peregrine Falcon (foraging) and Chuditch (resident, foraging) may all opportunistically use this habitat. The ground cricket <i>Pachysaga</i> spp. was recorded in this habitat in 2012 and is likely a resident.</p> <p>Habitat Value - High</p>	
<p>Mixed Banksia woodland 27.07 ha.</p> <p>This habitat incorporates vegetation types VT09, VT04</p> <p>This habitat type is dominated by Banksia species including <i>B. attenuata</i> and <i>B. menziesii</i> with some areas of <i>Banksia sessilis</i> incursion. Shrub layers of Acacia, Hallea, Xanthorrhoea, Zamia and Olearia species were also common. This habitat was often very dense and had excellent litter cover and woody debris. Few large logs were present due to the lack of large tree species, however large skirts from Xanthorrhoea and Zamia palms would provide excellent cover for terrestrial fauna species. Soils were predominantly deep sands. Numerous small reptiles and birds were recorded in this habitat type due to the cover it provides and deep sandy soils. No recent fire scars were evident.</p> <p>Conservation significant species:</p> <p>One species of conservation significance was recorded in this habitat type, Carnaby's Black Cockatoo. The Carnaby's Black Cockatoo was recorded feeding in the habitat type throughout the survey area. The Western Brush Wallaby (resident, foraging), Southern Brown Bandicoot (resident, foraging), Peregrine Falcon (foraging) and Chuditch (resident, foraging) may all opportunistically use this habitat. Two reptile species the Jewelled Skink (<i>Ctenotus gemmula</i>) and Black Striped snake (<i>Meelips caloratus</i>) are also known to utilise/reside in this habitat. The ground cricket <i>Pachysaga</i> spp. may also reside in this habitat.</p> <p>Habitat Value - High</p>	
<p>Conservation significant species:</p> <p>One species of conservation significance was recorded in this habitat type, Carnaby's Black Cockatoo. The Carnaby's Black Cockatoo was recorded feeding in the habitat type throughout the survey area. The Western Brush Wallaby (resident, foraging), Southern Brown Bandicoot (resident, foraging), Peregrine Falcon (foraging) and Chuditch (resident, foraging) may all opportunistically use this habitat. Two reptile species the Jewelled Skink (<i>Ctenotus gemmula</i>) and Black Striped snake (<i>Meelips caloratus</i>) are also known to utilise/reside in this habitat. The ground cricket <i>Pachysaga</i> spp. may also reside in this habitat.</p> <p>Habitat Value - High</p>	

Habitat type

Mixed tall shrubland – 26.14 ha

This habitat incorporates vegetation types VT01, VT07, VT10, VT11, VT13

This habitat type was dominated by shrubs including *Grevillea*, *Acacia*, *Callitriche*, *Hakea*, *Xanthorrhoea*, *Melaleuca* and *Cleome* species were most common. This habitat was often very dense and had excellent litter cover and small fine woody debris. Few large logs were present due to the lack of large tree species, however, the density of the vegetation would provide excellent cover for terrestrial fauna species. Soils were predominantly deep sands with minor limestone incursion. No recent fire scars were evident. Numerous birds were recorded in this habitat type due to the flowering plants present. This habitat is also where the Brush Wallaby was recorded.

Conservation significant species

Two species of conservation significance were recorded in this habitat type, Carnaby's Black Cockatoo and Western Brush Wallaby. The Carnaby's Black Cockatoo were recorded feeding in the habitat type throughout the survey area. The Western Brush Wallaby was recorded resting under an *Olearia* next to the track. This species is able to utilise all the habit areas of the survey area as a resident or foraging. The Southern Brown Bandicoot (resident, foraging), Peregrine Falcon (foraging) and Chuditch (resident, foraging) may all opportunistically use this habitat. Two reptile species the Jewelled Skink and Black Striped snake are also known to utilise/reside in this habitat.

Habitat Value – High

Lomandra herbland on secondary Dunes 7.42 ha

This habitat incorporates vegetation types VT05



Lomandra dominated herbland was present on secondary dune systems throughout small areas of the survey area. The habitat consisted of Lomandra species and low scattered shrubs. The habitat was mostly open with little litter or woody debris and no logs present. The secondary dunes consist of deep mobile sands and appear long unburnt. Few fauna species were recorded in this habitat type however species that prefer open areas like Australasian Pipit and Nankeen Kestrel were recorded.

Conservation significant species

No species of conservation significance were recorded in this habitat type. The Western Brush Wallaby may utilise the area for foraging. The Southern Brown Bandicoot (foraging), Peregrine Falcon (foraging) and Chuditch (foraging) may all opportunistically use this habitat. Two reptile species the Jewelled Skink

Indicative photograph



Habitat type	Indicative photograph
<p>and Black Striped snake may also utilise/ reside in this habitat. The Lomandra is known to be a host species for the Graceful Sun Moth (<i>Syemon gralosa</i>) and this habitat is likely important to this species</p> <p>Habitat Value - Medium</p> <p>Limestone ridgelines 0.69 ha</p> <p>This habitat incorporates vegetation types VT08</p> <p>Limestone ridgelines were present in small areas of the survey area and included shrubs of <i>Melaleuca</i>, <i>Grevilla</i> and <i>Spyridium</i> species. This habitat had litter and fine woody debris associated to the shrubs which would provide cover to small fossorial species however the limestone ridging would also provide denning and hides. No large logs were present in this habitat type due to the lack of large trees. Few fauna species were recorded in this habitat type however species that prefer to hide in small caves or under rock may utilise this area.</p> <p>Conservation significant species:</p> <p>No species of conservation significance were recorded in this habitat type. The Western Brush Wallaby (foraging), Southern Brown Bandicoot (foraging), Peregrine Falcon (foraging) and Chuditch (foraging, denning) may all opportunistically use this habitat.</p>	
<p>Habitat Value - Medium</p> <p>Planted Eucalypt Woodland 6.63 ha</p> <p>This habitat incorporates vegetation types VT12</p> <p>Several small areas of planted non-native trees were present in the survey area. These consisted of several Eucalypt species including cultivars. These tree species formed good canopy cover and connectivity for areal species however had little understorey present. Litter and branch material was numerous however few large logs were present.</p> <p>Conservation significant species:</p> <p>No conservation significant species were recorded in this habitat type. However, Carnaby's Black Cockatoo (feeding and roosting), Southern Brown Bandicoot (foraging), Peregrine Falcon (Foraging) and Chuditch (foraging) may all opportunistically use this habitat.</p> <p>Habitat value - Medium</p>	

Habitat type

Highly Disturbed 10.32 ha

Highly disturbed areas provide very little to fauna species but can be used by common insectivorous bird species for foraging and by avian and ground dwelling species as corridors.

Habitat value - Low

Indicative photograph



4.2.4 Fauna diversity

The fauna surveys recorded 60 vertebrate fauna species, including 44 birds, eight reptiles and eight mammals. The results of the survey are summarized in Appendix E. In addition to the species recorded in this survey, GHD recorded a number of species in 2012 that were not identified in 2016. With these species included in the assessment 74 species are known to utilise the survey area which includes 51 birds, 13 reptiles, eight mammals and two invertebrates.

4.2.5 Introduced fauna

Six introduced species were recorded during the field survey, including five mammals and one bird species. These were the Fox, Rabbit, House Mouse, Feral Cat, Dog and Laughing Kookaburra. All six species are known from the region; however the Dogs are likely roaming local pets.

4.2.6 Conservation significant fauna

Three fauna species of conservation significance were recorded during the field survey:

- Carnaby's Black Cockatoo (*Calyptorhynchus laliosiris*) (listed as Endangered under the EPBC Act and under Schedule 2 (Endangered) of the WC Act),
- Western Brush Wallaby (*Macropus irma*) (listed as Priority 4 by DBCA)
- Rainbow Bee-eater (*Merops ornatus*) (listed under Schedule 5 of the WC Act).

During the 2011 Graceful Sun-Moth survey the Graceful Sun-Moth (*Synemon gratiosa*) was recorded (GHD 2011), and during the 2012 survey, the ground cricket (*Pachysaga munggal* or *strobila*) was recorded (GHD 2012). Neither of these species were recorded during the current surveys.

Black Cockatoo assessment

Foraging habitat

The survey area is located within the modelled feeding and breeding distribution (Yanchep National Park) for Carnaby's Black Cockatoo (DSEWPac 2012). There are numerous records of this species occurring within and around the survey area. The Banksia Woodlands, Tall Shrubland and Eucalypt Woodland provide high foraging habitat value for Carnaby's Black Cockatoo. Approximately 90.80 ha of potential foraging habitat for Black Cockatoos was recorded within the survey area. Table 19 provides a summary of the vegetation types deemed suitable foraging habitat for the species within the survey area. The extent and type of foraging habitat was confirmed by the presence of foraging evidence (e.g. *Banksia* cones, see Plates 2-5) and a comparison of the flora species recorded with a list of known foraging species (Groom 2011).

Breeding habitat

The field survey identified 25 significant trees of suitable DBH from within the survey area (Figure 6, Appendix A). Trees of this size are considered to have nesting potential currently, or may develop hollows within 100 years. Breeding success is dependent on both the nesting and foraging areas being relatively close together and sufficient to support the population (DSEWPac 2012). The woodland habitats in the survey area are likely to be utilised by Carnaby's Black Cockatoos for foraging and there is potential for the species to breed in the survey area in the future.

Table 19 Black Cockatoo habitat within survey area

Habitat type	Survey area
Foraging habitat	<p>There is 90.80 ha of foraging habitat for Black Cockatoos within the survey area consisting of the following:</p> <ul style="list-style-type: none"> • Mixed Tall Shrubland- 26.14 ha • <i>Banksia sessilis</i> over low mixed Shrubland – 25.95 • Mixed <i>Banksia</i> Woodland – 27.07 ha • Eucalyptus Woodland – 3.11 ha • Planted Eucalypt Woodland – 8.53 ha
Actual breeding habitat	<p>No breeding events were recorded within the survey area of any species of Black Cockatoo during the current survey.</p>
Potential breeding habitat	<p>25 potential breeding habitat trees with DBH \geq 500 mm. Of the 25 trees none had hollows</p>
Roosting habitat	<p>No roosting sites were recorded as being used by Black Cockatoos within the survey area. Limited suitable roosting habitat occurs within the survey area and consists of Eucalypt woodland and Planted Eucalypts.</p>



Plate 2 One of the flocks of Carnaby's Black Cockatoo observed



Plate 3 Feeding Evidence on *Banksia attenuata*



Plate 4 Feeding evidence on *Banksia sessilis*



Plate 5 Feeding on grasses/weeds and *Rhagodia* sp.

Western Brush Wallaby

The Western Brush Wallaby (listed as Priority 4 by DBCA) occurs only in the South-west of WA and is primarily a grazer, with an optimum habitat of open forest or woodland with low grasses and scrubby thickets. Activity is greatest during the early morning and late afternoon whilst it rests during the hottest part of the day in pairs, or singly, in the shade of a bush or thicket (Van Dyke and Strahan 2008).

During the November 2016 field survey a single Western Brush Wallaby was sighted resting in the shade of a tall shrub (Plate 6). The Western Brush Wallaby may utilise all habitats within the survey area, however the Mixed Tail Shrubland, Banksia Woodlands and Eucalypt Woodlands are of highest value to this species for seeking shelter and foraging.



Plate 6 Western Brush Wallaby recorded during November survey

Rainbow Bee-eater

The Rainbow Bee-eater is a medium-sized bird, and the only species of bee-eater in Australia. The Rainbow Bee-eater is listed under International Agreement (IA) under the WC Act. The Rainbow Bee-eater is distributed across much of mainland Australia, and occurs on several near-shore islands (DotEE 2017). The Rainbow Bee-eater occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation (Higgins 1999). During the field survey a pair of Rainbow Bee-eaters were recorded in the Eucalypt woodland habitat, however the species may utilise all habitats within the survey area.

Graceful Sun-Moth

GHD undertook a Graceful Sun-Moth (GSM) survey in March 2011 in which the GSM was recorded. The GSM was not recorded during the November 2016 or May 2017 surveys however, the habitat is still considered to be suitable for the species. The GSM is listed as Priority 4 by DBCA.

Ground Cricket

The conservation significant invertebrate species *Pachysaga munggai* or *strobila* was observed during the October 2012 field survey. The identification was unable to be identified down to a species level however both species are listed as Priority species by DBCA. The *Pachysaga*

munggai or *strobila* was not recorded during the November 2016 or May 2017 surveys, however given suitable habitat is still present in the survey area it is likely the species could still occur.

Likelihood of Occurrence

Searches of the EPBC Act PMST and *NatureMap* database identified the presence/potential presence of 20 conservation significant fauna species. In addition to the 20 species identified by the database searches, 12 species were considered for this assessment as a result of a review of the species listed under Schedules 1–4 of the WC Act (revised February 2017). An assessment of the Likelihood of Occurrence for conservation significant fauna in the survey area was conducted (Appendix E). This assessment was based on species biology, habitat requirements, the quality and availability of suitable habitat and records of the species in the survey and surrounding areas (e.g. DBCA 2007–).

The assessment identified the likely presence of five additional species of conservation significance that were not recorded during the field survey (Table 20).

Table 20 Conservation significant fauna 'likely' to occur in the survey area

Species	Status		Likelihood of occurrence
	WC Act	EPBC	
Peregrine Falcon (<i>Falco peregrinus</i>)	S		Likely, the nearest record is within 10 km of the survey area.
Western Quoll (Chuditch) (<i>Dasyurus geoffroyi</i>)	Vu	Vu	Likely, there are records present within 10 km of the survey area and the habitat is suitable for this species.
Southern Brown Bandicoot (Quenda) (<i>Isocolon obesulus</i> subsp. <i>Fusciventer</i>)	P4		Likely, the habitat within the survey area is suitable for this species. There are records present within the survey area.
Jewelled South West Ctenotus (<i>Ctenotus gemmula</i> (SCP subsp.))	P3		Likely, the habitat within the survey area is suitable for this species. There are no records from the survey area however this is likely due to a lack of current data for this species.
Black-striped Snake (<i>Neeleps calanotos</i>)	P3		Likely, the habitat within the survey area is suitable for this species. There are multiple records within 5 km of the survey area.

5. Environmental approvals and referrals

This section provides preliminary advice on potential environmental approvals and referrals required, based on the ecological values identified within the survey area. Depending on the final project alignment and disturbance footprint, this preliminary advice may need to be revisited.

5.1 Federal government

Referral to DoTEE under the EPBC Act is triggered if a proposed action has or potentially has a significant impact on any Matters of National Environmental Significance (MNES). MNES are factors that require legislated protection in order to conserve biodiversity, protect world and national heritage places, and comply with international treaties. Table 21 shows an assessment of this Project against MNES.

Table 21 Assessment of Matters of National Environmental Significance

Matter of National Environmental Significance	Present	Need for referral to DoTEE under EPBC Act
World Heritage Properties	None	
National Heritage Places	None	
Wetlands of International Significance	None	
Listed Threatened Species and Ecological Communities	Carababy's Black Cockatoo (Endangered)	Likely There is 90.80 ha of foraging habitat and 25 potential breeding trees within the survey area. Based on an assessment against the risk referral guidelines for the species (DSEWPaC 2012), the project is likely to trigger a referral to the DoTEE.
	Potential TECs	Likely Two GHD vegetation types aligned with the <i>Banksia</i> Woodlands of the SCP TEC (19.27 ha).
Migratory Species	None	
Commonwealth Marine Areas	None	
Great Barrier Reef Marine Park	None	
Nuclear Actions (including uranium mines)	None	
A Water Resource (in relation to coal seam gas development and large coal mining development)	None	

5.1.1 Black Cockatoos risk referral assessment

The key potential impacts to Black Cockatoo species in the project area are:

- Loss of approximately 90.80 ha of foraging habitat from the project area for Carababy's Black Cockatoo
- Loss of 25 potential breeding habitat trees (>500 mm DBH)

In order to assess the potential impacts to Black Cockatoo within the survey area, the DSEWPaC (2012) *EPBC Act referral guidelines for three threatened Black Cockatoo species* was consulted. Within these guidelines, DSEWPaC provides a risk table that gives guidance on what it views as risks/impacts to Black Cockatoos that will trigger referral (Table 22). Risk is broken into three categories: high, uncertain and low and primarily focuses on breeding, feeding and roosting area as well as indirect impacts. If there is uncertainty with regard to risks on Black Cockatoos then the guidelines recommend referring the Project or contacting the DoEE to ensure legal certainty.

Outcome

Even though the clearing of habitat within the project area is likely to trigger referral, the impact to the Black Cockatoo is not considered to be significant.

Table 22 Black Cockatoo risk referral table

Risk type	Risk referral
High risk of significant impacts: referral to DSEWPaC recommended	
Clearing of any known nesting tree	Referral is unlikely to be triggered as there are no known nesting trees.
Clearing or degradation of any part of a vegetation community known to contain breeding habitat.	Referral is likely to be triggered, however there is only 25 potential breeding trees recorded and none of these had suitable hollows for breeding.
Clearing of more than 1 ha of quality foraging habitat.	Referral is likely to be triggered as there is 90.80 ha of quality foraging habitat for Black Cockatoos within the survey area.
Clearing or degradation (including pruning of top canopy) of a known roosting project area.	Referral is unlikely to be triggered because there are no known night roosting sites within the project area.
Creating a gap or greater than 4 km between patches of Black Cockatoo habitat breeding, foraging or roosting.	Referral is unlikely to be triggered as the project will not create a gap greater than 4 km between patches of Black Cockatoo habitat if the habitat tree species are removed.
Uncertainty: referral recommended or contact the DSEWPaC	
Degradation (such as through altered hydrology or fire regimes) of more than 1 ha of foraging habitat. Significance will depend on the level and extent of degradation and the quality of the habitat.	Referral is unlikely to be triggered as hydrology and fire regimes of the survey area will not be impacted. Clearing of foraging habitat as stated above is likely to trigger a referral.
Clearing or disturbance of areas surrounding Black Cockatoo breeding, foraging or night roosting habitat that has the potential to degrade habitat through introduction of invasive species, edge effect, hydrological	Referral is unlikely to be triggered as the project will not increase the edge effect, hydrological changes, increase human visitation or fire to the surrounding areas.

changes, increase human visitation or fire.	
Actions that do not directly affect the listed species but that have the potential for indirect impacts such as increasing competitors for nest hollows.	Referral is unlikely to be triggered as there are no known nesting hollows within the project area nor will the action increase competition for nest hollows.
Actions with the potential to introduce known plant diseases such as <i>Phytophthora</i> spp.	Referral is unlikely to be triggered as the area is low risk for dieback
Low risk of significant impacts: referral may not be required but may refer to DSEWPaC for legal certainty	
Actions that do not affect Black Cockatoo habitat or individuals.	N/A
Actions whose impacts occur outside the modelled distribution of the three Black Cockatoos.	N/A

5.2 Western Australian Government

5.2.1 Environmental Protection Authority

Significant proposals must be referred to the EPA under Section 38 of the *Environmental Protection Act 1986* (EP Act). In deciding whether a proposal will be subject to the formal environmental impact assessment process, the EPA takes into account the environmental significance of any potential impacts that may result from the implementation of the scheme or proposal.

In the absence of a broader environmental assessment, the majority of the potential biological impacts associated with the survey area are linked to native vegetation clearing and loss of fauna habitat. The potential impacts from the loss of native vegetation and loss of fauna habitat may be effectively assessed through the Environmental Protection (Clearing of Native Vegetation) Regulations 2004. Therefore, with consideration of the biological values discussed in this report, it is considered unlikely that the project would require referral to the EPA under Section 38 of the EP Act based solely on biological considerations.

5.2.2 Department of Water and Environmental Regulation

Clearing of native vegetation is regulated by the DWER and requires a clearing permit under Part V of the EP Act, except when a project is assessed under Schedule 6 of the Act or is prescribed by regulation in the Environmental Protection (Clearing Native Vegetation) Regulations 2004 and not in an ESA.

When preparing a native vegetation clearing application an assessment of the survey area against the "Ten Clearing Principles" should be undertaken to determine whether the Project is likely to be at variance to the Principles. The Ten Clearing Principles aim to ensure that potential impacts resulting from removal of native vegetation can be assessed in an integrated way. An assessment of the survey area against the Ten Clearing Principles was undertaken (Table 23). The assessment determined that clearing within the survey area is likely to be at variance to:

- a) – Native vegetation should not be cleared if it comprises a high level of biological diversity
- b) – Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to WA
- d) – Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community.
- (e) – Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.

If the EPA does not assess the Project, a clearing permit will be required for the Project.

Table 23 Assessment of the survey area against the ten clearing principles

Principle	Assessment	Outcome	Data sources
e) – Native vegetation should not be cleared if it comprises a high level of biological diversity.	<p>The survey area is situated in the South West Botanical Province of WA, within the SCP IBRA bioregion and Perth IBRA subregion. The flora of the Perth sub-region is diverse with 3,255 native vascular flora taxa recorded.</p> <p>The survey area comprised remnant vegetation in varying condition, historically and recently cleared areas, and existing infrastructure such as roads and tracks. Thirteen vegetation types were identified from the survey area. The vegetation types included five mixed shrubland types, two <i>Banksia</i> woodland types, three <i>Eucalyptus</i> woodland types, one Heibland type and two modified vegetation types. There is 90.38 ha of native vegetation; 8.53 ha of planted vegetation and 16.32 ha of previously cleared areas within the survey area (total: 109.23 ha). Vegetation that was rated as Degraded, Completely Degraded and cleared areas accounted for 47.00 ha (43%) of the overall survey area. A patch (1.3 ha) of Pristine vegetation was recorded in part of VT03.</p> <p>The survey area is linear and is surrounded by remnant native vegetation and areas of residential housing in the northern and southern parts. The survey area does not contain areas of native vegetation that are in better condition, or offer a higher floristic value than the surrounding environment.</p> <p>Desktop searches identified five TECs, and seven PECs within 10 km of the survey area, four of the PECs are also part of a TEC. The vegetation within the survey aligned with two PECs and two TECs</p> <ul style="list-style-type: none"> <i>Banksia</i> Woodlands of the SCP TEC, which is listed as Endangered under the EPBC Act <i>Banksia</i> dominated woodlands of the SCP IBRA region PEC, which is listed at Priority 3 by DBCA Northern Spearwood shrublands and woodlands (P4), PEC, listed as a Priority 3, by DBCA <i>Melaleuca huageli</i> – <i>M. scoopesii</i> (M) western shrublands on limestone ridges (269) TEC, which is listed as Endangered by DBCA. <p>There is 22.84 ha of the <i>Banksia</i> Woodlands of the SCP TEC within the survey area. There is 27.07 ha of the <i>Banksia</i> dominated woodlands of the SCP IBRA region PEC present within the survey area (this total includes 22.84 ha which also aligns with the <i>Banksia</i> Woodlands of the SCP TEC). There is 25.95 ha Northern Spearwood shrublands and woodlands PEC and 0.69 ha <i>Melaleuca huageli</i>-<i>Melaleuca systena</i> shrublands of limestone ridges TEC present within the survey area. The <i>Melaleuca</i> TEC is restricted to one area in the central part of the survey area, whilst the Northern Spearwood PEC is scattered along the survey area.</p> <p>The survey also contains vegetation considered 'other significant vegetation' as it supports one vegetation type dominated by Juat trees. This community has a restricted distribution, large</p>	<p>Likely to be at risk to this Principle</p>	<p>Beard (1990) Beard (1979) Doree (2016) DBCA (2007-) DBCA TEC and PEC databases DBCA TPFL and WAHERB WA Herbarium (1999-)</p>

Principle	Assessment	Outcome	Data sources
<p>b) – Native vegetation should not be cleared if it</p>	<p>Degree of historical impact from threatening processes and may represent a refuge for native fauna.</p> <p>Seven hundred and eighty nine native flora taxa have been previously recorded within 10 km of the survey area (DBCA, 2007-). The field survey recorded 210 flora taxa representing 97 families and 14 genera. In total computers for native flora taxa, 54 introduced taxa. The database also identified the presence of 49 conservation significant flora taxa within 10 km of the survey area. No EPBC Act or WC Act listed flora taxa were recorded within the survey area. However, one DBCA-listed Priority 3 taxon, <i>Hibbertia spicata</i> subsp. <i>epithemica</i> was recorded during the field survey. A likelihood of occurrence assessment conducted post-field survey concluded that in addition to the recorded <i>H. spicata</i> subsp. <i>epithemica</i> three taxa are likely to occur, 13 taxa may possibly occur and the remaining 32 taxa identified in desktop searches are considered unlikely or highly unlikely to occur in the survey area.</p> <p>Seven broad fauna habitat types were recorded from the survey area including highly disturbed areas. Four of these habitat types provide high value habitat for fauna.</p> <p>A search of the NatureMap database (DBCA, 2007-) identified 602 fauna species that have been previously recorded within 10 km of the study area. This total included 209 birds, 61 reptiles, nine amphibians and 43 mammals. The remainder of species are marine fish and invertebrates.</p> <p>The fauna surveys recorded 60 vertebrate fauna species, including 44 birds, eight reptiles and eight mammals. This included three conservation significant species:</p> <ul style="list-style-type: none"> • Carnaby's Black Cockatoo (<i>Calyptrornithus latirostris</i>) – listed as Endangered under EPBC Act and Threatened under WC Act; • Western Bush Warbler (<i>Macropus irma</i>) – Listed as P4 by DBCA • Rainbow Bee-eater (<i>Microps ornatus</i>) – Listed as IA under the WC Act <p>The survey area contains a number of vegetation and habitat types, conservation significant vegetation and supports a range of flora and fauna species, including conservation significant species. Whilst the survey area does not contain areas of native vegetation that are in better condition, or offer a higher floristic value than the surrounding environment, it supports approximately 50 taxa of native vegetation in good or better condition in a largely cleared/degraded landscape.</p>	<p>Likely to be at variance to this Principle</p>	<p>DocEE (2016a) DBCA (2007-) Beard (1976)</p>

Principle	Assessment	Outcome	Data sources
<p>comprises the whole or a part of, is necessary for the survival of, or is a significant habitat for fauna indigenous to WA</p>	<p>disturbed areas Four of these habitat types provide high value habitat for fauna. These four habitat types cover approximately 75% of the total survey area demonstrating the overall high value of the area. The remaining 25% includes medium to low value habitat for fauna.</p> <p>All of the habitat types are well represented at a local and regional scale, and overall, the survey area is well connected and regional connectivity to remnant vegetation to the east (including Yanchep National Park).</p> <p>Six hundred and two native fauna species have been previously recorded within 10 km of the survey area (DBCA 2007-). This total included 200 birds, 61 reptiles, nine amphibians and 43 mammals. The remainder of species are marine fish and invertebrates. The field surveys recorded 60 vertebrate fauna species, including 44 birds, eight reptiles and eight mammals.</p> <p>During the field survey, three conservation significant fauna species were recorded:</p> <ul style="list-style-type: none"> • Carnaby's Black Cockatoo – listed as Endangered under EPBC Act and WC Act • Western Brush Wallaby listed as Priority 4 by DBCA • Rainbow Bee-eater listed as A under the WC Act <p>A further five conservation significant species were assessed as likely to occur within the survey area, including:</p> <ul style="list-style-type: none"> • Southern Brown Bandicoot / Quenda (<i>Scoodon obesulus fusciventer</i>) – Priority 4 listed by DBCA • Peregrine Falcon (<i>Falco peregrinus</i>) – Listed as other specially protected fauna by DBCA • Western Quoll (<i>Dasyurus geoffroii</i>) – Listed as Vulnerable by the EPBC Act and DBCA • Jewelled South West Skink (<i>Ctenotus gemmule</i>) – Listed as Priority 3 by DBCA • Black Striped Snake (<i>Meleaps calorotus</i>) – Listed as Priority 3 by DBCA <p>Carnaby's Black Cockatoo were observed in several small groups foraging and flying over the survey area. There is 90 ha of suitable foraging habitat and 25 potential breeding trees for the species within the survey area. It is likely that the species utilises the survey area for foraging. The native vegetation within the survey area comprises significant habitat for Carnaby's Black Cockatoo.</p>	<p>Unlikely to be at variance to this Principle</p>	<p>DoIEE (2016a) DBCA (2007-) DBCA TPF and WAHERB WA Herbarium (1998-)</p>
<p>(c) – Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora</p>	<p>Desktop searches identified the presence/potential presence of eight EPBC Act and/or WC Act listed flora taxa within 10 km of the survey area. A likelihood of occurrence assessment, which takes into account the habitats present, known species distribution and previous records and intensity of field surveys and season, was completed for the Threatened flora taxa identified in desktop searches. This assessment determined that no Threatened flora taxa are likely or may possibly occur within the survey area.</p> <p>Searches for conservation significant flora taxa were undertaken during the field survey. No Threatened flora taxa were recorded from the survey area during the field surveys. Given the</p>		

Principle	Assessment	Outcome	Data sources
d) – Native vegetation should not be cleared if it comprises the whole or a part of an ecological community for the maintenance of a threatened ecological community	<p>survey effort dual season survey and reconnaissance survey if populations of Threatened flora taxa were present; it is expected they would have been identified in the field.</p> <p>Desktop searches identified the presence/potential presence of four TECs within 10 km of the survey area, including:</p> <ul style="list-style-type: none"> • Aquatic Root Mat Community in Caves of the SCP (TEC) (Caves SCP1) – Endangered EPBC Act listed TEC and Critically Endangered State listed TEC • Sedgeland in Hocene dune swales of the southern SCP (TEC) (SCP19) – Endangered EPBC Act listed TEC and Critically Endangered State listed TEC • <i>Melaleuca huegelii</i> – <i>M. acerosa</i> (<i>M. systena</i>) shrublands on limestone ridges (TEC) (SCP26a) – Endangered State listed TEC • Banksia Woodlands of the SCP – Endangered EPBC Act listed TEC <p>An assessment of the vegetation types described within the survey area, based on dominant species and general field observations determined that three vegetation types within the survey aligned with two TECs:</p> <ul style="list-style-type: none"> • Banksia Woodlands of the SCP TEC, which is listed as Endangered under the EPBC Act • <i>Melaleuca huegelii</i> – <i>M. acerosa</i> (<i>M. systena</i>) shrublands on limestone ridges (26a) TEC, which is listed as Endangered by DBCA <p>There is 22.84 ha of the Banksia Woodlands of the SCP TEC within the survey area. There is 0.69 ha <i>Melaleuca huegelii</i>–<i>Melaleuca systena</i> shrublands of limestone ridges TEC present within the survey area, restricted to three small patches within the survey area.</p> <p>The survey area is located within the SCP IBRA Bioregion, which has approximately 39% of its pre-European extent remaining.</p> <p>Regional vegetation mapping has been undertaken by Heddie <i>et al.</i> (1980). This mapping identified three vegetation complexes within the survey area: Quindalup complex, Cottesloe complex – north and Cottesloe complex central and south.</p> <p>The vegetation complexes described and mapped by Heddie <i>et al.</i> (1980) have been assessed against presumed pre-European extents within the SCP IBRA bioregion (The Local Biodiversity Program 2013) and the City of Wanneroo (GoWA 2017). The current extent of the Quindalup complex and Cottesloe complex – north within the SCP IBRA bioregion and the City of Wanneroo is greater than 31% of their calculated pre-European extents.</p> <p>The Cottesloe complex- central and south has a 07% remaining within the SCP. Where only 10 per cent or less of the pre-European extent of an ecological community remains that community is considered threatened. Within the City of Wanneroo the Cottesloe complex – central and south has 41% of its pre-European extent remaining.</p>	<p>Likely to be at variance to this Principle.</p>	<p>DoE (2016a) DBCA TEC and PEC databases</p>
e) – Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared	<p>The survey area is located within the SCP IBRA Bioregion, which has approximately 39% of its pre-European extent remaining.</p> <p>Regional vegetation mapping has been undertaken by Heddie <i>et al.</i> (1980). This mapping identified three vegetation complexes within the survey area: Quindalup complex, Cottesloe complex – north and Cottesloe complex central and south.</p> <p>The vegetation complexes described and mapped by Heddie <i>et al.</i> (1980) have been assessed against presumed pre-European extents within the SCP IBRA bioregion (The Local Biodiversity Program 2013) and the City of Wanneroo (GoWA 2017). The current extent of the Quindalup complex and Cottesloe complex – north within the SCP IBRA bioregion and the City of Wanneroo is greater than 31% of their calculated pre-European extents.</p> <p>The Cottesloe complex- central and south has a 07% remaining within the SCP. Where only 10 per cent or less of the pre-European extent of an ecological community remains that community is considered threatened. Within the City of Wanneroo the Cottesloe complex – central and south has 41% of its pre-European extent remaining.</p>	<p>Likely to be at variance to this Principle.</p>	<p>Heddie <i>et al.</i> (1980) Local Biodiversity Program (2013)</p>

Principle	Assessment	Outcome	Data sources
(f) – Native vegetation should not be cleared if it is growing in, or in an environment associated with a watercourse or wetland.	Desktop searches identified one nationally important wetland within 5 km of the survey area, the Loch Mochess System (Yanchep Lake). This wetland system, which is also a conservation category wetland occurs approximately 1.5 km east of the survey area. Vegetation clearing for the Project is not expected to impact this wetland. There are no drainage lines or wetlands within the survey area, nor is the vegetation within the survey area considered to grow in association with a wetland or watercourse.	Unlikely to be at variance to this Principle.	DoE (2015a) DoWER (2015)
(g) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.	The survey area is located on the Quindalup Dunes and Spearwood Dunes landforms. The Quindalup Dunes comprises dunes and ridges generally oriented parallel to the present coast line landward of the Quindalup Dunes and consist of mainly brown and yellow sands of varying depths over limestone (Tamsia Limestone). A review of Acid Sulfate Soils (ASS) risk mapping provided by DER indicates that the survey area is mapped as having 'no known risk' of ASS occurring within 3 m of natural soil surface. Any clearing of native vegetation within the survey area has the potential to cause water and wind erosion in areas with lighter-texture soils (e.g. sandy soils). The high sand content of the soils and ease with which these materials can be transported by the wind means there is a high risk of wind erosion in this area. However, given these soils are porous and well-drained and the survey area is linear in nature, the risk of water erosion is low. Overall, due to the long and linear nature of the native vegetation to be cleared, clearing for the Project is unlikely to cause substantial land degradation.	Unlikely to be at variance to this Principle.	DAFWA (2007) DER ASS risk mapping Natural Resource Management SLIP (GoWA 2016)
(h) – Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.	No reserves, conservation areas or other DBCA-managed estates are located within the survey area. The closest DBCA-managed conservation area is Yanchep National Park (R 9888, Class A) (also recognised as Bush Forever site 288), located adjacent to the northern extent of the survey area (east side). The survey area is connected to this National Park by native vegetation, however the small and linear nature of the proposed clearing reduces the likelihood for impacts to this conservation area. Bush Forever site 289 (Ningina Bushland, Yanchep/Eglington) intersects the middle of the survey area. This part of the Bush Forever site has been modified due to partial clearing, and the location of planned and exotic species and anthropogenic disturbances (e.g. vehicle and bike tracks). Overall, due to the long and linear nature of the native vegetation to be cleared, clearing for the Project is unlikely to significantly impact the environmental values of the conservations areas.	Unlikely to be at variance to this Principle.	DBCA Estate spatial dataset GoWA 2000

Principle	Assessment	Outcome	Data sources
<p>(i) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause or exacerbate the incidence of underground water.</p>	<p>The survey area is located in the RVI Act listed Yandrep Groundwater Area and the Perth Coastal and Gwelo Underground Water Pollution Control Area Public Drinking Water Source Area (PDWSA), which is a Priority 3 Protection Zone. Priority 3 areas are declared over land where water supply sources need to coexist with other land uses such as residential, commercial and light industrial developments. Vegetation clearing for the project is considered unlikely to impact upon groundwater and land for the RVI Act were identified within the survey area (DWER 2016). There are no drainage lines, lakes or wetlands in the survey area (DWER 2016). It is unlikely that the proposed works will disturb or interrupt any natural drainage and surface run-off patterns due to the deep sandy soils present in the area.</p> <p>There are no Environmental Protection Policy (EPP) lakes protected under the <i>Environmental Protection (Sivan Coastal Plain Lakes) Policy 1992</i> within or in immediate proximity to the survey area. The nearest EPP lake is located approximately 2.4 km east of the survey area, and therefore no direct impacts are expected to occur to any EPP lakes as a result of the proposed project.</p> <p>There are no watercourses or wetlands within the survey area. It is unlikely that any clearing of the vegetation within the survey area will result in any indirect impacts to this wetland, such as changes to hydrology and changes to surface water flows to this wetland.</p> <p>The soils of the survey area are sandy and porous and the area is generally well-drained. No wetlands, watercourses or areas subject to inundation are located within the survey area. It is unlikely that the removal of vegetation proposed for this project would cause or exacerbate the incidence or intensity of flooding in the local area.</p> <p>The survey area is unlikely to be susceptible to waterlogging due to the highly porous nature of the soils in the area and clearing is unlikely to cause or exacerbate waterlogging within the survey area.</p>	<p>Unlikely to be at variance to this Principle.</p>	<p>DWER (2016) Natural Resource Management Survey (CoNA 2016)</p>
<p>(i) – Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate the incidence of flooding</p>	<p>The survey area is unlikely to be susceptible to waterlogging due to the highly porous nature of the soils in the area and clearing is unlikely to cause or exacerbate waterlogging within the survey area.</p>	<p>Unlikely to be at variance to this Principle.</p>	

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Appendices

Appendix A – Figures

Figure 1 Project location

Figure 2 Constraints

Figure 3 Vegetation types and sample locations

Figure 4 Vegetation condition and significant weed locations

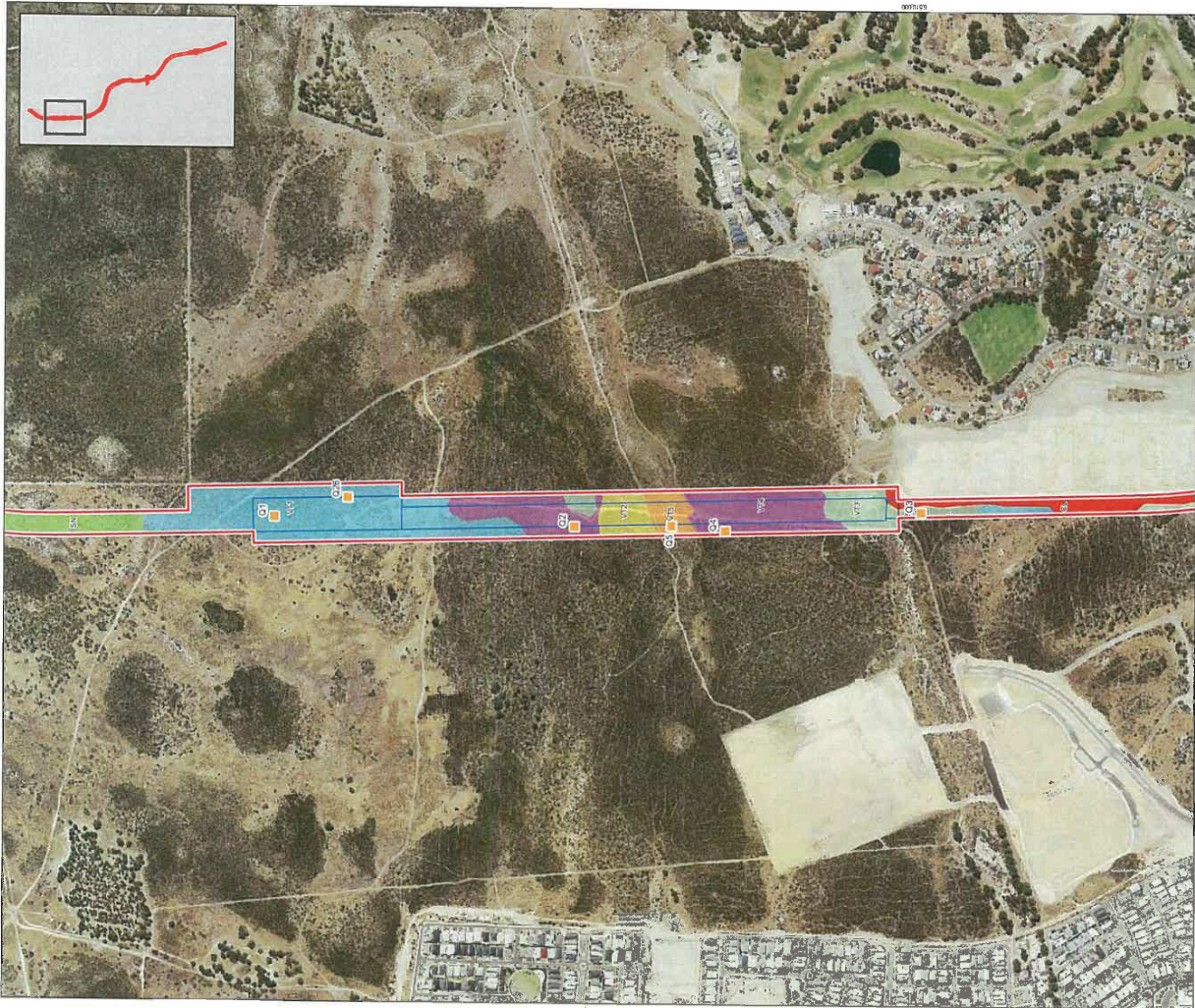
Figure 5 Conservation significant communities and flora

Figure 6 Fauna habitats



LEGEND

- Quatrat
 - Survey Area
 - Upgrade Alignment (PPA)
 - Original Alignment (PPA)
- Vegetation Types**
- VTC1 - *Acacia saligna* and *Macaranga* spp. woodland
 - VTC2 - *Macaranga* spp. tall shrubland
 - VTC3 - *Banksia* spp. and *Stylidium* spp. tall open forest
 - VTC4 - *Banksia* spp. and *Macaranga* spp. woodland
 - VTC5 - *Macaranga* spp. Open woodland
 - VTC6 - *Eucalyptus gomphocephala* tall open forest
- VTC's - Stationed Nodes**
- Cleared
 - Major Road



LEGEND

Quadrat	Vegetation Types	VT3 - Scattered Natives
Survey Area	VT1 - <i>Acacia saligna</i> and <i>Acacia melanoxylon</i> shrubland	VT4 - <i>Banksia affinis</i> and <i>Banksia menziesii</i> low woodland
Updated Alignment (PTA)	VT2 - <i>Banksia sessilis</i> and <i>Melicope</i> ssp. mid shrubland	Major Road
Original Alignment (PTA)	VT5 - <i>Lomandra</i> sp. Open heathland	

VT3 - *Banksia sessilis* and *Acacia melanoxylon* tall shrubland
 VT4 - *Banksia affinis* and *Banksia menziesii* low woodland
 VT5 - *Lomandra* sp. Open heathland

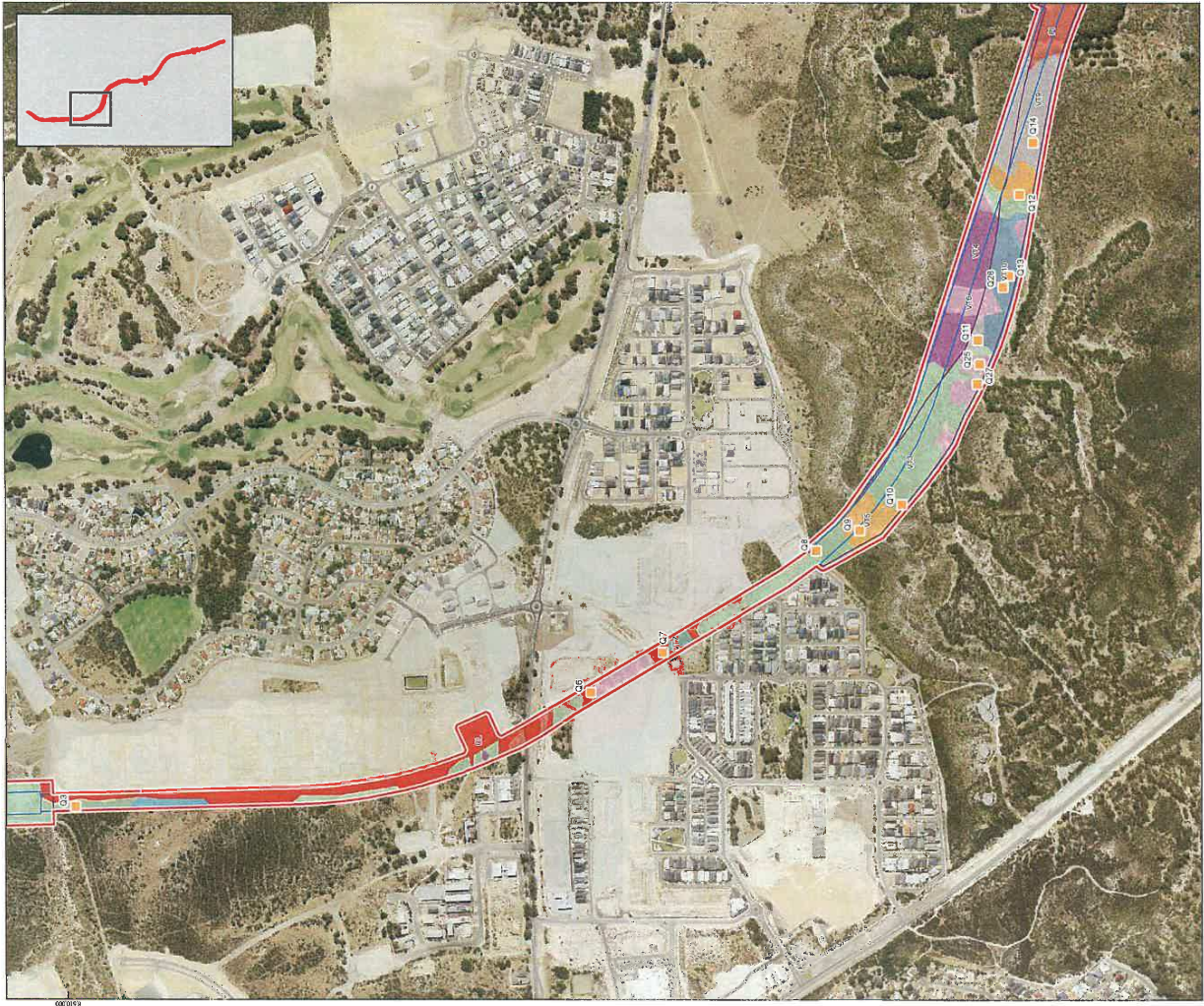
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 Map Prepared by: GHD
 Date: 17 Aug 2017

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 Vegetation Type and
 Quadrat Locations

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Figure 3
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LEGEND

- **Quadrat:**
 - Survey Area**
 - Updated Alignment (PTA)**
 - Original Alignment (PTA)**
- Vegetation Types**
- VT01 - *Antea saligna* and *Xanthorrhoea preissii* tall
 - VT02 - *Lomatium* sp. *Open*
 - VT03 - *Banksia aemula* and *Sporobolus diacanthus* tall
 - VT04 - *Banksia aemula* and *B. menziesii* low vegetation
 - VT05 - *Lomatium* sp. *Open* heathland
 - VT06 - *Escallonia* *gymnocarpa* tall open forest
 - VT07 - *Eucalyptus* sp. and *Agonis* *flexuosa* open forest
 - VT08 - *Yucca* *laevis* and *M. glabra* low scrubland
 - VT09 - *Yucca* *laevis* and *M. glabra* low scrubland
 - VT10 - *Xanthorrhoea preissii* tall
 - VT11 - *Planted*
 - VT12 - *Planted*
 - VT13 - *Banksia aemula* low
 - VT14 - *Banksia aemula* low
 - VT15 - *Banksia aemula* low
 - VT16 - *Banksia aemula* low
 - VT17 - *Banksia aemula* low
 - VT18 - *Banksia aemula* low
 - VT19 - *Banksia aemula* low
 - VT20 - *Banksia aemula* low
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 - VT96 - *Banksia aemula* low
 - VT97 - *Banksia aemula* low
 - VT98 - *Banksia aemula* low
 - VT99 - *Banksia aemula* low
 - VT100 - *Banksia aemula* low

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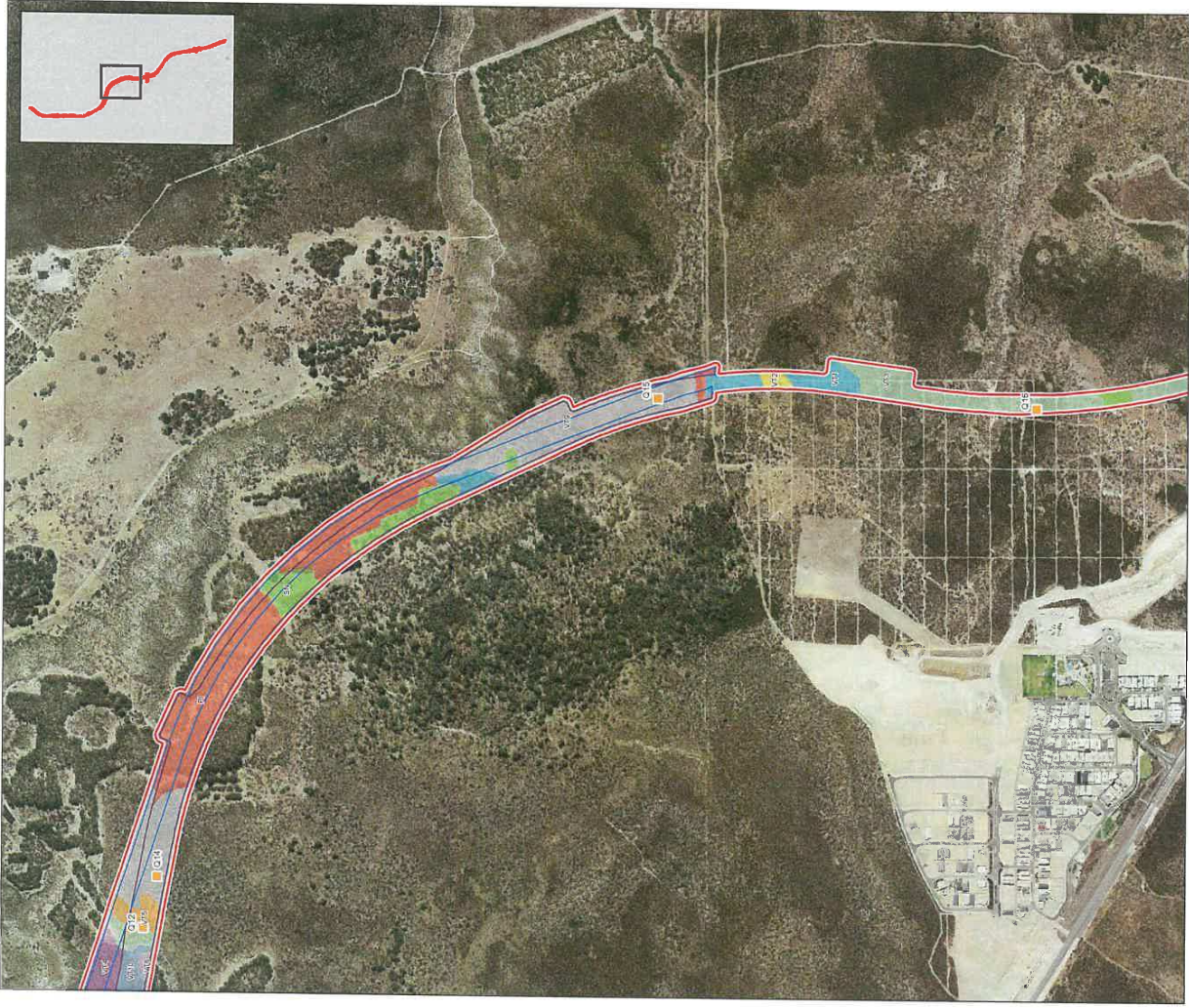
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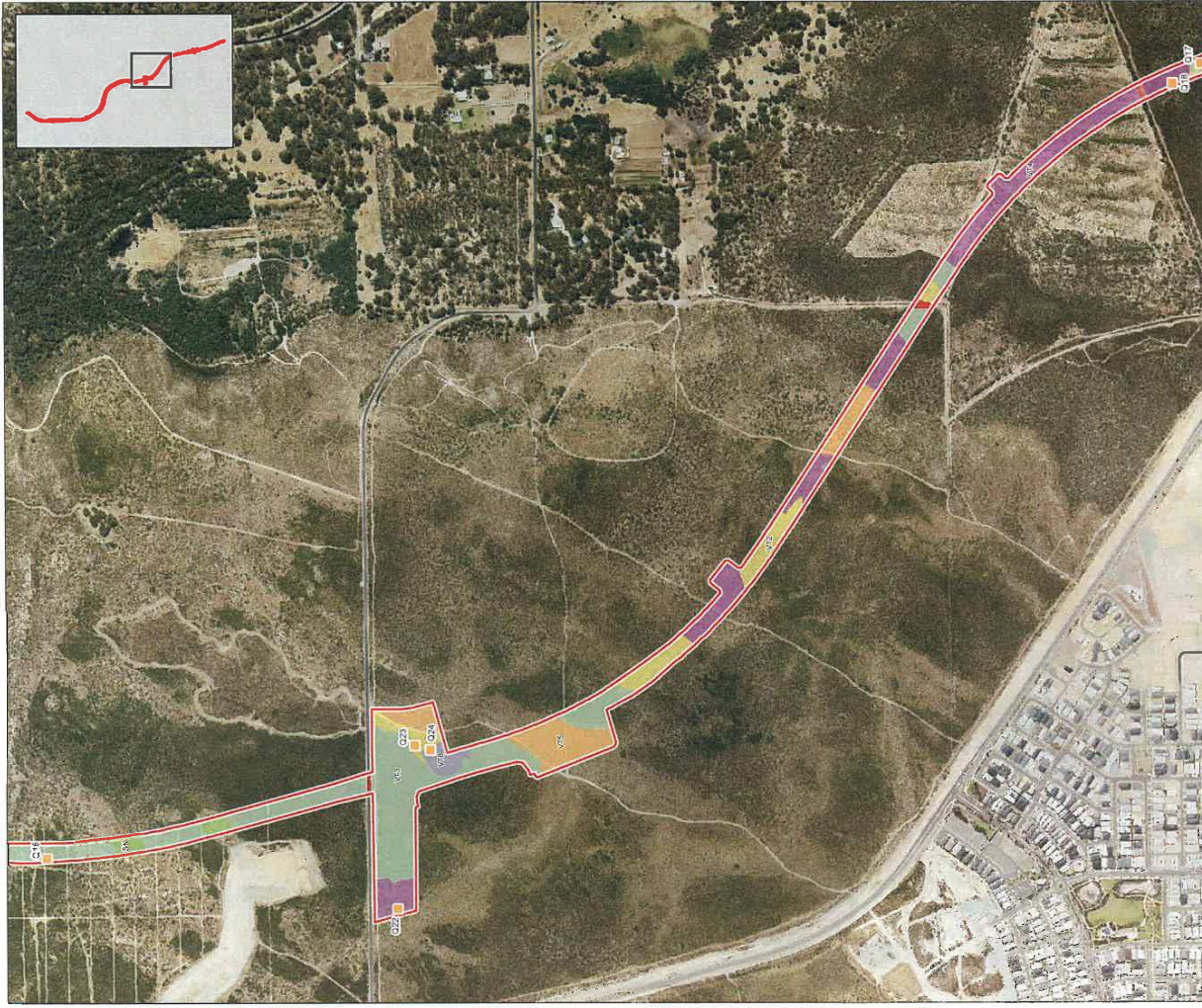
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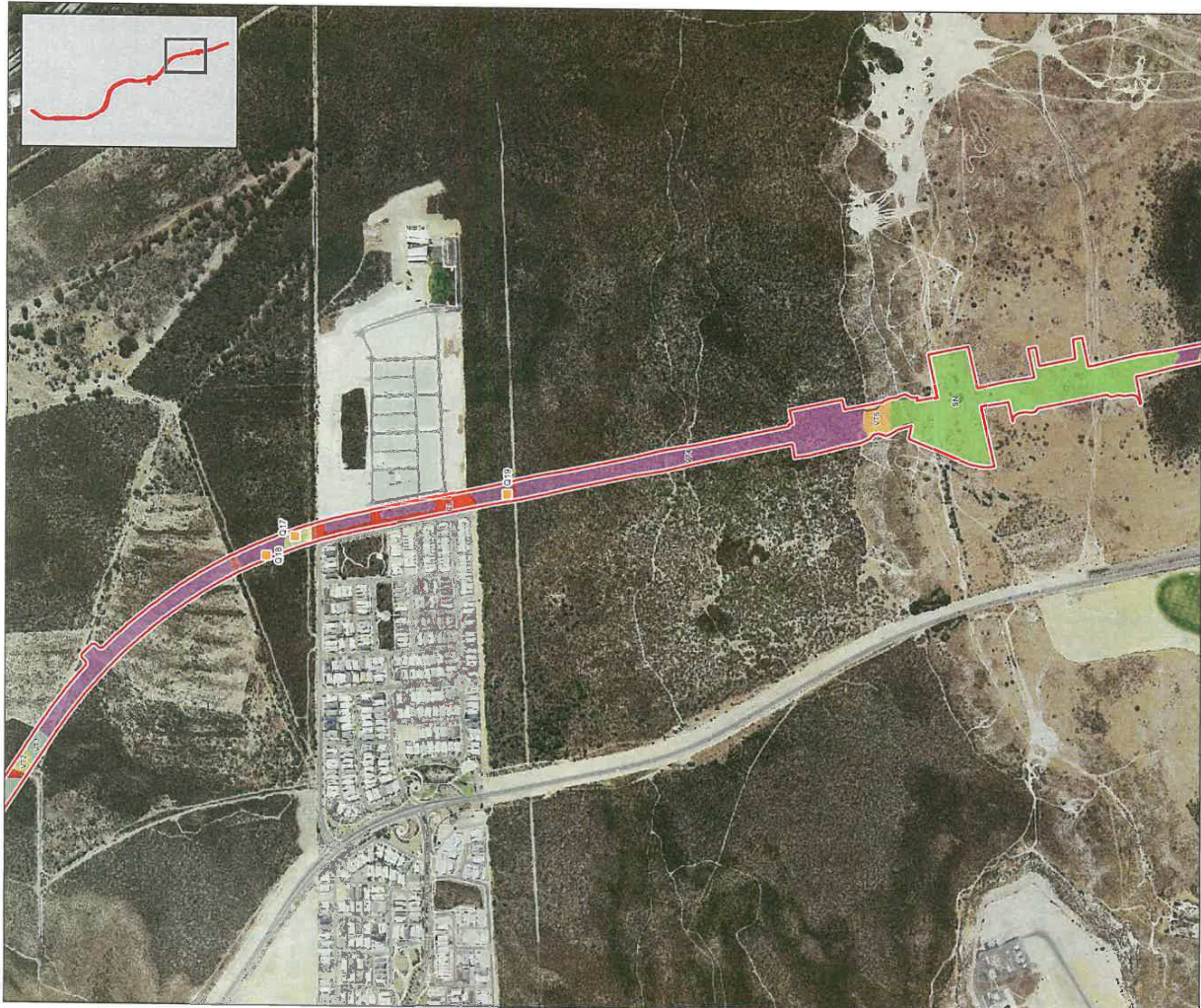
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- LEGEND**
- | | | | | | | | | | | | |
|--|---|---|--|---|--|---|--|---|---|--|--|
| Quadrat | Survey Area | Updated Alignment (PTA) | Original Alignment (PTA) | <i>VT03 - Banksia sessilis and Spondylium globulosum tall shrubland</i> | <i>VT04 - Banksia thicket and B. racemosa low woodland</i> | <i>VT05 - Lomandra sp. Open heathland</i> | <i>VT06 - Eucalyptus gomphocephala tall open forest woodland</i> | <i>VT10 - Xanthorrhoea preissii mid-shrubland</i> | <i>VT12 - Planned Bush Forever (Mile 280)</i> | <i>VT13 - Scattered Native Bush Forever (Mile 280)</i> | Major Road |
|--|---|---|--|---|--|---|--|---|---|--|--|



- LEGEND**
- Quadrat
 - Survey Area
 - Updated Alignment (PFA)
 - Original Alignment (PFA)
 - Major Road
 - Major Road
- Vegetation Types**
- V104 - Banksia arenulata and B. merriana; low woodland
 - V102 - Banksia sessilis and Melaleuca systena mitchellii shrubland
 - V103 - Banksia sessilis and Spyridium pectinatum tall shrubland
 - V105 - Melaleuca huegelii and M. systena low shrubland
 - V106 - Melaleuca huegelii and M. systena low shrubland
 - V111 - Eucalyptus dealbata low woodland
 - V112 - Planted
 - V113 - Scattered Natives
 - Clearcut



LEGEND

Quadrat	VT04 - <i>Banksia attenuata</i> and <i>B. menziesii</i> low woodland	VT12 - <i>Platanus</i>
Survey Area	VT05 - <i>Melicope aemula</i> and <i>Melicope sp.</i> shrubland	VT13 - <i>Scaevola</i> heath
Updated Alignment (PTA)	VT06 - <i>Lomandra</i> sp. Open heathland	Clearance
Original Alignment (PTA)	VT11 - <i>Eucalyptus delegatensis</i> low woodland	Major Road

Vegetation Types

- VT02 - *Banksia aemula* and *Melicope aemula* shrubland
- VT03 - *Banksia aemula* and *Sydneya globulosa* tall shrubland
- VT04 - *Banksia attenuata* and *B. menziesii* low woodland
- VT05 - *Melicope aemula* and *Melicope sp.* shrubland
- VT06 - *Lomandra* sp. Open heathland
- VT11 - *Eucalyptus delegatensis* low woodland
- VT12 - *Platanus*
- VT13 - *Scaevola* heath

Scale: 0 100 200 300 Meters

North Arrow: N

Logos: GHD, SLIP, Public Transport Authority, Bush Transport Authority

Job Number: 61-35117
Revision: 17 Aug 2017
Date: 17 Aug 2017

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Figure 3

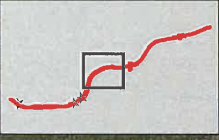
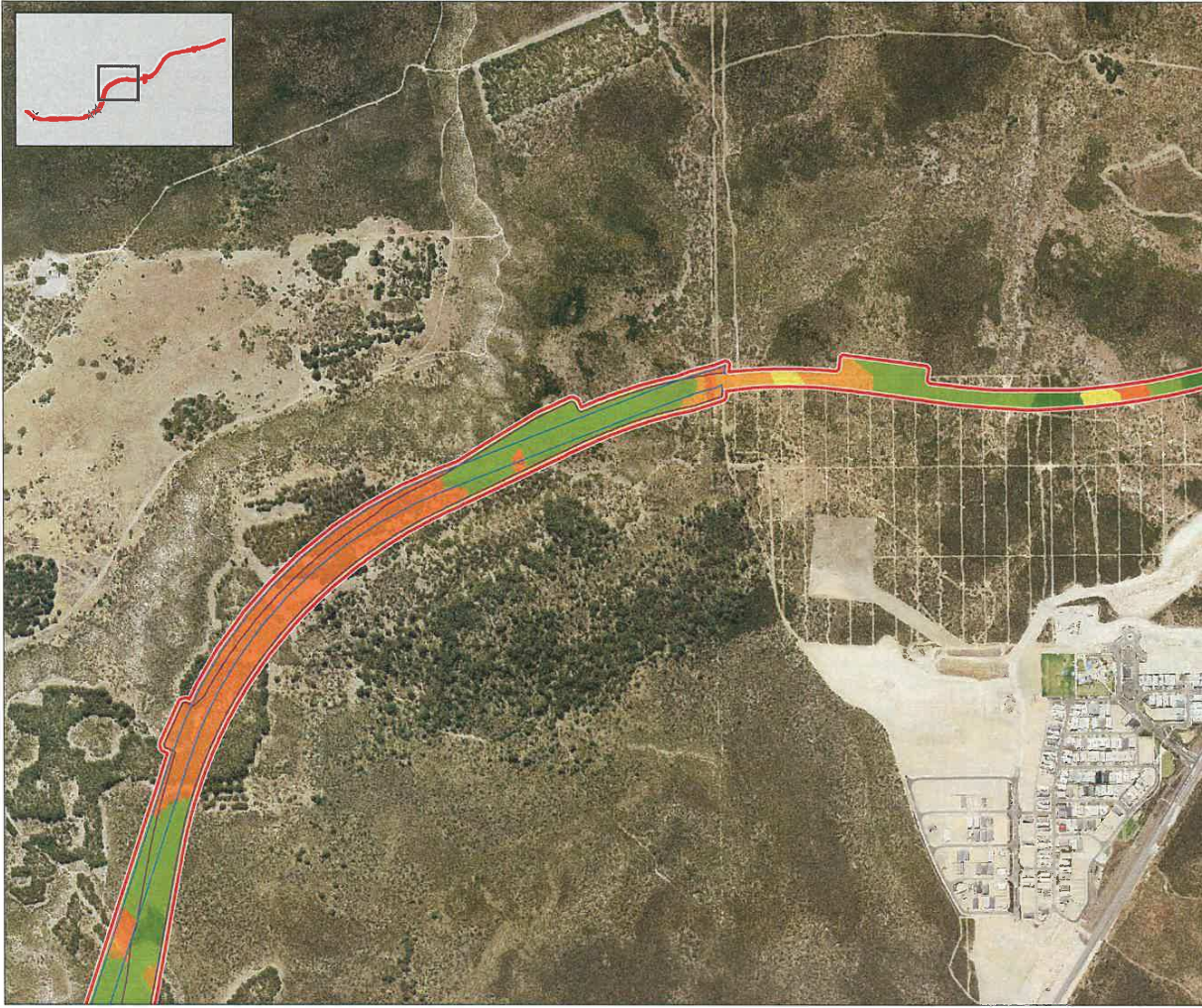
Vegetation Type and Quadrat Locations

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- LEGEND**
- Quacrat
 - Survey Area
 - Updated Alignment (PPA)
 - Original Alignment (PPA)
- Vegetation Types**
- VT02 - *Burkea assiatica* and *Melaleuca* systems mid shrubland
 - VT03 - *Burkea assiatica* and *Syzygium globosum* tall shrubland
 - VT04 - *Burkea assiatica* and *B. menziesii* low woodland
 - VT05 - *Lomandra* sp. Open herbland
 - VT06 - *Melaleuca huegelii* and *M. systena* low shrubland
- Other Features**
- VT13 - Scattered Natives
 - Channel
 - Major Road

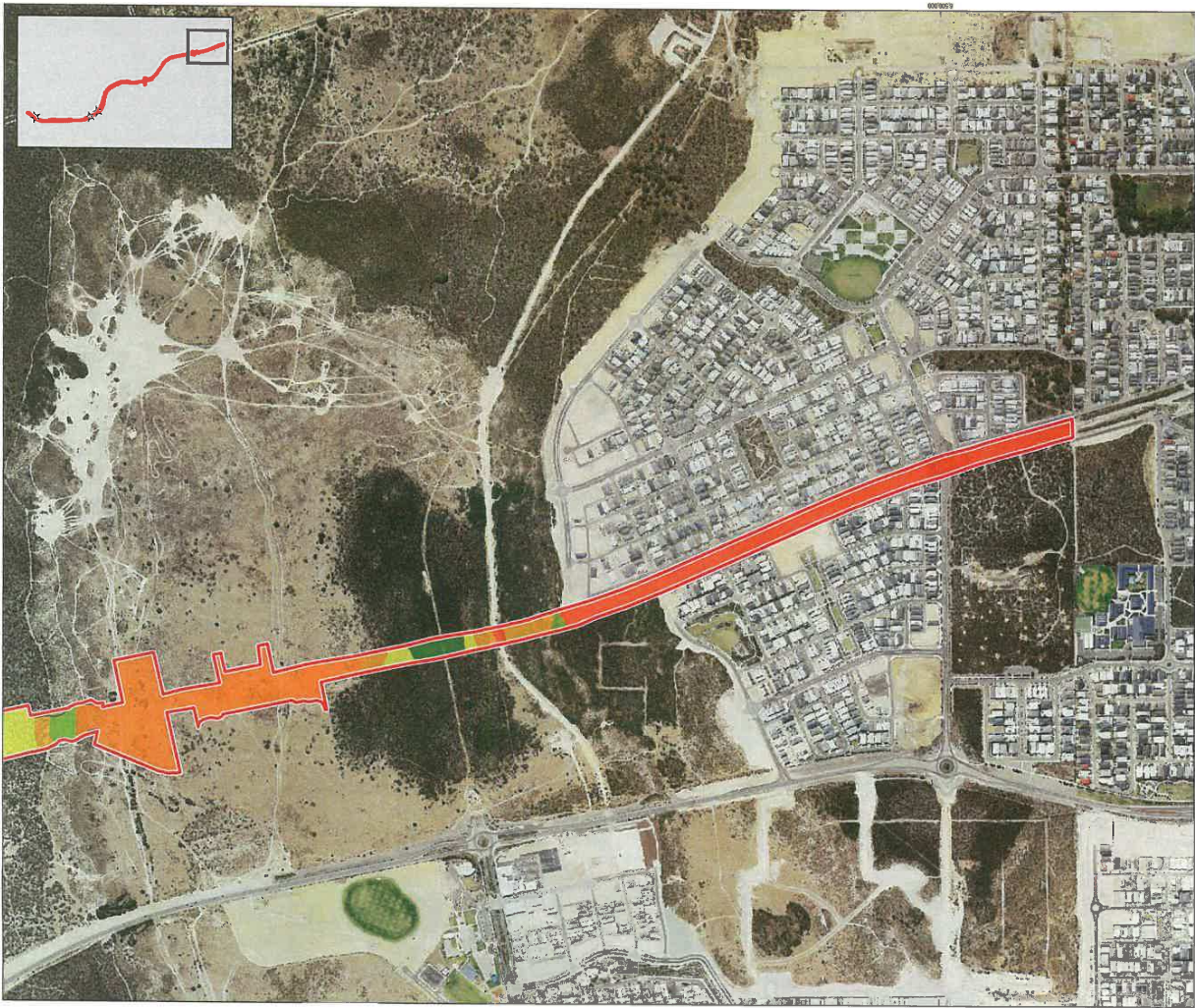


LEGEND

- Significant Weeds**
- Survey Area
 - Geophila rufescens*
 - Urosalpinx*
 - Urosalpinx*
 - Solanum torquatum*
 - Degraded
 - Critically Degraded
 - Cleared
 - Major Rese
- Vegetation Condition**
- Excellent
 - Very Good
 - Good
 - Fair
 - Poor
 - Degraded



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- Significant Weeds**
 - ★ *Chomolopogon fulvicornis*
 - ★ *Antrodia sacchara*
 - ★ *Callistemon linariiflorum*
- Survey Area**
 - Excellent
 - Very Good
 - Good
 - Degraded
 - Completely Degraded
- Proposed Alignment (PTA)**
- Original Alignment (PTA)**
- Vegetation Condition**
 - Good
 - Degraded
- Other**
 - Major Road

Scale: 0 to 300 Meters

North Arrow

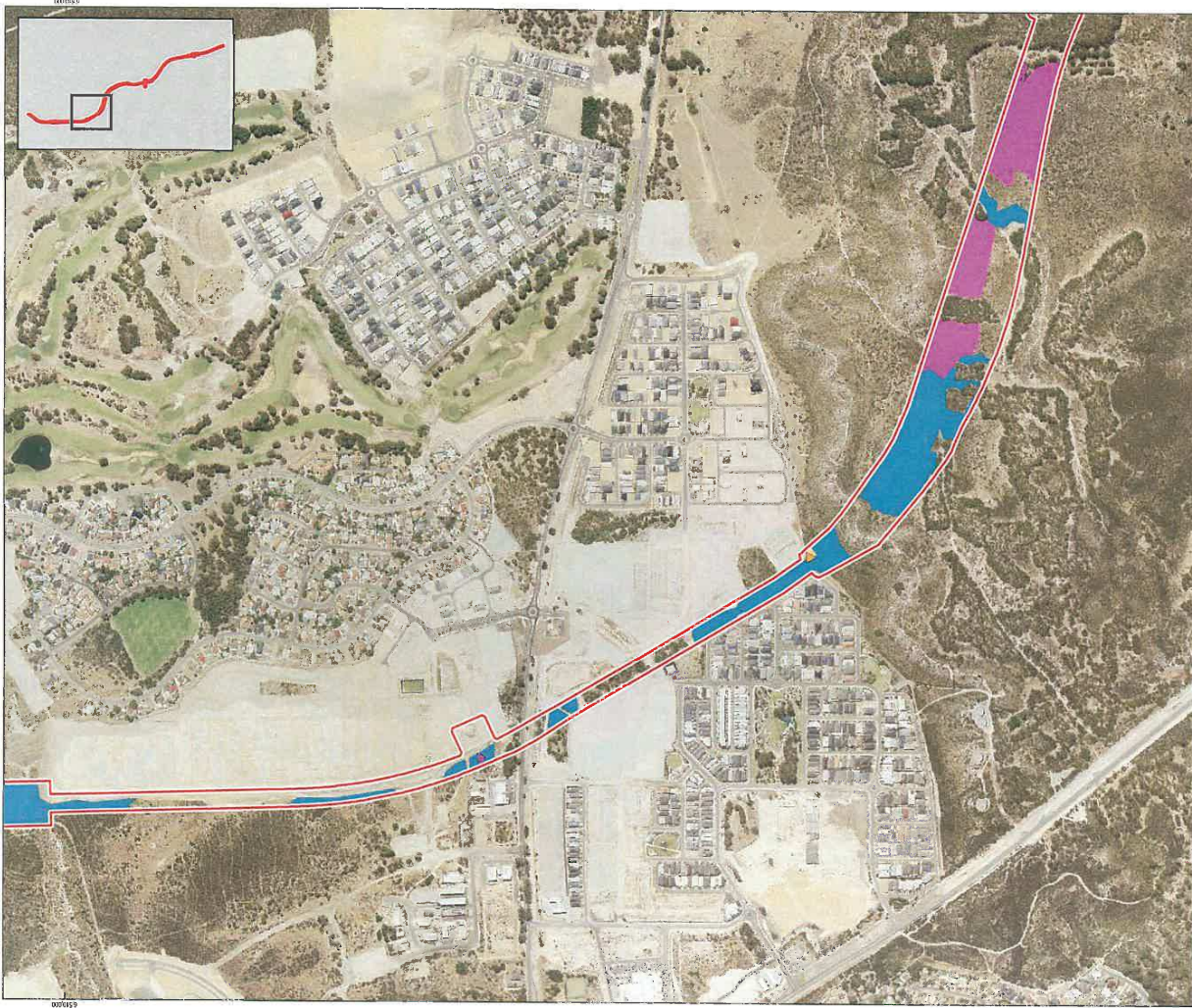
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 New Road - Main Road
 Projected Datum: GDA 1984
 GCS: GDA 1984 MGRS Zone 53

Public Transport Authority
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 Extension Flora & Fauna Survey
 Significant Weeds

Job Number: 61-3517
 Revision: 1
 Date: 17 Aug 2017

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 Figure 4

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LEGEND

Conservation significance (CSI)

Watercourse riparian zone (CSI)

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Date: 17 Aug 2017

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Figure 5

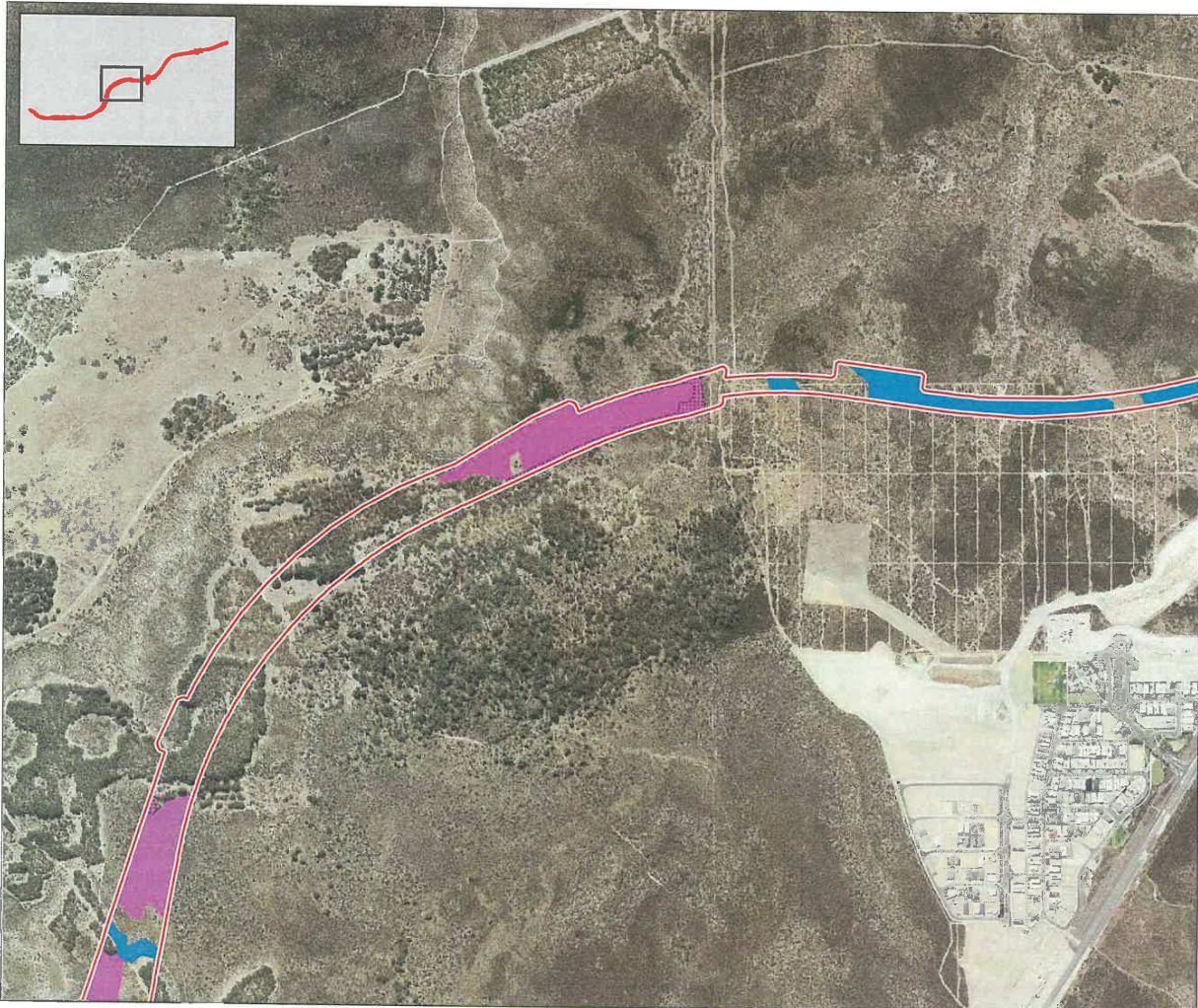
Conservation significant communities and flora

Conservation significant communities and flora

Conservation significant communities and flora

Conservation significant communities and flora

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LEGEND

- Survey Area
- VT04 & VT09 - Likely to be in good or better condition
- VT02 & VT03 - Likely to be in good or better condition
- Woodlands of the Swan Coastal Plain TEC (note: any of this veg type that is in good or better condition is this TEC)
- Woodlands of the Swan Coastal Plain TEC (note: any of this veg type that is in good or better condition is this TEC)
- Woodlands of the Swan Coastal Plain TEC (note: any of this veg type that is in good or better condition is this TEC)
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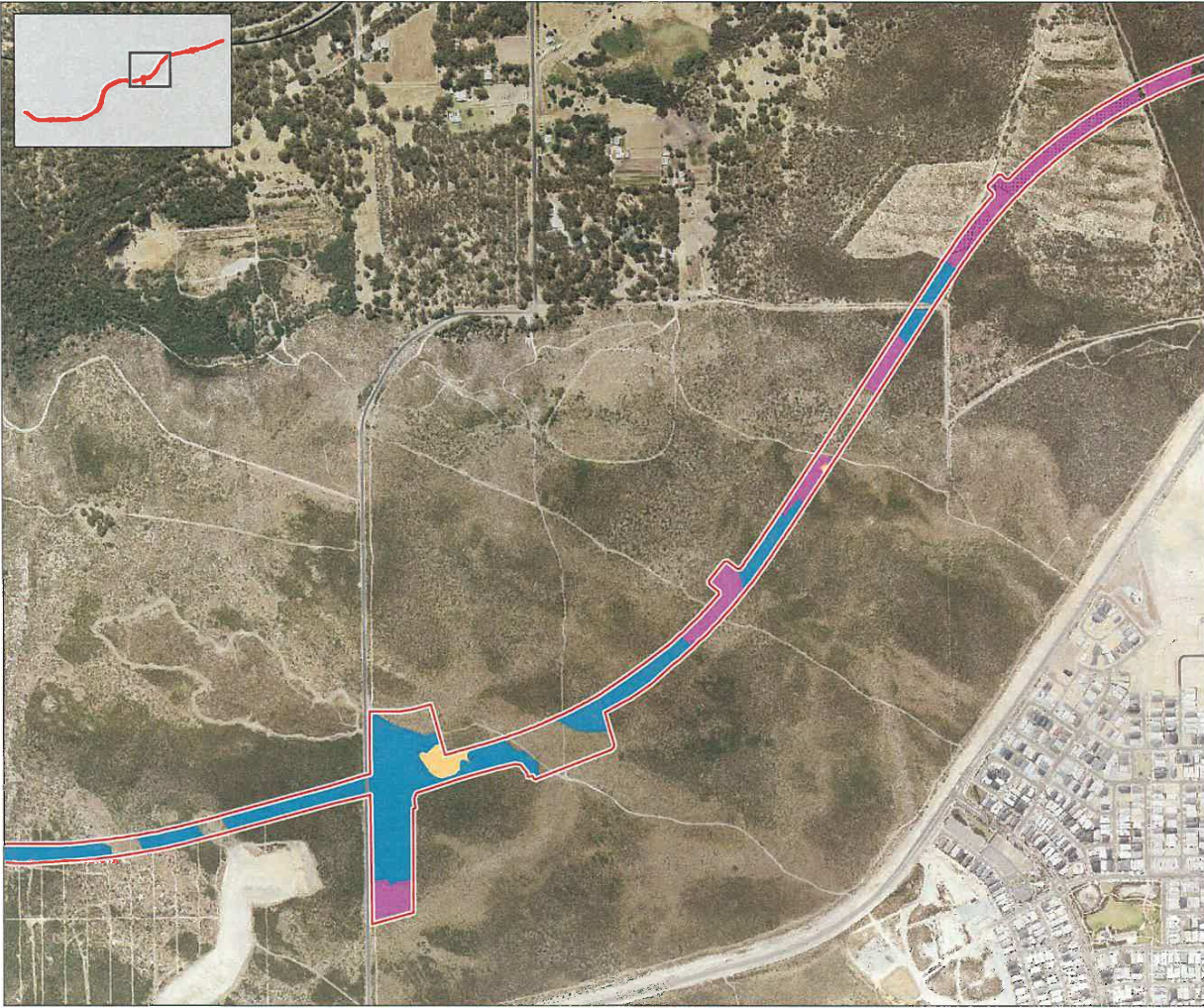
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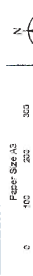
Page 4 of 7
Figure 5

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LEGEND

- Survey Area
- VTC2 & VTC3 - Likely to represent Northern Woodlands TEC
- VTC2 & VTC3 - Likely to represent Northern Woodlands TEC
- VTC4 & VTC6 - Likely to represent Banksia Scrub Coastal Plain TEC (note: any of this veg type that is in good or better condition is this TEC)
- VTC6 - Likely to represent Redgum riparian TEC



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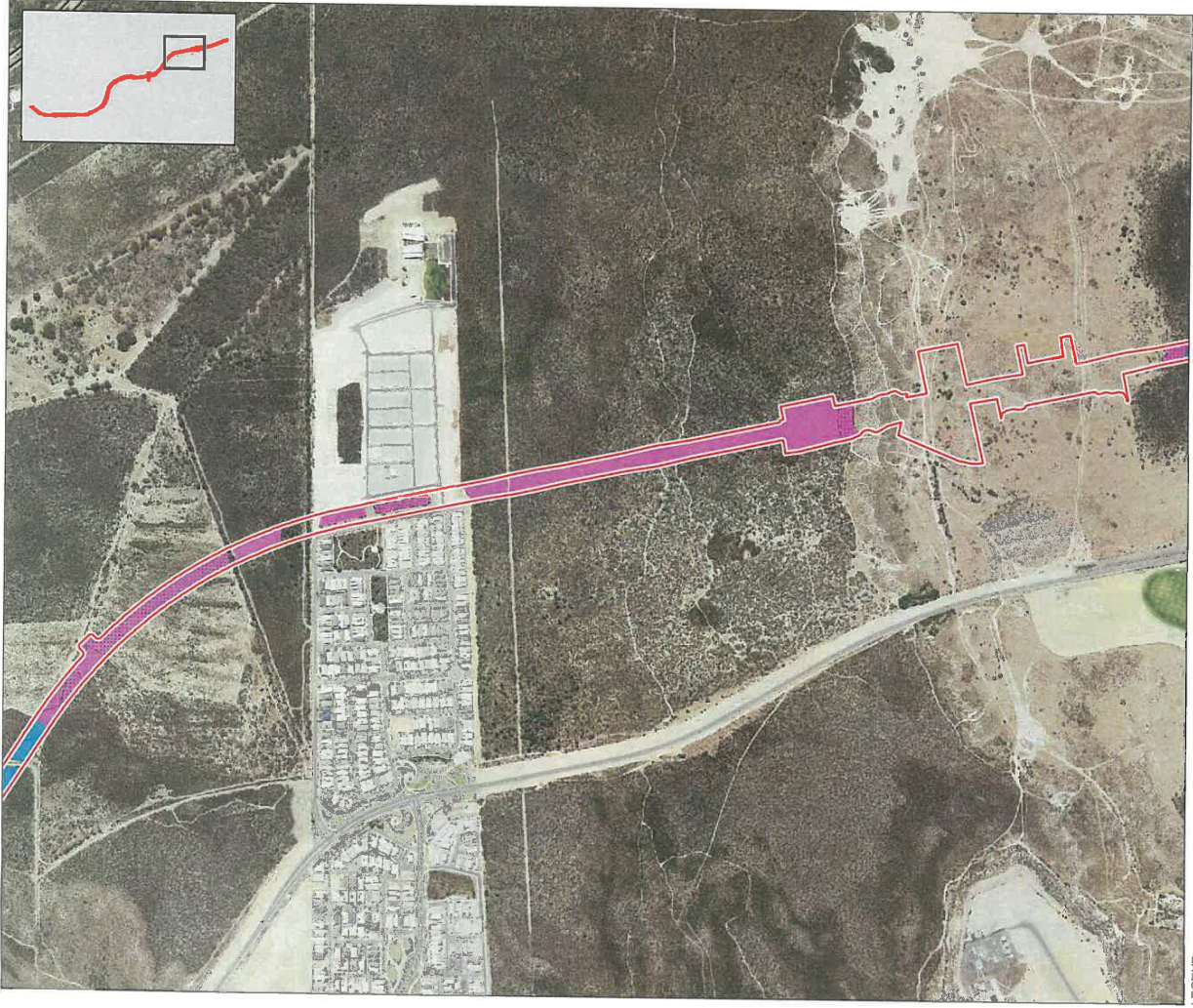


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LEGEND

- Survey Area
- VT04 & VT05 – Likely to be in poor or worse condition in the vegetation TEC (not all vegetation types are shown)
- VT02 & VT03 – Likely to be in good or better condition in the vegetation TEC
- VT04 & VT09 – Likely to be in good or better condition in the vegetation TEC
- Coastal Plain TEC (not any of this veg type that is in good or better condition is this TEC)
- Spanwood shrublands and woodlands PEC



Map Projection: Transverse Mercator
 Datum: GDA94
 Units: Meters
 Date: 17 Aug 2017



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 Conservation significant
 communities and flora

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