



**LEVEL 2 FLORA AND VEGETATION ASSESSMENT AND TARGETED
THELYMITRA STELLATA SURVEY**

**GREAT NORTHERN HIGHWAY, MUCHEA TO WUBIN UPGRADES,
STAGE 2 – BINDOON OPTIONS**

MAY 2017

ASJV

F  **FOCUSED
VISION**
consulting

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EXECUTIVE SUMMARY

Main Roads Western Australia (Main Roads) is upgrading the 218 km section of Great Northern Highway between Muchea and Wubin. Jacobs and Arup have formed the joint venture, ASJV, for the delivery of the project. The improvements to be made include town bypasses, wider roads, more passing lanes, flattening crests and easing curves, safer roadsides, more rest stops and additional facilities for heavy vehicles.

At the time of the surveys reported in this document, there were the following three proposed route options for the Great Northern Highway to bypass the town of Bindoon, which were broken down into the following four survey areas (collectively the 'study area'):

- Common Area (common to the southern commencement of both Areas 1 and 2) – Area 1
- Western Bypass A – Area 2
- Western Bypass B – Area 3
- Eastern Bypass – Area 4.

Focused Vision Consulting Pty Ltd (FVC) was commissioned by ASJV to undertake flora, vegetation and fauna assessments for the four survey areas, with this report presenting the results relevant to flora and vegetation. The results of the assessments will enable an environmental impact assessment for the preferred bypass route.

During spring 2016, experienced botanists from FVC carried out a single-phase Level 2 flora and vegetation assessment, in accordance with EPA Guidance Statement 51 (EPA 2004), and the Technical Guide for Flora and Vegetation Surveys (EPA & DPaW 2015). The survey incorporated a total survey effort of 18 person days and was conducted during October 2016. A total of 46 pegged quadrats and two relevés were established and sampled, to define the floristic values and documented a total of 13 different vegetation communities across the combined study area.

Additionally, a targeted survey for *Thelymitra stellata* (Star Sun-orchid) was carried out within selected areas in intact remnant vegetation within the study area, in accordance with the Commonwealth of Australia (2013b) Guidelines for Detecting Orchids Listed as 'Threatened' Under the *Environment Protection and Biodiversity Conservation Act 1999*. The targeted surveys were carried out utilising a combination of various survey intensities, in accordance with the guidelines (Commonwealth of Australia 2013b), and were carried out during November 2016 by three senior, experienced botanists, with a total of 21-person days invested. The aim was to survey at least 50% of the areas of suitable habitat for the species within the study area. *Thelymitra stellata* was not recorded in any location within any of the areas surveyed.

The key results and conclusions from the Level 2 flora and vegetation assessment, and targeted *Thelymitra stellata* survey are as follows:

- Seven species listed as Priority Flora under the *Wildlife Conservation Act 1950*, *Synaphea panhesya* (P1), *Gastrolobium ?crispatum* (P1), *Drosera sewelliae* (with *Drosera ?sewelliae*) (P2), *Acacia drummondii* subsp. *affinis* (P2), *Adenanthos cygnorum* subsp. *chamaephyton* (P3), *Anigozanthos humilis* subsp. *chrysanthus* (P3) and *Hibbertia miniata* (P4) were recorded during the field studies.

- It is considered likely that the distribution and abundance of the Priority flora recorded within the study area is greater than the recorded population extents and sizes and that additional species of Priority flora occur that were not recorded, due to the approach of the Level 2 assessment, highlighting the need for further, more detailed surveys to target Priority flora.
- No species of Threatened flora, including *Thelymitra stellata* were recorded within the study area.
- One State-listed Threatened Ecological Community (TEC) and two Priority Ecological Communities (PECs) are known to occur (based on database search results) within or closely adjacent to the study area, with all three of these ecological communities representative of the Commonwealth-listed Banksia woodlands of the Swan Coastal Plan TEC.
- The spring assessment scope was developed prior to the Banksia Woodlands of the Swan Coastal Plain being announced as a Commonwealth-listed TEC, in September 2016. However, future assessments will focus on Banksia woodlands and will enable assessment against the key diagnostic characteristics (Threatened Species Committee 2016) for determination of the presence of the TEC with certainty.
- The total area of likely Banksia woodland TEC within the study area is 22.67 ha, consisting of occurrences of vegetation communities BaXpAn, EtBeAn (including ?EtBeAn) and EtEpAn, all occurring within the Western A (Area 2) study area.
- Further assessment work would be required to accurately characterise and map the extent of the Banksia woodlands (Commonwealth) TEC within the study area, due to the prescriptive requirements of its definition.
- All of the recorded vegetation communities have been determined to be of local, regional or national significance, or a combination of these levels of importance. Most are locally significant due to supporting populations of Priority flora or having a limited local representation. Other factors determining local significance are, being considered floristically diverse or locally uncommon. Vegetation communities have been determined to be regionally significant due to being represented by less than 30% of their pre-European extent in the local government area, being limited to specific landform types, or being regionally uncommon. Three vegetation communities (BaXpAn, EtBeAn (including ?EtBeAn) and EtEpAn) are of national significance due to likely being representative the Commonwealth-listed Banksia woodlands of the Swan Coastal Plan TEC.

Table of Contents

Executive Summary	iii
1 Introduction	8
1.1 Background	8
1.2 Location	8
1.3 Scope of Work.....	10
2 Legislative Context	11
2.1 Threatened and Priority Flora.....	11
2.2 Threatened and Priority Ecological Communities	13
2.3 Locally or Regionally Significant Vegetation.....	14
2.4 Vegetation Clearing, Extent and Status.....	15
2.5 Environmentally Sensitive Areas.....	15
2.6 Introduced Flora	16
2.6.1 Weeds of National Significance.....	16
2.6.2 Declared Plants	16
2.6.3 Environmental Weeds.....	16
3 Existing Environment.....	17
3.1 IBRA Region	17
3.2 Climate	17
3.3 Geology and Soils	19
3.4 Vegetation	22
4 Biological Context.....	28
4.1 Threatened and Priority Flora.....	33
4.2 Threatened and Priority Ecological Communities	38
5 Methodology.....	41
5.1 Desktop Assessment and Literature Review.....	41
5.2 Field Assessment.....	41
5.3 Targeted <i>Thelymitra stellata</i> Survey	45
5.4 Data Processing and Analysis.....	54
5.5 Study Limitations.....	55
6 Results	57
6.1 Flora.....	57
6.1.1 Targeted <i>Thelymitra stellata</i> Survey.....	60
6.2 Vegetation Communities	60

6.3	Vegetation Condition	72
7	Discussion	80
7.1	Flora.....	80
7.1.1	Targeted Thelymitra stellata Survey.....	81
7.2	Vegetation	82
7.2.1	TECs and PECs	82
7.2.2	Local Representation and Significance.....	83
7.2.3	Regional Significance.....	85
7.2.4	National Significance	89
7.2.5	Summary of Vegetation Significance	89
8	Conclusions.....	91
9	List of Participants	92
10	References	93
Appendix A:	Threatened and Priority with the Potential to Occur within the Study Area	A1
Appendix B:	Quadrat Data.....	B1
Appendix C:	Flora Species Recorded within Each Quadrat	C1
Appendix D:	Flora Species Recorded within Each Vegetation Community.....	D1

Tables

Table 1	Definitions of Threatened and Priority Flora Species	12
Table 2	Categories of EPBC Act Threatened Flora Species	13
Table 3	Summary of Soil-Landscape Systems within the Study Area (DAFWA 2016b)	20
Table 4	Regional Vegetation of the Study Area and Surrounds (Shepherd et al. 2002)	23
Table 5	Vegetation Complexes of the Study Area (Heddle et. al. 1980; Havel and Mattiske 2000)....	25
Table 6	Summary of Key Findings from Recent Relevant Surveys	29
Table 7	Summary of Threatened and Priority Flora Occurring or Likely to Occur within the Study Area 34	
Table 8	Study Limitations	55
Table 9	Recorded Priority Flora Locations	58
Table 10	Summary of Recorded Vegetation Communities	62
Table 11	Codes for Tree Species Present in Pasture Communities	71
Table 12	Areas of Varying Vegetation Communities	72
Table 13	Areas of Varying Vegetation Condition	73
Table 14	Extent of Each Vegetation Community in the Study Area	84
Table 15	Regional Extent of Vegetation Associations within the Shire of Chittering and Study Area, as Represented by Vegetation Communities Recorded	88
Table 16	Summary of Significant Vegetation Communities	90
Table 17	Project Team	92

Figures

Figure 1	Study Area	9
Figure 2	IBRA Regions of the Study Area	18
Figure 3	Climate Data for Gingin Aero	19
Figure 4	Soil-Landscape Mapping of the Study Area	21
Figure 5	Regional Vegetation of the Study Area	26
Figure 6	Vegetation Complexes of the Study Area	27
Figure 7	Previously Recorded Threatened and Priority Flora	36
Figure 8	Known TECs and PECs	40
Figure 9	Quadrat Locations	44
Figure 10	Walked Tracks for Thelymitra stellata Survey	46
Figure 11	Recorded Locations of Priority Flora	59
Figure 12	Quadrat Cluster Analysis Dendrogram	61
Figure 13	Vegetation Communities of the Study Area	66
Figure 14	Vegetation Condition of the Study Area	75
Figure 15	Regional Vegetation Analysis Dendrogram	87

1 INTRODUCTION

1.1 BACKGROUND

Great Northern Highway is one of Western Australia's main land transport links and is the only sealed road connecting Perth with the Northern Territory. The highway forms part of the National Land Transport Network, which is defined as a national network of important road and rail infrastructure links (DoIRD 2015).

Main Roads Western Australia (Main Roads) is upgrading the 218 km section of Great Northern Highway between Muchea and Wubin. Jacobs and Arup together have formed a joint venture, ASJV, to partner with Main Roads for the delivery of the upgrade project. The integrated project team has completed a comprehensive planning review of the Muchea to Wubin section, and has prioritised a series of construction packages to be delivered between 2016 and 2019. The improvements to be made include town bypasses, wider roads, more passing lanes, flattening crests and easing curves, safer roadsides, more rest stops and additional facilities for heavy vehicles. These works will significantly improve safety and amenity and facilitate the future movement of road trains along this section of highway.

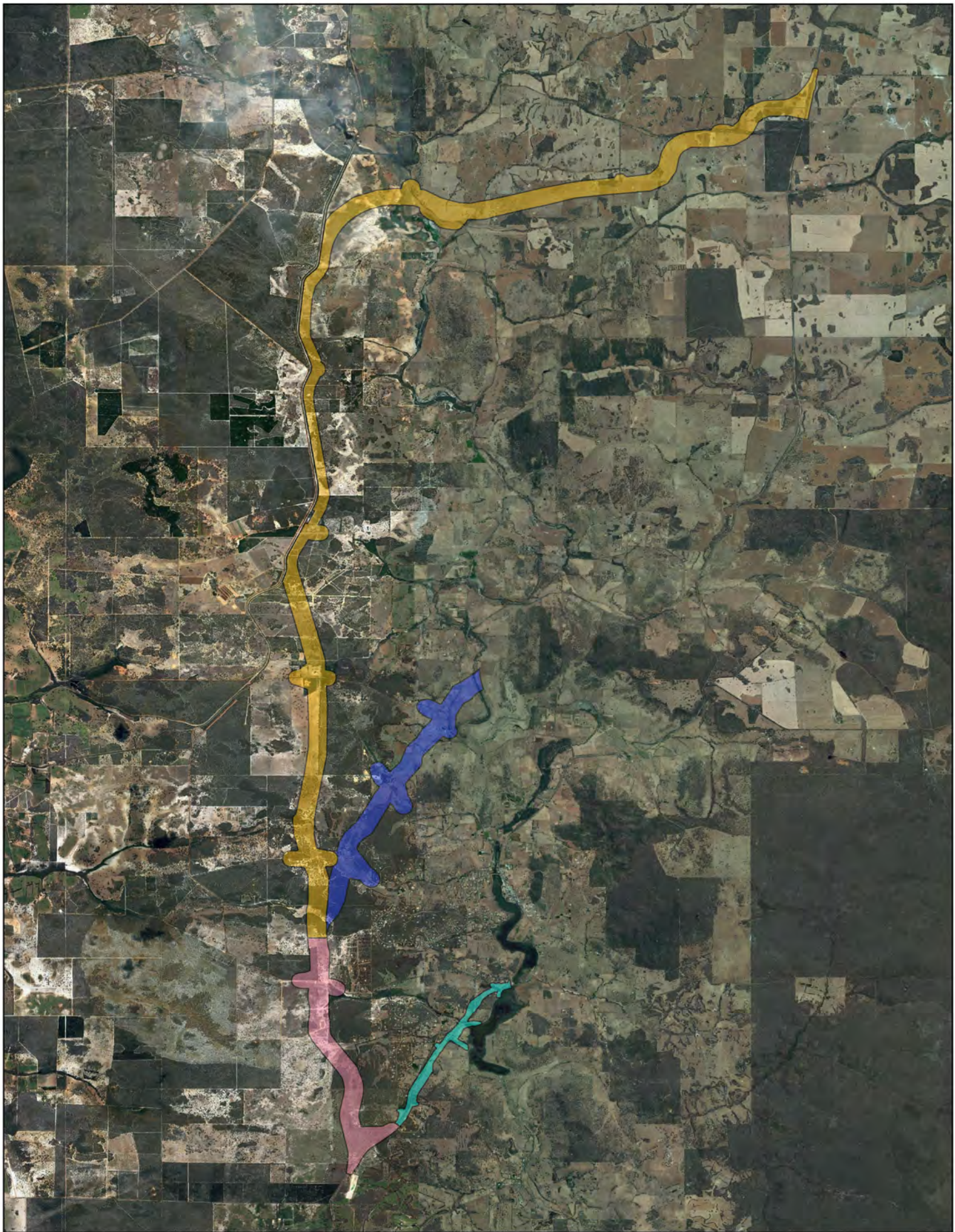
At the time of the surveys reported in this document, there were three proposed route options for the Great Northern Highway to bypass the town of Bindoon, which for the purpose of this scope were broken down into four survey areas (**Figure 1**). The four survey areas were:

- Common Area (common to the southern commencement of both Areas 1 and 2) – Area 1
- Western Bypass A – Area 2
- Western Bypass B – Area 3
- Eastern Bypass – Area 4.

ASJV undertook a multi-criteria analysis (MCA) of the routes, to determine the preferred option for further investigation. Focused Vision Consulting Pty Ltd (FVC) was commissioned by ASJV to undertake flora, vegetation and fauna assessments for the four route options, with this report presenting the results relevant to flora and vegetation. The results of the assessments will enable an environmental impact assessment for the preferred route.

1.2 LOCATION

The study areas are located in the Shire of Chittering between Chittering in the south, to Wannamal in the north, along the existing Great Northern Highway in the east and out to Mooliabeenee and Moondah in the west (**Figure 1**).







0 1 2 3 4 km

Figure 1 - Study Area



Legend

-  Common Area - Area 1
-  Western Bypass A - Area 2
-  Western Bypass B - Area 3
-  Eastern Bypass - Area 4

1.3 SCOPE OF WORK

The scope of the project was to undertake a spring assessment for flora and vegetation, including a targeted threatened flora survey for the study areas encompassing the route options.

Specifically, the scope of work included:

- desktop assessments to gather relevant biological information on the study area
- site assessments to determine the flora and vegetation values, including targeted threatened flora (*Thelymitra stellata*) assessments associated with the study areas, conducted in a single phase during spring 2016
- preparation of a spring flora and vegetation assessment report.

The assessments and reporting was carried out in accordance with relevant guidance, as listed in **Section 5**.

2 LEGISLATIVE CONTEXT

The flora and vegetation assessment was conducted in accordance with the following legislation:

- Commonwealth EPBC Act
- Western Australian *Environmental Protection Act* 1986 (EP Act)
- Western Australian *Wildlife Conservation Act 1950* (WC Act).

The assessment complied with requirements for environmental survey and reporting in Western Australia, as outlined in:

- EPA (2000) Position Statement No. 2: Environmental Protection of Native Vegetation in Western Australia
- EPA (2002) Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection
- EPA (2008) Guidance Statement No. 33: Environmental Guidance for Planning and Development
- EPA (2004) Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessments in Western Australia
- EPA & DPaW (2015) Technical Guide for Flora and Vegetation Surveys for Environmental Impact Assessment
- Commonwealth of Australia (2013b) Guidelines for Detecting Orchids Listed as 'Threatened' Under the Environment Protection and Biodiversity Conservation Act 1999.

2.1 THREATENED AND PRIORITY FLORA

The Department of Parks and Wildlife (DPaW) assigns conservation status to endemic plant species that are geographically restricted to few known populations or threatened by local processes. Allocating conservation status to plant species assists in protecting populations and conserving species from potential threats (DPaW 2016b, 2015).

Threatened flora species are gazetted under subsection 2 of section 23F of the WC Act. It is an offence to "take" or damage Rare Flora without Ministerial approval. Section 23F of the WC Act defines "to take" as "to gather, pick, cut, pull up, destroy, dig up, remove or injure the flora or to cause or permit the same to be done by any means."

Species designated as Priority Flora are under consideration for declaration as 'Threatened Flora' and are in urgent need of further survey (Priority 1 to 3) or require monitoring every 5-10 years (Priority 4). **Table 1** presents the definitions of Threatened and the four Priority ratings under the WC Act as extracted from DPaW (2015).

Table 1 Definitions of Threatened and Priority Flora Species

Conservation Code	Category
T	<p>Threatened Species</p> <p>Published as Specially Protected under the Wildlife Conservation Act, 1950 and listed under Schedules 1 to 4 of the Wildlife Conservation (Rare Flora) Notice for Threatened Flora.</p> <p>Flora that has been declared to be 'likely to become extinct or is rare, or otherwise in need of special protection', pursuant to section 23F(20) of the Wildlife Conservation Act.</p>
P1	<p>Priority 1 – Poorly Known Species</p> <p>Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey</p>
P2	<p>Priority 2 – Poorly Known Species</p> <p>Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.</p>
P3	<p>Priority 3 – Poorly Known Species</p> <p>Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.</p>
P4	<p>Priority 4 – Rare, Near Threatened and other species in need of monitoring</p> <p>(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands.</p> <p>(b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for Vulnerable, but are not listed as Conservation Dependent.</p> <p>(c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.</p>

Under the EPBC Act, actions that have, or are likely to have, a significant impact on a matter of national environmental significance (NES) require approval from the Federal Minister for the Environment.

Species at risk of extinction are recognised as Threatened at a Commonwealth level and are categorised according to the EPBC Act as summarised in **Table 2**.

Table 2 Categories of EPBC Act Threatened Flora Species

Conservation Code	Category
Ex	Extinct Taxa not definitely located in the wild during the past 50 years
ExW	Extinct in the Wild Taxa known to survive only in captivity
CR	Critically Endangered Taxa facing an extremely high risk of extinction in the wild in the immediate future
EN	Endangered Taxa facing a very high risk of extinction in the wild in the near future
VU	Vulnerable Taxa facing a high risk of extinction in the wild in the medium term
CD	Conservation Dependent Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened.

Any species listed in State and Commonwealth legislation as being of conservation significance is said to be a significant species. This incorporates species that are endangered, vulnerable and rare or covered by international conventions. Significance is not limited to species covered by State and Commonwealth legislation and also includes species of local significance and species showing significant range extensions or at the edge of their known range.

2.2 THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

Threatened Ecological Communities (TECs) are naturally occurring biological assemblages that occur in a particular type of habitat, which are subject to processes that threaten to destroy or significantly modify the assemblage across its range (DEC 2001).

Vegetation communities in Western Australia are described as 'TECs' if they have been defined by DPaW's Species and Communities Branch and found to be Presumed Destroyed (PD), Critically Endangered (CR), Endangered (EN) or Vulnerable (VU). The categories and the criteria for defining TECs have been described by English and Blyth (1997). A publicly available database, listing TECs within Western Australia is maintained by DPaW.

There is currently no legislation covering the conservation of TECs in WA, however some are protected under the Commonwealth EPBC Act. The TECs on the Commonwealth register are also listed on the Department of the Environment and Energy (DotEE) register on the website, and in the Protected Matters Database. For those State TECs not listed on the Commonwealth register, land clearing legislation under the EP Act also provides protection. The EPA's position on TECs states that proposals resulting in the direct loss of TECs are likely to be formally assessed.

Additional to TECs, ecological communities that are considered potentially of conservation significance (and potentially TECs) that do not currently meet survey criteria or that are not adequately defined,

are rare but not threatened, have been recently removed from the TEC list or require regular monitoring are considered to be Priority Ecological Communities (PECs) (DEC 2013) and they are required to be taken into consideration during environmental impact assessments.

2.3 LOCALLY OR REGIONALLY SIGNIFICANT VEGETATION

Vegetation may be locally or regionally significant in addition to significance according to statutory listings.

Vegetation communities are referred to as locally significant where they:

- support populations of Priority Flora species
- extend the geographic range of particular taxa from previously recorded locations
- are restricted to only one or a few locations
- occur as small isolated communities
- exhibit unusually high structural and species diversity.

Vegetation communities are referred to as regionally significant where they:

- are limited to specific landform types
- are uncommon or restricted plant community types within the regional context
- support populations of threatened flora.

Vegetation communities are referred to as Nationally significant where they

- support populations of Threatened (EPBC listed) species
- support TECs listed as nationally (EPBC) significant.

Guidance Statement 51 (EPA 2004) also states that “vegetation may be significant for a range of reasons, other than a statutory listing as a TEC or because the extent is below threshold level” (described in the following section). According to Guidance Statement 51, other significant vegetation may include communities that:

- exhibit scarcity
- support unusual species
- support a novel combination of species
- have a role as a refuge
- have a role as a key habitat for threatened species or large populations representing a significant proportion of the local to regional total population of a species
- are representative of the range of a unit (particularly, a good local and/or regional example of a unit in “prime” habitat, at the extremes of a range, recently discovered range extensions, or isolated outliers of the main range)
- have a restricted distribution.

2.4 VEGETATION CLEARING, EXTENT AND STATUS

Clearing of native vegetation is regulated in WA under the EP Act and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. Any clearing of native vegetation is an offence, unless carried out under a clearing permit or if the clearing is for an exempt purpose (DER 2016). A clearing permit is required under Part V of the EP Act, whereby permit applications to clear native vegetation must be assessed against the '10 Clearing Principles' as outlined in the regulations.

Where clearing of native vegetation is proposed to occur, purely from a biodiversity perspective, there are several key criteria applied to the assessment of clearing permit applications. The criteria, as outlined in EPA's Position Statement No. 2 (EPA 2000) are used to help reverse the long-term decline in the quality and extent of Western Australia's native vegetation cover. The criteria are as follows:

- the "threshold level" below which species loss appears to accelerate exponentially at an ecosystem level is regarded as being at a level of 30% of the pre-clearing extent of the vegetation type
- a level of 10% of the original extent is regarded as being a level representing "endangered"
- clearing which would put the threat level into the class below should be avoided
- from a biodiversity perspective, stream reserves should generally be in the order of at least 200 m wide.

The status of remaining vegetation can be delineated into five different classes:

- *Presumed extinct* - probably no longer present in the bioregion
- *Endangered* - <10% of pre-European extent remains*
- *Vulnerable* - 10-30% of pre-European extent exists*
- *Depleted* - >30% and up to 50% of pre-European extent exists*
- *Least concern* - >50% pre-European extent exists and has been subject to little or no degradation over a majority of this area.

* or a combination of depletion, loss of quality, current threats and rarity gives a comparable status.

2.5 ENVIRONMENTALLY SENSITIVE AREAS

Environmentally Sensitive Areas (ESAs) are areas that require special protection due to aspects such as landscape, wildlife of historical value and are generally considered to be areas of high conservation value. ESAs are declared in the Environmental Protection (Environmentally Sensitive Areas) Notice 2005, which was gazetted on 8 April 2005.

There are several types of ESAs relating to flora and vegetation, declared under Part V of the EP Act, which include:

- a defined wetland and the area within 50 m of that wetland
- the area covered by vegetation within 50 m of rare (Threatened) flora, to the extent where the vegetation is continuous with the vegetation in which the rare (Threatened) flora is located
- the area covered by a TEC
- Bush Forever sites
- areas covered by the following policies:
 - *Environmental Protection (Gnangara Mound Crown Land) Policy 1992*
 - *Environmental Protection (Western Swamp Tortoise) Policy 2002*

- *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992*
- *Environmental Protection (South West Agricultural Zone Wetlands) Policy 1998*
- areas of native fringing vegetation in the policy area as defined in *Environmental Protection (Swan and Canning Rivers) Policy 1998*.

2.6 INTRODUCED FLORA

To date, over 1,200 introduced (weed) species have been recognised to occur within Western Australia (EPA 2007). Introduced flora (weeds) are plants that are not indigenous to an area and have been introduced either directly or indirectly through human activity. They establish in natural ecosystems and adversely modify natural processes, resulting in the decline of the invaded community and the habitat value provided for native fauna. Weeds threaten the survival of many flora because of their rapid growth and the ability to out-compete native plants for available nutrients, water, space and sunlight.

2.6.1 Weeds of National Significance

Under the National Weed Strategy, there are currently 32 weed species listed as Weeds of National Significance (WONS). Each weed was considered for inclusion based on the following criteria; invasive tendencies, impacts, potential for spread and socioeconomic and environmental values.

2.6.2 Declared Plants

The Western Australian Organism List (WAOL) details organisms listed as Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) (DAFWA 2016a). Under the BAM Act, Declared Pests are listed under one of the following categories:

- C1 (exclusion), that applies to pests not established in Western Australia; control measures are to be taken to prevent their entry and establishment
- C2 (eradication), that applies to pests that are present in Western Australia but in low numbers or in limited areas where eradication is still a possibility
- C3 (management), that applies to established pests where it is not feasible or desirable to manage them in order to limit their damage.

2.6.3 Environmental Weeds

Introduced species have also been ranked by a number of attributes, including invasiveness, distribution and environmental impacts in the various DPaW regions in *An Environmental Weed Strategy* (CALM 1999). To advance the above categorisation, the Invasive Plant Prioritisation Process for DPaW was developed in 2011 (DEC 2011).

3 EXISTING ENVIRONMENT

3.1 IBRA REGION

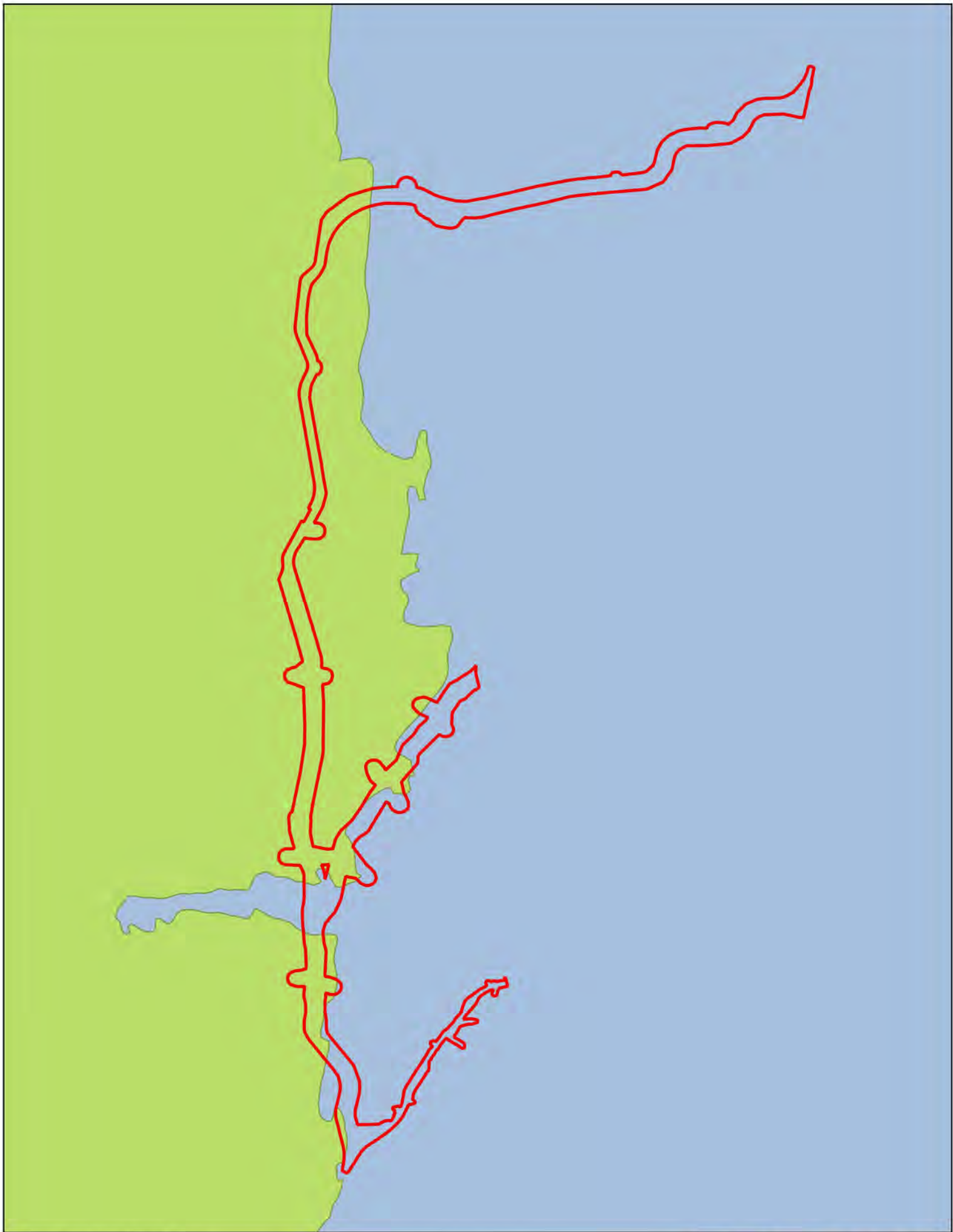
There are 89 recognised Interim Biogeographic Regionalisation for Australia (IBRA) regions across Australia that have been defined based on climate, geology, landforms and characteristic vegetation and fauna (Commonwealth of Australia 2013a). The study area lies within the Swan Coastal Plain and Jarrah Forrest IBRA regions (**Figure 2**). At a finer scale, the study area falls within the Dandaragan Plateau and the Northern Jarrah Forrest subregions.

The Dandaragan Plateau subregion of the Swan Coastal Plain is bordered by the Derby and Dandaragan Faults with cretaceous marine sediments mantled by sands and laterites. Vegetation of this subregion is characterised by Banksia low woodland, Jarrah–Marri woodland, Marri woodland and scrub heaths on laterite pavement and on gravelly sandplains. Large numbers of Threatened flora have been recorded from the area (Desmond 2001).

The Northern Jarrah Forest subregion incorporates the area east of the Darling Scarp, overlying Archaean granite and metamorphic rocks capped by an extensive lateritic duricrust (Williams & Mitchell 2001). Vegetation comprises Jarrah-Marri forest in the west with Bullich (*Eucalyptus megacarpa*) and Blackbutt (*E. patens*) in the valleys grading to Wandoo (*E. wandoo*) and Marri woodlands in the east with Powderbark (*E. accedens*) on breakaways. The extensive but localised sand sheets support Banksia low woodlands.

3.2 CLIMATE

The Bindoon area experiences a warm and temperate climate, where the winter months experience greater rainfall than the summer months (Climate data.org 2016). Gingin Aero (site number 9178) is the closest Bureau of Meteorology (BoM) recording station which has been recording since 1968 and has recorded an average annual rainfall of 620 mm. The annual mean maximum temperature ranges from 18.3°C in winter to 33.3°C in summer (BoM 2016) (**Figure 3**).






0 1 2 3 4 km



Figure 2 - IBRA Regions of the Study Area



Legend

-  Study Area
-  Jarrah Forest
-  Swan Coastal Plain

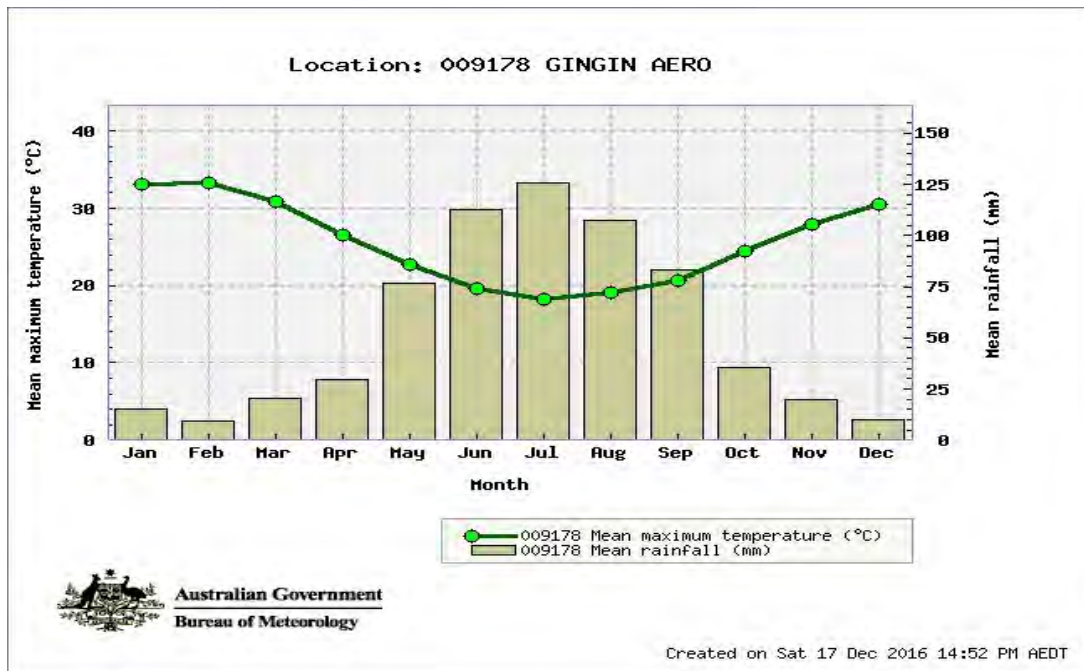


Figure 3 Climate Data for Gingin Aero

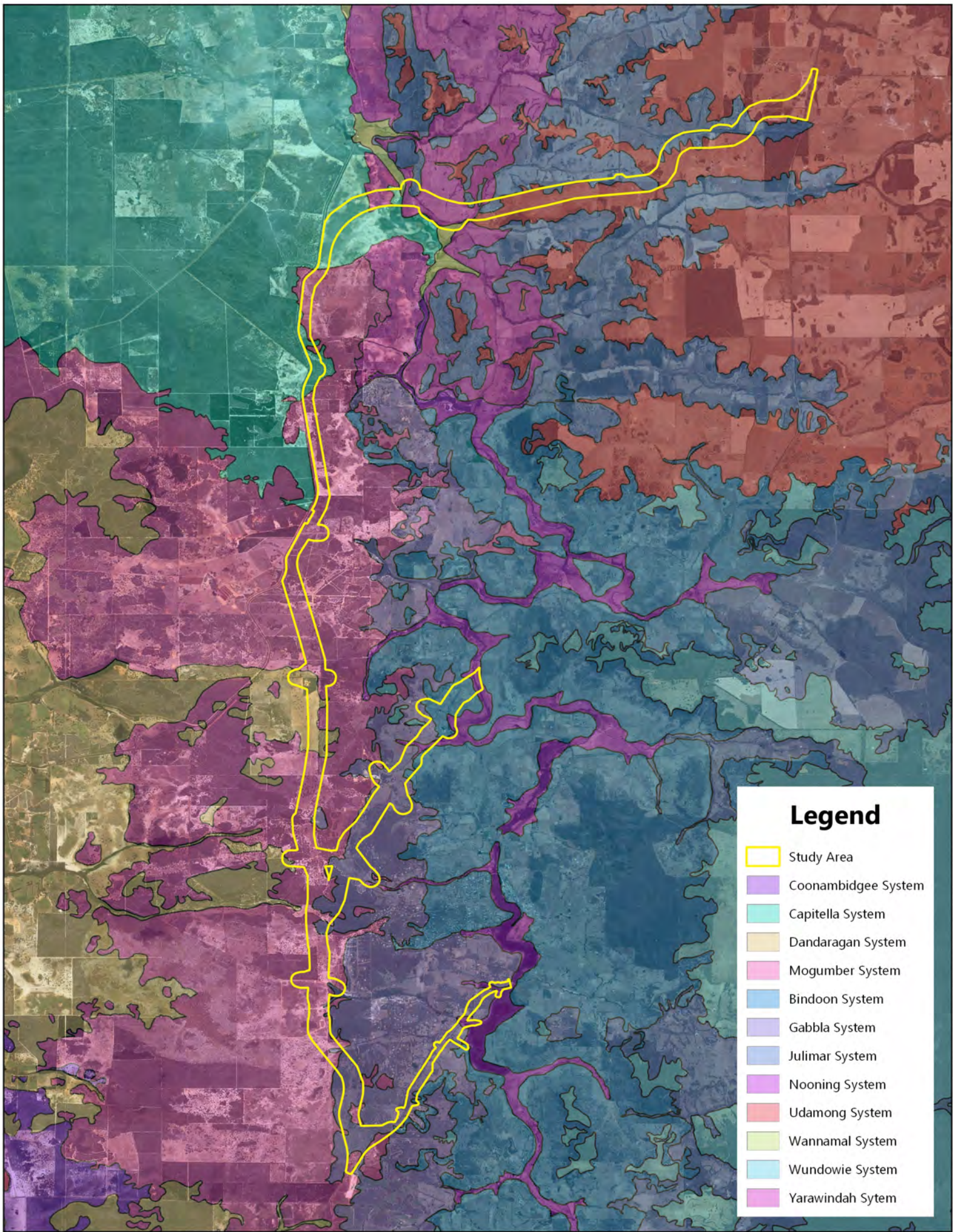
3.3 GEOLOGY AND SOILS

Soil-landscape mapping across Western Australia has been compiled by the Department of Agriculture and Food WA (DAFWA) (2016b) using various surveys at different scales varying between 1:20,000 and 1:3,000,000.

At the system scale, the study area traverses a number of regional soil-landscape mapping systems, as summarised in **Table 3**, with their extent in the study area shown in **Figure 4**.

Table 3 Summary of Soil-Landscape Systems within the Study Area (DAFWA 2016b)

Map Unit	Soil System	Description
222Cb	Coonambidgee System	Footslopes of sand, on the western margin of the Dandaragan Plateau. Low woodland and shrubland with occasional trees. Species include <i>Banksia prionotes</i> , low and occasional stunted <i>E. marginata</i> with <i>Adenanthos</i> spp..
222Cp	Capitella System	subdued stripped lateritic plateau, undulating to gently undulating low rises with gently undulating plain including dunes; pale and yellow deep sands, sandy gravels, some duplex; from sandstones plus alluvial and aeolian deposits.
222Da	Dandaragan System	Subdued dissected lateritic plateau, undulating low hills and rises with narrow alluvial plains. Variable deep sands and sandy gravels plus minor earths, duplexes and clays. Marri woodlands and shrublands.
222Mb	Mogumber System	Gentle to moderate sloping sandplain, varying from pale to yellow clayey sand with gravel and laterised ridges. Low woodland and shrubland of, <i>C. calophylla</i> , <i>Banksia</i> and <i>Acacia</i> spp.. Some tall <i>C. calophylla</i> and <i>E. marginata</i> .
253Bn	Bindoon System	Gentle to steep hills with gentle valleys on metamorphic gneiss and schist, and dolerite. Variable soils. Wandoo woodland with some <i>Casuarina huegeliana</i> in rocky areas and marri woodland on sandy areas, minor York gum woodland.
253Ga	Gabbla System	Western boundary of the Darling Pateau to the east of the Dandaragan plateau. Gently to moderately slopes. Yellow, red and grey loams and clays, with gravel common and sand pockets. <i>E. wandoo</i> and <i>E. loxophleba</i> on clay.
253Ju	Julimar System	Moderately dissected areas with gravelly slopes and ridges and minor rock outcrop on the eastern side of the Darling Plateau over weathered granite and granitic gneiss. loamy gravel, shallow duplexes and pale deep sand common. Wandoo woodland.
253Nn	Nooning System	Brockman river valley flattish valley floors of the upper that is prone to salinity. Loams, clays and gleyed salty sandy clays and gravelly soils are present. <i>E. rudis</i> , <i>E. camaldulensis</i> , <i>Melaleuca</i> and <i>Casuarina obesa</i> in the most salty areas.
253Ug	Udamong System	Northern Darling Range near New Norcia. Partially stripped lateritic plateau with undulating low hills to gently undulating rises. Loamy gravel, minor pale sand and clay; deep weathered granitic gneiss, gneiss and schist



0 1 2 3 4 km



Figure 4 - Soil-Landscape Mapping of the Study Area

3.4 VEGETATION

The vegetation within the study area has been broadly characterised as Banksia low woodland, Jarrah–Marri woodland, Marri woodland, Bullich (*Eucalyptus megacarpa*) and Blackbutt (*E. patens*) in the valleys and Wandoo (*E. wandoo*) and Marri woodlands with Powderbark (*E. accedens*) on breakaways (Desmond 2001, Mitchell & Williams, 2001). The study area traverses eight vegetation associations characterised by Shepherd *et al.* (2002), and the general vicinity of the study area supports 15 vegetation associations, as summarised in **Table 4**.

Vegetation complexes within the study area have also been defined by Heddle *et al.* (1980) and Havel and Mattiske (2000). These complexes are based on vegetation in association with landforms and underlying geology. A collective total of ten vegetation complexes occur within the study area. These are described as follows:

1. **Bindoon Complex.** This complex is broadly characterised by *Eucalyptus loxophleba* (York gum) on the lower valley slopes, flanked by Wandoo higher upslope.
2. **Coolakin Complex in low rainfall.** Comprises of Woodlands of *Eucalyptus wandoo* with mixtures of *Eucalyptus patens*, *Eucalyptus marginata* subsp. *thalassica* and *Corymbia calophylla* on the valley slopes in arid and perarid zones.
3. **Cullulla Complex.** Mixture of low open forest of Banksia spp. *Eucalyptus todtiana* and open woodland *Corymbia calophylla* with second storey of *Eucalyptus todtiana*, *Banksia attenuata*, *Banksia menziesii* and *Banksia ilicifolia*.
4. **Michibin Complex.** Open woodland of *Eucalyptus wandoo* over *Acacia acuminata* with some *Eucalyptus loxophleba* on valley slopes, with low woodland of *Allocasuarina huegeliana* on or near shallow granite outcrops in arid and perarid zones.
5. **Mogumber Complex–South.** Open woodland of *Corymbia calophylla* with some mixture of *Eucalyptus marginata* subsp. *thalassica* and a second storey of *Eucalyptus todtiana*, *Banksia attenuata*, *Banksia menziesii*, *Banksia ilicifolia* on sandy gravels on the uplands in arid and perarid zones.
6. **Moondah Complex.** Low closed to low open forest of *Banksia attenuata*, *Banksia menziesii*, *Eucalyptus todtiana* and *Banksia prionotes* on slopes, open woodland of *Corymbia calophylla* and *Banksia* spp. in valleys.
7. **Murray and Bindoon Complex in low to medium rainfall.** This complex is characterised by *Eucalyptus wandoo* woodland on the valley slopes and woodlands of *Eucalyptus rudis* (flooded gum) and *Melaleuca raphiophylla* (freshwater paperbark) on the fringes of watercourses.
8. **Nooning Complex.** This complex is restricted to the upper valley floors of the Brockman River. This complex is characterised by low open forest of *Casuarina obesa* (Swamp sheoak) and the presence of *Casuarina obesa*, *Eucalyptus rudis* and *Melaleuca raphiophylla* along streams.
9. **Wannamal Complex.** Low shrubland of the Dandaragan Plateau comprising of a mixture of low shrubland of *Melaleuca* spp. and open woodland of *Eucalyptus wandoo* and *Eucalyptus loxophleba*.
10. **Yalanbee Complex in low rainfall.** This complex is characterised by woodlands of *Eucalyptus wandoo*–*Eucalyptus accedens*, less consistently open forest of *Eucalyptus marginata* subsp. *thalassica*–*Corymbia calophylla* on lateritic uplands and breakaway landscapes in arid and perarid zones.

A summary of vegetation complexes occurring within the study area is presented in **Table 5**.

Table 4 Regional Vegetation of the Study Area and Surrounds (Shepherd *et al.* 2002)

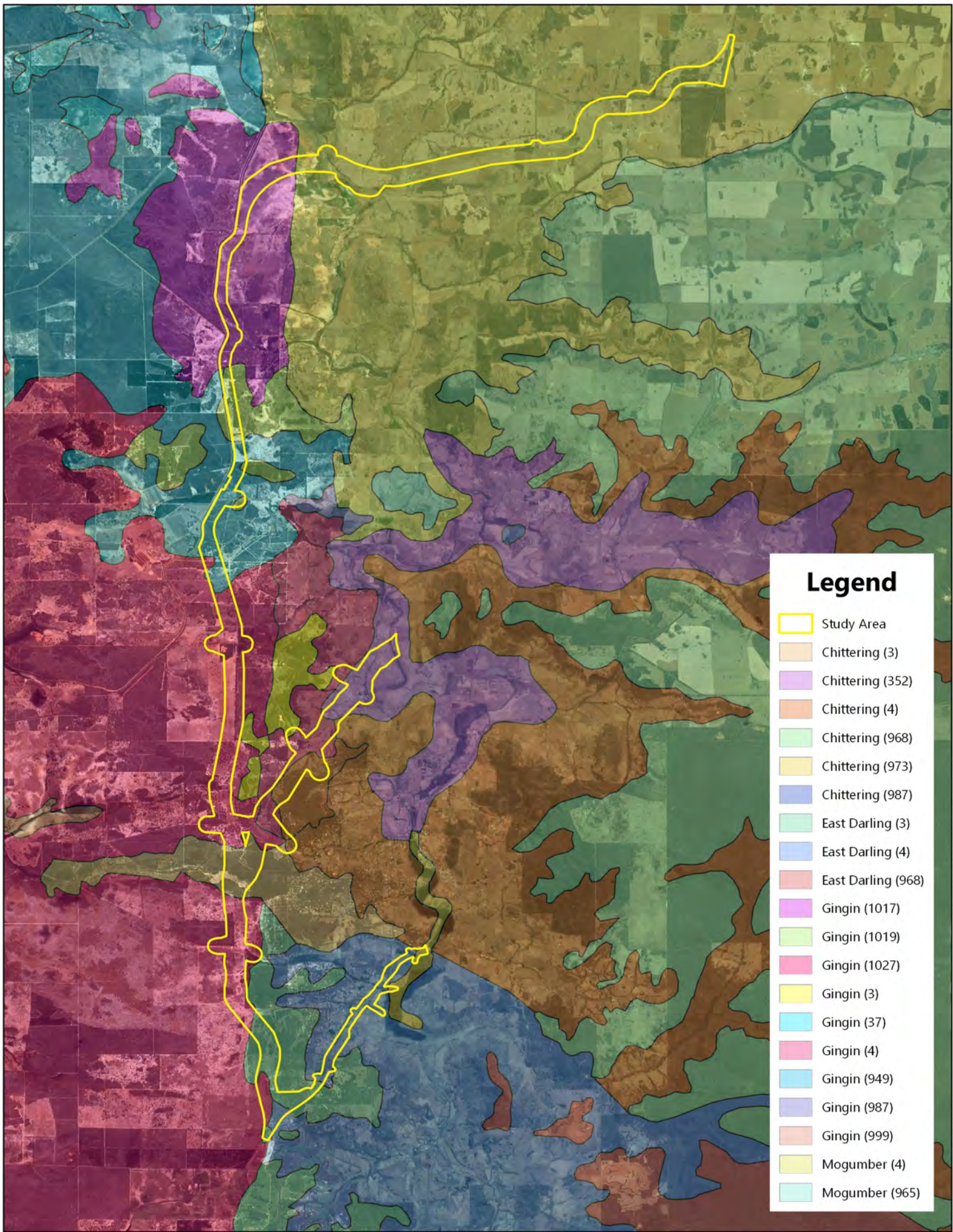
Shepherd Code	Intersects with Study Area	Short Description	Broad Vegetation Description
3	Area 1 Area 2 Area 3 Area 4	Medium forest; jarrah-marri	U <i>Eucalyptus marginata</i> , ^ <i>Corymbia calophylla</i> , <i>Allocasuarina fraseriana</i> \tree\7c;M <i>Acacia urophylla</i> , <i>Bossiaea aquifolium</i> , <i>Hakea cyclocarpa</i> \shrub\4i;G <i>Macrozamia riedlei</i> , <i>Styphelia tenuiflora</i> , <i>Lepidosperma angustatum</i> \cycad,forb,shrub,sedge\2i
4	Area 1 Area 2 Area 3 Area 4	Medium woodland; marri & wandoo	U ^ <i>Corymbia calophylla</i> , ^ <i>Eucalyptus wandoo</i> \tree\7i;M <i>Acacia cyanophylla</i> , <i>Jacksonia sternbergiana</i> , <i>Xanthorrhoea preissii</i> \shrub, <i>Xanthorrhoea</i> \4i
			U ^ <i>Corymbia calophylla</i> , ^ <i>Eucalyptus wandoo</i> , <i>Nuytsia floribunda</i> \tree\7i;M <i>Daviesia horrida</i> , <i>Dryandra sessilis</i> , <i>Hakea cristata</i> \shrub\3i;G <i>Acacia pulchella</i> , <i>Dryandra nivea</i> , <i>Hibbertia hypericoides</i> \shrub,cycad, <i>Xanthorrhoea</i> \2i
37	-	Shrublands; teatree thicket	U <i>Banksia littoralis</i> , <i>Melaleuca preissiana</i> \tree\6r;M ^ <i>Melaleuca</i> sp., <i>Hakea</i> sp., <i>Beaufortia squarrosa</i> \shrub\3d
			U <i>Eucalyptus rudis</i> ^ <i>Melaleuca raphiophylla</i> \tree\7cG <i>Viminaria denudata</i> \sedge\2i
352	Area 3	Medium woodland; York gum	U ^ <i>Eucalyptus loxophleba</i> \tree\7i;M <i>Acacia acuminata</i> , <i>Acacia cyanophylla</i> \shrub\4i
949	Area 2	Low woodland; <i>banksia</i>	U ^ <i>Banksia attenuata</i> , <i>Banksia menziesii</i> , <i>Eucalyptus todtiana</i> \tree\6i;G <i>Conospermum incurvum</i> , <i>Verticordia nitens</i> \shrub\4c
			U ^ <i>Banksia attenuata</i> , <i>Banksia menziesii</i> , <i>Eucalyptus todtiana</i> \tree\6i;M <i>Calothamnus sanguineus</i> , <i>Petrophile brevifolia</i> , <i>Eremaea pauciflora</i> \shrub\4i;G <i>Hibbertia hypericoides</i> , <i>Stirlingia latifolia</i> , <i>Synaphea polymorpha</i> \shrub,sedge\2c
965	-	Medium woodland; jarrah & marri	U ^ <i>Eucalyptus marginata</i> , ^ <i>Corymbia calophylla</i> \tree\7i
968	-	Medium woodland; jarrah, marri & wandoo	U ^ <i>Eucalyptus marginata</i> , <i>Banksia grandis</i> \tree\7i;M <i>Acacia varia</i> var. <i>affinis</i> , <i>Adenanthos cygnorum</i> , <i>Allocasuarina humilis</i> \shrub\4i;G <i>Anigozanthos humilis</i> , <i>Burchardia umbellata</i> , <i>Conostylis setosa</i> \forb,shrub,sedge\2i
973	Area 4	Low forest; paperbark (<i>Melaleuca raphiophylla</i>)	U <i>Eucalyptus rudis</i> , ^ <i>Melaleuca preissiana</i> \tree\7c

Shepherd Code	Intersects with Study Area	Short Description	Broad Vegetation Description
987	-	Medium woodland; jarrah & wandoo	U^ <i>Eucalyptus marginata</i> , ^ <i>Eucalyptus wandoo</i> \tree\7\i
999	-	Medium woodland; marri	U^ <i>Corymbia calophylla</i> , <i>Eucalyptus loxophleba</i> , <i>Acacia cyanophylla</i> \tree\7\i; M <i>Acacia pulchella</i> , <i>Boronia scabra</i> , <i>Bossiaea</i> sp. \shrub, cypad, <i>Xanthorrhoea</i> \4\i; G <i>Hibbertia hypericoides</i> , <i>Hybanthus calycinus</i> , <i>Lechenaultia biloba</i> \shrub, forb\2\i
1009	-	Medium woodland; marri & river gum	U^ <i>Corymbia calophylla</i> , ^ <i>Eucalyptus rudis</i> \tree\7\i
1017	Area 2	Medium open woodland; jarrah & marri, with low woodland; banksia	U <i>Eucalyptus marginata</i> , ^ <i>Corymbia calophylla</i> , <i>Banksia attenuata</i> \tree\7\i
1018	-	Mosaic: Medium forest; jarrah-marri / Low woodland; banksia / Low forest; teatree / Low woodland; <i>Casuarina obesa</i>	U^ <i>Eucalyptus marginata</i> , ^ <i>Corymbia calophylla</i> \tree\7\c; M <i>Melaleuca</i> sp., <i>Banksia</i> sp., <i>Casuarina obesa</i> \tree\6\c
1019	Area 2	Medium sparse woodland; jarrah & marri	U^ <i>Eucalyptus marginata</i> , ^ <i>Corymbia calophylla</i> \tree\7\r
1027	Area 1 Area 2 Area 3	Mosaic: Medium open woodland; jarrah & marri, with low woodland; banksia / Medium sparse woodland; jarrah & marri	U <i>Corymbia calophylla</i> , <i>Eucalyptus marginata</i> , ^ ^ <i>Banksia attenuata</i> \tree\7\I

Table 5 Vegetation Complexes of the Study Area (Heddle *et al.* 1980; Havel and Mattiske 2000)

Survey Area	Vegetation Complex
Common Area – Area 1	Coolakin Complex in low rainfall
	Mogumber Complex - South
	Yalanbee Complex in low rainfall
Western Bypass A – Area 2	Bindoon Complex
	Coolakin Complex in low rainfall
	Mogumber Complex - South
	Moondah Complex
	Nooning Complex
	Yalanbee Complex in low rainfall
Western Bypass B – Area 3	Coolakin Complex in low rainfall
	Cullulla Complex
	Michibin Complex
	Mogumber Complex - South
	Moondah Complex
	Nooning Complex
	Wannamal Complex
	Yalanbee Complex in low rainfall
Eastern Bypass – Area 4	Bindoon Complex
	Nooning Complex
	Murray and Bindoon complex in low to medium rainfall
	Yalanbee complex in low rainfall

The extent of each of each vegetation associations (Shepherd *et al.* 2002) and vegetation complexes (Heddle *et al.* 1980) present within the study area is presented in **Figures 4** and **5**, respectively.

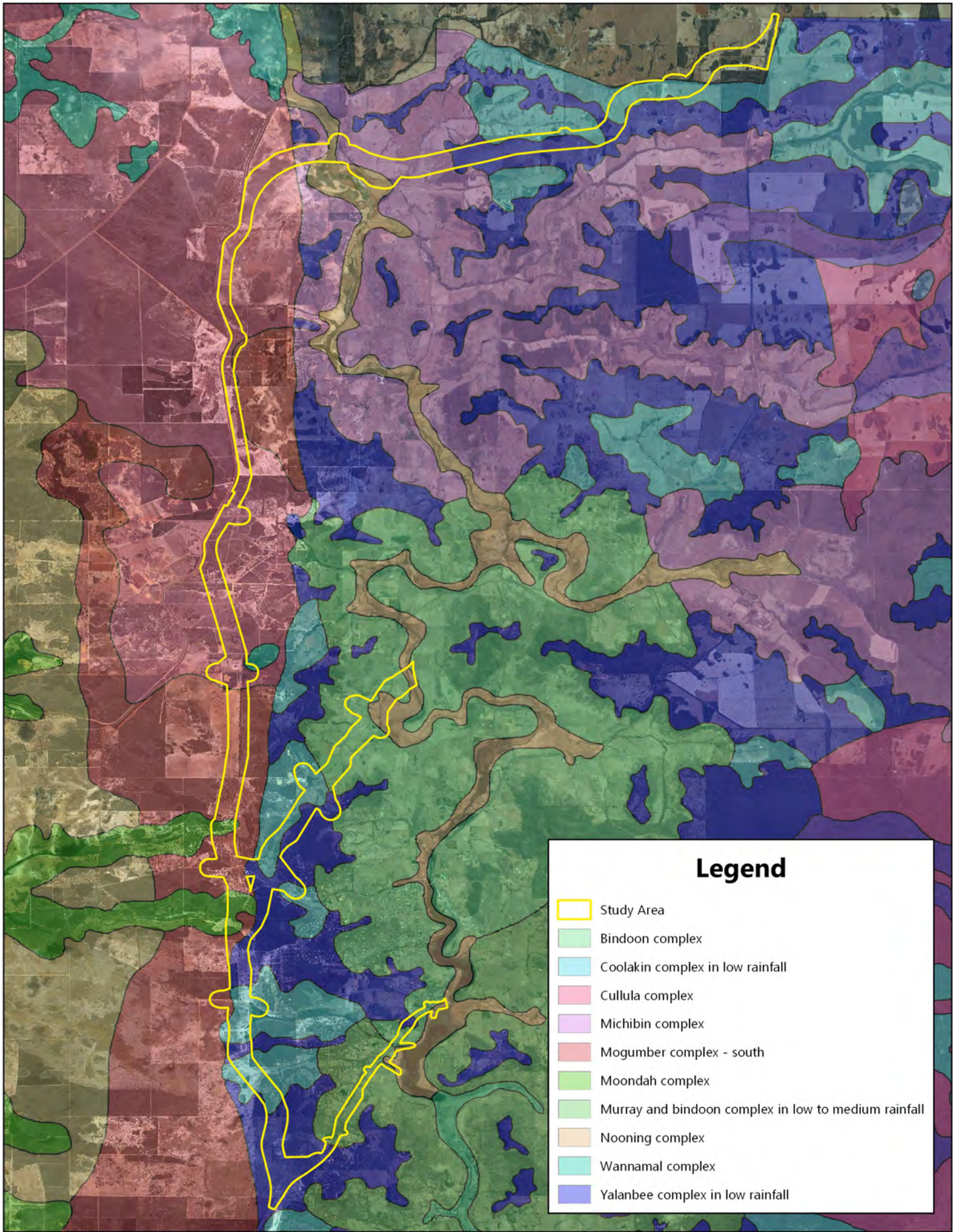


- ### Legend
- Study Area
 - Chittering (3)
 - Chittering (352)
 - Chittering (4)
 - Chittering (968)
 - Chittering (973)
 - Chittering (987)
 - East Darling (3)
 - East Darling (4)
 - East Darling (968)
 - Gingin (1017)
 - Gingin (1019)
 - Gingin (1027)
 - Gingin (3)
 - Gingin (37)
 - Gingin (4)
 - Gingin (949)
 - Gingin (987)
 - Gingin (999)
 - Mogumber (4)
 - Mogumber (965)

0 1 2 3 4 km



Figure 5 - Regional Vegetation of the Study Area



Legend

- Study Area
- Bindoon complex
- Coolakin complex in low rainfall
- Cullula complex
- Michibin complex
- Mogumber complex - south
- Moondah complex
- Murray and bindoon complex in low to medium rainfall
- Noonung complex
- Wannamal complex
- Yalanbee complex in low rainfall

0 1 2 3 4 km



Figure 6 - Vegetation Complexes of the Study Area



4 BIOLOGICAL CONTEXT

Numerous relevant surveys have been previously conducted within the area between Chittering and Bindoon to Wannamal and surrounds. A review of the most recent available studies was undertaken to collate existing information on Threatened and Priority Flora and previously mapped vegetation communities. Detailed findings have been reported in the following:

- Phoenix Environmental Sciences (2015) Flora and fauna assessment for Muchea North and Chittering study area
- GHD (2011a) Report for Great Northern Highway Upgrade: Muchea to Bindoon Environmental Impact Assessment (SLK 33.13 – 65.31)
- GHD (2011b) Report for Great Northern Highway Upgrade: Muchea to Bindoon Flora and Fauna Assessment (SLK 33.13 – 65.31)
- ENV (2007) Great Northern Highway Flora and Vegetation Assessment – SLK 89 to SLK 114
- KBR (2006) Environmental Impact Assessment and Management Plan. Great Northern Highway – Bindoon South SLK 54.6 to SLK 62.1
- Western Botanical (2006) Flora for extension of proposed disturbances on Great Northern Highway road reserve
- KBR (2005) Preliminary Environmental Impact Assessment. Great Northern Highway – Muchea (SLK 36) to Wubin (SLK 253)
- Goble-Garratt (2005) Great Northern Highway Upgrade – Bindoon South Section (Hart Drive to Bindoon Townsite SLK 54.6 to 62.0)
- Ecologia Environment (2004) Great Northern Highway: assessment of flora and vegetation.

These surveys form the basis of the literature review component of the desktop assessment and the key findings from each are summarised in **Table 6**.

Table 6 Summary of Key Findings from Recent Relevant Surveys

Author, Area, Scope and Methodologies	Key Findings
Phoenix Environmental Sciences (2015)	
<ul style="list-style-type: none"> -Level 2 Flora assessment of work package 1 (Muecha North – SLK 10.9 to SLK 46.44) and work package 2 (Chittering – SLK 46.44 to SLK 51.82) of Great Northern Highway Upgrade Area -Spring surveys conducted October 2014 (Phase 1) and September 2015 (Phase 2) -Additional targeted species searches where conducted in May 2015 -Average width of study area was 200 m with an approximate total survey area of 302.6 ha -Included vegetation type/condition mapping, targeted searches for conservation significant flora, vegetation and declared pest plants (weeds) -A total of 32 quadrats and 17 relevés sampled 	<ul style="list-style-type: none"> -Phoenix (2015) study area is approximately 600 m south of current study area at the closest point along Great Northern Highway -Database searches identified the potential for 17 Threatened Flora listed under the EPBC Act, 18 flora listed under the WC Act ,15 State Priority Flora and seven Declared Pest plants -A total of 273 taxa recorded, including seven conservation significant flora; <i>Darwinia foetida</i> (T; CE), <i>Stylidium squamellosum</i> (P2), <i>Acacia drummondii</i> subsp. <i>affinis</i> (P3), <i>Haemodorum loratum</i> (P3), <i>Verticordia serrata</i> var. <i>linearis</i> (P3), <i>Verticordia serrata</i> var. <i>linearis</i> (P4), <i>Eucalyptus caesia</i> (P4) -Targeted surveys conducted for <i>Darwinia foetida</i> (CE), <i>Trichocline</i> sp. <i>Treeton</i> (P2), <i>Daviesia debilior</i> subsp. <i>sinuans</i> (P3) and <i>Verticordia lindleyi</i> subsp. <i>lindleyi</i> (P4) -No Commonwealth or State listed TECs or PECs recorded, however five TECs and three PECs occur between 200 m and 4.5 km from the study area -19 vegetation associations defined within the study area, none considered to be representative of known TECs or PECs -16 vegetation associations may be considered to be locally significant due to limited representation of the vegetation type within the study area or as they represent habitat for conservation significant flora recorded within the study area -Vegetation condition ranged from Completely Degraded to Pristine
GHD (2011a)	
<ul style="list-style-type: none"> -Preferred general corridor alignment for Great Northern Highway between Muecha and Bindoon (northern portion overlaps with FVC study area) -19 km by approximate width of 160m -EIA prepared through desktop assessments of relevant literature and databases; field assessments where appropriate -Included; Level 2 flora and vegetation, Level 1 fauna, dieback, contaminated sites, noise, ethnographic/indigenous/European heritage 	<ul style="list-style-type: none"> -A number of impacts to flora and fauna were identified through EIA including; impact to Bindoon and Chittering Lakes and their associated vegetation, vegetation clearing of vegetation with less than 30% of pre-European extent remaining, potential impacts to listed Threatened fauna species such as Carnaby’s Black-cockatoos, dieback and weeds - No Commonwealth or State listed TECs or PECs identified to occur within the study area through database searches or field assessment -Database searches identified 12 Threatened Flora and 32 Priority Flora likely to occur within 10 km of the study area -Three Priority flora species recorded; <i>Millotia tenuifolia</i> var. <i>laevis</i> (P2), <i>Acacia drummondii</i> subsp. <i>affinis</i> (P3) and <i>Persoonia sulcata</i> (P4) -Vegetation clearing is considered to be at or may be at variance with Principles (b), (e), (f), (h) and (i) of the ten clearing principles -Three Nature Reserves (A Class: Bindoon and Chittering Lakes Nature Reserve, Barracca Nature Reserve and C Class; Burroloo Well Nature Reserve) occur within the vicinity of the study area. Small area of Bindoon and Chittering Nature Reserve likely to be impacted
GHD (2011b)	

Author, Area, Scope and Methodologies	Key Findings
<p>-Flora and fauna assessment of corridor alignment for upgrades and realignment of Great Northern Highway between Muchea and Bindoon, extends 19 km (northern portion overlaps with FVC study area)</p> <p>-Level 2 Flora and vegetation assessment in September 2010</p>	<p>-Approximately 119 ha of vegetation ranging from Pristine to Completely Degraded. Predominately considered to be in Degraded to Completely Degraded condition</p> <p>-A total of 277 taxa were recorded and 13 vegetation types described within the study area</p> <p>-Database search results identified two PECs within 10 km of the study area; Banksia Woodlands of the Gingin area restricted to soils dominated by yellow to orange sands (Priority 2) and Northern <i>Banksia attenuata</i>–<i>Banksia menziesii</i> woodlands (SCP23b) (Priority 3).</p> <p>-Two vegetation types (CcAcXpCaLs and AcCsMp) reported to exhibit similarities to (at the time) Endangered ecological community – <i>Banksia attenuata</i> woodland over species rich dense shrublands (SCP 20a) and Priority 3 ecological community – Northern <i>Banksia attenuata</i>-<i>Banksia menziesii</i> woodlands (SCP 23b). Both of which now correspond to Commonwealth-listed Banksia Woodlands of the Swan Coastal Plain TEC. However, advice from DEC confirmed that neither is representative of these communities based on location, soil type and species richness</p> <p>-Two vegetation types are represented by less than 30% of their pre-European extent and are considered Vulnerable</p> <p>-Three new Priority flora species populations were recorded by GHD (2011b); <i>Millotia tenuifolia</i> var. <i>laevis</i> (P2), <i>Acacia drummondii</i> subsp. <i>affinis</i> (P3) and <i>Persoonia sulcata</i> (P4). <i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i> (P3) was located within the current study area and <i>Verticordia lindleyi</i> subsp. <i>lindleyi</i> (P4) was recorded within the A Class Barracca Nature Reserve</p>
ENV (2007)	
<p>-Great Northern Highway south of New Norcia SLK 89 to SLK 114</p> <p>-Occurs to the north-east of the FVC study area, approximately 30 km north of Bindoon township along Great Northern Highway</p> <p>-Total survey length of 24 km</p> <p>-Level 2 Spring Flora and Vegetation survey conducted in November 2006</p> <p>-A total of 48 quadrats sampled</p>	<p>-A total of 357 taxa recorded, including eight current Priority flora</p> <p>-Priority flora recorded were; <i>Hemigenia curvifolia</i> (P2), <i>Synaphea rangiferops</i> (P2), <i>Acacia anarthros</i> (P3), <i>Acacia drummondii</i> subsp. <i>affinis</i> (P3), <i>Grevillea florida</i> (P3), <i>Hakea lasiocarpa</i> (P3), <i>Persoonia rudis</i> (P3) and <i>Grevillea drummondii</i> (P4)</p> <p>-No Threatened flora recorded</p> <p>-18 vegetation types described.</p> <p>-At the time of reporting there were no TECs listed for the study area</p> <p>-Declared Pest plants; <i>Asparagus asparagoides</i> and <i>Echium plantagineum</i> recorded</p> <p>-The vegetation condition varied from Completely Degraded to Excellent, however the majority of the road verge vegetation was found to be in Very Good or Excellent condition</p>

Author, Area, Scope and Methodologies	Key Findings
Western Botanical (2006)	
<p>-Flora and vegetation survey of eight work packages along Great Northern Highway from Brand Highway to Bindi Bindi-Toodyay Road</p> <p>-Work packages ranging in length from 3.49 km to 13.02 km; total survey length of 68.5 km</p> <p>-Level 1 spring flora and vegetation and an intensive Threatened and Priority flora survey, conducted between September and November 2005</p>	<p>-290 native species and 26 introduced flora species recorded</p> <p>-A total of 10 current Priority flora species recorded</p> <p>-34 vegetation types delineated; with those in the southern work packages predominantly consisting of Marri/Jarra/Wandoo/Powderbark woodlands, Banksia Woodlands, Casuarina Woodlands and creekline and swamp vegetation; and the northern work packages predominately consisting of York Gum/Salmon Gum/Wandoo/Powderbark Woodlands, Banksia Woodlands, Casuarina Woodlands, Mallee shrublands and succulent steppes with samphire</p> <p>-No determination of TECs or PECs made</p> <p>-Conservation significance of the vegetation within the road reserve was considered to be high due to the excellent condition, low weed invasion, the high number of Priority flora present and the extent of existing clearing that has occurred within the agricultural landscape</p>
KBR (2006)	
<p>-Great Northern Highway Bindoon South SLK 54.6 to SLK 62.1</p> <p>-EIA documented significant environmental aspects and management commitments of the GNH upgrade</p> <p>-Flora assessment undertaken as part of the EIA (Goble-Garret 2005) in late spring to early summer 2004/2005, encompassing roadsides of highway and areas immediately adjacent to footprint</p>	<p>-Close proximity to FVC study area along Great Northern Highway between Hart Drive and Bindoon townsite</p> <p>-A total project footprint of 15 ha (7 ha native vegetation and 8 ha of agricultural land)</p> <p>-EIA identified impacts pertaining to flora including disturbance to the Chittering Lakes Nature Reserve, dieback, weeds and presence of two Priority flora species; <i>Acacia drummondii</i> subsp. <i>affinis</i> and <i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i></p> <p>-Consultation with the DPaW (formerly CALM) regarding the presence of Priority flora concluded that; while both populations of Priority flora would be significantly impacted, both populations would be retained with reasonable numbers of plants and each taxa is well represented in the local area</p> <p>-Dieback assessment conducted in 2004 identified the majority of the project area to be dieback infected or at high risk of being infected</p> <p>-No TECs recorded</p>
Goble-Garratt (2005)	
<p>-Hart Drive to Bindoon Townsite SLK 54.6 to 62.0</p> <p>-General flora survey in November 2004. Follow-up survey during September 2005 targeting Priority flora</p>	<p>-Project area considered to be a floristically rich area</p> <p>-A total of 117 taxa recorded, considered to be low in comparison with the region survey due to small size of the survey area and mostly disturbed condition of remnant vegetation present</p> <p>-Two P3 flora species recorded within the study area (<i>Acacia drummondii</i> subsp. <i>affinis</i> and <i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>)</p> <p>-Seven vegetation units determined, none are considered to be comparable to TECs</p>

Author, Area, Scope and Methodologies	Key Findings
KBR (2005)	
<p>-Great Northern Highway – Muchea (SLK 36) to Wubin (SLK 253), 217 km in length</p> <p>-PEIA documented environmental aspects that are likely to be of concern and aimed to identify whether the project would be required to be referred to the EPA</p>	<p>-Numerous Threatened and Priority Flora identified through DPaW database searches. Two Threatened flora, <i>Banksia serratulooides</i> subsp. <i>serratulooides</i> (Vulnerable) and <i>Stylidium semaphorum</i> (Critically Endangered) identified within the road reserve</p> <p>-The section between SLK 79.17 and SLK 105.42 was considered particularly important due to 64% of Threatened or Priority flora species recorded falling within this area</p> <p>-One TEC (Coomberdale Chert) identified to occur near existing Great Northern Highway</p> <p>-Three A Class Nature Reserves and numerous C Class Reserves identified</p>
Ecologia Environment (2004)	
<p>-Great Northern Highway – Muchea (SLK 36) to Wubin (SLK 253) 217 km in length</p> <p>-Numerous vegetation surveys previously conducted however considered outdated; therefore desktop flora assessment was undertaken as part of PEIA and included DPaW Threatened and Priority Flora and TEC database searches</p>	<p>-Literature review of Ninox Wildlife Consulting (1989) identified a total of 300 flora taxa from 22 quadrats between SLK 37 and 149.</p> <p>-A total of 50 vegetation assemblages described.</p> <p>-DPaW database searches identified Threatened and Priority flora 28 species to occur between SLK 36 to SLK 253 within 1 km of the road centerline. Of these 11 are known to occur within the road reserve, although the Threatened and Priority flora assessment conducted by Sinclair Knight Mertz (2003) did not identify the presence of any conservation significant flora</p> <p>-DPaW database search identified the Coomberdale Chert TEC to occur near the existing Great Northern Highway, however, due to the absence of characteristic dominant flora species, it was determined that none of the communities described during the survey were representative of this TEC</p> <p>-Five additional WA TECs were identified outside the 500 m corridor. These were:</p> <ul style="list-style-type: none"> • <i>Corymbia calophylla</i>-<i>Xanthorrhoea preissii</i> woodlands and shrublands, (SCP 3c) – Critically Endangered • Perth to Gingin Ironstone Association (NTHIRON) – Critically Endangered • Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain) (Mound Springs SCP) – Critically Endangered • <i>Banksia attenuata</i> and/or <i>Eucalyptus marginata</i> woodlands on the eastern side of the Swan Coastal Plain (SCP 20b) - Endangered • Herb rich saline shrublands in clay pans (SCP 07) – Vulnerable

4.1 THREATENED AND PRIORITY FLORA

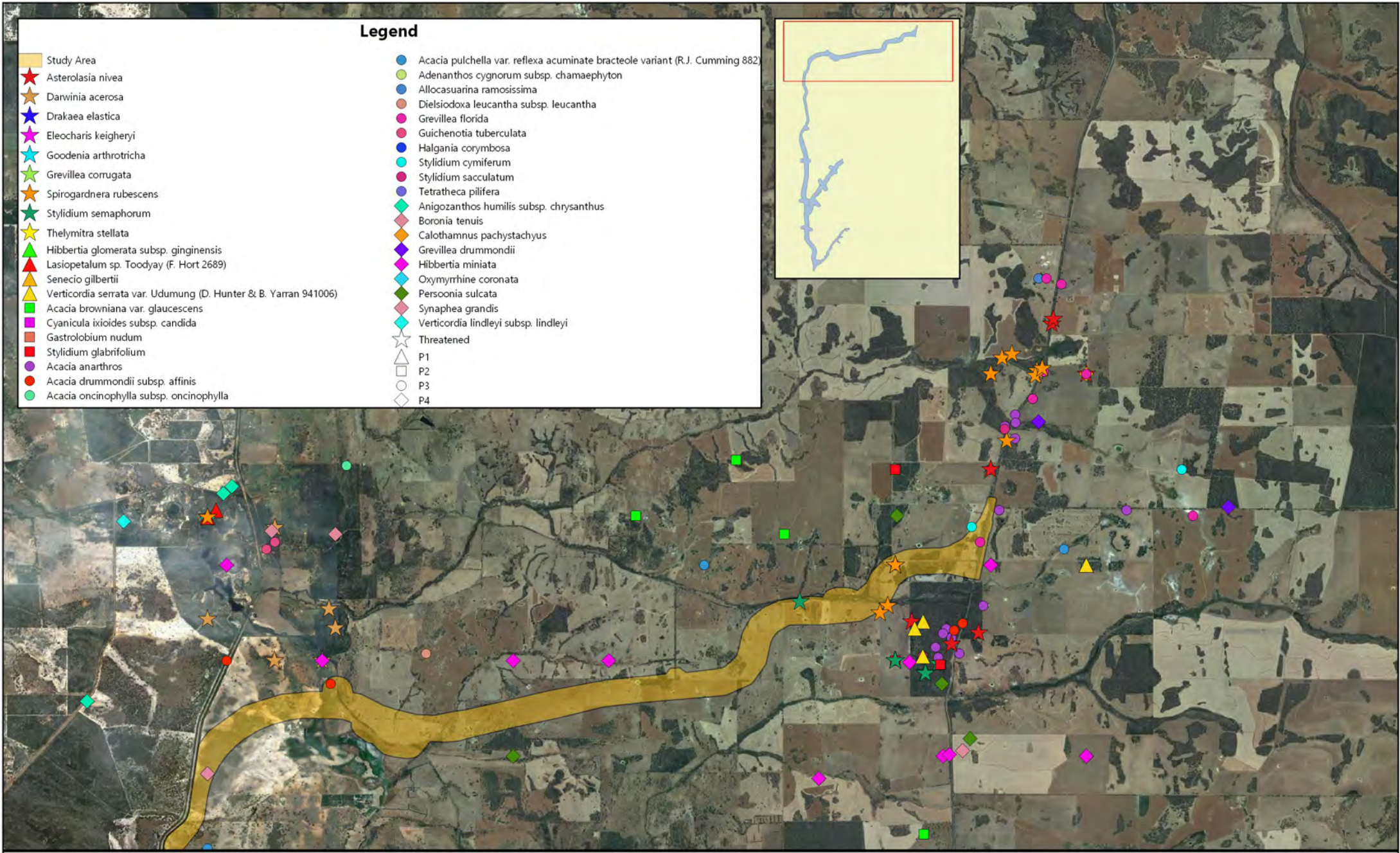
A desktop review for Threatened and Priority Flora was conducted using the EPBC Matters of National Environmental Significance (MNES) Protected Matters Search Tool, DPaW's NatureMap, DPaW database searches and a review of all literature reviewed as part of the desktop assessment. The review identified the presence or potential presence of 94 Threatened or Priority flora within the study area. This included 27 species protected under the EPBC Act, 29 WA Threatened flora (including the 27 EPBC-listed species), nine Priority 1, 12 Priority 2, 27 Priority 3 and 17 Priority 4 species. This complete list of previously recorded or potentially occurring Threatened and Priority flora relevant to the study area is presented in **Appendix A**.

Of the 94 flora species of conservation significance potentially relevant to the study area, it was determined (based on habitat preference, current distribution and known records) that three species are known to occur and have been previously recorded within the study area, eight are considered likely to occur and 35 species may occur, with the remaining 46 considered unlikely to occur (**Appendix A**). Species that have been previously recorded within the study area, those that were recorded during the current study and those that are likely to occur are summarised in **Table 7**. The distribution of known Threatened and Priority flora occurring in the region of the study area (based on desktop assessment results only) is spatially presented in **Figure 7**.

Table 7 Summary of Threatened and Priority Flora Occurring or Likely to Occur within the Study Area

Species	EPBC Act Cons. Status	WA Cons. Status	Description	Preferred Habitat	Likelihood of occurrence	Source
<i>Drakaea elastica</i>	Endangered	Critically Endangered	Tuberous, perennial, herb, 0.12-0.3 m high. Flowers red & green & yellow, October to November	White or grey sand. Low-lying situations adjoining winter-wet swamps	Likely to occur; previously recorded within Area 2	DPaW (2016) NatureMap
<i>Gastrolobium crispatum</i>		Priority 1	Tall shrub, to 2.5 m high. Flowers yellow and orange and red, September to October	Yellow or brown sandy loam, red laterite soils. Steep gullies, slopes, ridges, breakaways	Likely to occur, previously recorded from Bindoon area. Recorded plant identified as possibly this species.	DPaW (2016)
<i>Synaphea panhesya</i>		Priority 1	Erect shrub, 0.3-0.6 m high. Flowers yellow, August to September	Gravelly loam & sandy gravel	Recorded during current study	DPaW (2016)
<i>Drosera sewelliae</i>		Priority 2	Fibrous-rooted, rosetted perennial, herb, to 0.06 m high, to 0.025 m wide. Flowers orange, October	Laterite & silica sand soils	Recorded during current study	DPaW (2016)
<i>Stylidium squamellosum</i>		Priority 2	Caespitose perennial, herb, 0.12-0.35 m high. Inflorescence racemose. Flowers yellow, October to November	Brown to red-brown clay loam. Winter-wet habitats and depressions, open woodland, shrubland	Likely to occur, recorded by Phoenix (2015)	Phoenix (2015)
<i>Acacia drummondii</i> subsp. <i>affinis</i>		Priority 3	Erect shrub, 0.3-1 m high. Flowers yellow, July to August	Jarrah woodland. Plateau, laterite. Lateritic gravelly soils	Likely to occur, closest known record occurs within 900 m of Area 2. Recorded plant identified as possibly this species.	DPaW (2016) NatureMap Phoenix (2015) GHD (2010) Western Botanical (2006) KBR (2006) Ecologia (2004)
<i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>		Priority 3	Prostrate, mat-forming, non-lignotuberous shrub, to 0.3 m high. Flowers white-cream-pink-green/green, July or September to December or January	Low Heath with <i>Allocasuarina humilis</i> , <i>Calothamnus sanguineus</i> , <i>Hibbertia hypericoides</i> . Grey sand, lateritic gravel	Recorded and previously recorded within Area 2	DPaW (2016) NatureMap KBR (2006)
<i>Grevillea florida</i>		Priority 3	Erect shrub, to 0.9 m high. Flowers cream-yellow, July to September	In open low woodland of <i>Eucalyptus drummondii</i> , and <i>E. calophylla</i> . Sandy clay, gravel, laterite. Sandplain, slopes, road verges	Likely to occur; previously recorded within Area 2	DPaW (2016)
<i>Haemodorum loratum</i>		Priority 3	Bulbaceous, perennial, herb, 0.45-1.2(-2) m high. Flowers black/brown-black/green, November	Grey or yellow sand, gravel	Likely to occur, recorded by Phoenix (2015)	Phoenix (2015)

Species	EPBC Act Cons. Status	WA Cons. Status	Description	Preferred Habitat	Likelihood of occurrence	Source
<i>Stylidium cymiferum</i>		Priority 3	Perennial herb. Flowers yellow, laterally paired. Juvenile buds pendulous. Flowers October to November	In open Wandoo forest with <i>Stylidium caricifolium</i> . Loam and lateritic soils	Likely to occur, recorded Caligiri - Wongan Hills Road within 25 m of study area boundary	DPaW (2016)
<i>Verticordia serrata</i> var. <i>linearis</i>		Priority 3	Shrub, to 1 m high, Flowers September to October	White sand, gravel. Open woodland	Likely to occur, recorded by Phoenix (2015)	Phoenix (2015) Ecologia (2004)
<i>Anigozanthos humilis</i> subsp. <i>chrysanthus</i>		Priority 4	Rhizomatous, perennial, herb, 0.2-0.4 (-0.8) m high. Flowers yellow, July to October	Banksia Woodland. Grey or yellow sand	Recorded during current study	DPaW (2016)
<i>Hibbertia miniata</i>		Priority 4	Decumbent or erect shrub, 0.1-1 m high. Flowers orange/orange-red, August to November	Open Woodland of <i>Corymbia calophylla</i> . Lateritic gravelly soils	Recorded during current study, known records within 300 m of study area	DPaW (2016) NatureMap Ecologia (2005)



Legend

- Study Area
- ★ *Asterolasia nivea*
- ★ *Darwinia acerosa*
- ★ *Drakaea elastica*
- ★ *Eleocharis keigheryi*
- ★ *Goodenia arthrotricha*
- ★ *Grevillea corrugata*
- ★ *Spirogardnera rubescens*
- ★ *Stylidium semaphorum*
- ★ *Thelymitra stellata*
- ▲ *Hibbertia glomerata* subsp. *ginginensis*
- ▲ *Lasiopetalum* sp. *Toodyay* (F. Hort 2689)
- ▲ *Senecio gilbertii*
- ▲ *Verticordia serrata* var. *Udumung* (D. Hunter & B. Yarran 941006)
- *Acacia browniana* var. *glaucescens*
- *Cyanicula ixiioides* subsp. *candida*
- *Gastrolobium nudum*
- *Stylidium glabrifolium*
- *Acacia anarthros*
- *Acacia drummondii* subsp. *affinis*
- *Acacia oncinophylla* subsp. *ocninophylla*
- *Acacia pulchella* var. *reflexa acuminata bracteole variant* (R.J. Cumming 882)
- *Adenanthos cygnorum* subsp. *chamaephyton*
- *Allocasuarina ramosissima*
- *Dielsiodoxa leucantha* subsp. *leucantha*
- *Grevillea florida*
- *Guichenotia tuberculata*
- *Halgania corymbosa*
- *Stylidium cymiferum*
- *Stylidium sacculatum*
- *Tetratecha pilifera*
- ◆ *Anigozanthos humilis* subsp. *chrysanthus*
- ◆ *Boronia tenuis*
- ◆ *Calothamnus pachystachyus*
- ◆ *Grevillea drummondii*
- ◆ *Hibbertia miniata*
- ◆ *Oxymyrrhine coronata*
- ◆ *Persoonia sulcata*
- ◆ *Synaphea grandis*
- ◆ *Verticordia lindleyi* subsp. *lindleyi*
- ☆ Threatened
- P1
- P2
- P3
- ◇ P4

0 1 2 3 4 km



Figure 7a - Previously Recorded Threatened and Priority Flora

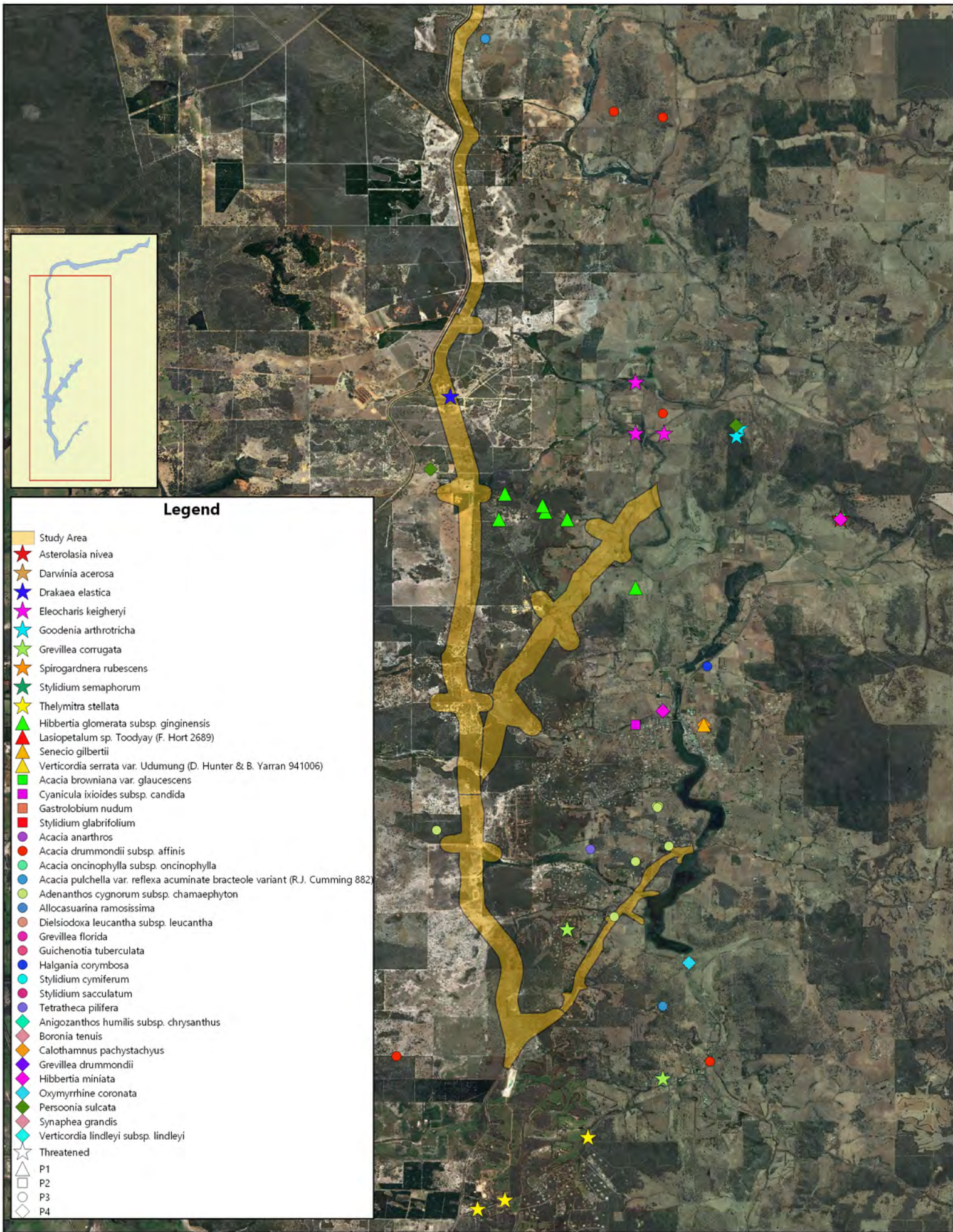


Figure 7b - Previously Recorded Threatened and Priority Flora

4.2 THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

The DPaW database search results reveal that at a State level, the study area and the immediate surrounds are known to support the following TEC and two PECs:

- TEC:
 - SCP 20a – *Banksia attenuata* woodlands over species rich dense shrublands (EN)
- PECs:
 - Banksia woodlands of the Gingin area restricted to soils dominated by yellow to orange sands (P2)
 - SCP 23b – Northern Swan Coastal Plain *Banksia attenuata* – *Banksia menziesii* woodlands (P3).

All three of these vegetation types are also classified as likely to be equivalent to the Commonwealth listed TEC, *Banksia Woodlands of the Swan Coastal Plain ecological community* (Threatened Species Scientific Committee 2016), which was further supported by the results of the EPBC Act MNES database search. However, at the time that the database search was conducted, DPaW's dataset had not yet been updated to reflect the State-listed TEC and PECs and their equivalence to the Commonwealth-listed Banksia woodlands TEC.

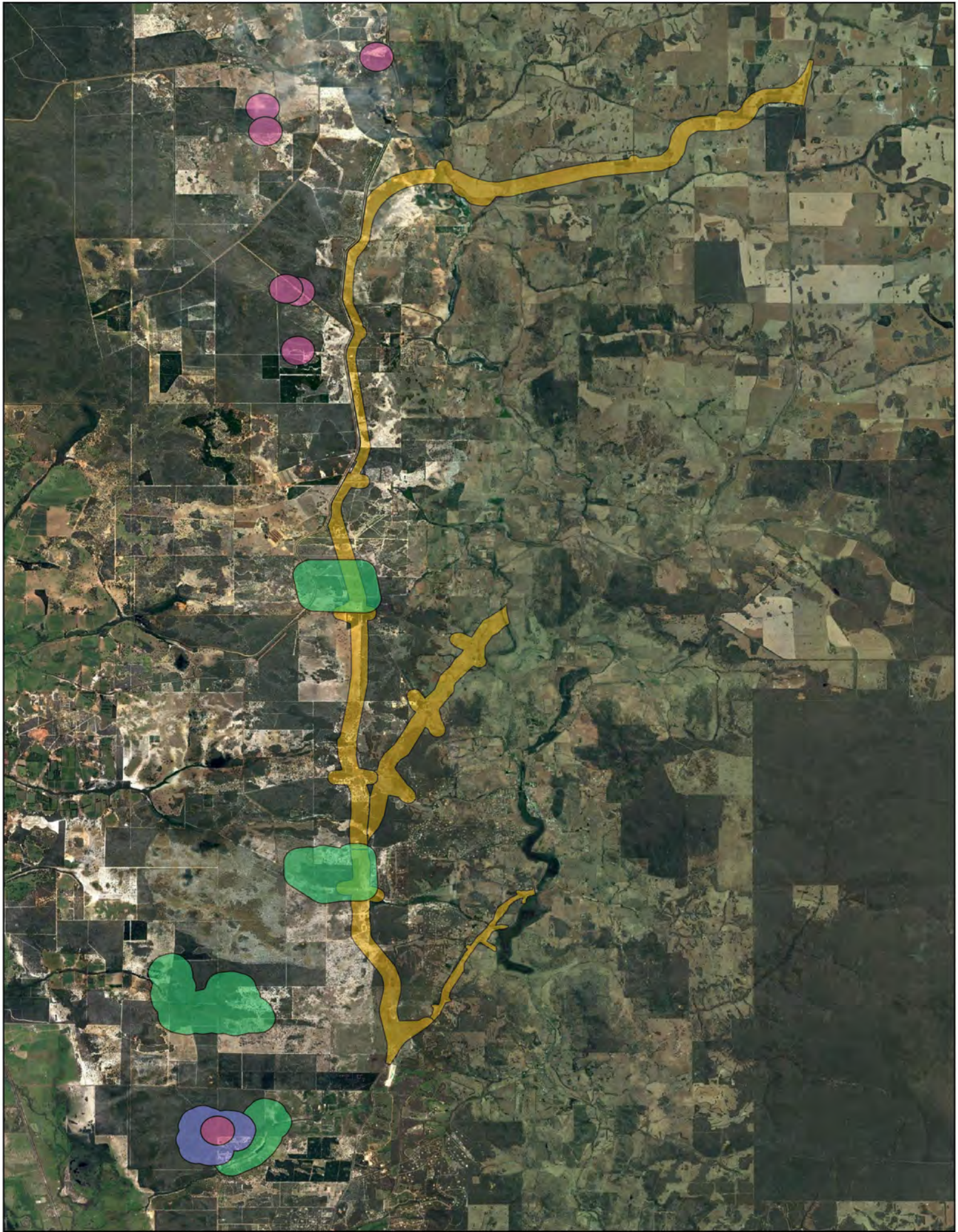
The known extent of these TECs/PECs, in accordance with results of the DPaW database search results is presented in **Figure 8**, showing that two occurrences of the 'Banksia woodlands of the Gingin area restricted to soils dominated by yellow to orange sands' or their buffers intersect with the Area 2 section of the study area. **Figure 8** also shows that there are occurrences of both of the other ecological communities listed above, or their buffers:

- SCP 23b – Northern Swan Coastal Plain *Banksia attenuata* – *Banksia menziesii* woodlands, within 1 km of the boundary of the Area 2 section of the study area, but not intersecting the study area
- Banksia woodlands of the Gingin area restricted to soils dominated by yellow to orange sands, within 4.5 km of the southern terminus of the Area 1 section of the study area, but not intersecting the study area.

The *Banksia Woodlands of the Swan Coastal Plain Ecological Community* was approved for inclusion as an Endangered TEC under the EPBC Act on 16 September 2016. This ecological community is woodland associated with the Swan Coastal Plain with a prominent tree layer of Banksia with scattered Eucalypts and other tree species among or emerging above the Banksia canopy. The understorey is comprised of a species rich mix of sclerophyllous shrubs, graminoids and forbs (Threatened Species Scientific Committee 2016).

The Banksia woodland Commonwealth-listed TEC is largely restricted to the Swan Coastal Plain IBRA bioregion, within the Perth (SWA02) and Dandaragan (SWA01) sub-regions. It extends into the adjacent Jarrah Forrest IBRA bioregion (JA01 and JA02 sub-regions) areas of the Whicher and Darling escarpments where pockets of Banksia Woodland may occur. This TEC mainly occurs on deep Bassendean and Spearwood sands or occasionally on Quindalup sands at the eastern edge (Threatened Species Scientific Committee 2016).

Twenty-one Floristic Community Types (FCTs) described by Gibson *et al.* (1994), Government of Western Australia (2000), Keighery *et al.* (2008) and the Urban Bushland Council (2011) best correspond to the Banksia woodland TEC. This includes a number of FCTs known to be supported by the study area (Gibson *et al.* 1994). The State-listed P2 PEC (Banksia woodlands of the Gingin area restricted to soils dominated by yellow to orange sands) is also considered a representation of the Banksia woodland TEC (Threatened Species Scientific Committee 2016).



0 1 2 3 4 km

Figure 8 - Known TECs and PECs



Legend

- Study Area
- Banksia attenuata* woodlands over species rich dense shrublands
- Banksia* woodland of the Gingin area (yellow to orange sands)
- Swan Coastal Plain *Banksia attenuata* - *Banksia menziesii* woodlands

5 METHODOLOGY

All survey and reporting for the spring 2016 Level 2 flora and vegetation assessment of the Bindoon study area was carried out in accordance with the following:

- EPA (2004) Guidance Statement 51, Guidance for Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia
- EPA & DPaW (2015) Technical Guide for Flora and Vegetation Surveys for Environmental Impact Assessment
- Commonwealth of Australia (2013b) Guidelines for Detecting Orchids Listed as 'Threatened' Under the *Environment Protection and Biodiversity Conservation Act 1999*.

5.1 DESKTOP ASSESSMENT AND LITERATURE REVIEW

As part of the desktop assessment, a literature review was undertaken of all available, relevant published and unpublished reports and documents. Database searches for Threatened and Priority flora and ecological communities were also requested from DPaW for the study area and surrounds. The Threatened and Priority flora search was conducted for the study area extent plus a 4 km buffer (search reference 40-1016FL). The Threatened and Priority ecological community database search was conducted for a geographical bounding box, as defined by DPaW within the following corners:

- north - -14.788854
- south - -35.005719
- east - 128.870214
- west - 113.765525.

The collective information from the desktop assessment and literature review was used to generate potential species lists for the study area, with a focus on Threatened and Priority flora and ecological communities.

The sources consulted included the following:

- Department of the Environment and Energy (DotEE) MNES search tool
- DPaW NatureMap search
- Threatened and Priority taxa listed under the WC Act and listed by DPaW
- TECs PECs listed by DPaW
- Declared Pests listed under the BAM Act.

The results of the desktop assessment are presented in **Section 4** of this report.

5.2 FIELD ASSESSMENT

The Level 2 flora and vegetation field assessment was carried out by Principal Ecologist, Kellie Bauer-Simpson and Senior Botanist, Gabriela Martinez on 10–14 and 17–20 October 2016, with a total survey effort of 18 person days.

Field data from quadrats and opportunistic observations and spatial mapping between was collected using electronic tablets equipped with the mobile mapping software, MAPPT™. This methodology

allowed in-field spatial mapping of boundaries for vegetation communities and condition, as well as the collection of spatial point data where other observations or photographs were captured. Physical data from each quadrat was also recorded electronically in the software, with species recorded by hand for later entry with identified collected specimens.

Vegetation mapping was conducted in the field and refined afterwards by defining the different plant communities based on vegetation structure, dominant species and species composition, and extrapolated based on the appearance in aerial imagery.

Field data was collected from 46 pegged 10 m x 10 m quadrats and two relevés (**Figure 9**). A single permanent peg was installed at the north-west corner of each quadrat and marked with quadrat number. Measuring tapes and temporary pegs marked the quadrat boundary during sampling, but were then removed, leaving only the north-west corner peg, to minimise impact on the landscape.

Quadrats were established and sampled in areas of good or better condition vegetation, in accordance with the requirements of EPA Guidance Statement 51. Detailed data collection points (relevés) were utilised in locations where land access permission had not been granted, but where vegetation was observable from outside property boundaries. This aided in defining vegetation types as much as possible for inaccessible locations. Observations and opportunistic data collection was also carried out continuously throughout assessment of the study areas, in order to draft maps for the extent of vegetation communities and condition, as well as other relevant features.

The following information was collected from within each quadrat sampled:

- date
- botanist name
- quadrat or relevé and dimensions
- location (GPS co-ordinates of the north-west corner peg in GDA94)
- digital photograph taken from the north-west corner peg
- habitat or landscape position
- topography/slope
- surface features
- soil type/texture and colour
- rock presence, type, size and abundance
- vegetation condition/degradation/disturbances (e.g. weed invasion, fire)
- time since fire (estimated)
- leaf litter distribution and abundance
- flora inventory, and for each species:
 - average height
 - total projected foliage cover within quadrat
 - dominance
- vegetation community, described in accordance with Level V of the National Vegetation Information System (NVIS)*
- vegetation condition, assessed against the currently accepted scale as required by EPA & DPaw (2015); an adaptation of the Keighery (1994) and Trudgen (1991) condition scales.

Once the floristic data for each quadrat was analysed and classified, with clusters (groups of similar types) defined via PATN™ analysis, they were rationalised into vegetation communities and described at NVIS Level III and VI. Each local scale vegetation community was then rationalised with regional vegetation associations as per Shepherd *et al.* (2002).

Description of the vegetation communities to NVIS Level VI has enabled conclusions regarding the TEC and PEC status of each of the recorded vegetation types. Rationalisation of the vegetation communities with the associations of Shepherd *et al.* (2002) enabled analysis of the remaining representation of pre-European extents, and determination of the regional significance of each of the vegetation types.

The flora data collected from the combination of quadrats and continuous opportunistic observations contributed to the flora inventory for the site.

In accordance with the guidance and as is typical for first phase Level 2 flora and vegetation assessments, a proportion of the field assessment effort was dedicated to selective and opportunistic searches Threatened and Priority flora, using the results of the desktop assessment as a basis. These searches were conducted in areas of better quality vegetation, along disturbance areas such as tracks and firebreaks (to target disturbance opportunists), when traversing to and between quadrats, and whilst carrying out the dedicated targeted survey for the Threatened orchid species, *Thelymitra stellata*, described in more detail in **Section 5.3**. The main focus of these targeted surveys was within quadrats and immediately surrounding quadrats once established and sampled. Further targeted surveys are well-suited to phases of assessment subsequent to the first phase, once some of the occurring species are known and detailed vegetation information is available for determination of suitable habitats for conservation significant flora.

The varying vegetation condition within the study area was documented continuously throughout the survey, as well as from within quadrats, which was then mapped in accordance with the Keighery (1994) scale (using qualitative and descriptive terms) and an adaptation of the Keighery (1994) and Trudgen (1991) condition scales (as per EPA & DPaW (2015) (using quantitative number scores in accordance with the qualitative scale).

Flora specimens were collected, pressed, dried and fumigated in accordance with the protocols of the Western Australian Herbarium, for later identification.

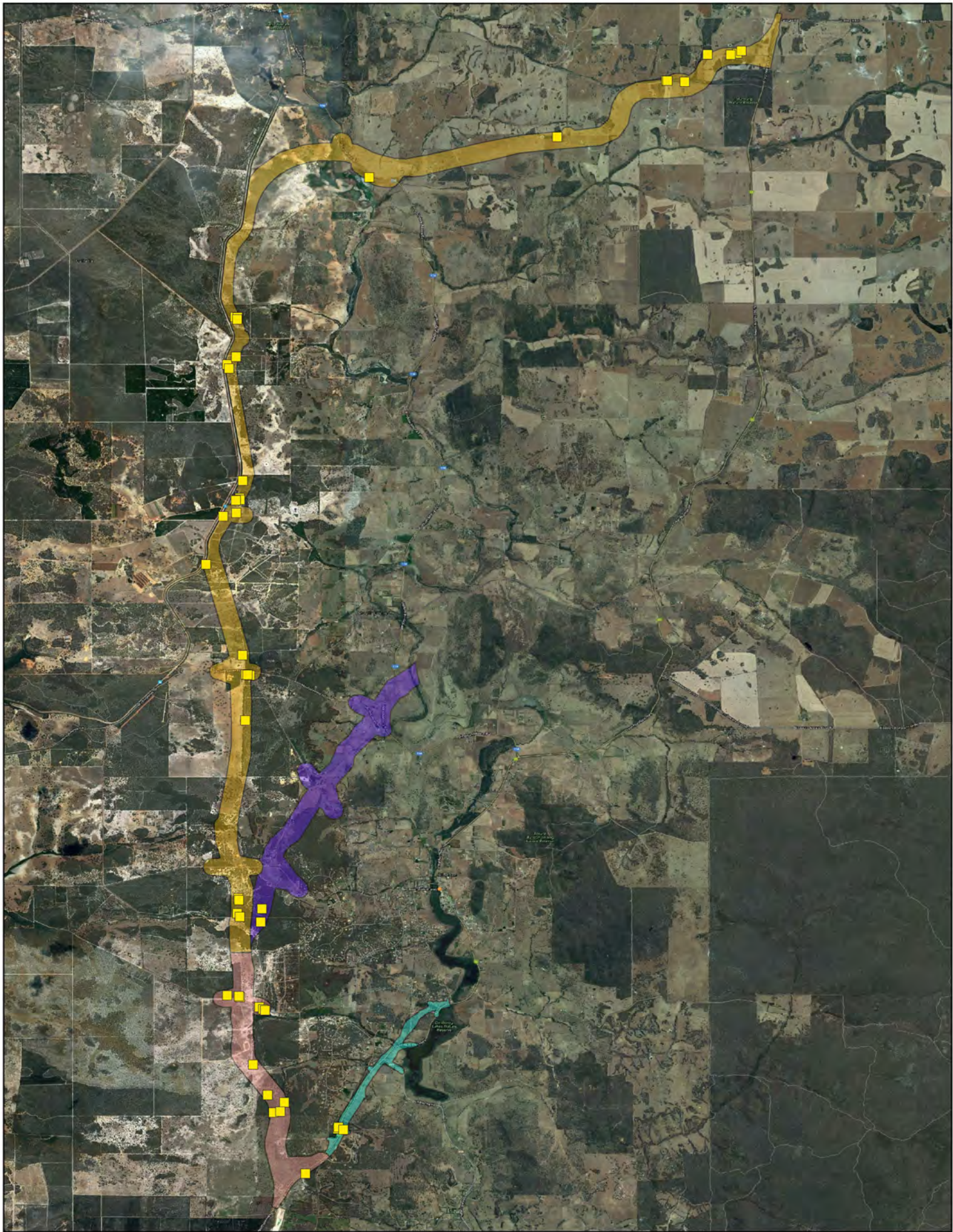


Figure 9 - Quadrat Locations



Legend

- Common Area - Area 1
- Western Bypass A - Area 2
- Western Bypass B - Area 3
- Eastern Bypass - Area 4

5.3 TARGETED THELYMITRA STELLATA SURVEY

A NatureMap search of the general study region identified the potential occurrence of a Threatened orchid species, *Thelymitra stellata* (Star Sun-orchid), within the study area. *Thelymitra stellata* is known to flower mostly between October and late November. In order to target *Thelymitra stellata* at the suitable flowering time, communication was maintained with DPaW's orchid specialist, Dr Andrew Brown, regarding field observations for spring 2016. It was anticipated that there was the potential for early flowering due to high rainfall in July and August, and observations of Spider Orchids in the Perth region flowering early (in the first week of August). Dr Brown's specialist knowledge and field observations contributed to the determination to mobilise to site during mid-November to conduct targeted surveys for the species along with guidance advice described in the Orchid Detection Guidelines (2013b).

The targeted *Thelymitra stellata* (Star Sun-orchid) survey was conducted between 14–18 and 22–23 November 2016 by Principal Ecologist, Kellie Bauer-Simpson and Senior Botanists, Gabriela Martinez and Lisa Chappell. A total survey effort of 21 person-days was invested.

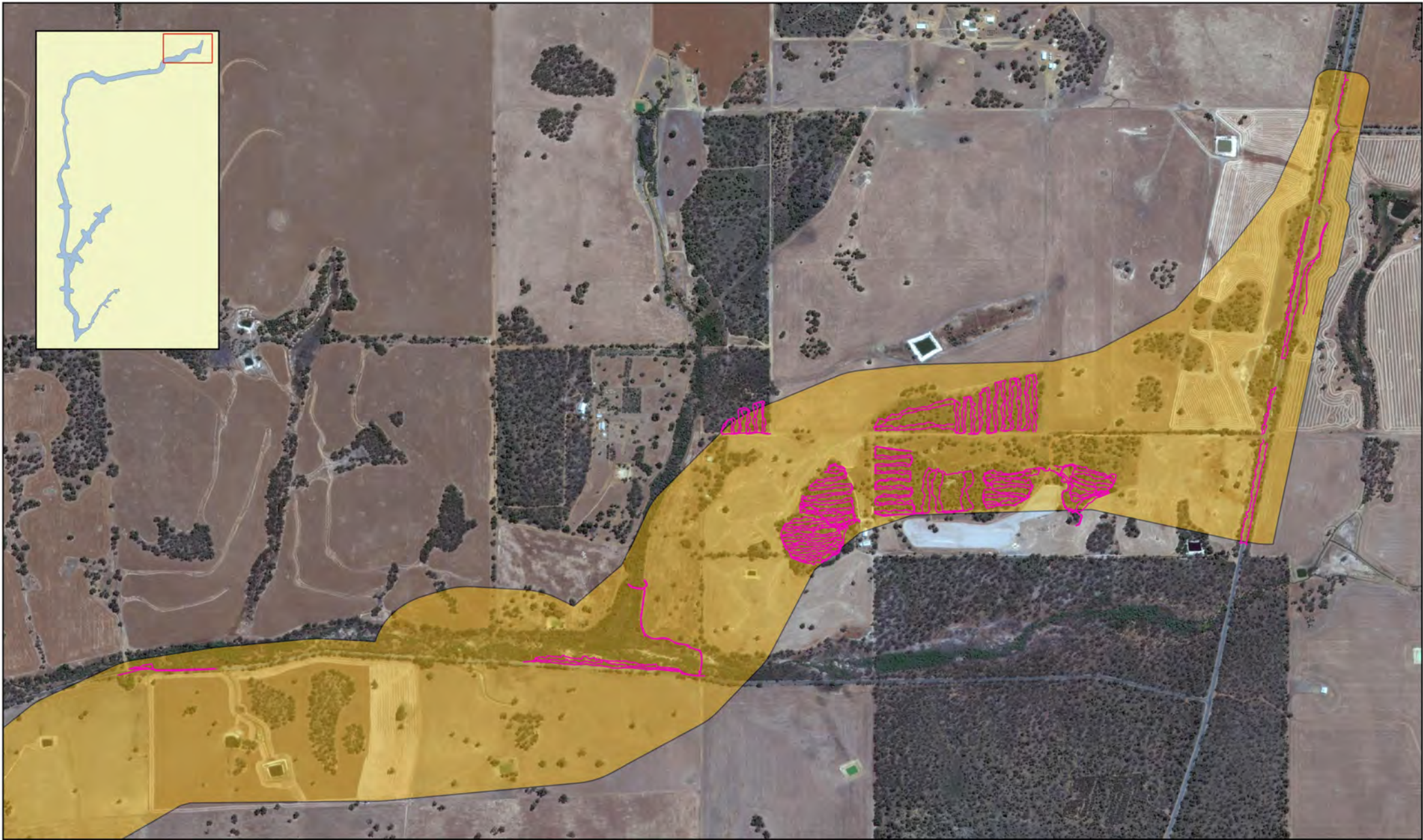
During the Level 2 flora and vegetation assessment conducted in September, a targeted reconnaissance of habitats suitable for *Thelymitra stellata* was carried out, which enabled the most suitable habitats to be targeted with greater survey effort during November. A sampling design to specifically target *Thelymitra stellata* was prepared. Methodologies for the targeted survey for *Thelymitra stellata* were conducted in accordance with the Department of the Environment's *Guidelines for Detecting Orchids Listed as 'Threatened'*.

A combination of the following four survey techniques were adopted to record potential *Thelymitra stellata* populations:

1. Chance finds (opportunistic records) whilst recording quadrat or relevé data or undertaking other aspects of the field survey.
2. Meandering searches in defined areas of suitable habitat, with meandering transects spaced 40-100 m apart.
3. Area searches, with more intensive meandering searches in defined areas considered likely suitable habitat, with meandering transects spaced 20-40 m apart
4. Systematic targeted searches in parallel transects, spaced 10 m apart, with visibility ranging from 2 m to 4 m either side of a centerline, thus covering up to 80% of the designated search areas.

The total survey effort aimed to search at least 50% of the intact vegetation remnants considered to provide suitable habitat within the study area.

All walked transects were tracked on GPS to verify and present the locations and extent of traversed and searched areas. The combined walked tracks for the targeted *Thelymitra stellata* searches are presented in **Figure 10**.





0 0.25 0.5 0.75 1 km

Figure 10a - Walked Tracks for Thelymitra stellata Survey



Legend

-  Walked Tracks
-  Study Area



0 0.25 0.5 0.75 1 km



Legend



-  Walked Tracks
-  Study Area

Figure 10b - Walked Tracks for *Thelymitra stellata* Survey



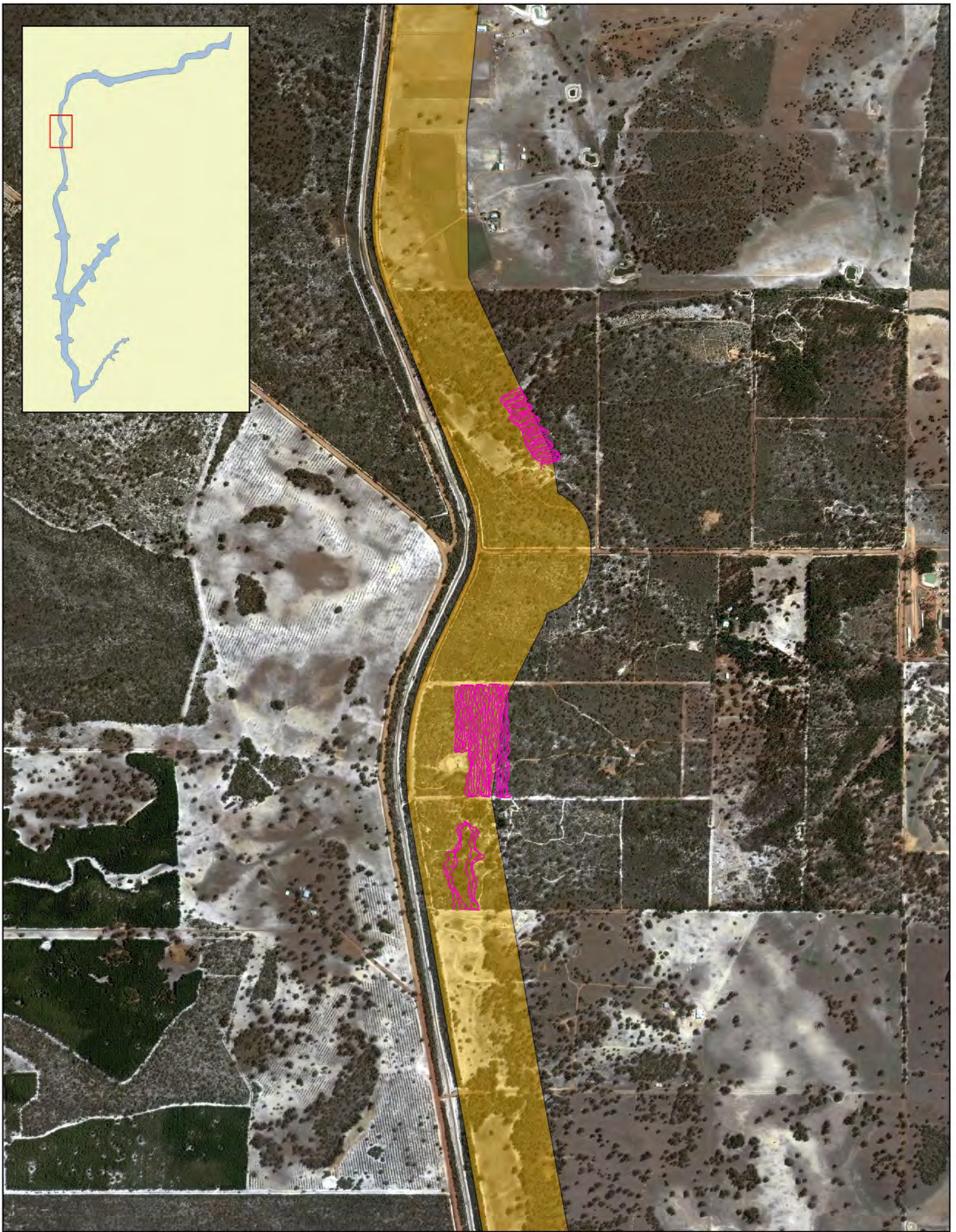


Figure 10c - Walked Tracks for *Thelymitra stellata* Survey

0 0.25 0.5 0.75 1 km



Legend

- Walked Tracks
- Study Area



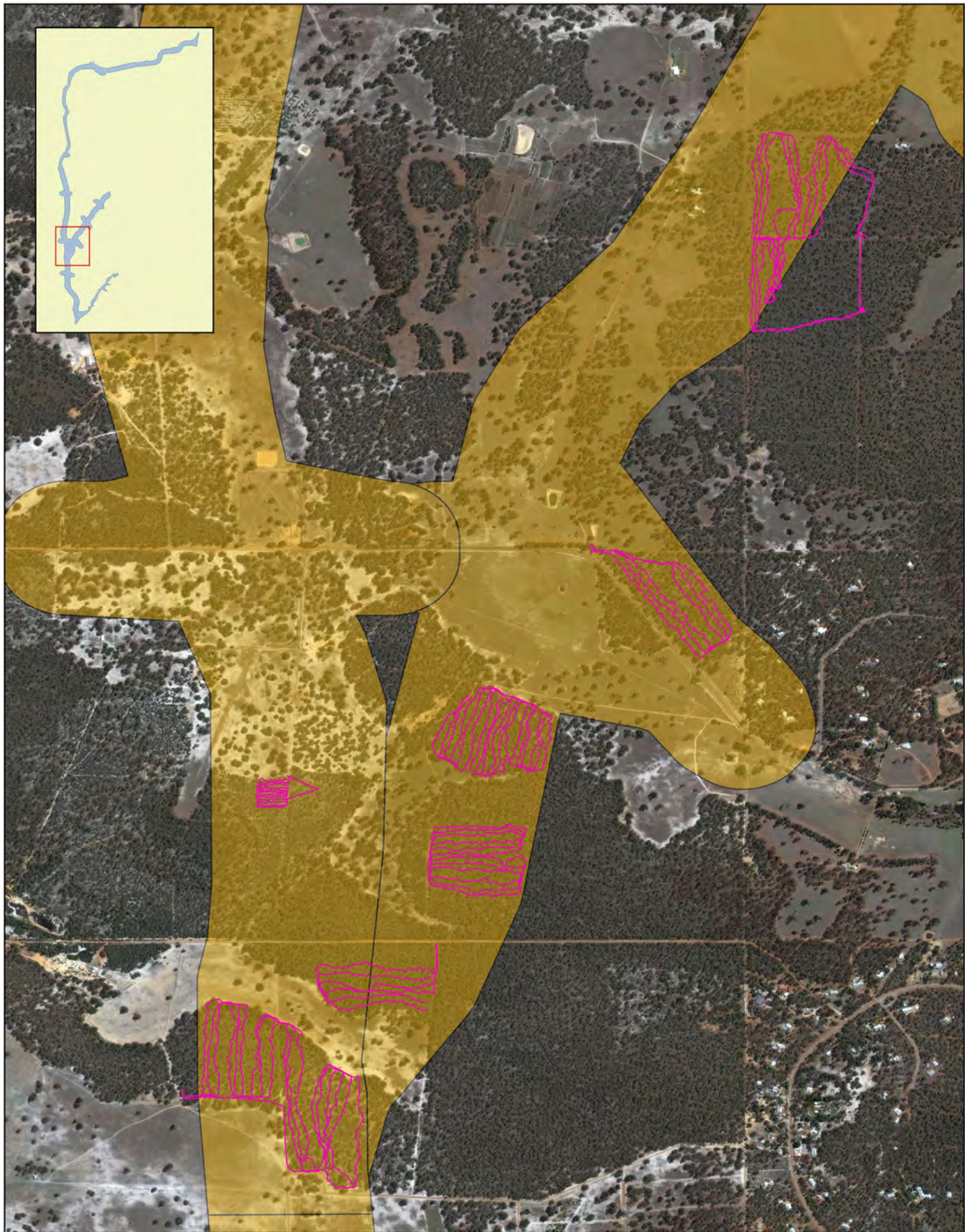
0 0.25 0.5 0.75 1 km

Figure 10d - Walked Tracks for *Thelymitra stellata* Survey



Legend

- Walked Tracks
- Study Area



0 0.25 0.5 0.75 1 km



Legend

- Walked Tracks
- Study Area

Figure 10e - Walked Tracks for Thelymitra stellata Survey

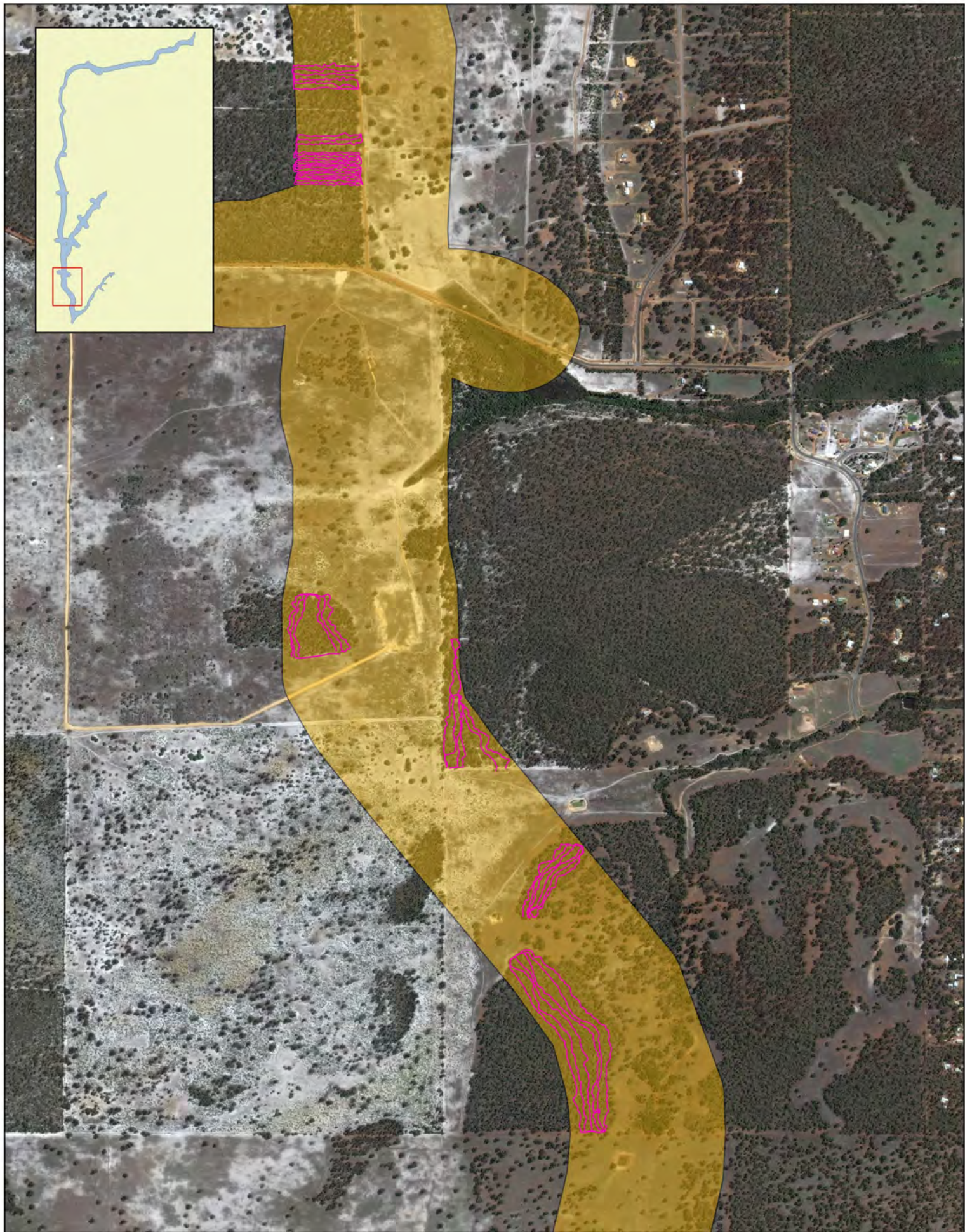
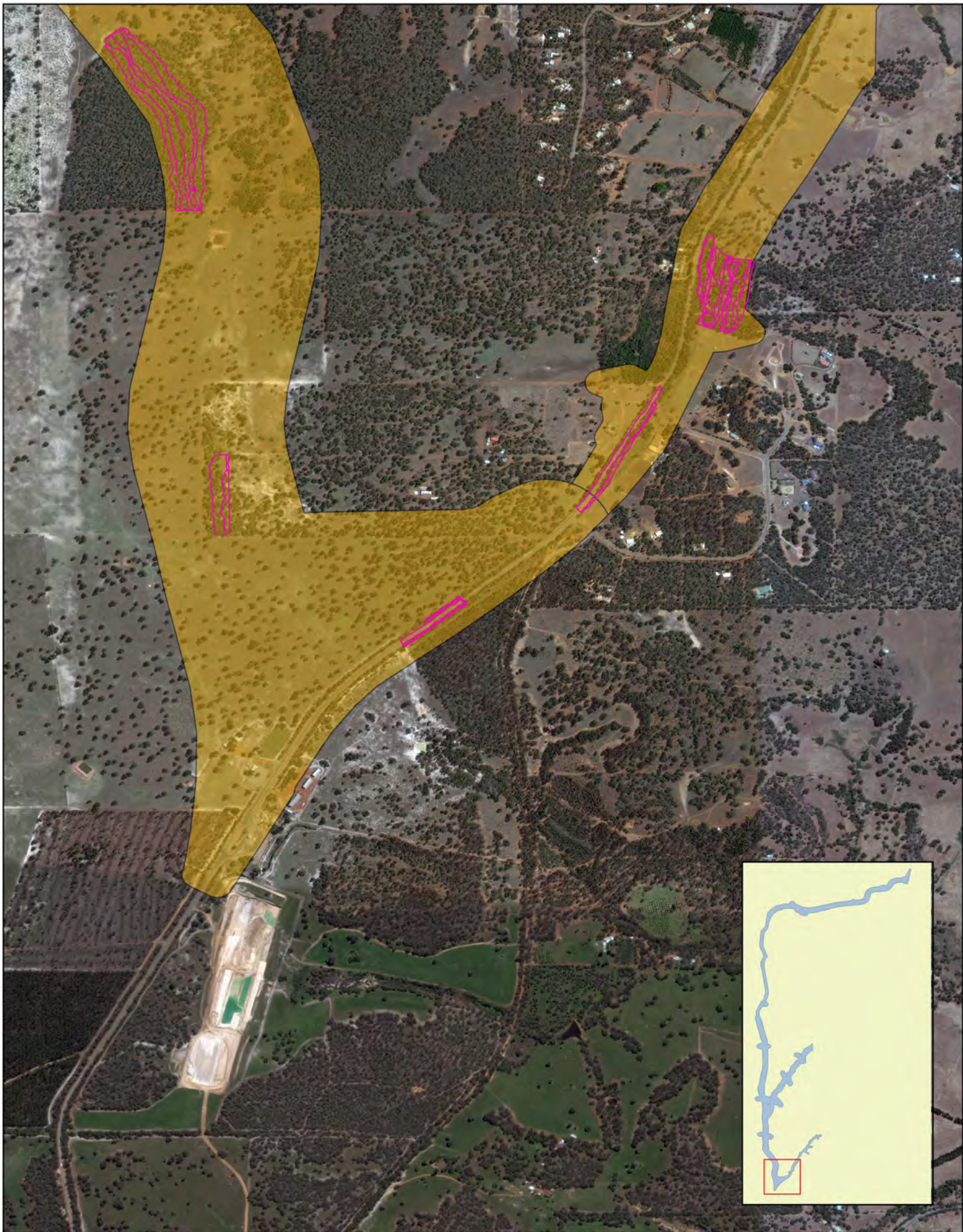


Figure 10f - Walked Tracks for *Thelymitra stellata* Survey

Legend

- Walked Tracks
- Study Area



0 0.25 0.5 0.75 1 km

Figure 10g - Walked Tracks for Thelymitra stellata Survey



Legend

- Walked Tracks
- Study Area



0 0.25 0.5 0.75 1 km

Figure 10h - Walked Tracks for *Thelymitra stellata* Survey



Legend

- Walked Tracks
- Study Area

If *Thelymitra stellata* individuals or suspected individuals were observed, the following data was to be recorded:

- GPS location of each individual plant
- vegetation type and condition at the recorded location
- condition of plants/populations recorded
- life-cycle stage (e.g. budding, flowering, fruiting)
- high resolution digital photographs of plants/populations encountered and the surrounding vegetation.

5.4 DATA PROCESSING AND ANALYSIS

Flora identifications were undertaken by specialist taxonomist, Dr Udani Sirisena. Plant group specialist taxonomists were consulted where required for challenging identifications. Taxonomy and nomenclature follows current protocols of the WA Herbarium.

Field data collected on tablets within the mobile mapping software program, MAPPT™ within customised data forms and spatial mapping shapefiles were downloaded for collation for the report. Quadrat species lists and flora identifications were entered into a customised Microsoft Access™ database called FloraData, which contains the WA flora inventory. The data was then able to be loaded into the PATN™ software (Belbin 2013) for floristic analysis.

Data was prepared for analysis including the grouping of some taxa to minimise or exclude ambiguity that could possibly be due to the identification of plants rather than a true difference in species composition. For example, removing infra-specific epithets and using only the specific epithet, considering uncertain species identification (indicated with '?') as the proper identification (e.g. *Drosera ?sewelliae* treated as *Drosera sewelliae*).

Data analysis carried out for flora quadrat data utilising PATN™ involves multivariate cluster analysis of species presence/absence. An association matrix of the Bray-Curtis coefficient was generated from the presence and absence site by species matrix using the software. The resultant dendrogram was used to identify the vegetation units, which were described at NVIS Levels III and VI.

Grouping of site data and the characterisation and description to NVIS Level VI enabled determination of floristic communities and potential TECs and PECs across the site. Rationalisation of recorded vegetation communities with regional vegetation associations as documented in Shepherd *et al.* (2002) enabled an analysis of regional extent and representation, and therefore regional significance.

Vegetation datasets from recent and relevant studies in the surrounding region were analysed with collected field data to determine similarities between vegetation units recorded and enable an analysis of regional representation of the vegetation. The most recent and relevant dataset was that of Phoenix (2015) for the Muchea North and Chittering study area for the Great Northern Highway project.

The local and regional vegetation analysis again used multivariate cluster analysis of species presence/absence using PATN™ (Belbin 2013), with data from each quadrat of the current FVC survey and Phoenix (2015), providing a total of 77 sampling points. The resultant dendrogram was used to

determine the similarity between the described vegetation units of the current survey and those from Phoenix (2015) to enable interpretation of the local distribution of vegetation communities.

In order to understand the more broadly regional distribution of vegetation units within the study area, vegetation types recorded during the current FVC survey were matched with the vegetation associations of Shepherd *et al.* (2002), as well as the vegetation units described by Phoenix (2015). The resultant dendrogram was used to determine the similarity between the described vegetation units of the current survey plus those of Phoenix (2015) in comparison to the regional extent and distribution of the Shepherd *et al.* (2002) vegetation types.

5.5 STUDY LIMITATIONS

The limitations of the flora and vegetation assessment have been considered in accordance with Guidance Statement 51 (EPA 2004) and these are summarised in **Table 8**.

Table 8 Study Limitations

Aspect	Constraint?	Commentary
Availability of regional data	No	A number of studies have been previously completed within the local study area and wider region, reflected in the broad range of previous study reports reviewed and summarised in Section 5.1 .
Scope (detail)	No	A single-phase, Level 2 flora and vegetation assessment was carried out in accordance with Guidance Statement 51, which included the sampling of 46 separate sampling points (quadrats and relevés). Survey effort was also invested in selective targeted surveys for Threatened and Priority flora, as well as a separate intensive survey dedicated to searching for one species of Threatened flora, <i>Thelymitra stellata</i> .
Experience of personnel	No	All of the personnel undertaking the field assessment, flora identifications, data analysis, vegetation mapping and reporting are experienced botanists, with specialist skills in their respective fields. All botanists have a minimum of seven and up to 18 year' experience. Field botanists are all experienced in undertaking surveys in the region, and in undertaking targeted significant flora surveys. Taxonomic identifications were undertaken by specifically trained taxonomists, including specialists on relevant groups, where required.
Survey effort/detail/intensity	No	A total survey effort of 18 and 21 person days was invested in the Level 2 flora and vegetation assessment and the targeted <i>Thelymitra stellata</i> survey, respectively. These studies included the sampling of 44 quadrats and two relevés across 13 vegetation communities, with at least three quadrats per type (besides two which resulted from unexpected splits in the branching of the dendrogram during statistical analysis), and more than 150 km of transect lines covering approximately 75 hectares of searched ground, within more than 220 hectares of search areas (62% of suitable habitat area within the study area).
Seasonal timing and climatic conditions	No	The field assessment was conducted during the optimal spring season, with the Level 2 assessment undertaken during mid-October and the targeted <i>Thelymitra stellata</i> survey conducted during mid-November. Following unseasonably high rainfall in July and August, the regions experienced a favourable spring season and field timing was considered suitable. One <i>Thelymitra stellata</i> from a known population nearby to the study area was past peak flowering period, but still visible and distinguishable at the start and end of the targeted survey, despite high temperature on the second and third days of the field searches.

Aspect	Constraint?	Commentary
Access	Somewhat	The majority of the study area is easily accessible and being linear corridors, most areas are accessible at least on foot from nearby roads or properties. One significantly sized property just east of Cullulla Road, between just north of Mooliabeenee Road and Barn Road was not able to be accessed. This property supports intact native vegetation, including areas expected to be representative of the Banksia woodland TEC. This gap in the data is considered a constraint for the study and will limit the environmental impact assessment process unless it is able to be filled.
Mapping reliability	No	The mapping has been prepared at a scale based on mostly ground-truthed areas, with limited extrapolation given the good accessibility for most of the study area (besides inaccessible properties). Therefore, mapping reliability based on scale is considered high.
Disturbances	No	The majority (75.35%) of the total study area supports pasture with occasional trees, or planted areas which include plantations and some small areas of rehabilitated vegetation. Only 18.73% of the study area was mapped to be in Good condition or better. However, significant areas were found to be in Very Good to Excellent and Excellent condition. The higher quality vegetation in a regional context of largely cleared vegetation is of greater significance in terms of conservation. Dieback infestations are apparent in some areas and weed invasion adjacent to pastoral areas are evident, however, within intact remnants, disturbance if mostly limited and was not considered to affect collected data.
Survey completeness	Somewhat	Most areas were easily accessible and despite those areas that were not, the Level 2 assessment is considered to be a suitably complete first phase survey. Quadrat sampling is considered adequate for a phase 1, Level 2 assessment, with 44 quadrats and two relevés across 13 vegetation communities. Quadrat frequency provided at least three quadrats per type (besides two vegetation communities which resulted from unexpected splits in the branching of the dendrogram during statistical analysis). The two vegetation communities sampled from only two quadrats will require additional quadrat sampling during subsequent phases of assessment.

6 RESULTS

6.1 FLORA

The desktop assessment determined that a total of 94 flora species of conservation significance have the potential to occur within the study area, based on previous records within or in the vicinity (**Appendix A**). Of these, five Priority flora species were recorded during the spring survey, with a further two species not able to be certainly identified, but expected to also be Priority flora species. Eleven of the 94 species resulting from the desktop assessment have been determined to be 'likely to occur' in the study area, with 30 classified as 'may occur' and 48 considered 'unlikely to occur, based on the proximity of previous records, currency of the data, and whether suitable habitat is provided in the study area.

A total of 350 flora taxa from 183 genera and 56 families were recorded during the field survey. The total includes 311 (88.6%) native species and 40 (11.4%) introduced (weed) species. The most dominant families recorded were Fabaceae (47 (13.4%) species), Myrtaceae (36 (10.3%) species) and Proteaceae (35 (10.0%) species). The full list of vascular flora species recorded is presented in **Appendix B**, with the quadrats and vegetation communities in which they were recorded to occur presented in **Appendices C and D**, respectively.

None of the Threatened flora resulting for the desktop assessment (**Appendix A**) were recorded during the spring 2016 survey and none of the recorded flora species are listed as Threatened under the WC Act or under the EPBC Act.

The seven species listed as Priority Flora under the WC Act which were recorded during the field studies, their conservation status and the survey areas, quadrats and vegetation communities in which they occur are presented below in **Table 9** and these recorded locations (quadrats) are presented in **Figure 11**. No Priority flora were recorded within Area 3.

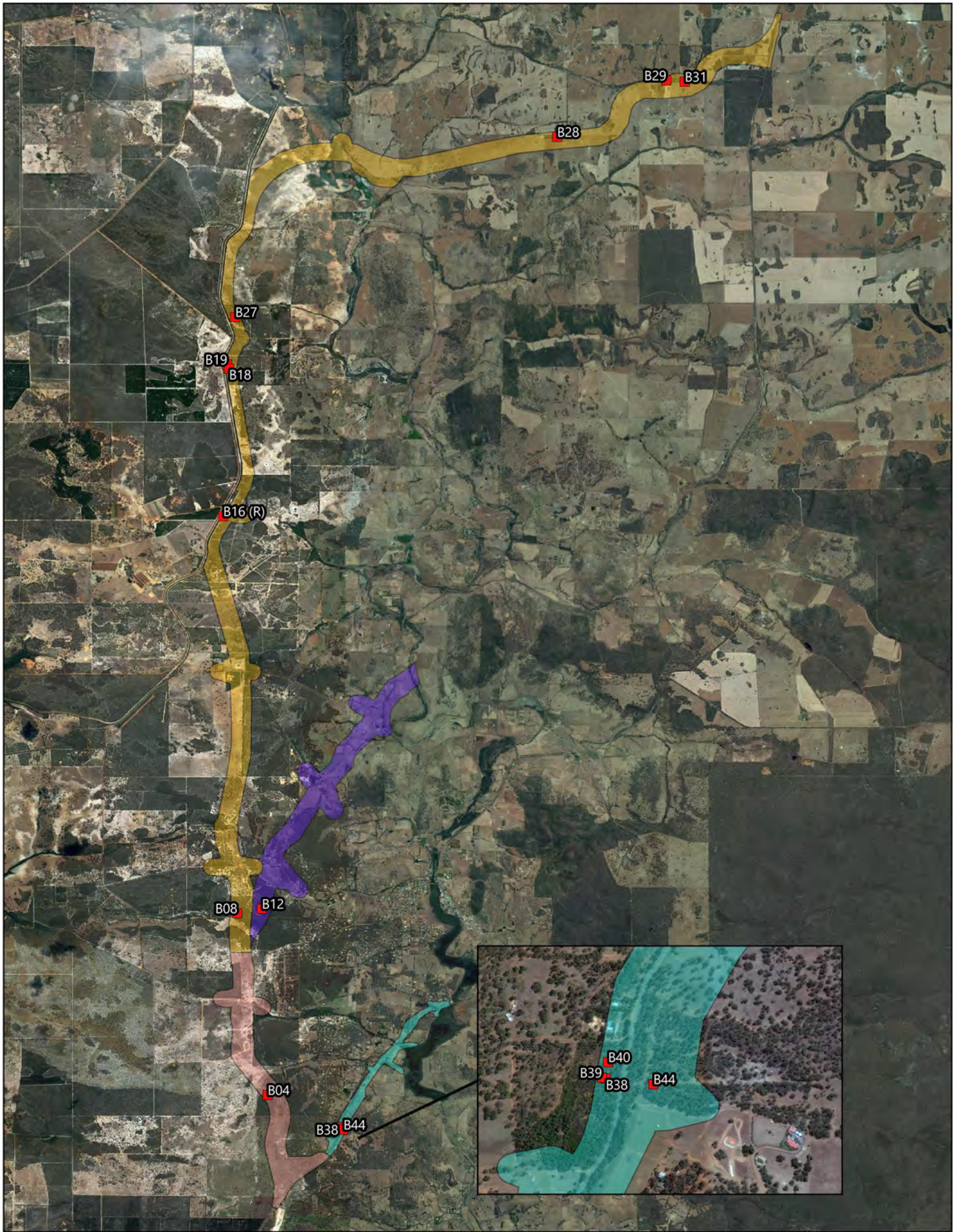
None of the recorded flora were found to be occurring outside their known range, based on distributions from Western Australian Herbarium records.

None of the recorded introduced (weed) species are listed as Declared Pest plants under the BAM Act within the districts of the study area. *Moraea flaccida* (One-leaf Cape-tulip) is listed as a Declared Pest plant with C3 (management) control requirements for a number of districts in the south-west and the Yilgarn, but not for the districts of the study area.

Table 9 Recorded Priority Flora Locations

Species	WA Conservation Status	Recorded from Quadrat/s	Recorded within Vegetation Community/ies
Area 1			
<i>Gastrolobium ?crispatum*</i>	P1	40	CcXpBe
<i>Synaphea panhesya</i>	P1	4, 40	EmXpHh, CcXpBe
<i>Drosera sewelliae</i>	P2	28	EmBsHh
<i>Drosera ?sewelliae*</i>	P2	4	EmXpHh
<i>Acacia drummondii</i> subsp. <i>affinis</i>	P2	28	EmBsHh
Area 2			
<i>Synaphea panhesya</i>	P1	12	EmBsHh
<i>Drosera ?sewelliae*</i>	P2	16R, 18, 19, 27	EtBeAn, ErXpLt
<i>Hibbertia miniata</i>	P4	28	EmBsHh
Area 4			
<i>Drosera ?sewelliae*</i>	P2	8, 31	EmBsHh, EwBeNa
<i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>	P3	44	EmBsHh
<i>Anigozanthos humilis</i> subsp. <i>chrysanthus</i>	P3	38, 39, 40	CcXpBe

*from specimen collections unable to be identified with certainty due to lack of identifiable material



0 1 2 3 4 km

Figure 9 - Quadrat Locations



Legend

- Common Area - Area 1
- Western Bypass A - Area 2
- Western Bypass B - Area 3
- Eastern Bypass - Area 4

6.1.1 Targeted *Thelymitra stellata* Survey

More than 150 km of transects totalling approximately 75 ha of searched ground over more than 200 ha of searched sites was included in the targeted searches for *Thelymitra stellata* during November 2016. Despite the intensive surveys which focused on areas of optimal habitat, no individuals were recorded.

During the Level 2 quadrat-focused survey conducted in October 2016, a number of single leafed orchids were observed (e.g. **Plate 1**), with locations of those considered to potentially represent *Thelymitra* plants recorded to enable verification during the *Thelymitra stellata* flowering period. None of these locations revisited during November 2016 confirmed the presence of this species. In these locations, no orchid was observed (likely had finished flowering and senesced (died off), or plants were identified as orchid species other than *Thelymitra stellata* (i.e. *Thelymitra crinita* and *Eliochilus dilatatus*).



Plate 1 Single-leaf orchids recorded during October and revisited to verify identity during November 2016

6.2 VEGETATION COMMUNITIES

The vegetation of the study area found to be in 'Good' or better condition was defined from a total of 46 quadrats and two relevés (**Figure 9**). Floristic analysis of the quadrat data using multivariate cluster analysis of species presence/absence in PATN™ resulted in the dendrogram presented below in **Figure 12**.

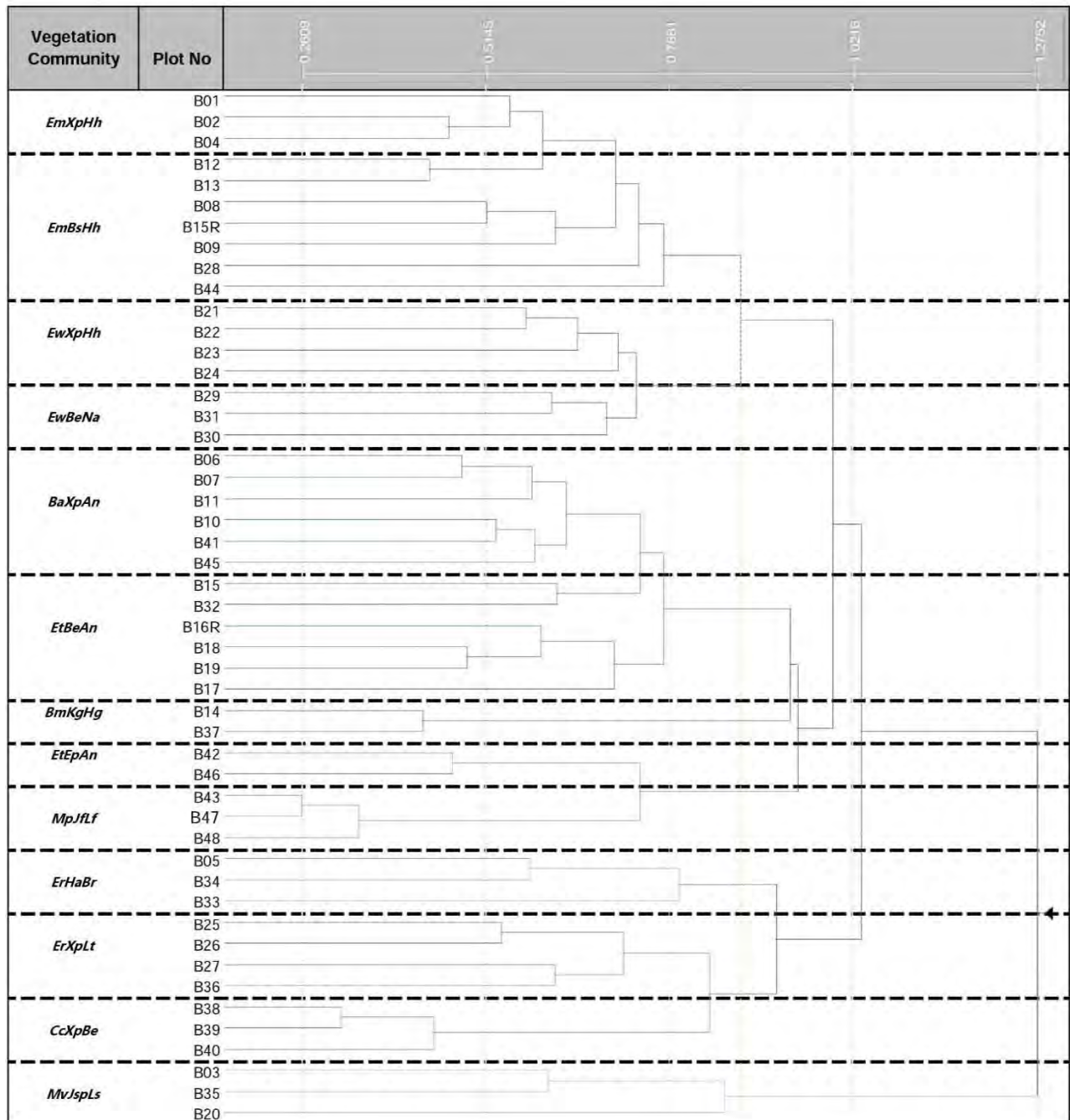


Figure 12 Quadrat Cluster Analysis Dendrogram

The clusters of quadrats resulting from the dendrogram produced 13 separate vegetation communities, and the recorded quadrat data was then used to describe each community to NVIS Levels III and VI. In a broad sense, the vegetation units comprise Eucalypt woodlands (Jarrah, Marri, Wandoo and Flooded Gum), Banksia woodlands and Melaleuca woodlands and shrublands. The recorded vegetation communities are described in **Table 10**. The structure and floristic composition of each quadrat is detailed in **Appendix E** and species composition of each of the quadrats/sites and intact vegetation communities is provided in **Appendices C** and **D**, respectively. The spatial extent of the various vegetation communities is presented in **Figure 13**.

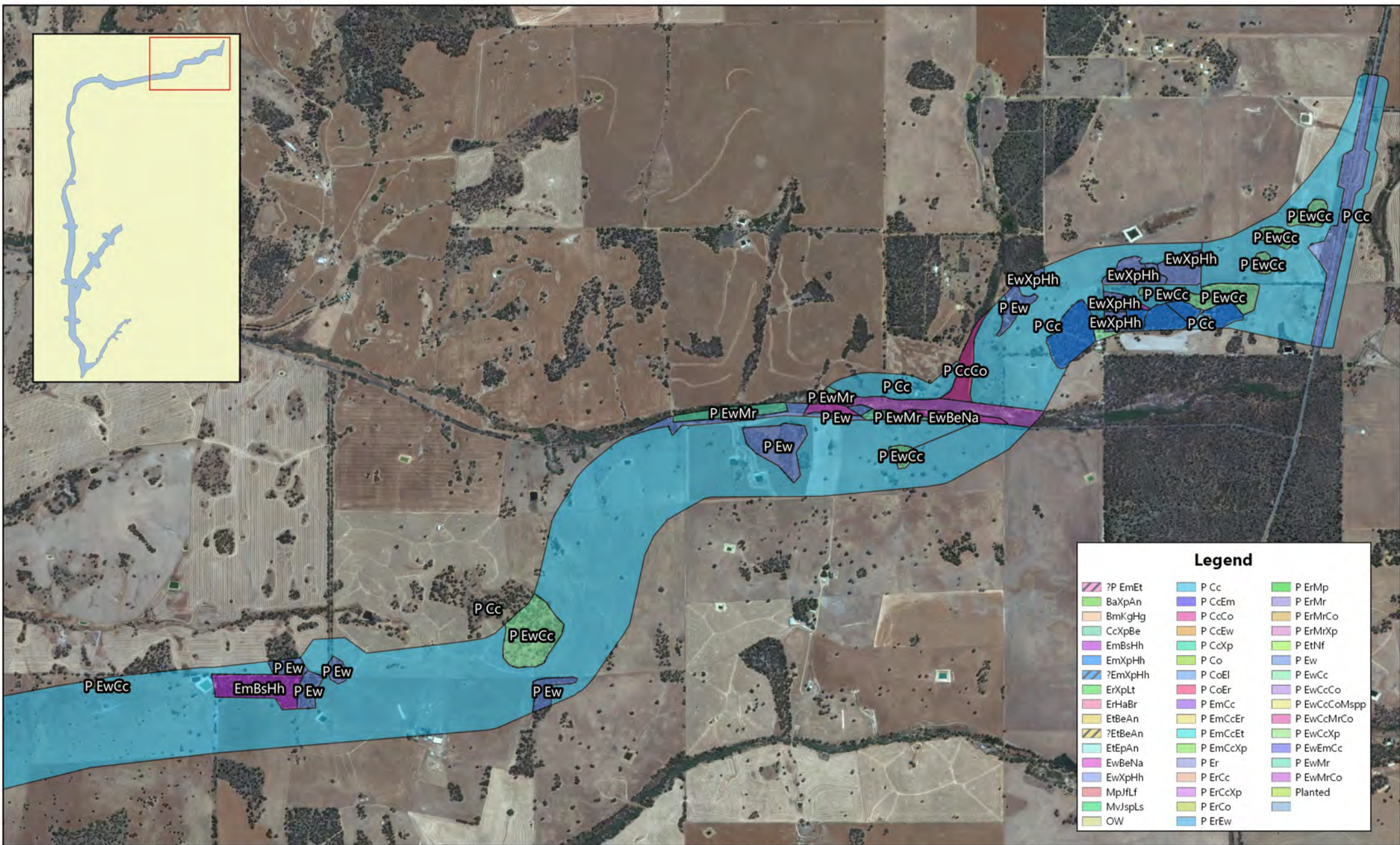
Table 10 Summary of Recorded Vegetation Communities

Vegetation Community and Description	Representative Quadrats	Represented within Survey Area/s	Corresponding Shepherd <i>et.al.</i> code	Equivalent Phoenix Quadrat/s
<p><i>EmXpHh</i></p> <p><i>Eucalyptus marginata</i> sparse woodland</p> <p><i>Eucalyptus marginata</i> low sparse woodland over <i>Xanthorrhoea preissii</i> mid sparse shrubland over <i>Hibbertia hypericoides</i>, <i>Bossiaea eriocarpa</i> and <i>Banksia dallanneyi</i> low isolated shrubs over <i>Conostylis setosa</i>, <i>Xanthosia huegelii</i> and <i>Philothea spicata</i> isolated herbs</p> <p>Average species richness: 39 ± 3.51</p>	B01, B02, B04	Area 1 Area 2 Area 3 Area 4	1019	MNP2012
<p><i>EmBsHh</i></p> <p><i>Eucalyptus marginata</i> and <i>Banksia sessilis</i> sparse woodland</p> <p><i>Eucalyptus marginata</i> low sparse woodland over <i>Banksia sessilis</i> and <i>Xanthorrhoea preissii</i> tall to mid sparse shrubland over <i>Hibbertia hypericoides</i> and <i>Bossiaea eriocarpa</i> low isolated to sparse shrubland over <i>Hypochaeris glabra</i> and <i>Ursinia anthemoides</i> isolated herbs</p> <p>Average species richness: 35.42 ± 2.35</p>	B08, B09, B12, B13, B15R, B28, B44	Area 2 Area 3	1019	MNP2012
<p><i>EwXpHh</i></p> <p><i>Eucalyptus wandoo</i> sparse woodland</p> <p><i>Eucalyptus wandoo</i> mid sparse woodland over <i>Xanthorrhoea preissii</i> mid isolated shrubs over <i>Hibbertia hypericoides</i>, <i>Bossiaea eriocarpa</i> and <i>Banksia dallanneyi</i> low isolated shrubs over <i>Conostylis setosa</i>, <i>Hypochaeris glabra</i> and <i>Drosera menziesii</i> isolated herbs</p> <p>Average species richness: 39 ± 2.34</p>	B21, B22, B23, B24	Area 1 Area 2	4	MNP2014
<p><i>EwBeNa</i></p> <p><i>Eucalyptus wandoo</i> and <i>Casuarina obesa</i> sparse woodland</p> <p><i>Eucalyptus wandoo</i> and <i>Casuarina obesa</i> mid to low sparse woodland over <i>Bossiaea eriocarpa</i> and <i>Gastrolobium calycinum</i> and <i>Hakea lissocarpha</i> low isolated shrubs over <i>Neurachne alopecuroidea</i> and <i>Lepidosperma tenue</i> isolated grasses and sedges</p> <p>Average species richness: 33 ± 5.50</p>	B29, B30, B31	Area 2	1018	Not represented

Vegetation Community and Description	Representative Quadrats	Represented within Survey Area/s	Corresponding Shepherd <i>et.al.</i> code	Equivalent Phoenix Quadrat/s
<p>BaXpAn</p> <p><i>Banksia</i> spp. sparse woodland</p> <p><i>Banksia attenuata</i> and <i>Banksia menziesii</i> low sparse woodland over <i>Xanthorrhoea preissii</i> mid isolated to sparse shrubs over <i>Bossiaea eriocarpa</i> and <i>Petrophile linearis</i> low isolated shrubs over <i>Alexgeorgea nitens</i> and <i>Lyginia imberbis</i> sparse sedges</p> <p>Average species richness: 40 ± 2.50</p>	B06, B07, B10, B11, B41, B45	Area 1 Area 2	1027	MNP2013
<p>EtBeAn</p> <p><i>Eucalyptus todtiana</i> sparse woodland</p> <p><i>Eucalyptus todtiana</i> and <i>Banksia attenuata</i> low sparse woodland over <i>Bossiaea eriocarpa</i> and <i>Hibbertia hypericoides</i> low isolated shrubs over <i>Trachymene pilosa</i> and <i>Gladiolus caryphyllaceus</i> isolated herbs and <i>Alexgeorgea nitens</i> and <i>Mesomelaena pseudostygia</i> sedges</p> <p>Average species richness: 38.50 ± 3.95</p>	B15, B16R, B17, B18, B19, B32	Area 2	949	MNP2002
<p>BmKgHg</p> <p><i>Kunzea glabrescens</i> shrubland</p> <p><i>Banksia menziesii</i> and <i>Banksia</i> spp low sparse to open woodland over <i>Kunzea glabrescens</i> and <i>Xanthorrhoea preissii</i> mid shrubland over <i>Hypochaeris glabra</i> and <i>Drosera erythrorhiza</i> isolated herbs</p> <p>Average species richness: 14 ± 1.00</p>	B14, B37	Area 2	Regionally not represented, locally distributed vegetation unit	NA
<p>EtEpAn</p> <p><i>Eucalyptus todtiana</i> sparse woodland</p> <p><i>Eucalyptus todtiana</i> and <i>Banksia</i> spp. low sparse woodland over <i>Adenathos cygnorum</i> tall sparse shrubland over <i>Eremaea pauciflora</i> and <i>Stirlingia latifolia</i> mid sparse to isolated shrubland over <i>Bossiaea eriocarpa</i> and <i>Conostephium pendulum</i> low isolated shrubs over <i>Austrostipa hemipogon</i> and <i>Briza maxima</i> grasses and <i>Alexgeorgea nitens</i> sedges</p> <p>Average species richness: 24.50 ± 0.70</p>	B42, B46	Area 2	949	MNP2002

Vegetation Community and Description	Representative Quadrats	Represented within Survey Area/s	Corresponding Shepherd <i>et.al.</i> code	Equivalent Phoenix Quadrat/s
<p>MpRcLf</p> <p><i>Melaleuca preissiana</i> sparse woodland</p> <p><i>Melaleuca preissiana</i> and <i>Banksia attenuata</i> low sparse woodland over <i>Regelia ciliata</i> and <i>Jacksonia furcellata</i> mid shrubland over <i>Lechenaultia floribunda</i> low isolated shrubs over <i>Hypochaeris glabra</i> and <i>Ursinia anthemoides</i> isolated herbs and <i>Austrostipa hemipogon</i>, <i>Ehrharta calycina</i> and <i>Pentameris airoides</i> isolated grasses</p> <p>Average species richness: 21.67 ± 1.45</p>	B43, B47, B48	Area 2	37	M1.31
<p>ErHaBr</p> <p><i>Eucalyptus rudis</i> and <i>Melaleuca preissiana</i> sparse woodland</p> <p><i>Eucalyptus rudis</i> and <i>Melaleuca preissiana</i> low sparse woodland over <i>Aotus gracillima</i> and <i>Xanthorrhoea preissii</i> mid isolated shrubs over <i>Hypocalymma angustifolium</i> low shrubland over <i>Baumea rubiginosa</i> and <i>Cyperus polystachyos</i> sedgeland</p> <p>Average species richness: 17.33 ± 8.25</p>	B05, B33, B34	Area 1	973	Not represented
<p>ErXpLt</p> <p><i>Eucalyptus rudis</i> and <i>Corymbia calophylla</i> sparse woodland</p> <p><i>Eucalyptus rudis</i> and <i>Corymbia calophylla</i> low to mid sparse woodland over <i>Xanthorrhoea preissii</i> and <i>Hakea varia</i> mid isolated shrubs over <i>Lepidosperma tenue</i> and <i>Lepidosperma ?squamatum</i> sparse sedgeland over <i>Hypochaeris glabra</i> and <i>Ursinia anthemoides</i> isolated herbs and <i>Briza maxima</i> isolated grass</p> <p>Average species richness: 22.25 ± 2.81</p>	B25, B26, B27, B36	Area 2	1009 (or 4)	Not represented

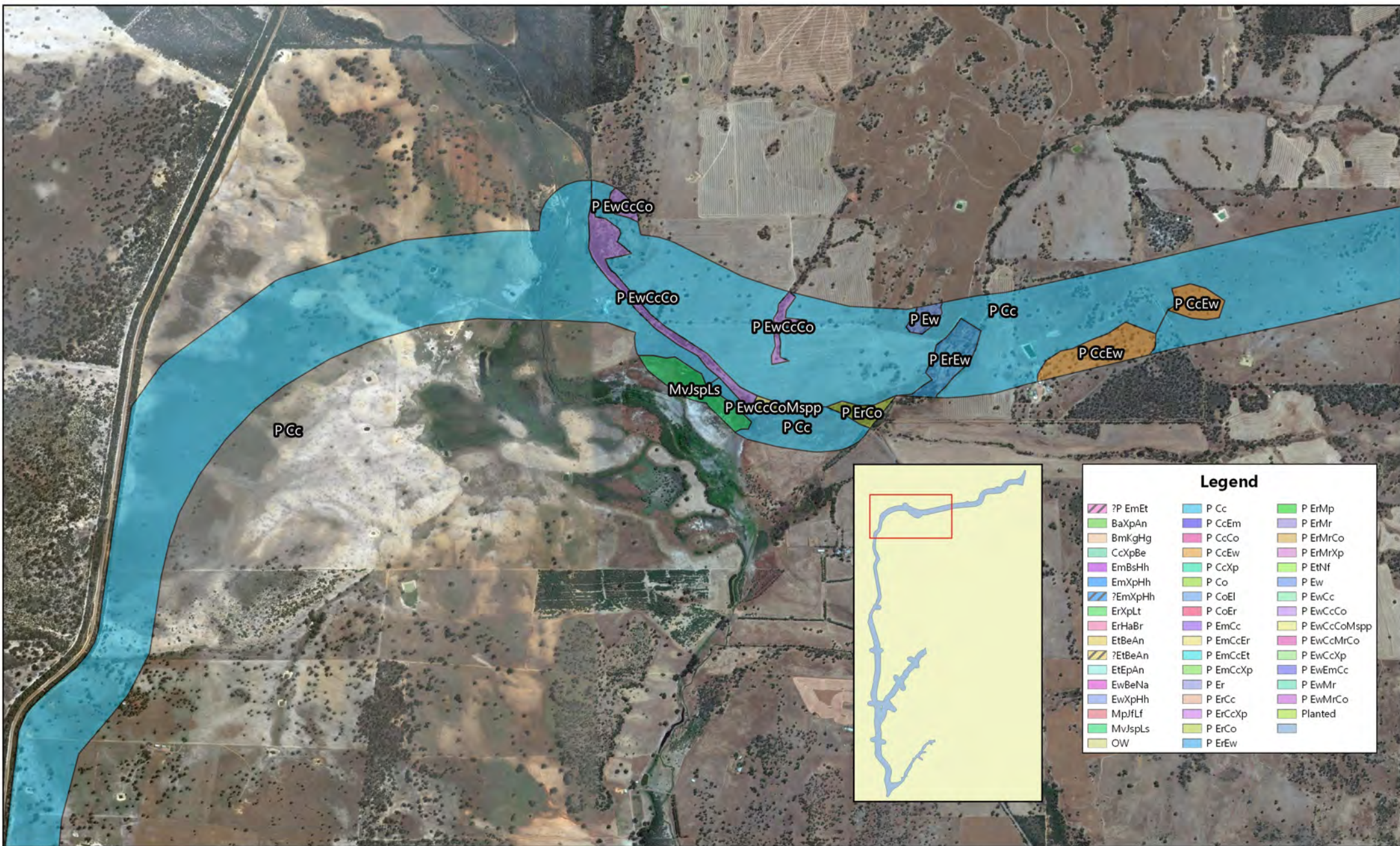
Vegetation Community and Description	Representative Quadrats	Represented within Survey Area/s	Corresponding Shepherd <i>et.al.</i> code	Equivalent Phoenix Quadrat/s
<p>CcXpBe</p> <p><i>Corymbia calophylla</i> sparse woodland</p> <p><i>Corymbia calophylla</i> mid to low sparse woodland over <i>Xanthorrhoea preissii</i> and <i>Grevillea bipinnatifida</i> subsp. <i>bipinnatifida</i> mid sparse shrubland over <i>Bossiaea eriocarpa</i>, <i>Phyllanthus calycinus</i> and <i>Hypocalymma angustifolium</i> low open shrubland over <i>Hypochaeris glabra</i>, <i>Lysimachia arvensis</i> and <i>Haemodorum laxum</i> isolated herbs and <i>Briza maxima</i> and <i>Neurachne alopecuroidea</i> isolated grasses</p> <p>Average species richness: 36.33 ± 3.18</p>	B38, B39, B40	Area 4	999	M1.14a M1.23
<p>MvJspLs</p> <p><i>Melaleuca viminea</i> shrubland</p> <p><i>Melaleuca viminea</i> tall shrubland over <i>Juncus</i> spp. and <i>Isolepis</i> spp. sparse sedgeland and <i>Cotula cornopifolia</i>, <i>Lotus</i> spp. and <i>Utricularia multifida</i> isolated herbs</p> <p>Average species richness: 8.00 ± 1.00</p>	B03, B20, B35	Area 1 Area 2	37	M1.31



0 0.25 0.5 0.75 1 km

Figure 13a - Vegetation Communities of the Study Area

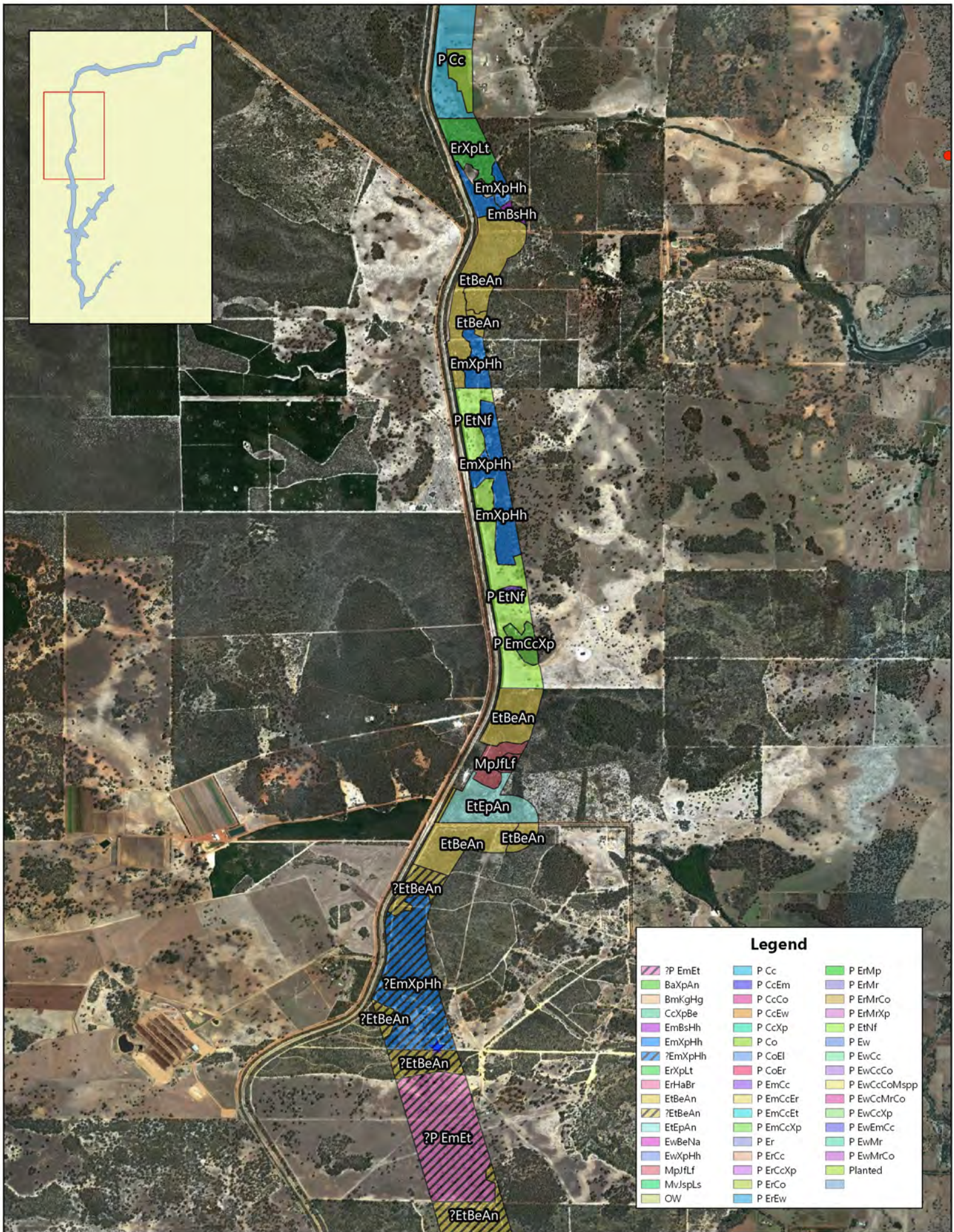




0 0.25 0.5 0.75 1 km

**Figure 13b - Vegetation
Communities of the Study Area**

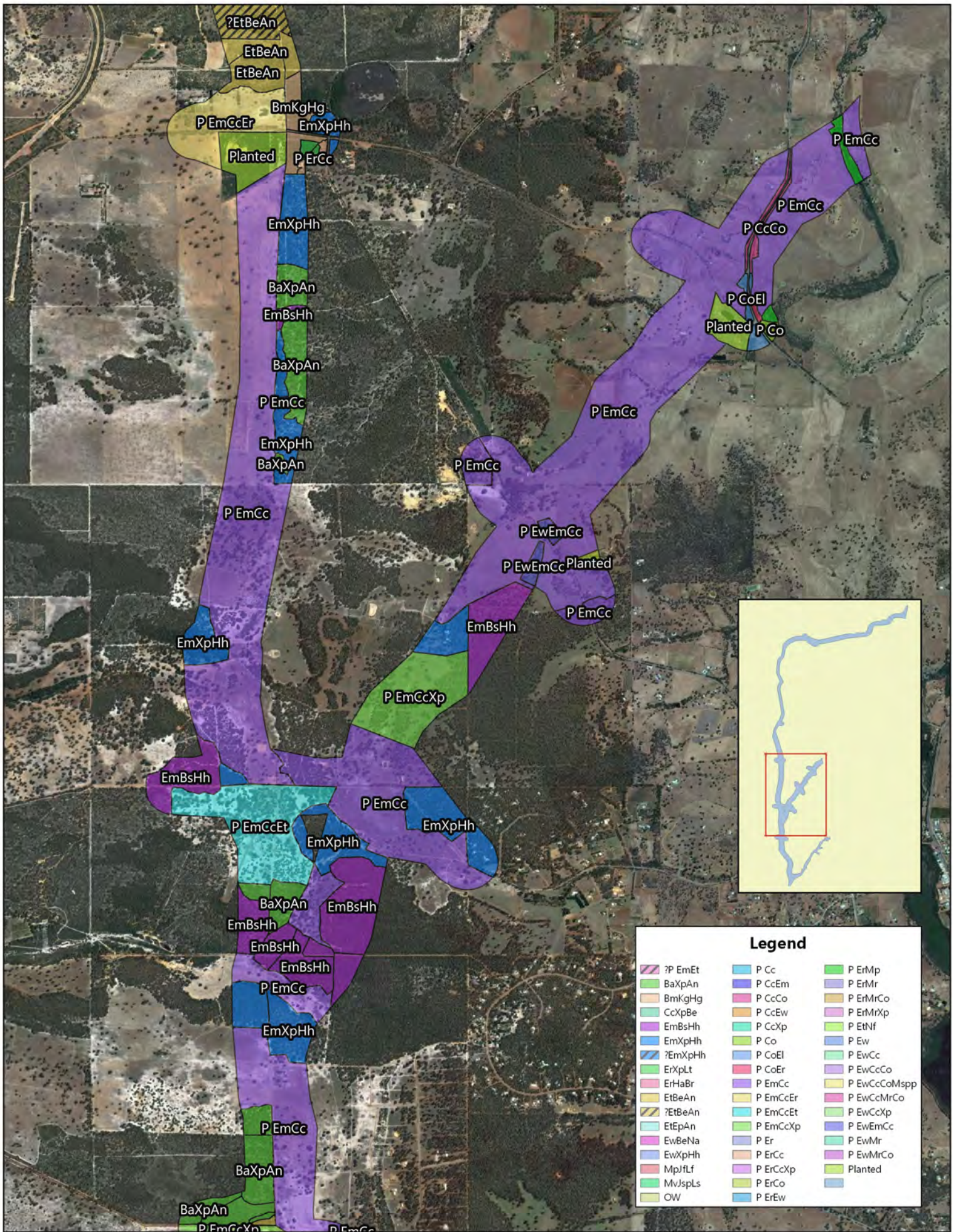




0 0.25 0.5 0.75 1 km

Figure 13c - Vegetation Communities of the Study Area

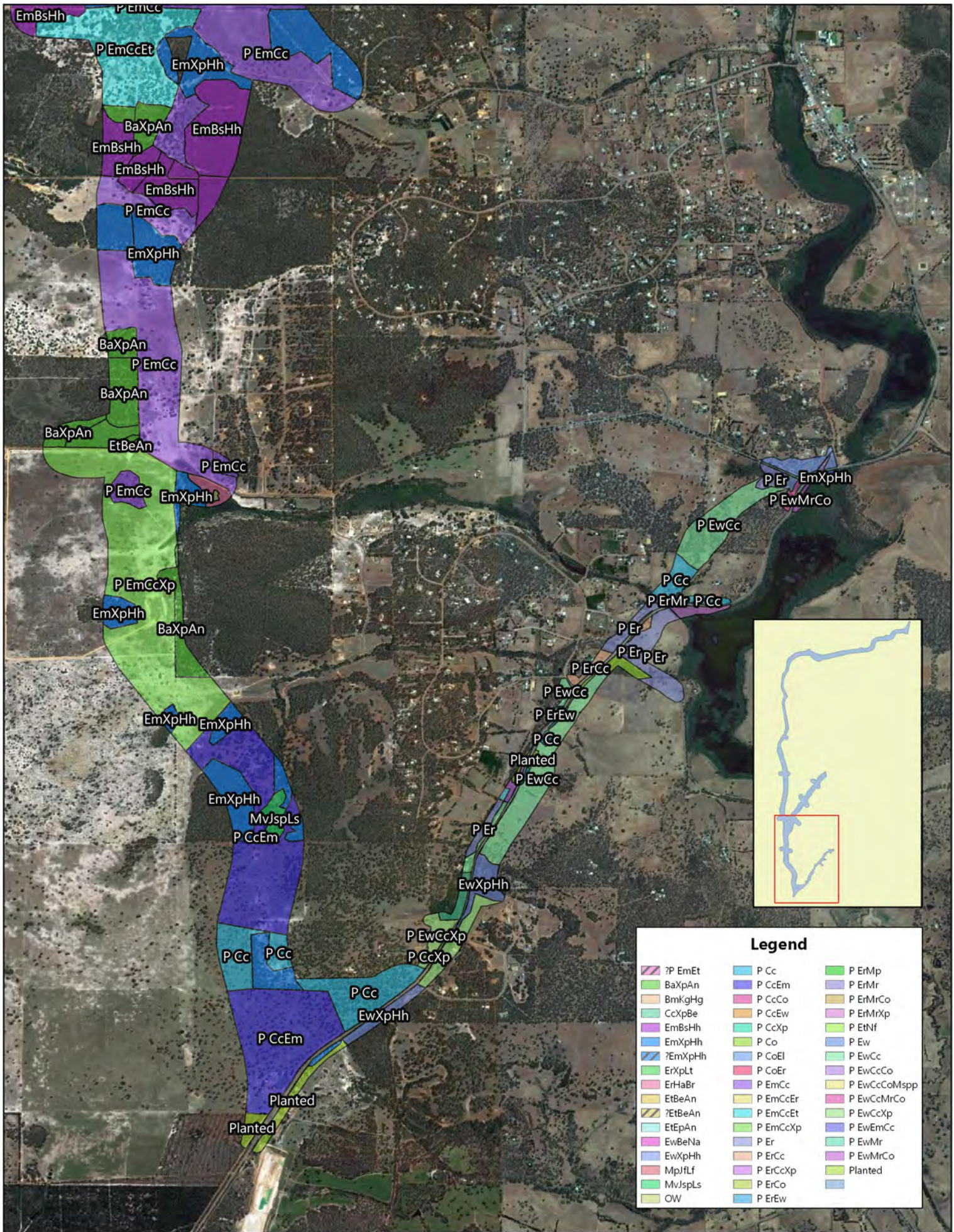




0 0.25 0.5 0.75 1 km

Figure 13d - Vegetation Communities of the Study Area





0 0.25 0.5 0.75 1 km



Figure 13e - Vegetation Communities of the Study Area

A large proportion of the study area comprises cleared land/pasture, mostly cleared or degraded areas, usually supporting native trees in varying densities. Where native understorey is completely lacking or almost so, and the ground cover is entirely pasture grasses and/or other weeds, areas have been mapped as 'Pasture' (P) communities. In the vegetation mapping, such areas are designated a 'P' before a two-letter code for the genus and species of the trees present in that area of pasture. For example, an area of pasture or completely degraded understorey with Marri (*Corymbia calophylla*) is coded 'P Cc'. A number of areas were found to support multiple tree species and therefore, the mapping codes indicate this also. The species of trees as present in the pasture communities of the study area are listed in **Table 11**.

Table 11 Codes for Tree Species Present in Pasture Communities

Code	Species
Cc	<i>Corymbia calophylla</i>
Co	<i>Casuarina obesa</i>
El	<i>Eucalyptus loxophleba</i> subsp. <i>loxophleba</i>
Em	<i>Eucalyptus marginata</i>
Er	<i>Eucalyptus rudis</i>
Et	<i>Eucalyptus todtiana</i>
Ew	<i>Eucalyptus wandoo</i>
Mp	<i>Melaleuca preissiana</i>
Mr	<i>Melaleuca rhapsiophylla</i>
M spp	<i>Melaleuca</i> species
Mv	<i>Melaleuca viminea</i>
Nf	<i>Nuytsia floribunda</i>
Xp	<i>Xanthorrhoea preissii</i>

Most of the vegetation communities recorded relatively high average species richness values (with at least 20-30 taxa per quadrat). The most floristically diverse vegetation units were BaXpAn (*Banksia* spp. sparse woodland), EmXpHh (*Eucalyptus marginata* sparse woodland) and EwXpHh (*Eucalyptus wandoo* sparse woodland), recording average species richness values of 40, 39 and 39 taxa, respectively. The lowest average species richness of eight species was recorded from the vegetation unit MvJspLs (*Melaleuca viminea* shrubland), a wetland vegetation type.

The total area occupied by each of the intact vegetation communities, the combined degraded 'pasture' communities, planted areas and other areas such as those completely cleared and supporting open water, within each of the survey areas is presented in **Table 12**.

Table 12 Areas of Varying Vegetation Communities

Vegetation Community/ Area Type	Area (ha)				
	Area 1	Area 2	Area 3	Area 4	Total
BaXpAn	42.54	35.29	-	-	77.83
BmKgHg	-	13.02	-	-	13.02
CcXpBe	-	-	-	3.55	3.55
EmBsHh	-	62.8	79.99	-	142.79
EmXpHh	48.82	147.12	77.31	18.27	291.52
?EmXpHh	-	48.93	-	-	48.93
ErHaBr	4.06	-	-	-	4.06
ErXpLt	-	16.37	-	-	16.37
EtBeAn	0.95	102.62	-	-	103.57
?EtBeAn	-	48.67	-	-	48.67
EtEpAn	-	19.43	-	-	19.43
EwBeNa	-	3.43	-	-	3.43
EwXpHh	6.76	22.71	-	-	29.47
MpRcLf	-	9.48	-	-	9.48
MvJspLs	4.99	7.66	-	-	12.65
Open water	0.34	-	-	-	0.34
Pasture	384.23	1,490.18	639.11	211.26	2,724.78
Planted	12.45	26.69	12.64	18.66	70.44
Cleared	-	3.18	-	-	3.18
Total	505.14	2,057.58	809.05	251.74	3,623.51

6.3 VEGETATION CONDITION

The vegetation of the study area was found to range from Completely Degraded (CD) to Excellent (Ex) (7 to 2 in accordance with the quantitative scale), with most areas found to be in 'Degraded to Completely Degraded' (D-CD) condition. The spatial extent of the varying vegetation condition across the study area is presented in **Figure 14**, and the areas of each condition category are presented in **Table 13**.

Table 13 Areas of Varying Vegetation Condition

Qualitative Vegetation Condition Rating	Quantitative Vegetation Condition Rating	Area 1 (ha)	Area 2 (ha)	Area 3 (ha)	Area 4 (ha)	Total Area (ha)	Proportion of Total Study Area (%)
Pristine (P)	1	0	0	0	0	0	0
Excellent (Ex)	2	16.50	11.30	36.13	NA	63.93	1.76
Very Good to Excellent (VG-Ex)	2-3	24.23	36.46	17.55	NA	78.24	2.16
Very Good (VG)	3	23.42	215.60	27.98	3.55	270.55	7.47
Good to Very Good (G-VG)	3-4	0.77	195.23	13.46	NA	209.46	5.78
Good (G)	4	7.69	56.33	6.42	NA	70.44	1.94
Degraded to Good (D-G)	4-6*	16.89	12.12	NA	25.79	54.80	1.51
Degraded (D)	6	27.54	21.58	62.46	12.08	123.66	3.41
Degraded to Completely Degraded (D-CD)	6-7	384.23	1479.09	632.41	206.45	2702.18	74.57
Completely Degraded (CD)	7	3.87	29.87	12.64	3.87	50.25	1.39
Total		505.14	2057.58	809.05	251.74	3623.51	100

*No rating score of 5 applies to the South-West and Interzone regions (EPA & DPaW 2015)