



**DETAILED FLORA AND VEGETATION ASSESSMENT
BINDOON BYPASS, GREAT NORTHERN HIGHWAY**

JULY 2018

**INTEGRATED PROJECT TEAM (IPT)
(MAIN ROADS WA WITH THE ARUP JACOBS JOINT VENTURE)**

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Focused Vision Consulting Pty Ltd
ABN 25 605 804 500

Please direct all inquiries to:
Focused Vision Consulting Pty Ltd
8/83 Mell Road, SPEARWOOD WA 6163
P: (08) 6179 4111 E: admin@focusedvision.com.au

Document History

Rev.	Author	Reviewed	Approved	Date
A	Gaby Martinez Senior Botanist Udani Sirisena Botanist	Lisa Chappell Senior Botanist		28/02/2018
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EXECUTIVE SUMMARY

Main Roads Western Australia (Main Roads) is upgrading the 218 km section of Great Northern Highway (GNH) between Muchea and Wubin. Jacobs and Arup have formed the joint venture, ASJV (now referred to as the Integrated Project Team (IPT)), 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. As part of the GNH upgrades project, the IPT is also progressing work for a section of the GNH that will bypass the town of Bindoon (the Bindoon Bypass).

During spring 2016, Focused Vision Consulting Pty Ltd (FVC), supported by specialist sub-consultants, including Bamford Consulting Ecologists (BCE), were engaged by ASJV to conduct spring flora, vegetation, fauna and habitat assessments of three proposed corridors (comprising four areas; the three corridors plus a section common to two corridors) for the Bindoon Bypass. The initial study aimed to collect data that would inform a multi-criteria analysis (MCA) of the route options.

In January 2017, a preferred corridor, referred to as 'Western A' was selected to be pursued for the Bindoon Bypass. The FVC team was then engaged to undertake autumn, winter and spring assessments of the preferred alignment (herein study area), which included further detailed flora and vegetation assessments, and Targeted Threatened and Priority flora surveys in accordance with EPA (2016) Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment. The surveys incorporated a total survey effort of 87 person-days, additional to the 39 person-days invested in the 2016 assessments (total survey effort of 128 person-days across 2016-2017). Across 2016 and 2017, a total of 117 vegetation assessment quadrats have been established and sampled, to define the floristic values of the study area and the surrounding region.

The flora and vegetation studies have culminated in the description and mapping of a total of 12 different vegetation units across the study area.

Targeted surveys for Threatened and Priority flora were carried out throughout the study area, including particular effort invested in dedicated surveys for Threatened orchid species, *Thelymitra stellata* (Star Sun-orchid) and *Drakaea elastica* (Glossy-leafed Hammer Orchid). Targeted Threatened orchid surveys were carried out 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). Neither *Thelymitra stellata* nor *Drakaea elastica* were recorded in any of the areas surveyed.

The key results and conclusions from the detailed flora and vegetation assessment, and targeted Threatened and Priority flora survey are as follows:

- No species of Threatened flora, including *Thelymitra stellata* and *Drakaea elastica* were recorded within the study area, despite intensive and systematic targeted surveys having been carried out.
- Eight species listed as Priority Flora (*Drosera sewelliae* (with *Drosera ?sewelliae*) (P2), *Hibbertia glomerata* subsp. *ginginensis* (P2), *Acacia drummondii* subsp. *affinis* (with *Acacia drummondii* subsp. *?affinis*) (P3), *Adenanthos cygnorum* subsp. *chamaephyton* (P3), *Hibbertia miniata* (P4), *Hypolaena robusta* (P4), *Jacksonia ?sericea* (P4) and *Verticordia paludosa* (with *Verticordia ?paludosa*) (P4)) were recorded during the 2017 field assessments.

- A collective total of 11 species listed as Priority Flora (*Gastrolobium ?crispatum* (P1), *Synaphea panhesya* (with *Synaphea ?panhesya*) (P1), *Drosera sewelliae* (with *Drosera ?sewelliae*) (P2), *Hibbertia glomerata* subsp. *ginginensis* (P2), *Acacia drummondii* subsp. *affinis* (with *Acacia drummondii* subsp. *?affinis*) (P3), *Adenanthos cygnorum* subsp. *chamaephyton* (P3), *Anigozanthos humilis* subsp. *chrysanthus* (P4), *Hibbertia miniata* (P4), *Hypolaena robusta* (P4), *Jacksonia ?sericea* (P4) and *Verticordia paludosa* (with *Verticordia ?paludosa*) (P4)) were recorded between the 2016 and 2017 field assessments.
- A collective total of 1,967 individual Priority flora plants were recorded in the study area between 2016 and 2017.
- It is considered likely that the distribution and abundance of the Priority flora recorded within the study area is greater than the assessment results would suggest, and that additional species of Priority flora occur that were not recorded, due to the unfavourable season experienced by the region with lower than expected rainfall received during winter 2017.
- Two flora species, *Jacksonia ?sericea* (P4) and *Synaphea ?flabelliformis* were found to be occurring outside their known range, based on distributions from the WA Herbarium.
- One of the recorded weed species, *Chondrilla juncea* (Skeleton weed) is listed as category 'C2' Declared Pest plant under the BAM Act within the study area, which, requires landholders to eradicate infestations, prevent the spread of seed or plant parts and undertake searches during summer and control activities during winter.
- One State-listed Threatened Ecological Community (TEC) and two Priority Ecological Communities (PECs) are known to occur within or closely adjacent to the study area, with all three of these community types representative of the Commonwealth-listed Banksia Woodlands of the Swan Coastal Plan TEC (Banksia Woodland TEC).
- The study area has been confirmed to support areas of the Commonwealth-listed Banksia Woodland TEC, within 476 ha of the TEC mapped, consisting of occurrences of vegetation units BaXpAn, BaXpUa, EmXpAn, EtBeAn and EtEpAn.
- All of the recorded vegetation units have been determined to be of local, regional or national significance, or a combination of these levels of importance. All are locally significant due to supporting populations of Priority flora and many having a limited local representation. Other factors determining local significance are, being considered floristically diverse or locally uncommon. Vegetation units 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. Five vegetation units (BaXpAn, BaXpUa, EmXpAn, EtBeAn, EtEpAn) are of national significance due to representing a TEC of Commonwealth significance.

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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 2018).

Main Roads Western Australia (Main Roads) is upgrading the 218 km section of Great Northern Highway (GNH) between Muchea and Wubin. Jacobs and Arup together with Main Roads have formed the Integrated Project Team (IPT) for the delivery of the upgrade project. The IPT 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 have and will significantly improve safety and amenity and facilitate the future movement of road trains along this section of highway. As part of the GNH upgrades project, the IPT is also progressing work for a section of the GNH that will bypass the town of Bindoon (the Bindoon Bypass).

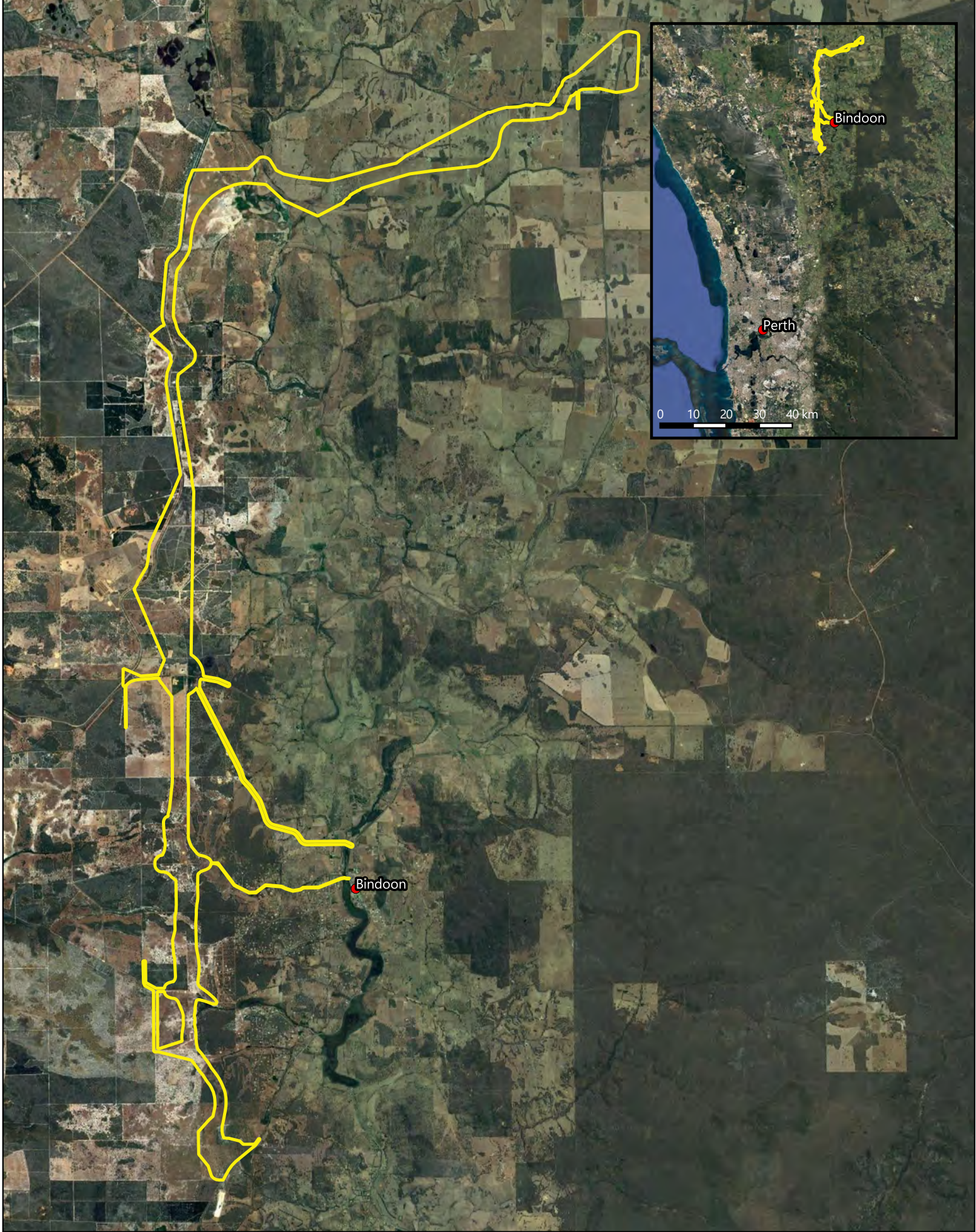
During 2016, Focused Vision Consulting Pty Ltd (FVC), supported by specialist sub-consultants, including Bamford Consulting Ecologists (BCE), were engaged by the IPT (formerly ASJV) to conduct spring flora, vegetation, fauna and habitat assessments of three proposed corridors comprising of four areas (the three corridors plus a section common to two corridors), for the Bindoon Bypass section of the GNH upgrade project.

A preferred corridor, referred to as 'Western A' was selected in January 2017 to be pursued for the Bindoon Bypass (**Figure 1**). The FVC team was then engaged to undertake autumn, winter and spring assessments of the preferred alignment, including revisions to this which were incorporated into the project (the boundary of which is herein referred to as the study area) in 2017.

This report consolidates the findings of the flora and vegetation assessments undertaken within the study area to date in accordance with current EPA guidance, as part of regulatory requirements of formal environmental approvals that will be sought for the Bindoon Bypass project. This report focuses on results from the 2017 autumn, winter and spring surveys, following the previous reporting of spring 2016 results (FVC 2017).

1.2 LOCATION

The study area is located in the Shires of Chittering and Gingin between the localities of Chittering in the south, to Wannamal in the north, from the existing Great Northern Highway at the southern end to the Moora-Bindoon Road in Wannamal then extending eastward through Wannamal to Great Northern Highway. Additional survey areas within the revised study area extend west to east along Gray and Mooliabeenee Roads and north-west to south-east along Crest Hill Road (**Figure 1**).




0 1 2 3 4 km

GDA 94 / MGA Zone 50

Figure 1 - Study Area



Legend

 Study Area



1.3 SCOPE OF WORK

The scope of the project was to undertake a flora and vegetation assessment, including targeted Threatened and Priority flora surveys in the study area during suitable seasons, with a focus on spring 2017. The surveys were undertaken to refine the definition of biological values and address additional areas encompassed within the revised study area. The tasks required to be carried out included:

1. Desktop review to determine significant flora species relevant to the new study area, and to locate suitable sites to target during autumn, winter and spring (based on existing survey data), as well as locations and species to target for repeated survey effort (including *Thelymitra stellata*)
2. Desktop review to select a suitable representation of quadrats to resample during 2017
3. Desktop review to select suitable sites for new quadrats to be sampled during 2017, represented within the new survey areas, in the wider region and other locations as applicable; including addressing Environmental Protection Authority (EPA) comments on floristic analysis revisions to consider
4. Desktop review to map and quantify the likely extent of Banksia Woodland within and connected to the study area, for a targeted Banksia Woodlands of the Swan Coastal Plain Threatened Ecological Community (TEC) assessment
5. Field assessment of selected relevant areas targeting relevant significant flora as identified in task 1 above
6. Field assessment and establishment/rescoring of new or selected relevant quadrats, as identified in tasks 2 and 3 above
7. Field assessment to fill survey gaps in properties not able to be accessed previously, including the establishment and sampling of quadrats as appropriate
8. Field assessment of selected relevant areas targeting Banksia woodland, including quadrat sampling, as identified in task 4 above
9. Preparation of a report that summarises all of the above and makes reference to previous (spring 2016 and autumn/winter 2017) results as in accordance with relevant guidelines.

The assessments and reporting were carried out in accordance with relevant guidance, as listed in **Sections 2 and 5**.

2 LEGISLATIVE CONTEXT

The flora and vegetation assessments were conducted in accordance with the following legislation:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- Western Australian *Environmental Protection Act 1986* (EP Act)
- Western Australian *Biodiversity Conservation Act 2016* (BC Act)
- Western Australian *Wildlife Conservation Act 1950* (WC Act).

The assessments 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 (2016) Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment
- Threatened Species Scientific Committee (2016) Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain Ecological Community
- 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 Biodiversity, Conservation and Attractions (DBCA) 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 (DBCA 2018b, DPaW (Department of Parks and Wildlife) 2016).

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 protected by the WC Act as extracted from DBCA (DPaW 2017).

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 (MNES) 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 2007).

Vegetation communities in Western Australia are described as 'TECs' if they have been defined by DBCA's Species and Communities Branch and found to be Presumed Totally 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 DBCA.

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 (DEE) list 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 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.

Technical Guidance for Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016) also states that vegetation may be considered significant for a range of reasons, including but not limited to the following:

- being identified as threatened or priority ecological communities
- have a restricted distribution
- have a degree of historical impact from threatening processes
- have a role as a refuge
- provide an important function required to maintain ecological integrity of a significant ecosystem.

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 (DWER 2018). 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, there are several key criteria applied to the assessment of clearing permit applications, in the interests of biodiversity conservation. 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 or 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 Pest Plants

The Western Australian Organism List (WAOL) details organisms listed as Declared Pests, including pest plants, under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) (DAFWA 2018a). 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 regions in *An Environmental Weed Strategy* (CALM 1999). To advance the above categorisation, the Invasive Plant Prioritization Process for DBCA was developed in 2008 (DPaW 2013).

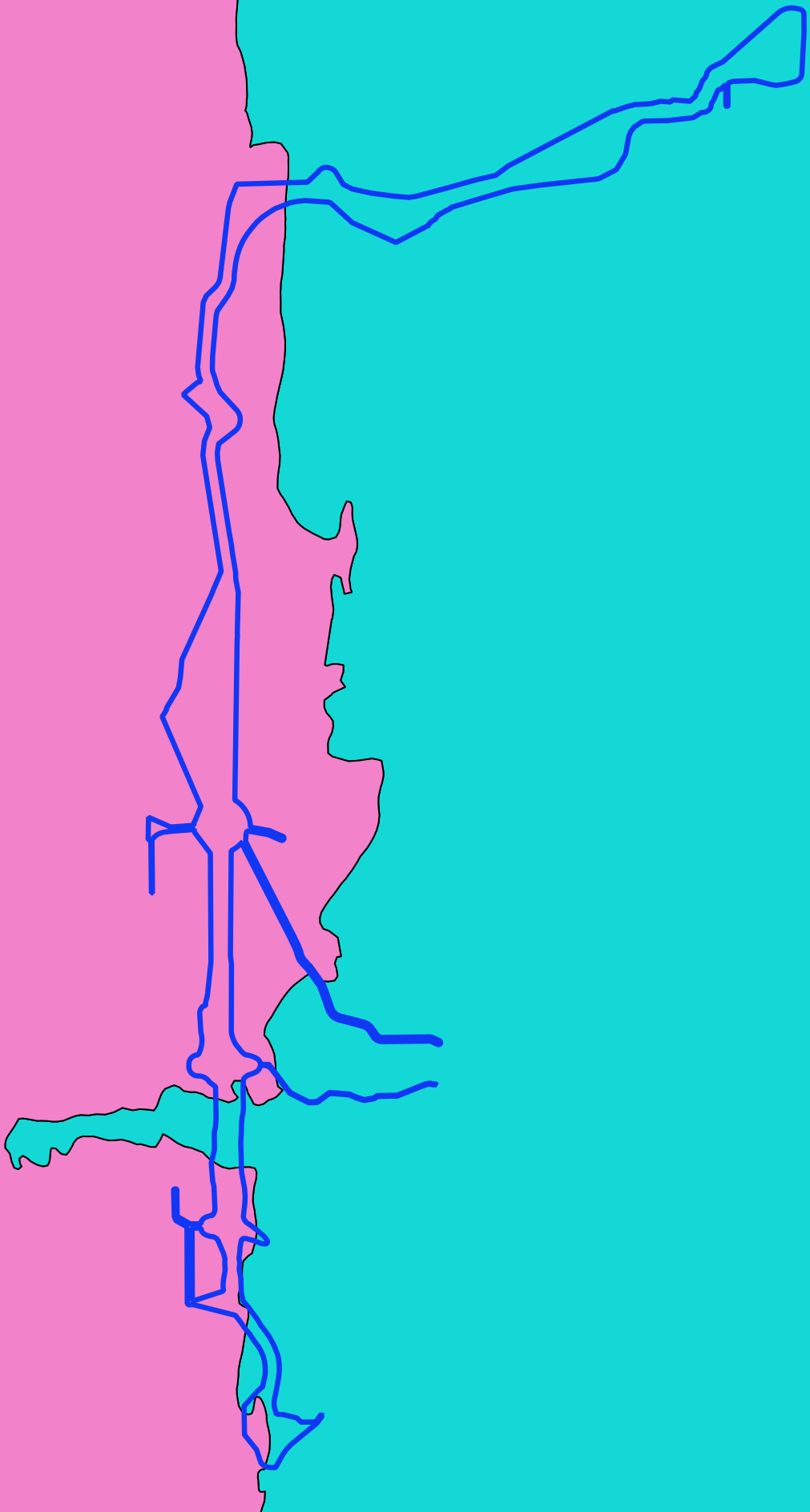
3 EXISTING ENVIRONMENT

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 and 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.






0 1 2 3 4 km

GDA 94 / MGA Zone 50

Figure 2 - IBRA Regions of the Study Area



Legend

-  Study Area
-  Jarrah Forest
-  Swan Coastal Plain



3.2 CLIMATE

The Bindoon area experiences a warm and temperate climate, where the winter months experience greater rainfall than the summer months (Climatedata.org 2018). 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 632.5 mm. The annual mean maximum temperature ranges from 18.3°C in winter to 33.2°C in summer (BoM 2018) (**Figure 3**).

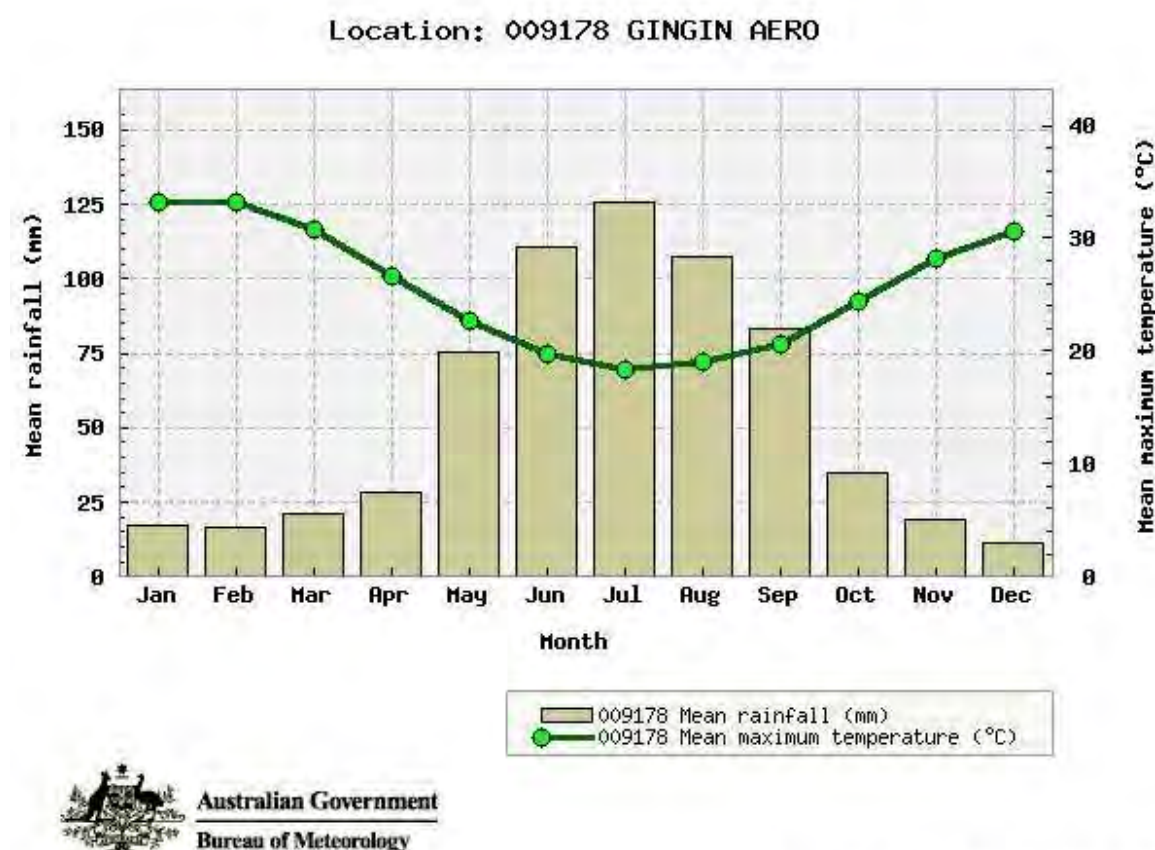


Figure 3 Climate Data for Gingin Aero

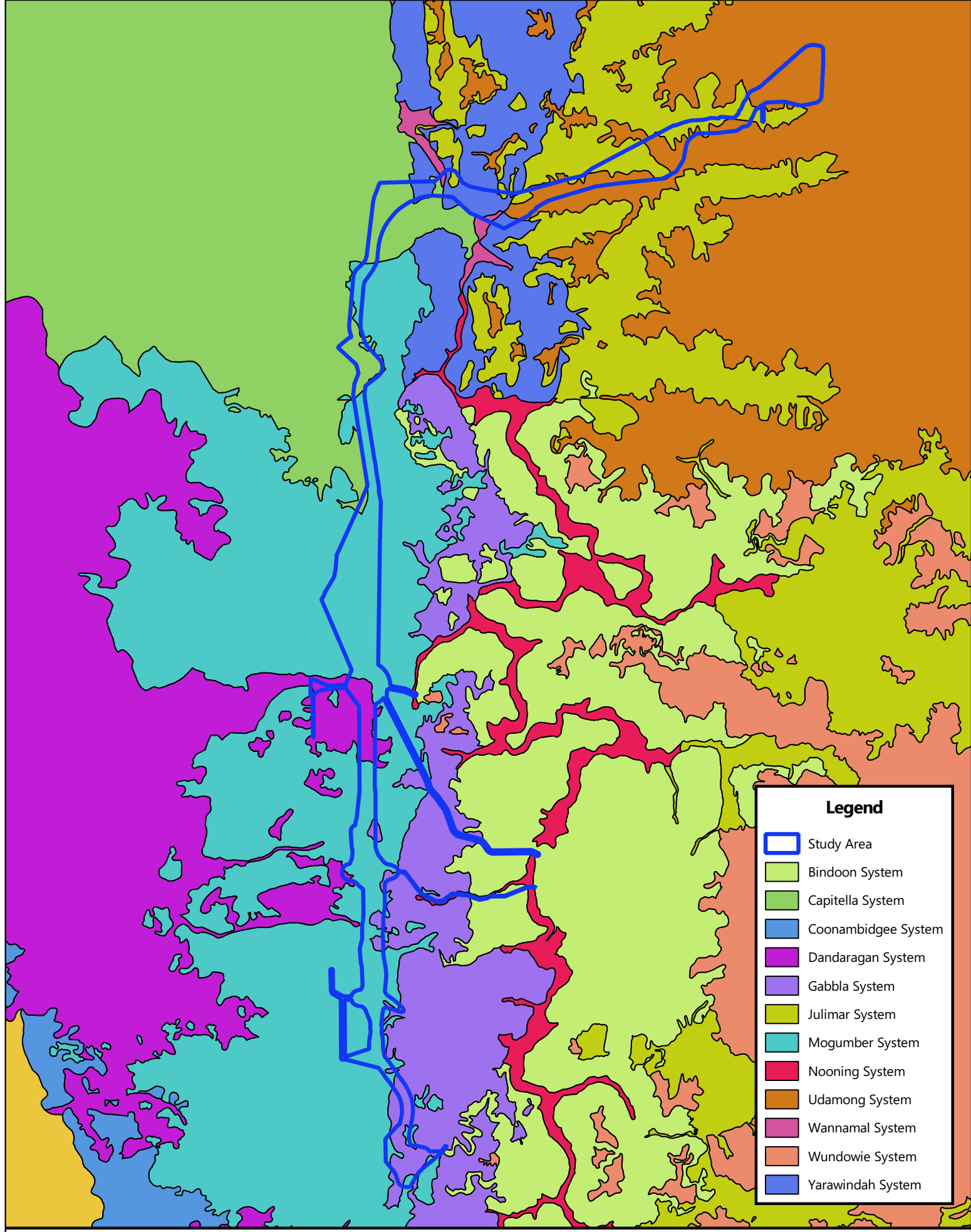
3.3 GEOLOGY AND SOILS

Soil-landscape mapping across Western Australia has been compiled by the Department of Agriculture and Food WA (DAFWA) (2018b) using various surveys at different scales varying between 1:20,000 and 1:3,000,000.

At the system scale, the study area traverses ten 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
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 Plateau 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 saltiest 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
253Wa	Wannamal System	Alluvial plain and fans; Brown and red loamy earths, Yellow/brown sandy duplexes, loamy duplexes
253Yh	Yarawindah System	Dissected lateritic plateau with rolling to undulating low hills and undulating rises; loamy gravel, loamy earth, loamy duplex, some rock; weathered schist and some gneiss



Legend

- Study Area
- Bindoon System
- Capitella System
- Coonambidgee System
- Dandaragan System
- Gabbla System
- Julimar System
- Mogumber System
- Nooning System
- Udamong System
- Wannamal System
- Wundowie System
- Yarawindah System

0 1 2 3 4 km

GDA 94 / MGA Zone 50



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 and Williams 2001). The study area traverses eight vegetation associations characterised by Shepherd *et al.* (2002), and the general vicinity of the study area supports 20 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 nine vegetation complexes occur within the study area. These are described as follows:

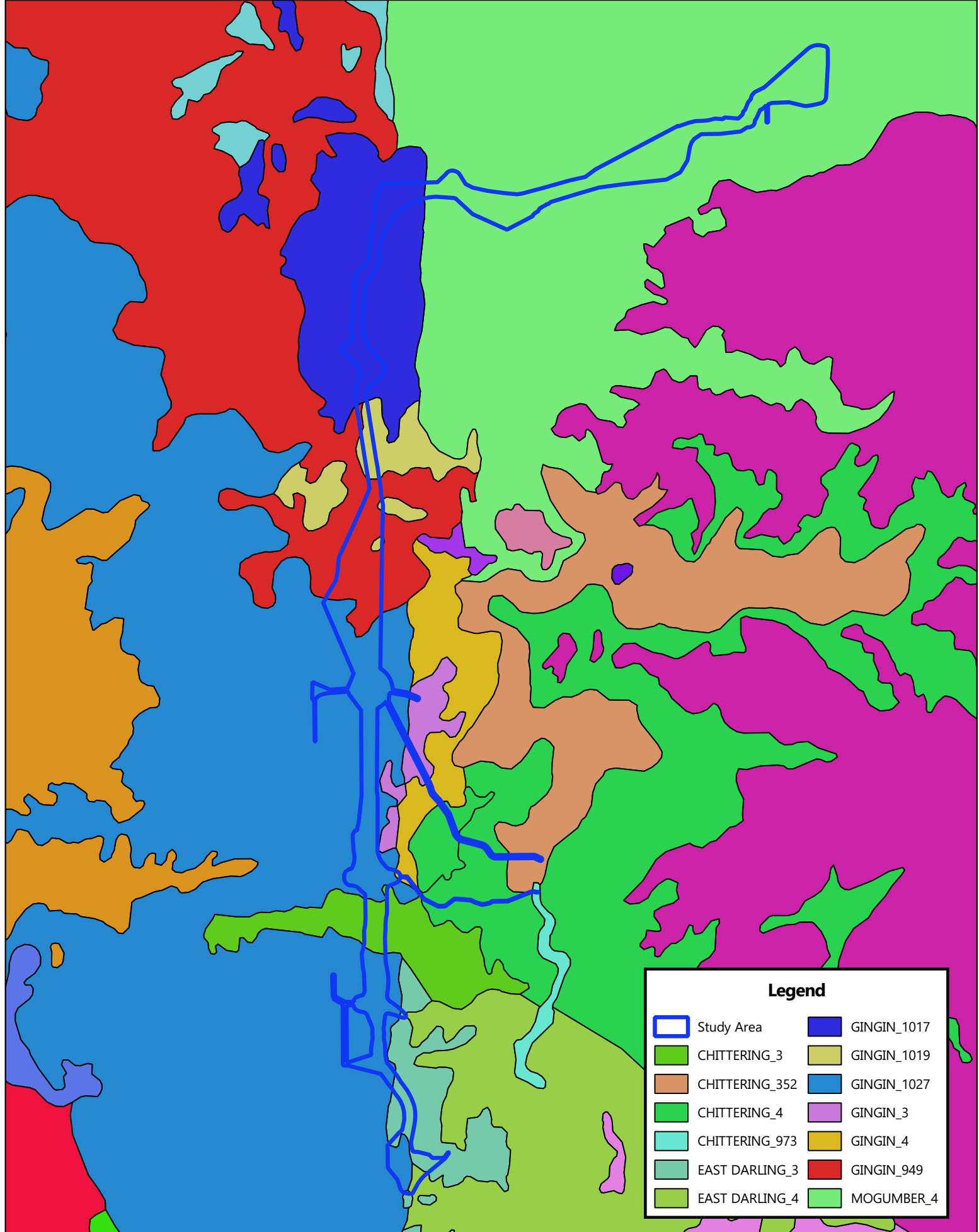
1. **Bindoon Complex.** This complex is broadly characterised by *Eucalyptus loxophleba* (York gum) on the lower valley slopes, flanked by Wandoo higher upslope.
2. **Coolakin Complex in low rainfall.** Comprises of Woodlands of *Eucalyptus wandoo* with mixtures of *Eucalyptus patens*, *Eucalyptus marginata* 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. **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.
8. **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*.
9. **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.

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 5** and **6**, respectively.

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

Shepherd Code	Short Description	Broad Vegetation Description
3	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	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\3\ d
		U [^] <i>Eucalyptus rudis</i> [^] <i>Melaleuca raphiophylla</i> \tree\7cG <i>Viminaria denudata</i> \sedge\2i
352	Medium woodland; York gum	U [^] <i>Eucalyptus loxophleba</i> \tree\7i;M <i>Acacia acuminata</i> , <i>Acacia cyanophylla</i> \shrub\4i
946	Medium woodland; wandoo	U [^] <i>Eucalyptus wandoo</i> \tree\7i
949	Low woodland; banksia	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

Shepherd Code	Short Description	Broad Vegetation Description
973	Low forest; paperbark (<i>Melaleuca raphiophylla</i>)	U^ <i>Eucalyptus rudis</i> , ^ <i>Melaleuca preissiana</i> \tree\7\c
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
1008	Medium open woodland; marri	U^ <i>Corymbia calophylla</i> \tree\7\i
1009	Medium woodland; marri & river gum	U^ <i>Corymbia calophylla</i> , ^ <i>Eucalyptus rudis</i> \tree\7\i
1014	Mosaic: Low woodland; banksia / Shrublands; teatree thicket	U^ <i>Banksia attenuata</i> , <i>Banksia menziesii</i> \tree\6\i
1016	Mosaic: Low woodland; banksia / Shrublands; dryandra heath	M <i>Dryandra</i> sp. \shrub\3\c
1017	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	Medium sparse woodland; jarrah & marri	U^ <i>Eucalyptus marginata</i> , ^ <i>Corymbia calophylla</i> \tree\7\r
1027	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
1030	Low woodland; <i>Banksia attenuata</i> & <i>B. menziesii</i>	U^ <i>Banksia attenuata</i> , ^ <i>Banksia menziesii</i> \tree\6\i



Legend

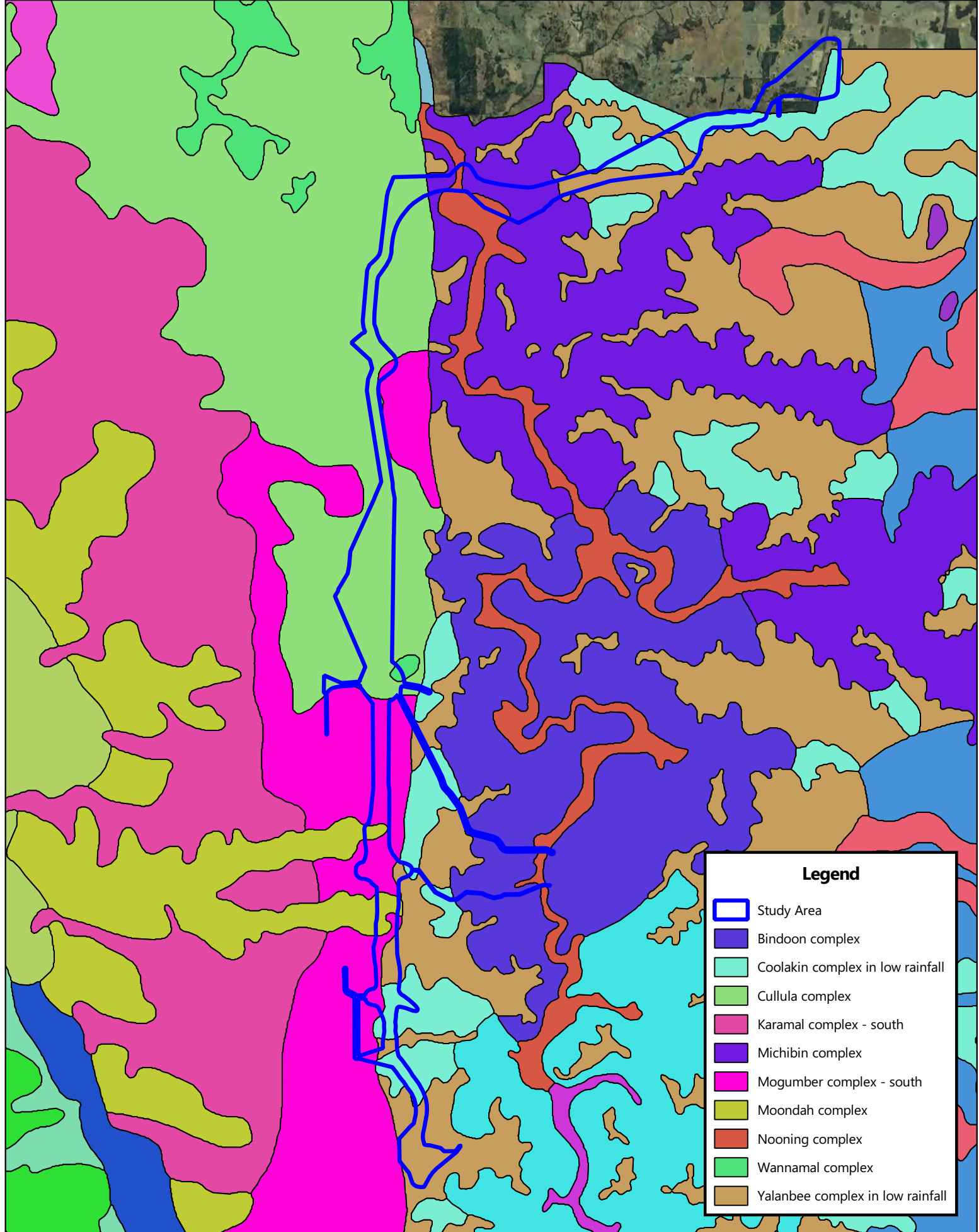
Study Area	GINGIN_1017
CHITTINGING_3	GINGIN_1019
CHITTINGING_352	GINGIN_1027
CHITTINGING_4	GINGIN_3
CHITTINGING_973	GINGIN_4
EAST DARLING_3	GINGIN_949
EAST DARLING_4	MOGUMBER_4

0 1 2 3 4 km

GDA 94 / MGA Zone 50



Figure 5 - Regional Vegetation of the Study Area



Legend

- Study Area
- Bindoon complex
- Coolakin complex in low rainfall
- Cullula complex
- Karamal complex - south
- Michibin complex
- Mogumber complex - south
- Moondah complex
- Nooning complex
- Wannamal complex
- Yalanbee complex in low rainfall

0 1 2 3 4 km

GDA 94 / MGA Zone 50



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 units of the study area and surrounding region. Detailed findings have been reported in the following:

- Focused Vision Consulting (2018a) Memorandum – Phase 2 Autumn and Winter Flora and Vegetation Surveys, Great Northern Highway, Bindoon Bypass
- Focused Vision Consulting (2018b) Memorandum – Great Northern Highway, Bindoon Bypass, Key Flora, Vegetation, Fauna and Habitat Constraints
- Focused Vision Consulting (2017) Level 2 Flora and Vegetation Assessment and Targeted *Thelymitra stellata* Survey, Great Northern Highway, Muchea to Wubin Upgrades, Stage 2 – Bindoon Options
- Phoenix Environmental Services (2016) Flora and fauna assessment for Calingri to Wubin study areas. Great Northern Highway, Muchea to Wubin Upgrade Stage 2 Project
- 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 5**.

Table 5 Summary of Key Findings from Recent Relevant Surveys

Author, Area, Scope and Methodologies	Key Findings
Focused Vision Consulting (2018a)	
<ul style="list-style-type: none"> Level 2 Flora and Vegetation assessment of the preferred corridor (Western A) for the Bindoon Bypass Vegetation unit/condition mapping, targeted searches for conservation significant flora, vegetation and declared pest plants (weeds), quadrat re-sampling and gap filling undertaken Autumn surveys conducted March to May 2017 Winter surveys conducted June to August 2017 A total of 47 quadrats and two relevés from 13 vegetation associations recorded during spring 2016 assessment of the three route options A total of 17 quadrats established in 2016 were resampled and an additional 13 new quadrats were established and recorded during autumn/winter 2017 	<ul style="list-style-type: none"> During autumn and winter phase assessments, three Threatened flora and 17 Priority flora were targeted, based on suitable flowering times. Of these, seven Priority flora were targeted during the autumn phase and three Threatened flora and 13 Priority flora were targeted during the winter phase. Two Priority flora species recorded, <i>Verticordia paludosa</i> (P4) recorded during autumn phase of assessment at three confirmed locations. One additional collection of a possible <i>Verticordia paludosa</i> (P4) was recorded. Initial taxonomic identification of this species indicated that it was possibly <i>Verticordia paludosa</i> (P4), however it was not possible to definitively confirm the species due to lack of flowering material. <i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i> (P3) recorded from one location north of Teatree road, where majority of population occurs outside the study area Initial assessment of quadrat data collected during the autumn and winter phase flora and vegetation assessment verified vegetation unit and vegetation condition mapping conducted during 2016. No changes in vegetation unit composition, spatial extent or vegetation condition were noted at the time of the interim reporting.
Focused Vision Consulting (2018b)	
<ul style="list-style-type: none"> Focused Vision Consulting (FVC) were engaged by the Integrated Project Team (IPT) to conduct spring flora, vegetation, fauna and habitat assessments of the Bindoon Bypass alignment, across spring 2016 and into autumn, winter and spring 2017 The following relevant key biological constraints were reported: <ul style="list-style-type: none"> Threatened and Priority Flora Banksia Woodland TEC 	<ul style="list-style-type: none"> No Threatened Flora recorded Various Priority Flora recorded including: <ul style="list-style-type: none"> <i>Synaphea panhesya</i> (P1) and <i>Synaphea ?panhesya</i> (P1) <i>Hibbertia glomerata</i> subsp. <i>ginginensis</i> (P2) <i>Drosera sewelliae</i> (P2) and <i>Drosera ?sewelliae</i> (P2) <i>Acacia drummondii</i> subsp. <i>affinis</i> (P3) and <i>Acacia drummondii</i> subsp. <i>?affinis</i> (P3) <i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i> (P3) <i>Anigozanthos humilis</i> subsp. <i>chrysanthus</i> (P4) <i>Hibbertia miniata</i> (P4) <i>Hypolaena robusta</i> (P4) <i>Jacksonia ?sericea</i> (P4) <i>Verticordia paludosa</i> (P4) and <i>Verticordia ?paludosa</i> (P4) Banksia Woodland likely to be equivalent to <i>Banksia Woodland of the Swan Coastal Plain</i> TEC was recorded within study area

Author, Area, Scope and Methodologies	Key Findings
Focused Vision Consulting (2017)	
<ul style="list-style-type: none"> • Level 2 flora and vegetation assessment of three proposed route options for the Great Northern Highway Bindoon Bypass; broken down into four survey areas (collectively the 'study area'): <ul style="list-style-type: none"> ○ 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 • Total survey effort of 18-person days conducted during October 2016 • Total of 46 pegged quadrats and two relevés were established and sampled • Targeted survey conducted for <i>Thelymitra stellata</i> in November 2016 within selected areas with a total of 21-person days invested. • Aim to survey at least 50% of suitable habitat areas for <i>Thelymitra stellata</i> within the study area 	<ul style="list-style-type: none"> • Total of 13 different vegetation communities recorded in study area • Seven Priority Flora recorded: <i>Synaphea panhesya</i> (P1), <i>Gastrolobium ?crispatum</i> (P1), <i>Drosera sewelliae</i> (with <i>Drosera ?sewelliae</i>) (P2), <i>Acacia drummondii</i> subsp. <i>affinis</i> (P2), <i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i> (P3), <i>Anigozanthos humilis</i> subsp. <i>chrysanthus</i> (P3) and <i>Hibbertia miniata</i> • Considered likely that distribution and abundance of Priority flora recorded is greater than the recorded population extents and sizes and that additional species of Priority flora occur that were not recorded, due to a focus on quadrats and vegetation definition rather than targeted flora surveys • Further, more detailed surveys to target Priority flora were recommended • No species of Threatened flora, including <i>Thelymitra stellata</i> were recorded within 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 near study area; with all three ecological communities' representative of the Commonwealth-listed <i>Banksia</i> woodlands of the Swan Coastal Plain TEC • The spring 2016 assessment scope was developed prior to the <i>Banksia</i> Woodlands of the Swan Coastal Plain being announced as a Commonwealth-listed TEC, in September 2016. However, future assessments will focus on <i>Banksia</i> 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 <i>Banksia</i> woodland TEC within study area is 22.67ha, 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 is required to accurately characterize and map the extent of <i>Banksia</i> woodland (Commonwealth) TEC within study area, due to 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.

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 (Muehea 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 releves 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’

Author, Area, Scope and Methodologies	Key Findings
GHD (2011a)	
<ul style="list-style-type: none"> • Preferred general corridor alignment for Great Northern Highway between Muchea 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 identified through EIA including; impact to Bindoon and Chittering Lakes and associated 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 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 recorded; <i>Millotia tenuifolia</i> var. <i>laevis</i> (P2), <i>Acacia drummondii</i> subsp. <i>affinis</i> (P3), <i>Persoonia sulcata</i> (P4) • Vegetation clearing 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

Author, Area, Scope and Methodologies	Key Findings
GHD (2011b)	
<ul style="list-style-type: none"> • 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) • Level 2 Flora and vegetation assessment in September 2010 	<ul style="list-style-type: none"> • Approximately 119 ha of vegetation ranging from Pristine to Completely Degraded. Predominately considered to be in Degraded to Completely Degraded condition • A total of 277 taxa were recorded and 13 vegetation types described within the study area • 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). • 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 • Two vegetation types are represented by less than 30% of their pre-European extent and are considered Vulnerable • 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
ENV (2007)	
<ul style="list-style-type: none"> • Great Northern Highway south of New Norcia SLK 89 to SLK 114 • Occurs to the north-east of the FVC study area, approximately 30 km north of Bindoon township along Great Northern Highway • Total survey length of 24 km • Level 2 Spring Flora and Vegetation survey conducted in November 2006 • A total of 48 quadrats sampled 	<ul style="list-style-type: none"> • A total of 357 taxa recorded, including eight current Priority flora • 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) • No Threatened flora recorded • 18 vegetation types described. • At the time of reporting there were no TECs listed for the study area • Declared Pest plants and WONS; <i>Asparagus asparagoides</i> and <i>Echium plantagineum</i> recorded • 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

Author, Area, Scope and Methodologies	Key Findings
Western Botanical (2006)	
<ul style="list-style-type: none"> • Flora and vegetation survey of eight work packages along Great Northern Highway from Brand Highway to Bindi Bindi–Toodyay Road • Work packages ranging in length from 3.49 km to 13.02 km; total survey length of 68.5 km • Level 1 spring flora and vegetation and an intensive Threatened and Priority flora survey, conducted between September and November 2005 	<ul style="list-style-type: none"> • 290 native species and 26 introduced flora species recorded • A total of 10 current Priority flora species recorded • 34 vegetation types delineated; with those in the southern work packages predominantly consisting of Marri/Jarrah/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 • No determination of TECs or PECs made • 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
KBR (2006)	
<ul style="list-style-type: none"> • Great Northern Highway Bindoon South SLK 54.6 to SLK 62.1 • EIA documented significant environmental aspects and management commitments of the GNH upgrade • 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 	<ul style="list-style-type: none"> • Close proximity to FVC study area along Great Northern Highway between Hart Drive and Bindoon townsite • A total project footprint of 15 ha (7 ha native vegetation and 8 ha of agricultural land) • 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> • Consultation with the DPaw (now DBCA) 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 • Dieback assessment conducted in 2004 identified the majority of the project area to be dieback infected or at high risk of being infected • No TECs recorded

Author, Area, Scope and Methodologies	Key Findings
Goble-Garratt (2005)	
<ul style="list-style-type: none"> Hart Drive to Bindoon Townsite SLK 54.6 to 62.0 General flora survey in November 2004. Follow-up survey during September 2005 targeting Priority flora 	<ul style="list-style-type: none"> Project area considered to be a floristically rich area 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 Two P3 flora species recorded (<i>Acacia drummondii</i> subsp. <i>affinis</i> and <i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>) Seven vegetation units determined, none are considered to be comparable to TECs
KBR (2005)	
<ul style="list-style-type: none"> Great Northern Highway – Muchea (SLK 36) to Wubin (SLK 253), 217 km in length 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 	<ul style="list-style-type: none"> Numerous Threatened and Priority Flora identified through DBCA database searches. Two Threatened flora, <i>Banksia serratuloides</i> subsp. <i>serratuloides</i> (Vulnerable) and <i>Stylidium semaphorum</i> (Critically Endangered) identified within road reserve 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 One State-listed TEC (Coomberdale Chert) identified to occur near existing Great Northern Highway Three A Class Nature Reserves and numerous C Class Reserves identified

Author, Area, Scope and Methodologies	Key Findings
Ecologia Environment (2004)	
<ul style="list-style-type: none"> • Great Northern Highway – Muchea (SLK 36) to Wubin (SLK 253) 217 km in length • Numerous vegetation surveys previously conducted however considered outdated; therefore, desktop flora assessment was undertaken as part of PEIA and included DBCA Threatened and Priority Flora and TEC database searches 	<ul style="list-style-type: none"> • Literature review of Ninnox Wildlife Consulting (1989) identified 300 flora taxa from 22 quadrats between SLK 37 and 149. • A total of 50 vegetation assemblages described. • DBCA database searches identified 28 species of Threatened and Priority flora 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 survey conducted by Sinclair Knight Mertz (2003) did not identify the presence of any conservation significant flora • DBCA database search identified the Coomberdale Chert State-listed 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 • Five additional WA TECs were identified outside the 500 m corridor. These were: <ul style="list-style-type: none"> ○ <i>Corymbia calophylla-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 (DBCA) NatureMap, DPaw (2016) database searches and a review of all literature reviewed as part of the desktop assessment. The review identified the presence or potential presence of 103 Threatened or Priority flora within the study area. This included 36 species protected under the EPBC Act, 38 WA Threatened flora (including the 36 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**.

The likelihood of conservation significant flora occurring within the study area was assessed based on known records, proximity to the study area and the presence of suitable habitat. Based on this, 10 species were recorded (five during spring 2017), six species were considered 'likely' to occur, with 32 classified as 'may occur' and the remaining 55 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 6**. 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 the **Figure 7** series.

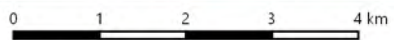
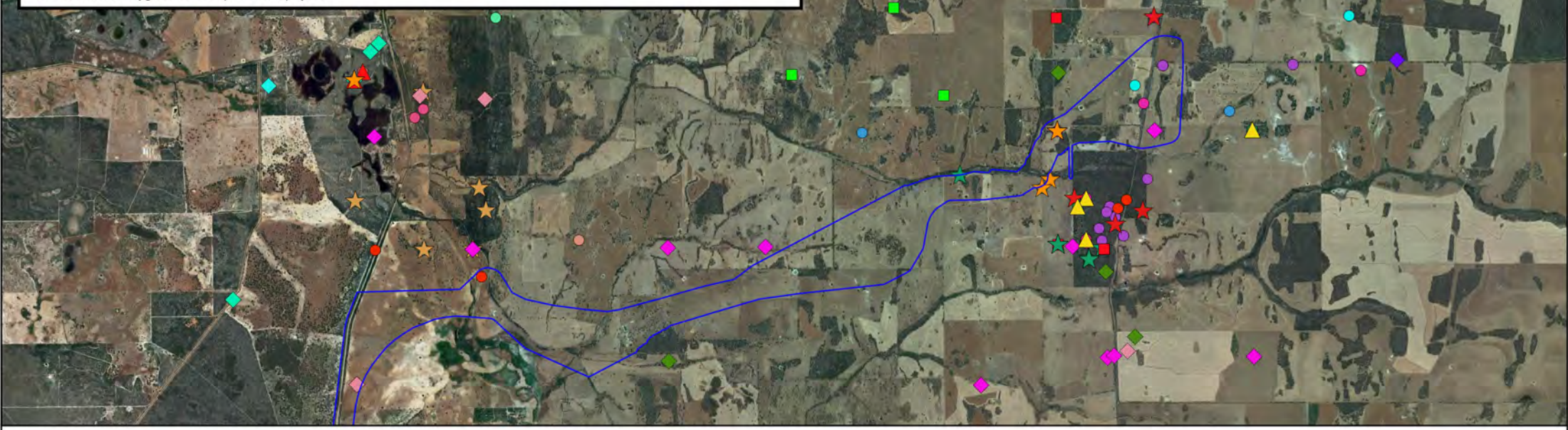
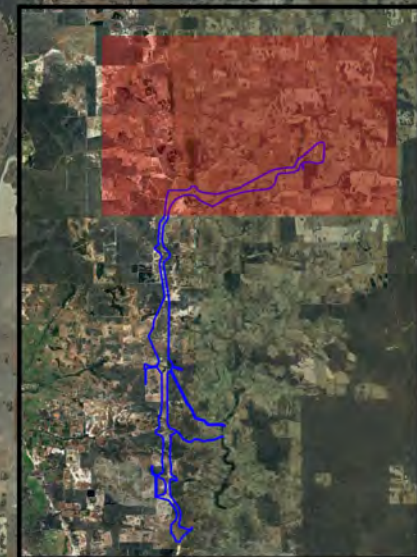
Table 6 Summary of Threatened and Priority Flora Occurring or Likely to Occur within the Study Area

Species	EPBC Act Cons. Status	WA Cons. Status	Description	Preferred Habitat	Likelihood of occurrence	Source
<i>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	Recorded during FVC (2017) study, recorded plant identified as possibly this species.	DPaW (2016)
<i>Hibbertia glomerata</i> subsp. <i>ginginensis</i>		Priority 1	Erect shrub, to 0.5 m high. Flowers yellow, July to September	In <i>Eucalyptus-Dryandra-Xanthorrhoea</i> woodland. Sand, brown clay, laterite. Near roadsides	Recorded during FVC spring 2017 study, previously recorded within 300 m of study area	DPaW (2016) NatureMap Phoenix (2015)
<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 FVC (2017) 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 FVC (2017) and FVC spring 2017 studies	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	Recorded during FVC (2017) and FVC spring 2017 studies	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 during FVC (2018a) study 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 FVC (2017) 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 FVC (2017) and FVC spring 2017 studies	DPaW (2016) NatureMap Ecologia (2005)
<i>Hypolaena robusta</i>		Priority 4	Dioecious rhizomatous, perennial, herb, ca 0.5 m high. Flowers September to October	White sand. Sandplains	Recorded during FVC spring 2017 study	Phoenix (2015)
<i>Jacksonia sericea</i>		Priority 4	Low spreading shrub, to 0.6m high. Flowers orange ususally December or January to February	Calcareous and sandy soil	Recorded during FVC spring 2017 study	DBCA (2018a)
<i>Verticordia lindleyi</i> subsp. <i>lindleyi</i>		Priority 4	Erect shrub, 0.2-0.75 m high. Flowers pink, May or November to December or January	Sand, sandy clay. Winter-wet depressions. Banksia and Melaleuca winter wetland	Likely to occur, recorded by Phoenix (2015), study area supports suitable habitat	Phoenix (2015) Western Botanical (2006) KBR (2005) Ecologia (2004)
<i>Verticordia paludosa</i>		Priority 4	Erect shrub, 0.3-0.9 m high. Flowers pink-white, January to May	White/grey sand. Winter-wet flats	Recorded during FVC (2018a) study, study area supports suitable habitat	DPaW (2016)

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 ixioides* subsp. *candida*
- *Gastrolobium nudum*
- *Acacia anarthros*
- *Acacia drummondii* subsp. *affinis*
- *Acacia oncinophylla* subsp. *oncinophylla*
- *Acacia pulchella* var. *reflexa acuminata bracteole variant* (R.J. Cumming 882)
- *Adenanthos cygnorum* subsp. *chamaephyton*
- *Allocasuarina ramosissima*
- *Dielsiodoxa leucantha* subsp. *leucantha*
- *Guichenotia tuberculata*
- *Halgania corymbosa*
- ◆ *Anigozanthos humilis* subsp. *chrysanthus*
- ◆ *Boronia tenuis*
- ◆ *Calothamnus pachystachyus*
- ◆ *Grevillea drummondii*
- ◆ *Hibbertia miniata*
- ◆ *Oxymyrrhine coronata*
- ◆ *Persoonia sulcata*
- *Stylidium cymiferum*
- *Stylidium glabrifolium*
- *Stylidium sacculatum*
- ◆ *Synaphea grandis*
- *Tetratheca pilifera*
- ◆ *Verticordia lindleyi* subsp. *lindleyi*
- ◆ *Grevillea florida*
- ☆ Threatened
- △ P1
- P2
- P3
- ◇ P4



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Figure 7a - Previously Recorded Threatened and Priority Flora



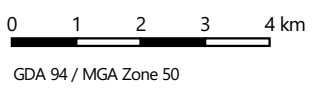
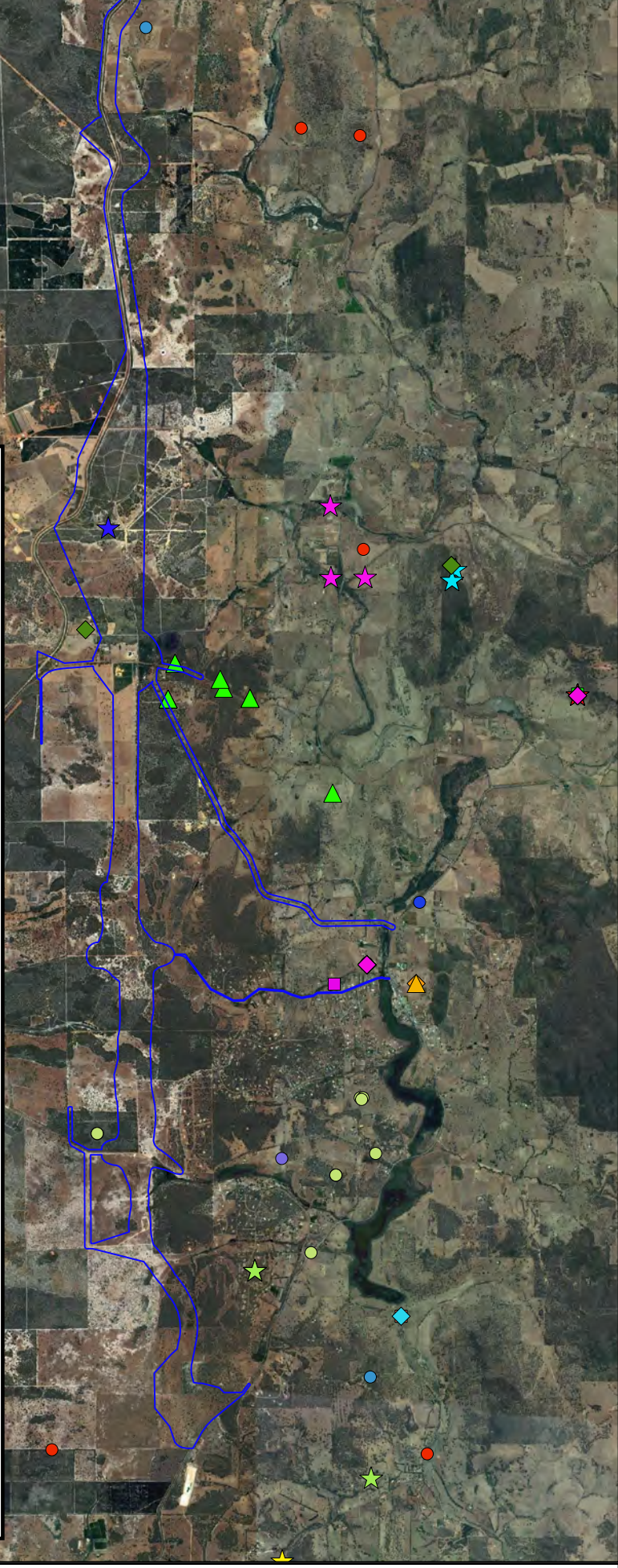
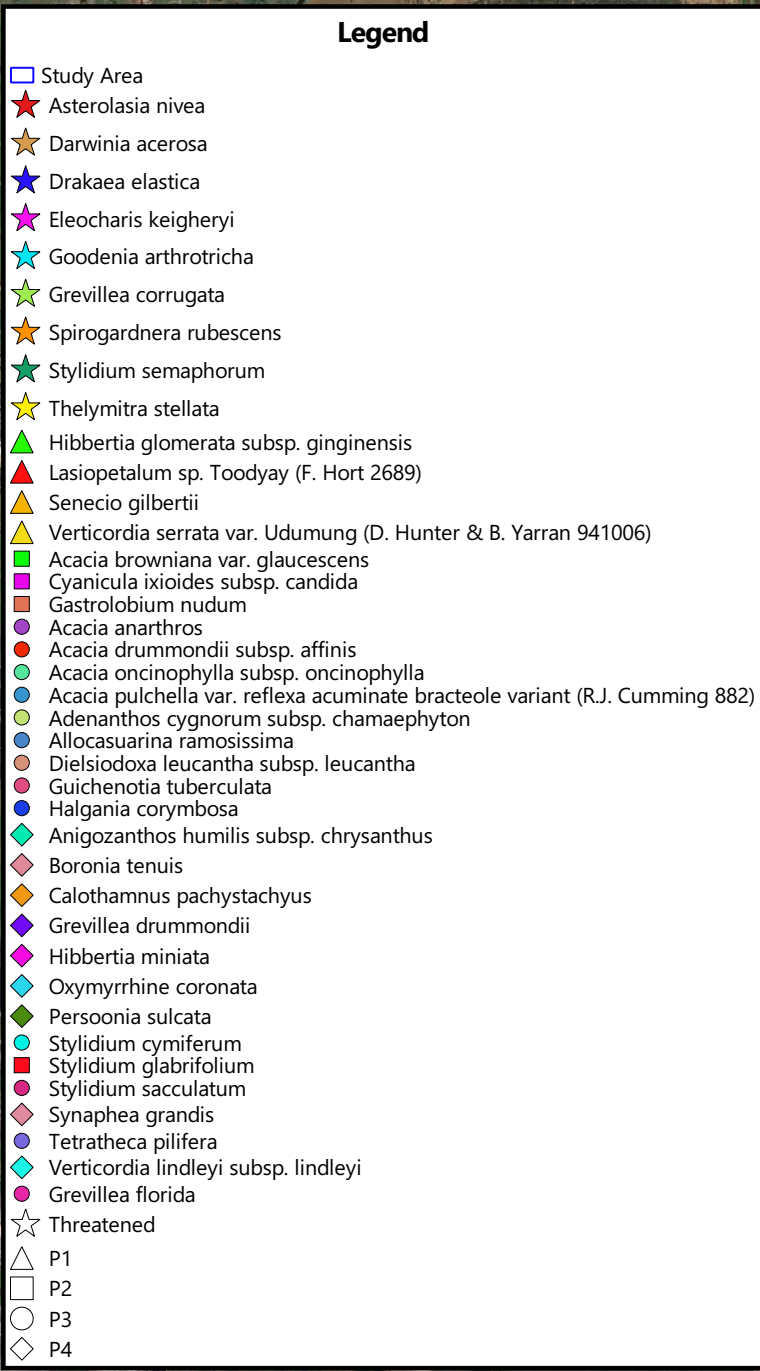
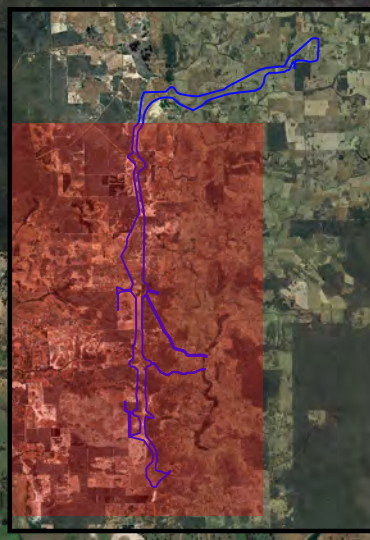


Figure 7b - Previously Recorded Threatened and Priority Flora

4.2 THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

The DBCA 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 (during 2016, in preparation for the initial spring surveys), DBCA'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. State listed TEC and PEC lists were updated on 6 October 2016 and 30 June 2017, respectively and both lists confirm equivalence of the three aforementioned State-listed ecological communities to the Commonwealth-listed TEC, *Banksia Woodlands of the Swan Coastal Plain Ecological Community*.

The known extent of these ecological communities in accordance with results of the DPaW (2016) 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 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 north-west extent 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, intersects the study area north of Mooliabeenee Road and along Teatree Road.

4.2.1 Banksia Woodland of the Swan Coastal Plain TEC

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 2007). Vegetation communities in Western Australia may be considered threatened once they have been identified as such by the Western Australian Threatened Ecological Communities Scientific Advisory Committee.

With regards to Commonwealth significance, some TECs of State (WA) significance are listed under the EPBC Act. Under the EPBC Act, a person must not take an action that has or will have significant impact on a listed TEC without approval from the Commonwealth Minister for the Environment, unless those actions are not prohibited under the Act.

The Banksia Woodland TEC was approved for inclusion as an Endangered TEC under the EPBC Act on 16 September 2016. This ecological community is woodland associated with some soils of the Swan Coastal Plain with a prominent tree layer of Banksia with scattered Eucalypts and other tree species

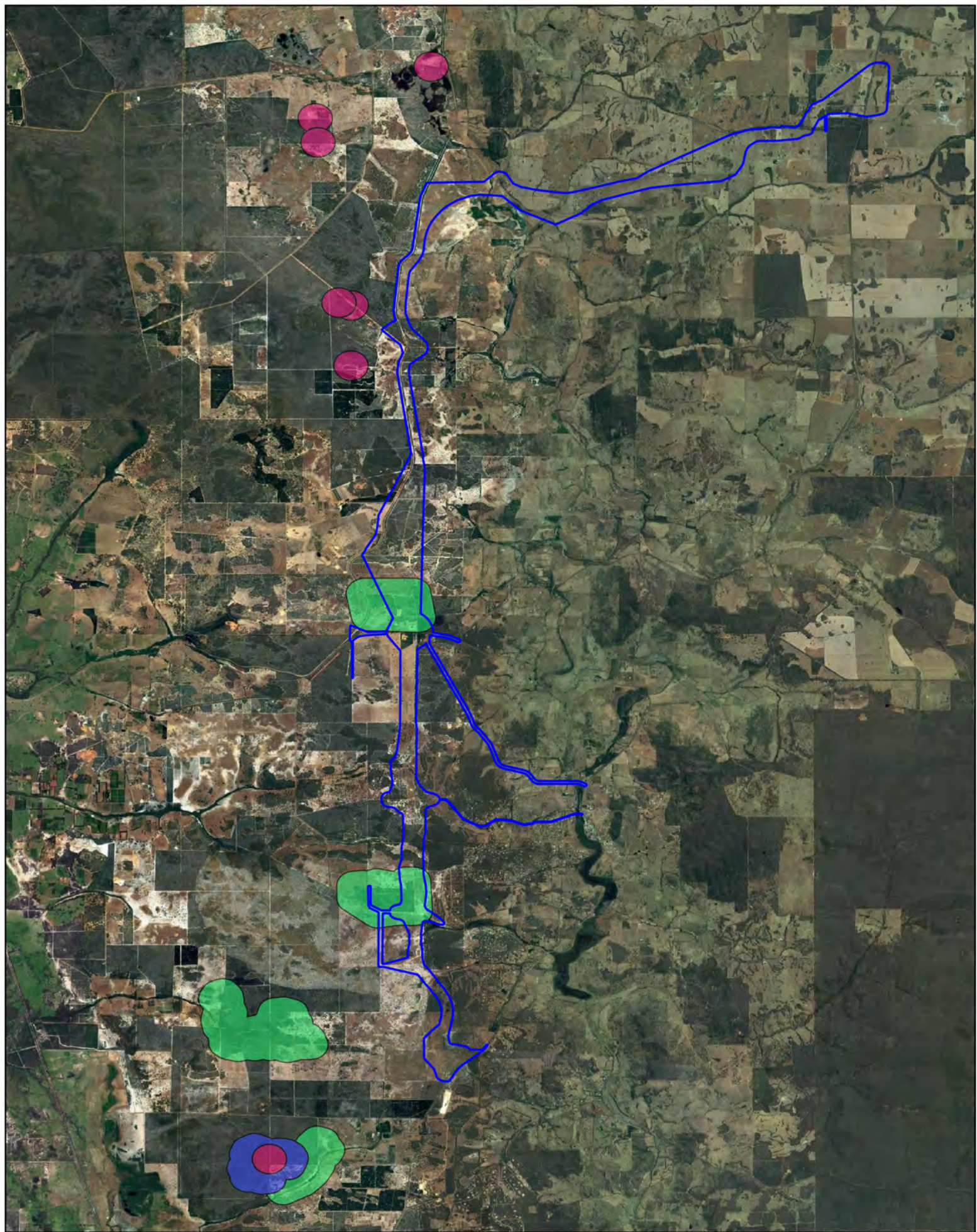
among or emerging above the canopy. The understorey is comprised of a species rich mix of sclerophyllous shrubs, graminoids and forbs (Threatened Species Scientific Committee 2016).

The Banksia Woodland TEC is largely restricted to the Swan Coastal Plain IBRA bioregion, within the Perth (SWA02) and the Dandaragan (SWA01) sub-regions. It extends into the adjacent Jarrah Forrest IBRA region (JA01 and JA02 sub-regions) and areas of the Whicher Darling escarpments where pockets of Banksia woodland may occur. This TEC mainly occurs on deep Bassendean and Spearwood sand 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), in Bush Forever (Government of Western Australia 2000), Keighery *et al.* (2008) and Urban Bushland Council (2011) best correspond to the Banksia Woodland TEC (Threatened Species Scientific Committee 2016) and these are summarised in **Table 7**.

Table 7 Floristic Community Types corresponding to the Banksia Woodland TEC

FCT	FCT Name	WA TEC/PEC	EPBC TEC
Supergroup 3 – Uplands centred on Bassendean Dunes and Dandaragan Plateau			
20a	<i>Banksia attenuata</i> woodlands over species rich dense shrublands	Endangered	
20b	Eastern <i>Banksia attenuata</i> and/or <i>Eucalyptus marginata</i> woodlands	Endangered	
20c	Eastern shrublands and woodlands	Critically Endangered	Endangered
21a	Central <i>Banksia attenuata</i> - <i>Eucalyptus marginata</i> woodlands		
21b	Southern <i>Banksia attenuata</i> woodlands	P3	
21c	Low lying <i>Banksia attenuata</i> woodlands or shrublands	P3	
22	<i>Banksia ilicifolia</i> woodlands	P2	
23a	Central <i>Banksia attenuata</i> - <i>Banksia menziesii</i> woodlands		
23b	Northern <i>Banksia attenuata</i> - <i>Banksia menziesii</i> woodlands	P3	
23c	North-eastern <i>Banksia attenuata</i> - <i>Banksia menziesii</i> woodlands		
S09	<i>Banksia attenuata</i> woodlands over dense low shrublands		
Supergroup 4 – Uplands centred on Spearwood and Quindalup Dunes			
24	Northern Spearwood shrublands and woodlands	P3	
25	Southern <i>Eucalyptus gomphocephala</i> – <i>Agonis flexuosa</i> woodlands	P3	
28	Spearwood <i>Banksia attenuata</i> or <i>Banksia attenuata</i> – <i>Eucalyptus</i> woodlands		
Whicher Scarp FCTs (Keighery <i>et al.</i> 2008)			
A1	Central Whicher Scarp Mountain Marri Woodland WHSFCT_A1	P1	
A2	North Whicher Scarp Jarrah and Woody Pear woodland WHSFCT_A2		
A3	North Whicher Scarp <i>Banksia</i> and Woody Pear woodland WHSFCT_A3		
A4	Whicher Scarp <i>Banksia grandis</i> , Jarrah and Marri woodland WHSFCT_A4		
B1	Swan Coastal Plain /North Whicher Scarp <i>Banksia attenuata</i> woodland WHSFCT_B1		
B2	West Whicher Scarp <i>Banksia attenuata</i> woodland WHSFCT_B2		
C2	Whicher Scarp Jarrah woodland on deep coloured sands WHSFCT_C2		



0 1 2 3 4 km

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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 2017 detailed flora and vegetation assessment of the Bindoon Bypass study area was carried out in accordance with the following:

- EPA (2016) Technical Guidance – 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*.
- Threatened Species Scientific Committee (2016) Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain Ecological Community.

Due to the presence of Banksia woodland within the study area, a targeted assessment to determine the status of the study area as representative of the Banksia Woodland TEC, in accordance with the TECs Conservation Advice (Threatened Species Scientific Committee 2016) was also carried out. Furthermore, targeted surveys for any flora species of conservation significance, with the potential to occur within the study area were also conducted, in accordance with general approaches described in Commonwealth of Australia (2013b).

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 for the study area and surrounds were initially requested from DPaW (now DBCA) on 30 September 2016 and have been used as the basis for the review in this report. 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-west -14.788854, 113.765525
- south-west -35.005719, 113.765525
- north-east -14.788854, 128.870214
- south-east -35.005719, 128.870214.

The collective information from the desktop assessment and literature review formed the foundation of the field survey and 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 (DEE) MNES search tool
- DPaW (DBCA) NatureMap search
- Threatened and Priority taxa listed under the WC Act and listed by DBCA
- TECs PECs listed by DBCA
- Declared Pests listed under the BAM Act.

The results of the desktop assessment are presented in **Section 6** of this report.

5.2 FIELD ASSESSMENT

The second phase of the detailed (formerly referred to as Level 2) flora and vegetation field assessments were carried out by Principal Ecologist, Kellie Bauer-Simpson, Senior Botanists Gabriela Martinez, Lisa Chappell and Catherine Krens and field technician William Bauer-Simpson between April and November 2017, with a total survey effort of 87-person days. The surveys were undertaken to supplement results of the spring 2016 study (FVC 2017) and to fill any gaps in survey data (i.e. vegetation units that required additional quadrats to be sampled in order to meet EPA Guidance requirements for survey adequacy). Additional quadrats were sampled, a selection of existing quadrats were re-sampled, further targeted significant flora surveys were undertaken and other verifications, revisions and supplementary observations were made to update and confirm spatial mapping of vegetation units and condition, as well as other floristic values throughout the study area.

A collective total of 117 quadrats (inclusive of two releves) have been sampled in the study area since October 2016. During the 2017 field assessments, vegetation data was collected from a total of 89 pegged 10 m x 10 m quadrats, comprising 68 new and 21 resampled quadrats (**Figure 9** series, **Table 8**). Of the quadrats sampled, 40 quadrats are located in the wider region, outside of the Bindoon Bypass corridor and contribute to the definition of regional context.

Table 8 Summary of Sampled Quadrats

Quadrat Location	Timing				
	Spring 2016	Resampled Autumn/Winter 2017	Newly Established Autumn/Winter 2017	Resampled Spring 2017	Newly Established Spring 2017
Within the Bindoon Bypass corridor	38	17	13	4	24
Regional (outside of the Bindoon Bypass corridor)	9	0	0	0	31
TOTAL	47	17	13	4	55
GRAND TOTAL					117

Field data from quadrats and opportunistic observations was collected using electronic tablets equipped with the mobile mapping software, Mappt™. This methodology allowed in-field spatial mapping of boundaries for vegetation units 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.

Quadrats that had been previously established and re-scored were differentiated by a decimal point and a number two at the end (i.e. B02.2, numbered as the rescore of quadrat B02). New quadrats established for the first time during the second phase assessment were differentiated with a number 2 and a decimal

point prior to the new quadrat/site number (i.e. B2.01 as the first quadrat of the second phase assessment, and distinct from quadrat B01).

A single permanent peg was installed at the north-west corner of each quadrat and marked with the 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 and private properties.

Quadrats were established and sampled in areas of 'Good' or better condition vegetation, in accordance with the requirements of EPA (2016). 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 area, in order to produce maps for the extent of vegetation units and condition, as well as other relevant features.

The following information was collected from within each quadrat sampled:

- date
- botanist name
- quadrat or relevés 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 units, 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 (2016); an adaptation of the Keighery (1994) and Trudgen (1991) condition scales.

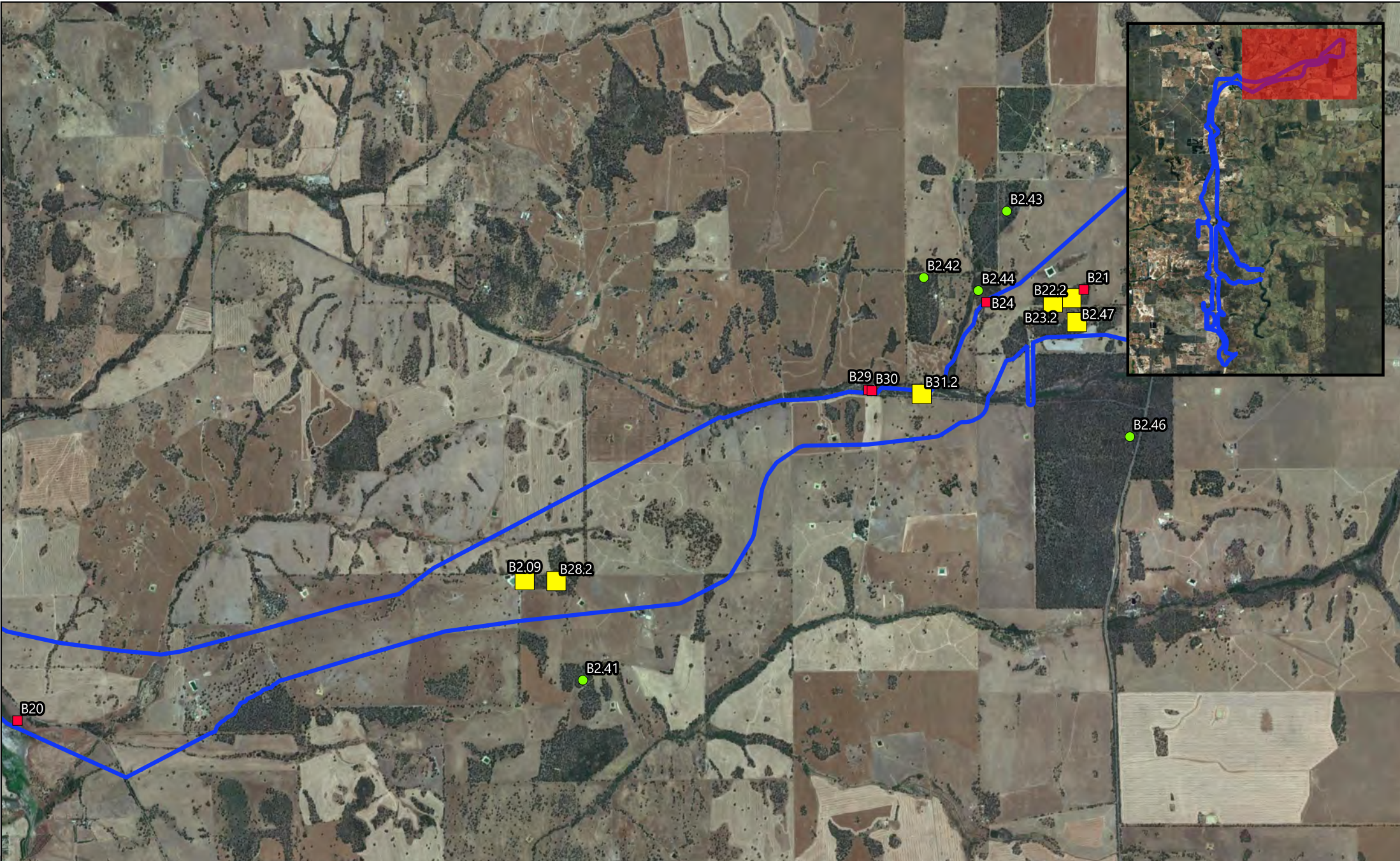
Description of the vegetation units to NVIS Level VI has enabled conclusions regarding the TEC and PEC status of each of the recorded vegetation types. Rationalisation of the vegetation units with the associations of Shepherd *et al.* (2002) enabled analysis of the remaining representation of pre-European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

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 an adaptation of

the Keighery (1994) and Trudgen (1991) condition scales (as per EPA 2016 and DBCA (2018b)) (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.



0 0.25 0.5 0.75 1 km

GDA 94 / MGA Zone 50

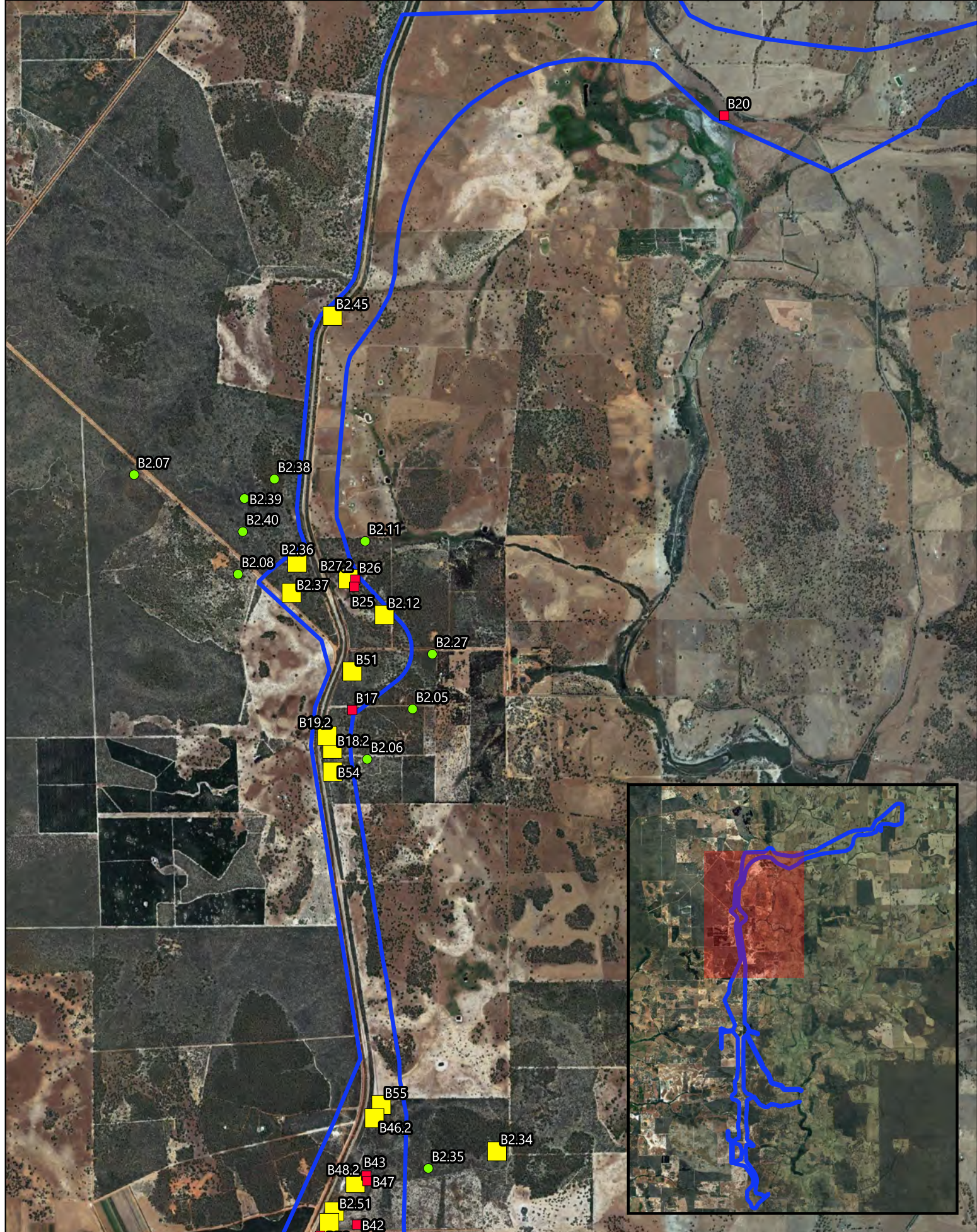
Figure 9a - Quadrat Locations



Legend

- Study Area
- 2017 Quadrats
- 2016 Quadrats
- Regional Quadrats





0 250 500 750 1000 m

GDA 94 / MGA Zone 50

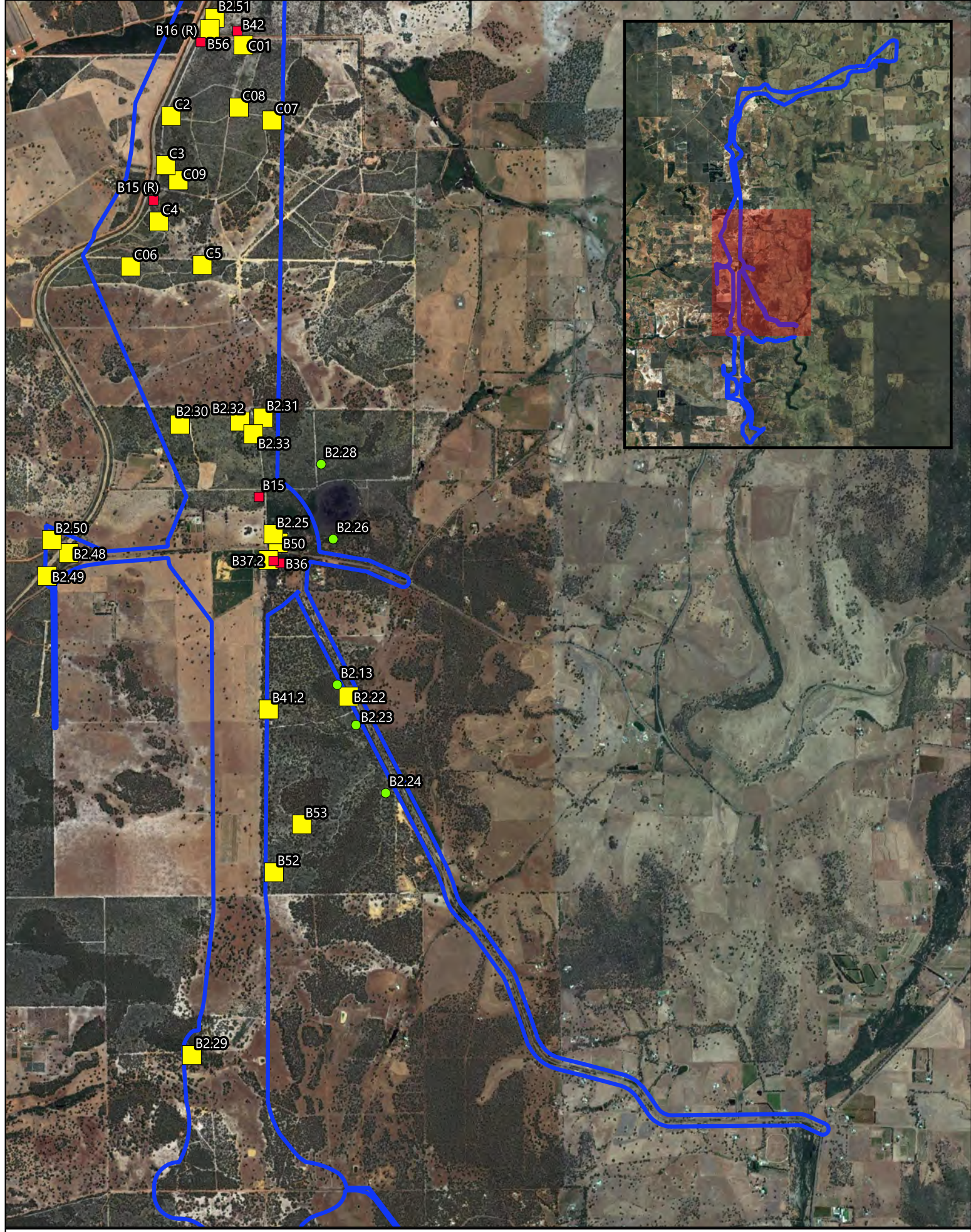
Figure 9b - Quadrat Locations



Legend

- Study Area
- 2017 Quadrats
- 2016 Quadrats
- Regional Quadrats





0 250 500 750 1000 m
 GDA 94 / MGA Zone 50

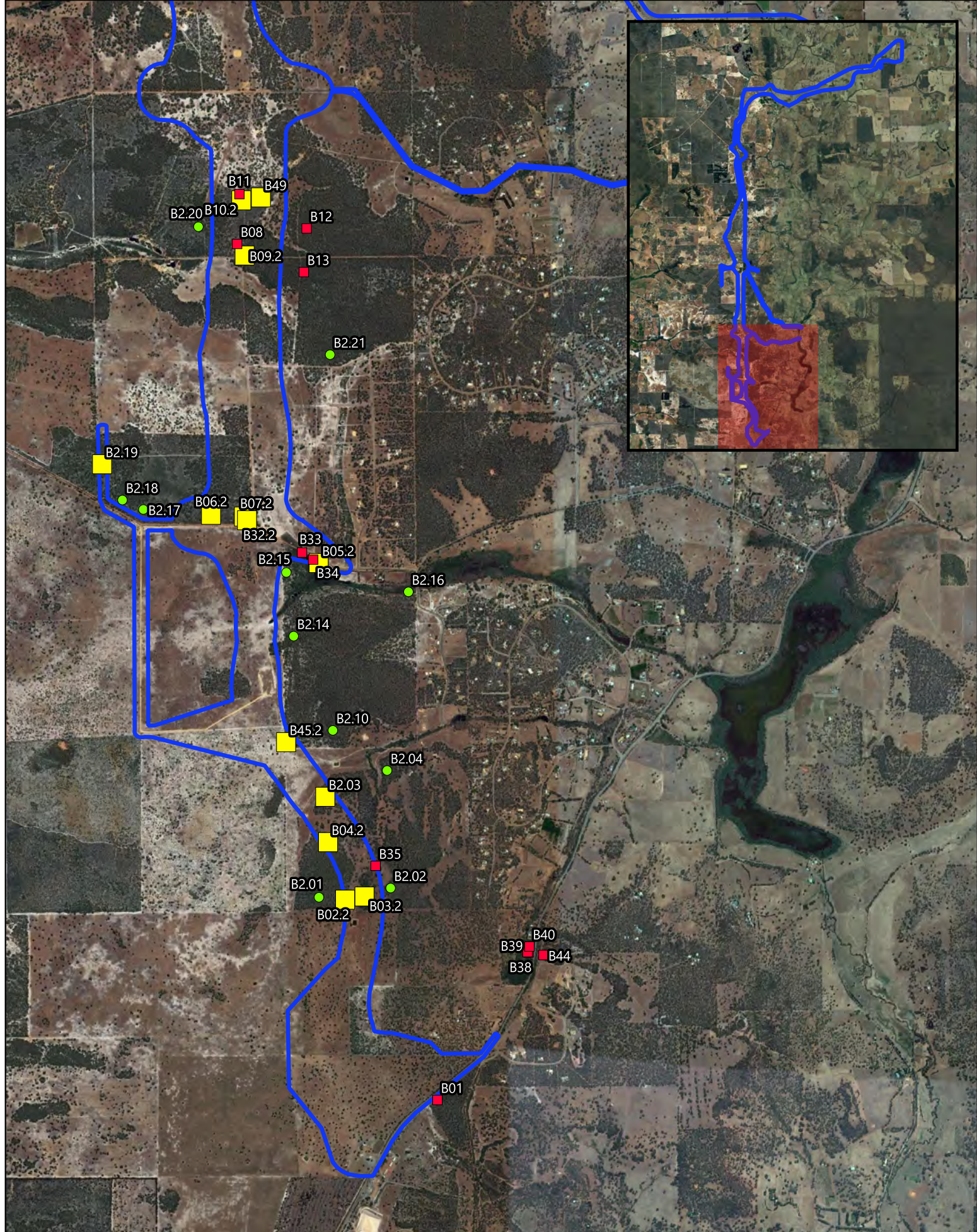
Figure 9c - Quadrat Locations



Legend

- Study Area
- 2017 Quadrats
- 2016 Quadrats
- Regional Quadrats





0 250 500 750 1000 m
 GDA 94 / MGA Zone 50

Figure 9d - Quadrat Locations



Legend

- Study Area
- 2017 Quadrats
- 2016 Quadrats
- Regional Quadrats



5.3 TARGETED THREATENED AND PRIORITY FLORA SURVEY

Targeted searches for relevant Threatened and Priority flora were conducted in suitable habitats, within pre-determined areas selected during the desktop assessment. A systematic method was utilised, via parallel meandering transects across the better condition areas of the study area, to target Threatened and Priority flora species. 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 surveys in selected sites. Given the level of detail of previously targeted searches conducted within the study area during spring 2016, a more detailed survey effort was employed in areas of vegetation associations that had previously recorded conservation significant flora.

A dedicated targeted *Thelymitra stellata* (Star Sun-orchid) survey was conducted between 1-2 November 2017 by Senior Botanists, Gabriela Martinez and Lisa Chappell and field technician, William Bauer-Simpson. A total survey effort of 6-person days was invested. Targeted searches for other species of conservation significance were carried out concurrently with the Level 2 flora assessments, across numerous dates during autumn, winter and spring 2017.

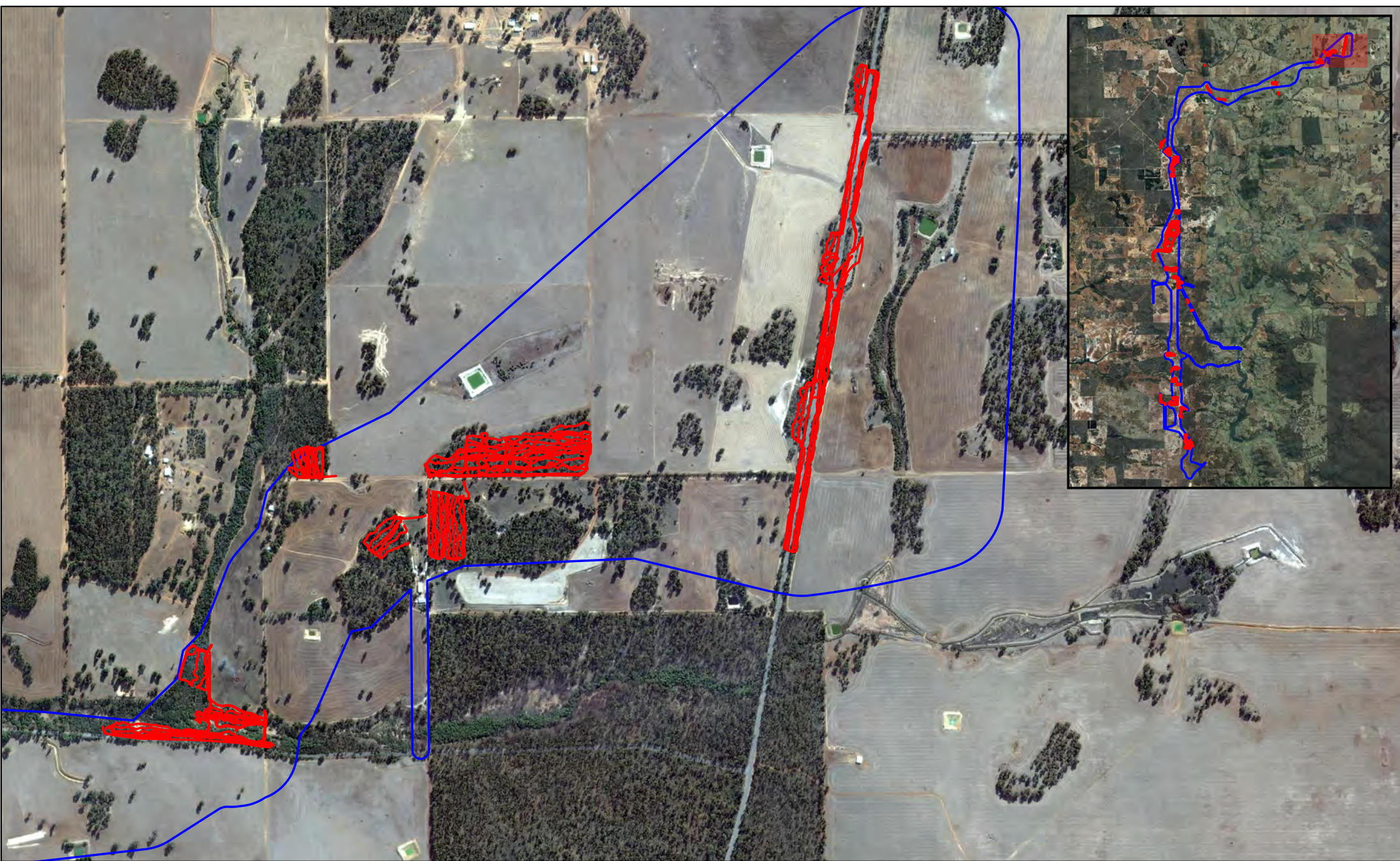
The targeted survey conducted during winter (3-6 July) 2017 focused on winter flowering or emergent species, including the Threatened orchid species, *Drakaea elastica*, which has a leaf which will best identify the species during winter, and the flower can then confirm the identification in spring.

Methodologies for the targeted survey of all species, and specifically for Threatened orchid species, *Thelymitra stellata* and *Drakaea elastica*, were conducted in accordance with the Department of the Environment's *Guidelines for Detecting Orchids Listed as 'Threatened'*.

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 Threatened and Priority flora searches are presented in the **Figure 10** series.

If Threatened and Priority flora plants 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.





0 0.25 0.5 0.75 1 km

GDA 94 / MGA Zone 50

Figure 10a - Walked Tracks for Threatened and Priority Flora



Legend

-  Study Area
-  Threatened and Priority Search Tracks





0 0.25 0.5 0.75 1 km

GDA 94 / MGA Zone 50

Figure 10b - Walked Tracks for Threatened and Priority Flora



Legend

- Study Area
- Threatened and Priority Search Tracks







0 0.25 0.5 0.75 1 km

GDA 94 / MGA Zone 50

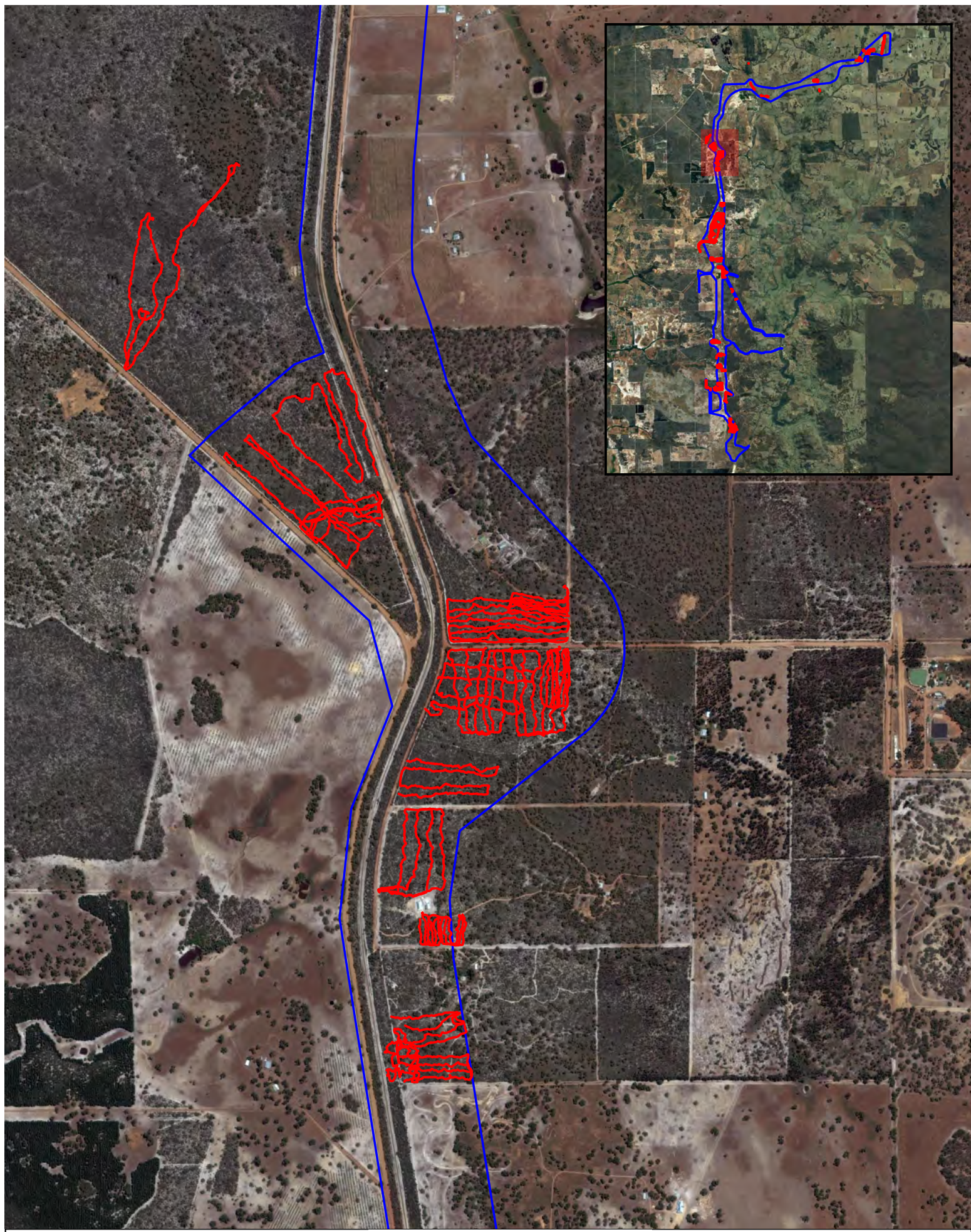
Figure 10c - Walked Tracks for Threatened and Priority Flora



Legend

-  Study Area
-  Threatened and Priority Search Tracks





0 0.15 0.3 0.45 0.6 km
 GDA 94 / MGA Zone 50

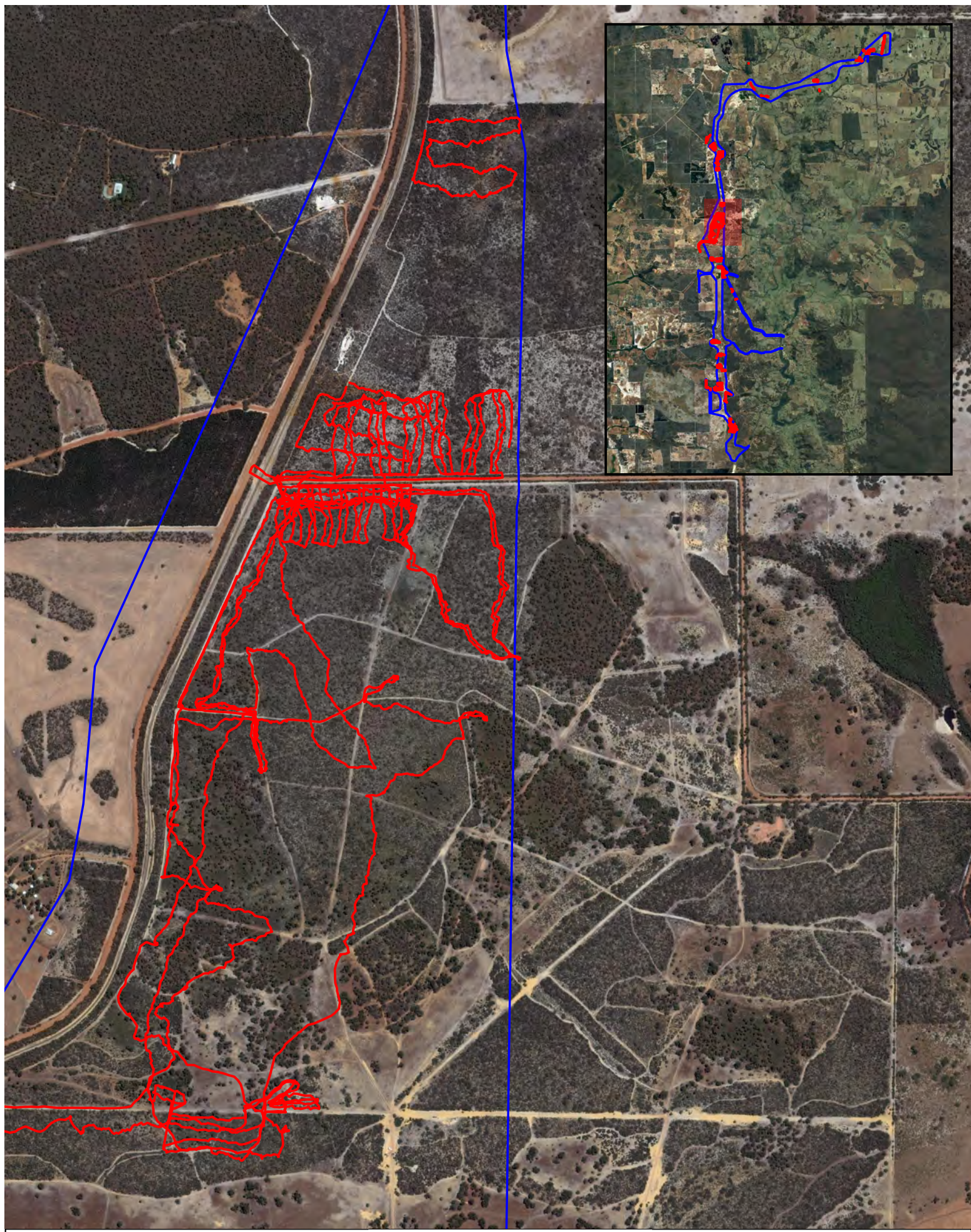


Legend

- Study Area
- Threatened and Priority Search Tracks



Figure 10d - Walked Tracks for Threatened and Priority Flora Survey



0 0.15 0.3 0.45 0.6 km
 GDA 94 / MGA Zone 50

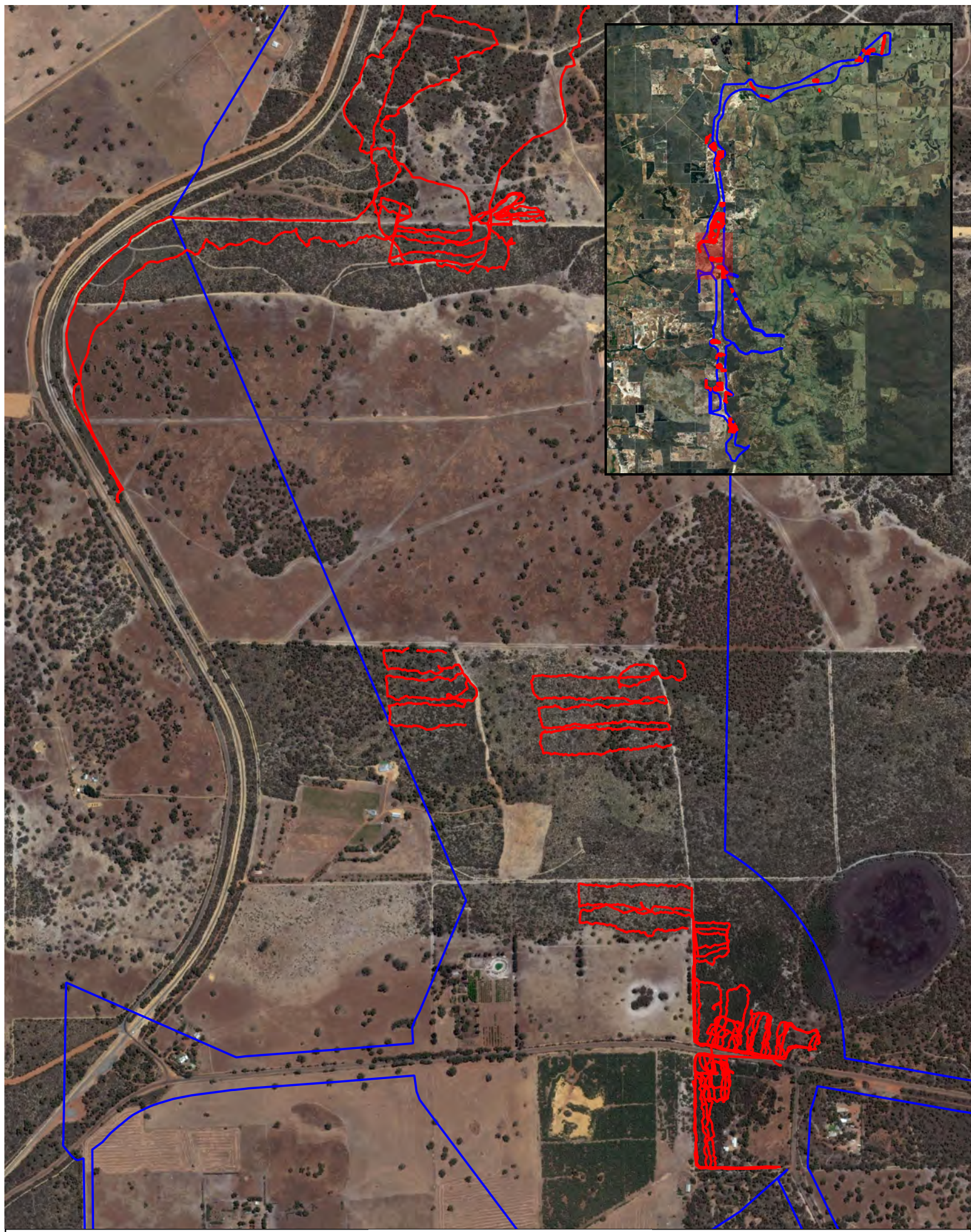


Legend

- Study Area
- Threatened and Priority Search Tracks



Figure 10e - Walked Tracks for Threatened and Priority Flora Survey



0 0.15 0.3 0.45 0.6 km
 GDA 94 / MGA Zone 50

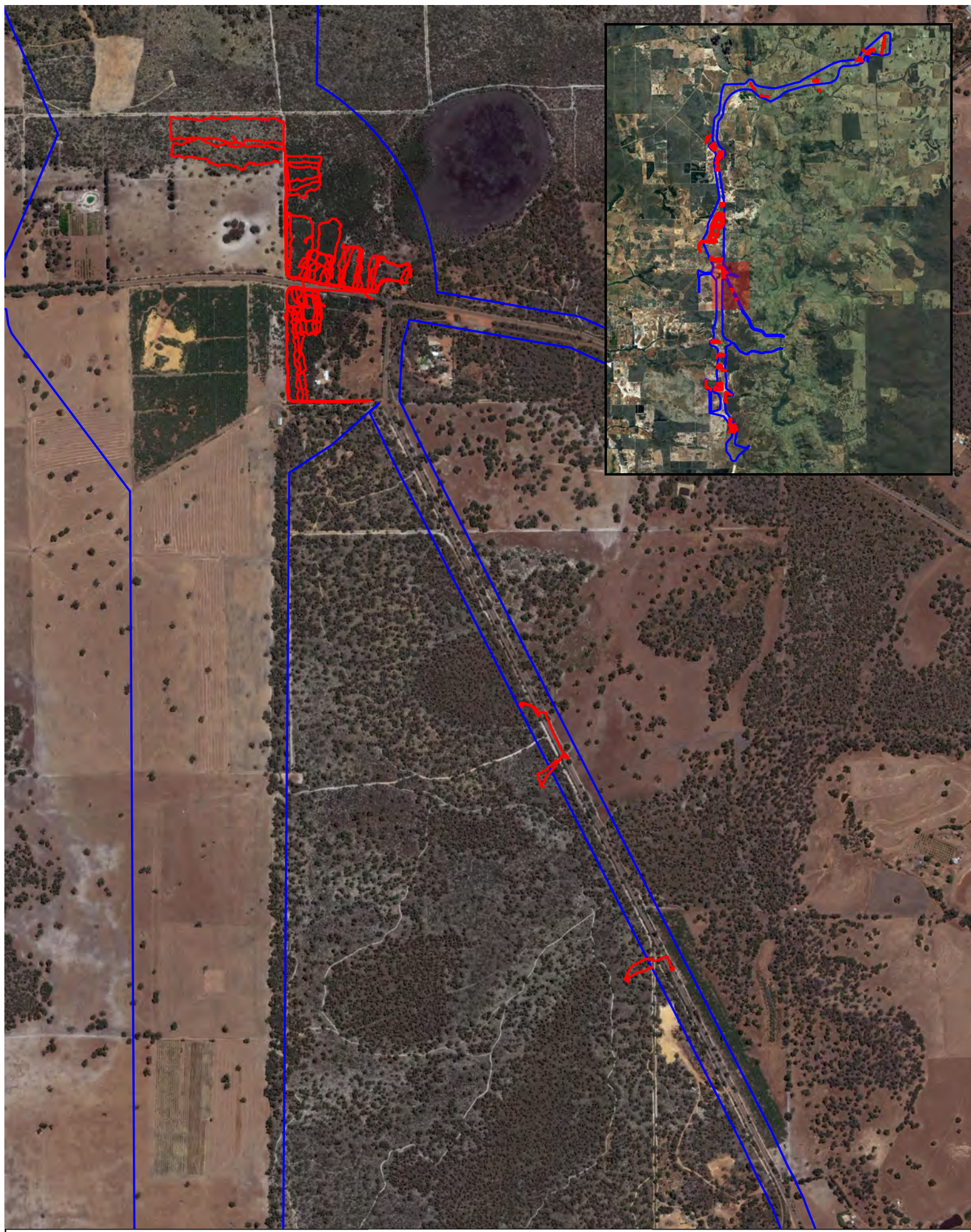


Legend

- Study Area
- Threatened and Priority Search Tracks



Figure 10f - Walked Tracks for Threatened and Priority Flora Survey



0 0.15 0.3 0.45 0.6 km
 GDA 94 / MGA Zone 50

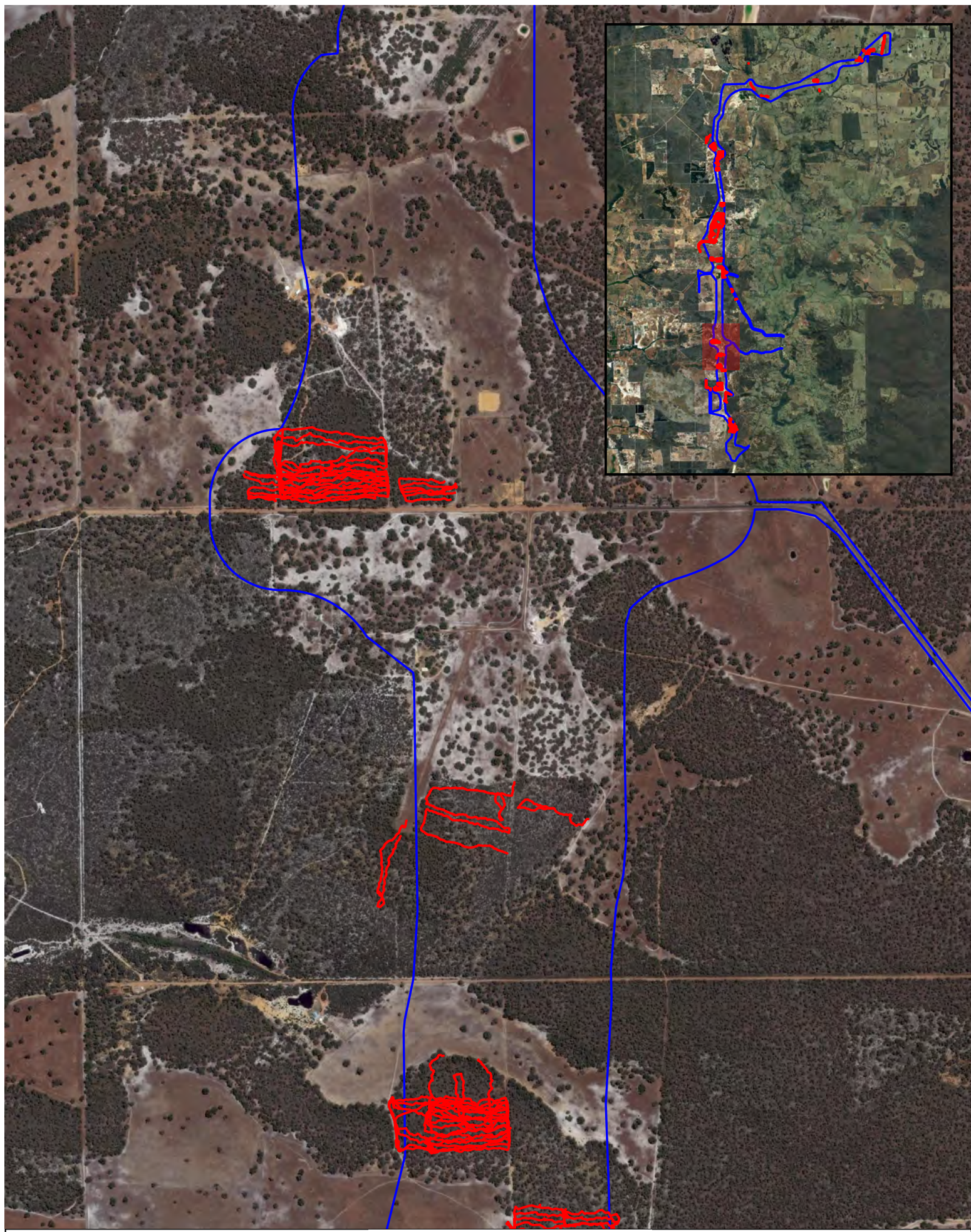


Legend

- Study Area
- Threatened and Priority Search Tracks



Figure 10g - Walked Tracks for Threatened and Priority Flora Survey



0 0.15 0.3 0.45 0.6 km
 GDA 94 / MGA Zone 50

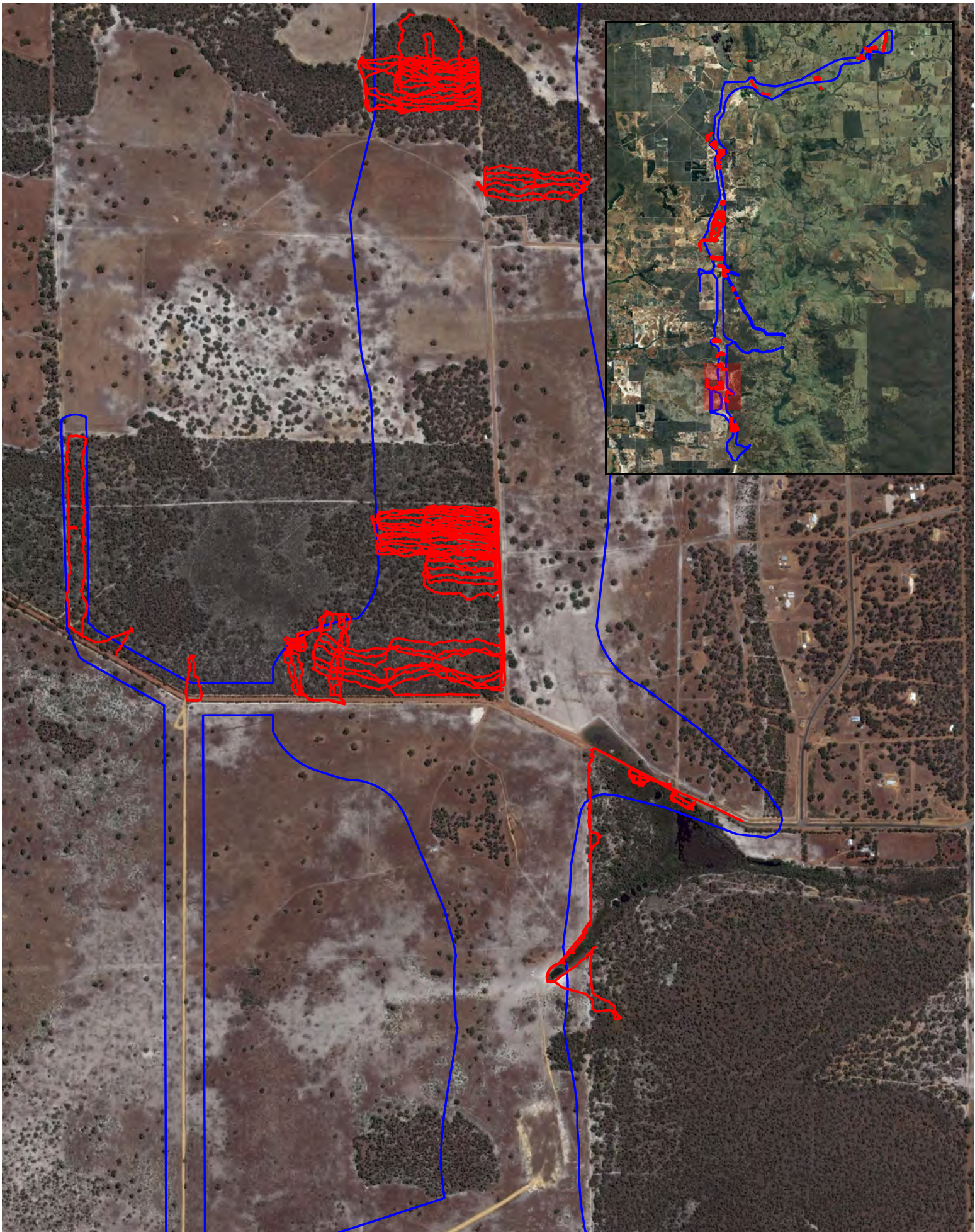


Legend

- Study Area
- Threatened and Priority Search Tracks



Figure 10h - Walked Tracks for Threatened and Priority Flora Survey



0 0.15 0.3 0.45 0.6 km

GDA 94 / MGA Zone 50

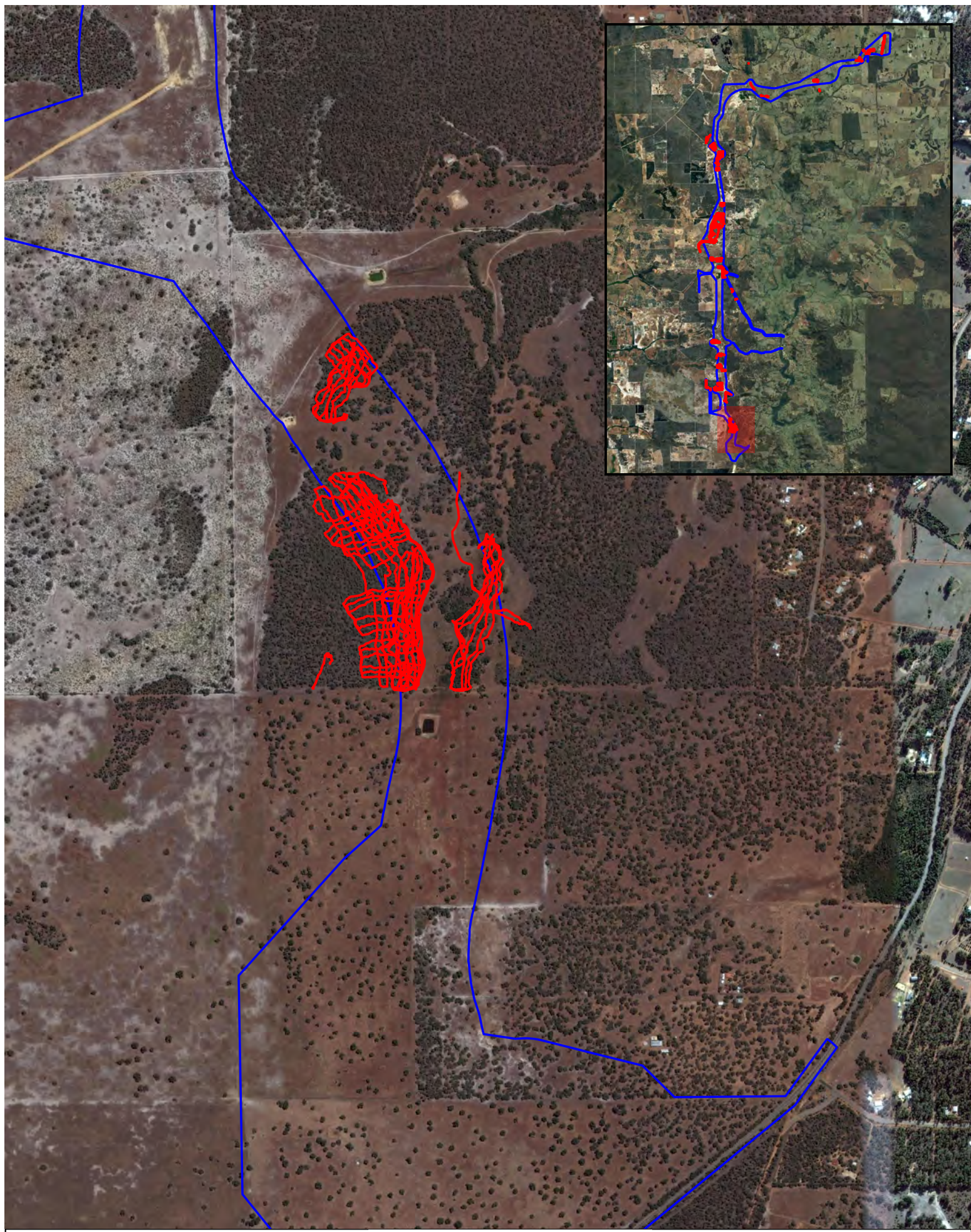


Legend

- Study Area
- Threatened and Priority Search Tracks



Figure 10i - Walked Tracks for Threatened and Priority Flora Survey



0 0.15 0.3 0.45 0.6 km
 GDA 94 / MGA Zone 50



Legend

- Study Area
- Threatened and Priority Search Tracks



Figure 10j - Walked Tracks for Threatened and Priority Flora Survey