



Main Roads Western Australia

Brand Highway, Western Australia - Various Sections: SLK
74 to 150

Biological Survey

April 2016

Executive Summary

Main Roads Western Australia (Main Roads) proposes to upgrade various sections of the Brand Highway, Western Australia between SLK 74 to 150 (the Project Area). The Project Area is located within the Shire of Dandaragan and includes five sections along the Brand Highway including Study Area 1 (SLK 77.54 to 79.7), Study Area 2 (SLK 120 to 125.13), Study Area 3 (SLK 130.1 to 136), Study Area 4 (SLK 139 to 146.9) and Study Area 5 (SLK 148.8 to 152).

The proposed works aim to widen the seal lanes to 3.5 metres and widen sealed and unsealed shoulders to one metre on either side of the existing Brand Highway. To facilitate these works Main Roads requires clearing of some road-side vegetation.

Main Roads commissioned GHD Pty Ltd (GHD) to undertake a biological assessment to identify vegetation, flora and fauna constraints within the Project Area to assist in project design.

The desktop and field assessment determined:

- Environmentally Sensitive Areas (ESAs) were recorded within Study Areas 2, 3, 4 and 5. These are associated with the Badgingarra National Park which occurs immediately west of these Areas.
- Three conservation areas were identified within 20 km of the Study Areas. The Badgingarra National Park runs immediately adjacent to the western edge of the Brand Highway road reserve of Study Areas 4 and 5. An unnamed Conservation Park (Reserve 41986), south of Badgingarra National Park, runs adjacent to the western edge of the road reserve of Study Areas 2 and 3. The Namming Nature Reserve is located approximately 1.6 kms to the west of Study Area 1.
- There were eight vegetation types recorded in the Study Areas, most of which are well represented at a local government authority (LGA) level with greater than 30% remaining, with the exception of Vegetation Type 6 (Beard's Vegetation Association 1031 and 1035); and Vegetation Type 6 (Beard's Vegetation Association 1031). Vegetation Types 6 and 8 are underrepresented, with less than 30% remaining at an LGA level.
- One vegetation type, Vegetation Type 1, 'Banksia Woodland on White Sand' recorded in Study Area 1 was considered to align with the Priority Ecological Community (PEC) (Priority 3) "Banksia dominated woodlands of the Swan Coastal Plain Interim Biogeographic Regionalisation of Australia (IBRA) region". This vegetation type covers an extent of 7.5 ha of Study Area 1.
- A geomorphic wetland was recorded within Study Area 1. A buffer is recommended to protect vegetation associated with and dependant on the wetland.
- Four-hundred and forty flora taxa from 67 families were recorded from the Study Areas during the field surveys. This total comprised 375 (85 %) native taxa and 65 (15%) introduced taxa.

- The flora “Likelihood of Occurrence Assessment” concluded that two flora taxa listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Wildlife Conservation Act 1950* (WC Act) are considered “likely to occur” within the Study Areas. However, no EPBC Act- or WC Act-listed flora was recorded during the survey.
- The flora “Likelihood of Occurrence Assessment” also concluded that 46 Department of Parks and Wildlife (DPaW) listed Priority Flora are considered “likely to occur” or “possible to occur” within the Study Areas. The results of the field surveys indicated that 13 DPaW-listed Priority Flora were recorded from the Study Areas.
- Two conservation significant fauna were recorded from the Study Areas, including the Carnaby’s Black-Cockatoo (listed Endangered) and the Rainbow Bee-eater (listed as Migratory).
- There is approximately 202.7 hectares (ha) of suitable foraging habitat for Carnaby’s Black-Cockatoo within the Study Areas. This habitat comprises Marri-Banksia woodland, Banksia woodland, Low Banksia Woodland and Heath Shrubland, which provide high value foraging resources for the species, including Marri nuts and a diversity of proteaceous species. The habitat assessment identified four potential breeding trees with a suitable DBH throughout the Study Area 1; however, they did not contain any hollows. An approximate area of 3.3 ha of suitable roosting habitat occurs within Study Area 1 (Figure 6), however there was no evidence of roosting recorded during the survey.
- The Rainbow Bee-eater was recorded from Study Area 2, which is considered suitable non-breeding habitat for the Rainbow Bee-eater. The Rainbow Bee-eater’s habitat is broadly represented in the local region, with 385,099 ha of potential habitat with 20 km of the Study Areas.
- The “likelihood of occurrence” assessment of Conservation Significant fauna taxa indicated by database searches concluded that one fauna taxon listed under the EPBC and WC Acts that is “likely to occur” (i.e. the Carnaby’s Black-Cockatoo) and four other conservation significant fauna taxa that are “likely to occur” or “possible to occur”.
- An assessment was undertaken to determine whether the Project will have a significant impact upon Matters of National Environmental Significance (MNES) and it was determined that **referral is recommended** to the Australian Government for the following reasons:
 - Carnaby’s Black-Cockatoo foraging (and potential roosting) habitat was recorded within all of the Study Areas.
Important habitat covering an extent of 3.42 ha for the Endangered *Eucalyptus absita* (Badgingarra Box) was recorded within Study Area 5 and associated with the north-eastern portion of Vegetation Type 6..
 - Whilst it is unlikely that Study Area 1 offers important habitat to the Chuditch, due to the fragmentation of remnant vegetation and the entirety of the Study Area being surrounded by broad acre agriculture, it may form part of an ecological linkage between larger reserves (particularly the conservation reserves south and south-west of this Study Area).
- A preliminary assessment of the project against the Ten Clearing Principles has been undertaken and has determined that the Project is likely to be **at variance** with Principles (a), (b), (c) and (e). The Project **maybe at variance** with Principles (d) and (h) due to uncertainty with regard to the clearing extent. The Project is **not likely to be at variance** with Principles (f) and (i) if Main Roads develop a buffer zone for the geomorphic wetland to avoid clearing such vegetation in Study Area 1. GHD also recommends Main Roads avoid clearing of vegetation within and along the ephemeral drainage line in Study Area

3. The Project is **not likely to be at variance** with Principles (j). GHD makes several key recommendations to Main Roads that should be incorporated into the design and impact area refinement for the project, including:

- develop an appropriate buffer for the geomorphic wetland in Study Area 1 prior to finalising the clearing extent;
- avoid the PEC identified within Study Area 1;
- minimise clearing of native vegetation adjacent to the existing road alignment to reduce to the likelihood of undertaking works in areas that would be prone to water and wind erosion;
- avoid the clearing of vegetation within or along the two ephemeral drainages lines within Study Area 3;
- implement relevant weed management plans to prevent the spread of introduced flora within the Study Areas, which are relatively weed-free in intact vegetation; and
- implement water/erosion management to minimise alteration to hydrology and the erosion of susceptible landscapes.

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

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1. Introduction

1.1 Background

The Brand Highway is a major arterial road connecting Perth and Geraldton, Western Australia. Main Roads Western Australia (Main Roads) proposed to upgrade various sections of the road between straight line kilometre (SLK) 74 to 150. The upgrade includes seal shoulder widening and installing audible edgelines. The proposed works aim to widen the seal lanes to 3.5 metres (m), widen sealed and unsealed shoulders to one metre on either side of the Brand Highway. To facilitate these works Main Roads requires clearing of some road side vegetation.

1.2 Purpose of this Report

Main Roads commissioned GHD Pty Ltd (GHD) to undertake a biological assessment for the Project. The purpose was to identify vegetation, flora and fauna constraints within the Project Area to assist in project design and the environmental assessment and approvals process.

This report presents the findings of the desktop and field survey. The report concludes with recommendations to assist with minimising, managing and/or mitigating potential biological constraints associated with the Project.

1.3 Scope of Work

The scope of works included:

- Complete a desktop assessment of the Project Area with a 20km buffer prior to the field survey to identify all biological constraints, which may be in, or nearby the Project Area;
- Identify and review any existing and relevant environmental reports;
- Identify significant flora, fauna, soil, groundwater and surface water values and potential sensitivity to impact;
- Identify broad vegetation type(s) using Beard (various) or Heddlé (1980);
- Conduct a field survey (to be done by an environmental specialist) to verify / ground truth the desktop assessment findings;
- Undertake vegetation condition mapping using Keighery (1994) and ecological community mapping;
- Undertake relevant environmental constraints mapping using (Geographic Information Systems) GIS mapping software (eg. ArcMap);
- Assess the Project Area plant species diversity, density, composition, structure and weed cover, recording the percentage of each in nominated quadrats
- Assess all biological aspects likely to require referral of the project to the Environmental Protection Authority (EPA);
- Assess Matters of National Environmental Significance (MNES) and indicate whether potential impacts on MNES as protected under the EPBC Act are likely to require referral of the project to the Australian Government Department of the Environment (DotE). Provide justification of decision as to whether referral to DotE is likely to be required. Ensure to reference relevant Australian Government significant impact guidelines;
- Determine the legislative context of environmental aspects required for the assessment; and

- Provide a concise report on the findings of the biological survey.

1.4 Project Definitions

1.4.1 Project Area

The Project Area is located within the Shire of Dandaragan. The Project Area includes five sections of road along the Brand Highway. For the purpose of this report the Project Area was divided into five Study Areas as shown in Table 1. The total survey area was 459 hectares (ha) as defined by shapefiles provided by Main Roads.

Table 1 Study Areas

Study Area	Description
Study Area 1	SLK 77.54 to 79.7
Study Area 2	SLK 120 to 125.13
Study Area 3	SLK 130.1 to 136
Study Area 4	SLK 139 to 146.9
Study Area 5	SLK 148.8 to 152

1.5 Relevant Legislative Requirements

Key Australian Government and Western Australian State environmental legislation that may be relevant to the Project is outlined in Table 2. This Biological Assessment identifies (but does not apply for) additional clearances required under legislative requirements, including those required under the following Acts.

Table 2 Key Environmental Legislation Relevant to the Project

Legislation	Responsible Government Agency	Aspect
Commonwealth Legislation		
<i>Environment Protection and Biodiversity Conservation Act 1999</i> (EPBC Act)	DotE	MNES including threatened flora and fauna
State Legislation		
<i>Biosecurity and Agricultural Management Act 2007</i> (BAM Act)	Department of Agriculture and Food Western Australia (DAFWA)	Weeds and feral animals
<i>Wildlife Conservation Act 1950</i> (WC Act)	Department of Parks and Wildlife (DPaW)	Protection of Flora and Fauna
<i>Conservation and Land Management Act 1984</i> (CALM Act)	Department of Parks and Wildlife (DPaW)	Use, protection and management of public lands and waters and its flora and fauna
<i>Environmental Protection Act 1986</i> (EP Act)	Department of Environment Regulation (DER)	Environmental impact assessment and management
Environmental Protection (Clearing of Native Vegetation) Regulations	DER	Clearing of native vegetation

Legislation	Responsible Government Agency	Aspect
2004 (EP Regulation)		
<i>Land Administration Act 1997</i> (LA Act)	Department of Regional Development	Administration of State Land
<i>Rights in Water and Irrigation Act 1914</i> (RiWI Act)	Department of Water (DoW)	Access to and use of water resources; protection and management of river flows and drainage
<i>Soil and Land Conservation Act 1945</i> (SLC Act)	DAFWA	Protection of soil and prevention/management of soil erosion

1.6 Limitations

This report has been prepared by GHD for Main Roads (Western Australia) and may only be used and relied on by Main Roads for the purpose agreed between GHD and the as set out in Section 1.3 of this report.

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

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

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

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

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

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

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

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

1.7 Assumptions

It should be noted that the assessment is based upon the Project location shown in Figure 1 and Study Areas shown in Figure 3 and further assessment would be required should the Study Areas significantly change.

This report was based on desktop assessment and a field survey conducted in September and October 2015.

2. Methodology

2.1 Desktop Information Sources

A desktop assessment was undertaken prior to the commencement of the field investigation to identify the environmental aspects likely to be associated with the Study Areas at a local and regional scale.

Table 3 presents the information sources that were used to identify the existing environment within and surrounding the Study Areas and to assess potential ecological constraints. The background information and conservation codes that apply to these environmental aspects are included in Appendix A.

Table 3 Information Sources for Desktop Investigations

Aspect	Information Source
Climate	Climatic data available from the Bureau of Meteorology (BoM) (BoM, 2015).
Matters of National Environmental Significance	Search of the EPBC Act Protected Matters Search Tool (PMST) for MNES in the Study Areas (DotE, 2015a) with a 20 km buffer: <ul style="list-style-type: none"> • Study Area 1: PMST_DQ5AOQ; • Study Area 2: PMST_1Z635Z; • Study Area 3: PMST_V7ZSVQ; • Study Area 4: PMST_Q7Y8HY; • Study Area 5: PMST_8175M7.
Reserves	Reserves for conservation as shown in the Department of Parks and Wildlife Estate (DPaW) spatial dataset.
Environmentally Sensitive Areas	Identification of Environmentally Sensitive Areas utilising the DER (2015) Clearing Permit System.
Vegetation	Vegetation in the Study Areas as shown in: <ul style="list-style-type: none"> • Natural Resource Management (NRM) Shared Land Information Platform (SLIP) mapping portal (NRM SLIP 2015); • Statewide Vegetation Statistics (Government of Western Australia 2013a); • Beard (1977) vegetation mapping.
Threatened and Priority Ecological Communities	Ecological communities listed in the following databases as being within the Study area: <ul style="list-style-type: none"> • PMST (DotE 2015a); • DPaW Threatened Ecological Community (TEC) and Priority Ecological Community (PEC) spatial datasets (DPaW 2015a, 2015c) (Buffer 20 km); • Priority Ecological Communities List DPaW (2015b).

Aspect	Information Source
Conservation Significant Flora and Fauna	<p>Conservation significant flora and fauna listed in the following databases as being within the Study area:</p> <ul style="list-style-type: none"> • PMST (DotE 2015a) (Buffer 20 km); • NatureMap (DPaW 2007-) (Buffer 20 km); • DPaW Declared Rare and Priority Flora spatial datasets.(Western Australian Herbarium 1998-) (Buffer 20 km).
Weeds Weeds of National Significance and Declared Plants as listed under the Biosecurity and Agriculture Management Act 2007 (BAM Act)	<p>Significant weeds that had previously been recorded within the Study area;</p> <p>NatureMap (DPaW 2007-) (Buffer 20 km);</p> <p>DAFWA BAM Act Western Australia Organism List (Government of Western Australia 2013b).</p>

2.2 Vegetation and Flora Assessment

GHD Ecologists Joshua Foster, Scientific Flora Collection Licence SL011358 and Steven Petts, SL011359 completed a vegetation and flora assessment of the Study Areas from 29 September to 2 October, 2015. This vegetation and flora survey was with reference to a Level 1 assessment with reference to the EPA Guidance Statement No. 51, Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004a). The survey was conducted in one season only.

The survey was undertaken to identify and describe the dominant vegetation units, assess vegetation condition and identify and record vascular flora taxa present at the time of survey. In addition, opportunistic searching for conservation significant communities and flora taxa was undertaken.

2.2.1 Data Collection

Field survey methods involved a combination of sampling methods, using 10 m x 10 m quadrats in identified vegetation units and points to identify significant flora species populations. The Study Areas were traversed on foot and vehicle. Thirty-two quadrats were surveyed throughout the Study Areas. Quadrat locations generally avoided obvious ecotonal zones between vegetation units and disturbed vegetation (e.g. through human/mechanical means or fire), where possible. A minimum of two quadrats were located within each identified vegetation unit, where possible.

Data recorded during the field surveys is provided in Table 4. The location of formal sampling points is shown on Figure 4 (GHD notes that this figure does not show all the opportunistically sampled locations or flora collection locations).

Table 4 Data Recorded During the Field Survey

Aspect	Measurement
Physical features	Aspect, soil attributes. Percentage surface cover by: rocks, logs and branches, leaf litter, bare ground.
Location of important features	Coordinates recorded in GDA94 datum using a hand-held Global Positioning System (GPS) tool. All data was in MGA Zone 50
Vegetation Type	Vegetation types were described based on Muir (1977) and Aplin (1979).
Vegetation Condition	Vegetation condition was assessed using the condition rating scale developed by Keighery (1994) and as summarised in Bush Forever (Government of Western Australia, 2000).
Disturbance	Level and nature of disturbances (e.g. weed presence, fire — and time since last fire, impacts from grazing, exploration activities, etc.).
Flora	List of vascular flora taxa recorded and total within each Study Areas.

A flora inventory was compiled from taxa listed in described quadrats, relevés, transects, and opportunistic floristic records throughout the Study Areas.

2.2.2 Vegetation Units

Vegetation units were identified and boundaries delineated using a combination of aerial photography, topographical features, previous mapping (Beard, 1979) and field data.

Vegetation units were described based on structure, dominant taxa and cover characteristics as defined by quadrat data using NVIS. A representative photograph of each vegetation unit was also taken and is presented in Section 4.2.

2.2.3 Vegetation Condition

The vegetation condition of the site was assessed using the vegetation condition rating scale developed by Keighery (1994). This rating scale recognises the intactness of vegetation, which is defined by the following:

- Completeness of structural levels;
- Extent of weed invasion;
- Historical disturbance from tracks and other clearing or dumping; and
- The potential for natural or assisted regeneration.

The scale consists of six rating levels, as outlined in Table 5.

Table 5 Vegetation Condition Rating Scale

Vegetation Condition Rating	Vegetation Condition	Description
1	<i>Pristine or Nearly So</i>	No obvious signs of disturbance.
2	<i>Excellent</i>	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
3	<i>Very Good</i>	Vegetation structure altered obvious signs of disturbance.
4	<i>Good</i>	Vegetation structure significantly altered by very obvious signs of multiple disturbances retains basic vegetation

Vegetation Condition Rating	Vegetation Condition	Description
		structure or ability to regenerate it.
5	<i>Degraded</i>	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not in a state approaching good condition without intensive management.
6	<i>Completely Degraded</i>	The structure of the vegetation is no longer intact and the area is completely or almost without native species.

2.2.4 Flora Identification and Nomenclature

Flora taxa that were well known to the survey botanist were identified in the field. The species not known were collected and assigned a unique collection number to facilitate tracking. All plants that were unknown had their location recorded by hand-held GPS. In addition, significant weed species (such as those species listed under the BAM Act) were also recorded for mapping.

Plant species were identified by the use of taxonomic literature, electronic keys and online electronic databases. Where necessary, plant taxonomists considered to be authorities on particular plant groups were consulted.

The conservation status of all recorded flora was compared against the current lists available on *FloraBase* (WA Herbarium, 1998–) and the EPBC Act PMST database provided by the DotE (2015a).

Nomenclature used in this report follows that used by the Western Australian (WA) Herbarium as reported on *FloraBase* (WA Herbarium, 1998–).

2.3 Fauna Identification and Habitat Assessment

GHD ecologists completed a fauna and habitat assessment of the Study Areas from 29 September to 2 October, 2015. The Level 1 fauna assessment was undertaken with reference to the EPA Guidance Statement No. 56 Assessment of Environmental Factors for Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004b) and Technical Guide Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA, & DEC, 2010).

Nomenclature used in the report follows that used by the DPaW and Western Australian Museum (WAM) *NatureMap* program for vertebrate fauna, as it is deemed to contain the most up-to-date species information for reptiles, amphibians and mammals in Western Australia.

The methodology used to undertake the fauna assessment included:

- Opportunistic active searches across all habitat types within the Study Areas. The survey involved searching through microhabitats including turning over logs or rocks, turning over leaf litter and examining hollow logs;
- Opportunistic visual and aural surveys. This accounted for many bird species potentially utilising the Study Areas;
- Searching for tracks, scats, bones, diggings and feeding areas for both native and feral fauna; and
- Habitat assessments, including targeting the known habitat preferences of fauna species of conservation significance that are suspected to occur in the Study Areas.

2.4 Desktop and Field Assessment Limitations and Assumptions

Desktop investigations used a variety of online resources (such as the WAM and DPaW (DEC, 2007-) *NatureMap* database and the EPBC Act PMST database) and the responsibility for the accuracy of such data remains with the issuing authority, not with GHD. The PMST database is used to identify species listed under the EPBC Act. This database draws on various sources to report on the potential of the species occurrence within the area. The EPBC Act search tool is broad-scale in its reporting and often the specific habitat requirements of the species do not occur within the Study Areas. For this reason not all species reported by the search tool need to be considered in management decisions.

The *NatureMap* database reports on actual records of the species within the designated area and can provide more accurate information of the likelihood of species presence.

New Wildlife Conservation (Rare Flora) and Wildlife Conservation (Specially Protected Fauna) Notices were gazetted on 3 November 2015. The format of these Notices has been changed to align with the EPBC Act threatened species lists. To date, information contained in publically available databases such as *NatureMap* does not reflect these newly gazetted Notices. This report has been updated to reflect the conservation status of flora and fauna listed in these Notices. However, the outputs of database searches contained in this report, such as *NatureMap*, does not reflect the conservation status of flora and fauna listed in these Notices.

There were no substantial limitations to the field survey as described in Table 6.

Table 6 Field Survey Limitations

Aspect	Constraint	Comment
Sources of information and availability of contextual information.	Minor	<p>Adequate information is available for the Study Areas, this includes:</p> <ul style="list-style-type: none"> • Broad scale (1:1,000,000) mapping by Beard (1979) and digitised by Shepherd <i>et al.</i> (2002); • Regional biogeography (Desmond and Chant, 2001; Desmond, 2001).
Scope (what life forms were sampled etc.).	Nil	Vascular flora and terrestrial vertebrate fauna were sampled during the survey. Non-vascular flora, invertebrate and aquatic fauna were not assessed as part of survey, although opportunistic records were taken of invertebrate fauna during the survey.
<p>Proportion of flora collected and identified (based on sampling, timing and intensity).</p> <p>Proportion of fauna identified, recorded and/or collected.</p>	Minor	<p>The vegetation and flora survey was undertaken in Spring between 29 September and 2 October, 2015. This is generally considered the most optimal time to undertake flora and vegetation surveys in the Geraldton Sandplains and Swan Coastal Plain. The flora recorded from the field survey is detailed in Section 4.4 and a full flora species list is provided in Appendix C. The portion of flora collected and identified was considered high.</p> <p>The fauna survey was undertaken in late in conjunction with the flora survey and was a reconnaissance survey only. The fauna assessment sampled those species that can be easily seen, heard or has distinctive signs, such as tracks, scats, diggings, etc. Many cryptic (e.g. invertebrate species) and nocturnal species would not have been identified during a reconnaissance survey and seasonal variation within species often requires targeted surveys at a particular time of the year. Of the fauna species recorded during the survey, all species were identified to a species level.</p> <p>The fauna assessment was aimed at identifying habitat types and terrestrial vertebrate fauna utilising the surveyed areas. No sampling for invertebrates or aquatic species occurred. Where terrestrial invertebrate fauna were recorded opportunistically, these findings were mentioned in this report. However, this report is limited to an assessment of terrestrial vertebrate fauna, as the information available on the identification, distribution and conservation status of invertebrates is generally less extensive than that of vertebrate species.</p>
Flora determination.	Minor	<p>Flora determination was undertaken by GHD ecologists in the field. The proportion of flora collected and identified was considered high; however, four flora taxa were identified to a genus level, due to insufficient material such as flowers and fruit.</p> <p>Some species, particularly grasses, may have been overlooked due to lack of material; however this is unlikely to affect the results of the survey as these species are not likely to be conservation significant species, nor dominate throughout the survey area.</p> <p>The taxonomy and conservation status of the Western Australian flora is dynamic. This report was prepared with reliance on taxonomy and conservation status current at the time report development, but it should be noted this may change in response to ongoing research and review of IUCN criteria.</p>

Aspect	Constraint	Comment
Completeness and further work which might be needed (e.g. was the relevant area fully surveyed).	Minor	The majority of the surveyed areas were accessible on foot and by vehicle. Information gained from the survey was extrapolated across those sections of the Study Areas not accessed on foot during the field survey to assist with determining the vegetation and habitat types for the entire survey area.
Mapping reliability.	Minor	<p>The vegetation was mapped at a scale of 1:7,500 using high resolution ESRI aerial imagery obtained from LandGate, topographical features, previous mapping (Beard 1979) and field data. The distribution of non-permanent quadrats is considered adequate for the definition of vegetation within the surveyed areas.</p> <p>Data was recorded in the field using hand-held GPS tools (e.g. Garmin GPS). Certain atmospheric factors and other sources of error can affect the accuracy of GPS receivers. The Garmin GPS units used for this survey are accurate to within ± 5 metres on average. Therefore the data points consisting of coordinates recorded from the GPS may contain inaccuracies.</p>
Timing/weather/season/cycle.	Minor	<p>The field survey was conducted from 29 September to 2 October 2015 following below average rainfall. The closest Bureau of Meteorology (BoM) weather station at Badgingarra Reseach Stn (9037) to Study Areas 2, 3, 4, 5, recorded 172.2 mm of rain in the three months (June to August) preceding the field survey, which is below the long term average of 288 mm over the same months (BoM, 2015a). The below average rainfall may influence the outcome of annuals recorded within the Study Areas. The closest BoM weather station to Study Area 1 is Gingin Aero (9178), which recorded 291.8 mm in the three months (June to August) preceding the field survey, which is below the long-term average of 342.7 mm over the same months (BoM, 2015b)</p> <p>Some flora species, such as annuals, are only available for collection at certain times of the year and others are only identifiable at certain times (such as when they are flowering). Additionally, climatic and stochastic events (such as fire) may affect the presence of plant species. Species that have a very low abundance in the area are more difficult to locate, due to the above factors.</p> <p>Flora composition changes over time, with flora species having specific growing periods, especially annuals and ephemerals (some plants lasting for a markedly brief time, some only a day or two). Therefore, the results of future botanical surveys in this location may differ from the results of this survey.</p> <p>Complete flora and fauna surveys can require multiple surveys, at different times of year, and over a period of a number of years, to enable observation of all species present.</p>

Aspect	Constraint	Comment
Disturbances (e.g. fire, flood, accidental human intervention).	Nil	There were no disturbances observed that impacted the survey.
Intensity (in retrospect, was the intensity adequate).	Nil	The vascular flora of the survey area was sampled with reference to EPA (2004a) and terrestrial fauna sampled with reference to EPA (2004b). The Study Areas were sufficiently covered by GHD's ecologists during the survey on foot and via vehicle.
Resources.	Nil	Adequate resources were employed during the field survey. A total of eight person days were spent undertaking the survey using two ecologists.
Access restrictions.	Nil	No access problems were encountered during the survey.
Experience levels.	Nil	The ecologists who executed the survey were practitioners suitably qualified in their respective fields. Joshua Foster (Scientific Flora Collection Licence: SL011358) is a Principle Ecologist with over 18 years experience in undertaking ecological (flora and fauna) surveys within Western Australia. Steven Petts (Scientific Flora Collection Licence: SL011359) is an Ecologist with over four years experience in undertaking ecological surveys in Western Australia.

3. Desktop Assessment

This section describes the Project Area’s physical, biological aspects based on previous studies and desktop investigations.

3.1 Physical Environment

3.1.1 Climate

The Bureau of Meteorology (BoM) Badgingarra station (Site Number 009037) is the nearest weather station to the Study Areas 2, 3, 4 and 5, with continuous long-term data. Climatic data from this BoM Station is provided in Plate 1.

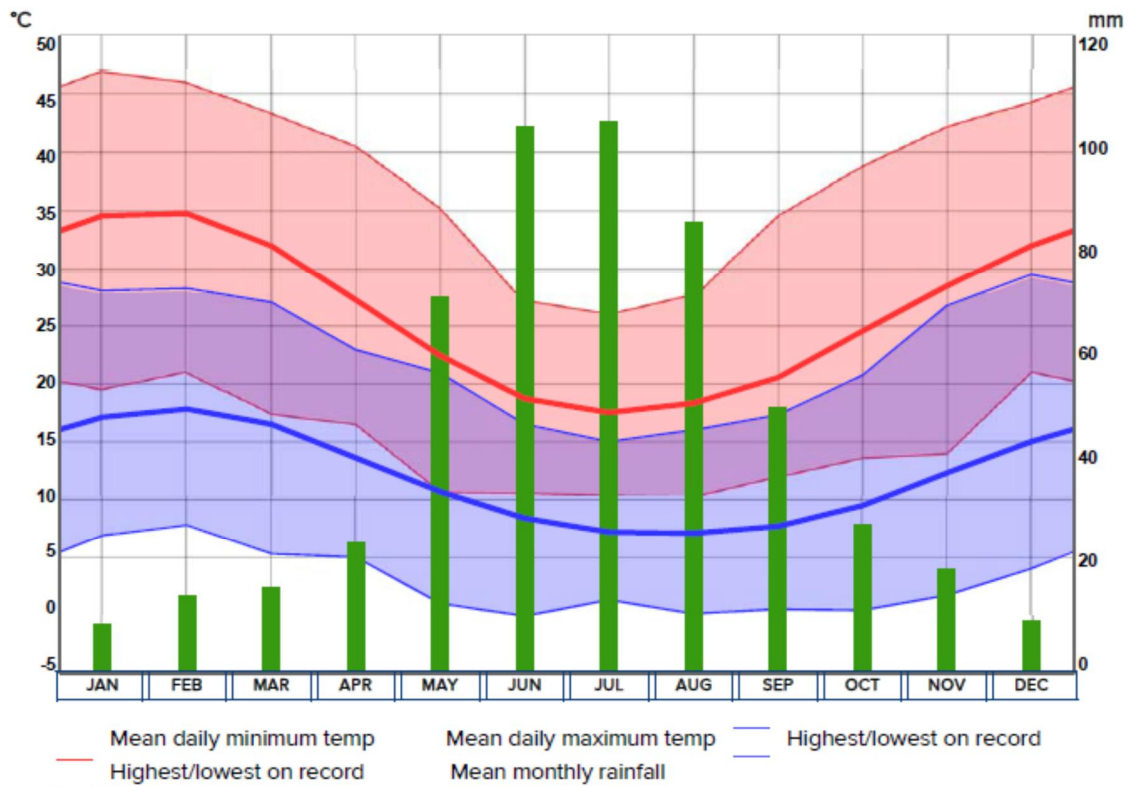


Plate 1 Badgingarra Annual Temperature and Rainfall (Weatherzone, 2015a)

The BoM Gingin Aero station (site number: 009178) is the nearest weather station to the Study Area 1 with continuous long-term data. Climatic data for thi BoM Station is provided in Plate 2.

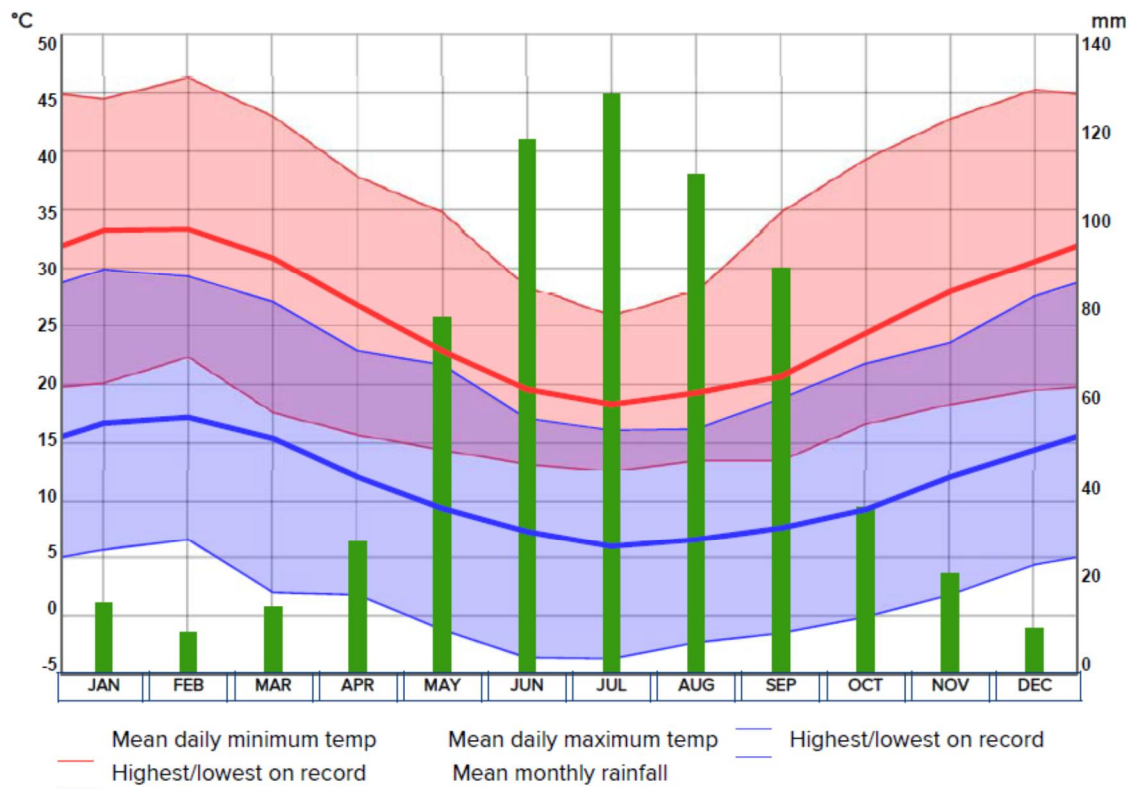


Plate 2 Gingin Aero Annual Temperature and Rainfall (Weatherzone, 2015b)

3.1.2 Bioregion

The Interim Biogeographic Regionalisation of Australia (IBRA) divides the Australian continent into 85 biogeographic regions based on their climatic, faunal, vegetation, landform and geological features.

Study Areas 2, 3, 4 and 5 are located in the Geraldton Sandplains IBRA region and within the Lesueur Sandplain IBRA sub-region. “The Lesueur Sandplain (GS3) comprises coastal Aeolian and limestones, Jurassic siltstones and sandstones (often heavily lateritised) of central Perth Basin. Alluvials are associated with drainage systems. There are extensive yellow sandplains in south-eastern parts, especially where the subregions overlaps the western edge of the Pilbara Craton. Shrub-heaths rich in endemics occur on a mosaic of lateritic mesas, sandplains, coastal sands and limestones. Heath on lateritised sandplains along the subregions north-eastern margins. The climate is Mediterranean and the subregional area is 1,358,915 ha” (Desmond and Chant, 2001, p. 293).

Study Area 1 is located within the Swan Coastal Plain IBRA region and the Dandaragan Plateau subregion. “The plateau is bordered by Derby and Dandaragan Faults. Cretaceous marine sediments are mantled by sands and laterites. It is “Characterised by Banksia low woodland, Jarrah - Marri woodland, Marri woodland and by scrub-heaths on laterite pavement and on gravelly sandplains” (Desmond, 2001, p. 595).

3.1.3 Geology and Soils

Geology

Table 7 details the search results of the Department of Mines and Petroleum Interactive Geological Map (GeoVIEW.WA) database for the interpreted Bedrock Geology at 1:500,000 underlying the Study Areas.

Table 7 Geology

Study Area	Description
1	Interbedded sandstone, siltstone and shale, with minor conglomerate. This geology bedrock forms part of the Warnbro Group of the Perth Basin.
2	Sandstone and siltstone, lessor limestone.
3	
4	
5	

Soil Landscapes

The mapping of the South-West of Western Australia was investigated to determine the soil-landscapes present within the Study Area (DAFWA 2015). The majority of the Study Area is covered by the Moore River System, with a small portion in the south-east corner of the Study Area covered by the Capitella system (DAFWA 2015).

The soil-landscapes that occur within the Project Area are detailed in Table 8.

Table 8 Soil Landscapes within the Study Areas (DAFWA, 2015)

Soil-Landscape Mapping			
System	Subsystem/Phase	Description	Location
Bassendean system (212B)		Sand dunes and sandplains with flats and swamps on sandy alluvium over sedimentary rocks in the Swan Coastal Plain from Busselton to Jurien. Pale deep sand, semi-wet soil and wet soil. Banksia-paperbark woodlands and mixed heaths	Southern portion of Study Area 1 and Study Area 2.
	Bassendean 1 Subsystem (212Bs_1)	Undulating to flat sandplain, with minor low dunes and swampy depressions on unconsolidated sand, aeolian and alluvial in the Coastal plain north of Perth inland from coastal limestone. Pale deep sand dominate; minor areas of yellow deep sand, gravelly sands, sandy duplexes and wet soil. Banksia woodland; heathland or melaleuca scrub	Southern portion of Study Area 1 and Study Area 2.
Rowe system (222Rw)		Sand dunes and sandplains with flats and swamps on sandy alluvium over sedimentary rocks in the Swan Coastal Plain from Busselton to Jurien. Pale deep sand, semi-wet soil and wet soil. Banksia-paperbark woodlands and mixed heaths	Eastern portion of Study Area 1.
	Rowes 3 Subsystem (222Rw_3)	Colluvial slopes, very gently to gently inclined hillslopes and sand filled minor valleys on colluvium in the East and S of Dandaragan. yellow deep sand, some pale deep and gravelly pale deep sand gravel and sandy earths. <i>Banksia prionotes</i> and <i>B. attenuata</i> open low woodland and patches of heath.	All Study Areas.
Yerramullah system (224Ye)		Subdued dissected lateritic plateau, undulating low hills and rises on lateritised weathered sandstone in the East of the Northern Coastal Plain. Pale deep sand, sandy gravels, shallow gravel and yellow deep sand. Banksia woodlands on lower slopes/depressions, heathlands elsewhere.	All Study Areas.
	Yerramullah 2 subsystem (224Ye_2)	Plateau residuals, very gently to gently inclined hillcrest and hillslopes on colluvium in the Badgingarra area. Pale	Study Area 2, 3 and 4

Soil-Landscape Mapping	System	Subsystem/Phase	Description	Location
			sandy gravels, shallow gravel over duricrust, gravelly pale deep sand, pale and yellow deep sands.	
		Yerramullah 3 subsystem (224Ye_3)	Colluvial slopes and some plateau remnants, very gently to gently inclined hillslopes and sand filled minor valleys on colluvium in the Badgingarra area. Pale and yellow deep sands, pale sandy gravels, shallow gravel over duricrust, some sandy duplexes and sandy earths. Heath, occasionally <i>Banksia attenuata</i> low open woodland, commonly with <i>Eucalyptus todtiana</i> .	Study Areas 2, 3, 4 and 5
		Yerramullah 4 subsystem (224Ye_4)	Plateau residuals, complex of small patches of Ye2 in Ye3 on colluvium in the Badgingarra area. Pale sandy gravels, gravelly pale deep sand, shallow gravel over duricrust, pale deep sand, some sandy duplexes, yellow deep sand. Heath, occasionally with <i>Eucalyptus todtiana</i> .	Study Areas 2 and 3
		Yerramullah 6 subsystem (224Ye_6)	Colluvial slopes, very gently to gently inclined mid to lower hillslopes and sand filled minor valleys on colluvium in the Badgingarra area. Pale deep sand, some sandy duplexes and shallow sand over pan or bog iron. Heath with emergent <i>Eucalyptus todtiana</i> , <i>E. calophylla</i> or <i>lane-polei</i> .	Study Area 2
		Yerramullah 12 subsystem (224Ye_12)	Dunes blown from old drainage lines on aeolian sand in the S of Badgingarra. Pale and yellow deep sands. Open low woodland of <i>Banksia attenuata</i> over heath with occ. <i>Eucalyptus todtiana</i> .	Study Area 3

Acid Sulphate Soils

The Australian Soil Resource Information System (ASRIS, 2015) described that probability of acid sulphate soils occurring within the Study Areas were considered “Extremely Low Probability” with a “Very Low Confidence”.

3.2 Land Uses

3.2.1 Surrounding Land Use

The Study Areas are situated within the Intensive Land Use Zone of Western Australia (NRM). The surrounding landuses included: broadacre agriculture; conservation reserves, including the Badgingarra National Park; gazetted roads such as the Brand Highway; mining (Cooljarloo) and the townsite of Badgingarra.

3.2.2 Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are subject to definition under Section 51B of the EP Act and may include areas requiring special management attention to protect important scenic values, fish and wildlife resources, historical and cultural values, and other natural systems or processes. The DER’s Native Vegetation Map Viewer indicated that ESA’s are present in the Study Areas associated with the Badgingarra National Park (DER, 2015).

3.2.3 Conservation Areas

Conservation areas shown on *NatureMap* within the vicinity of the Study Areas are presented in Table 9 (DPaW, 2007-).

Table 9 Conservation Areas

Name	Class	Location
Badgingarra National Park	C	Runs adjacent to the western boundary of the road reserve of Study Areas 4 and 5.
Naming Nature Reserve	C	Located approximately 1.6 km to the west of Study Areas 1.
Unnamed Conservation Park (Reserve 41986), south of Badgingarra National Park	C	Runs adjacent to the western boundary of the road reserve of Study Areas 2 and 3.

3.3 Conservation Significant Ecological Communities

3.3.1 Threatened Ecological Communities

A search of the EPBC Act PMST database (DotE, 2015a) did not identify any Threatened Ecological Communities (TECs) within 20 km of the Study Areas. No WC Act listed TECS were identified within 20 km of the Study Areas.

The closest TEC is located 21 km South of Study Area 1. This will not be impacted by the proposed works.

3.3.2 Priority Ecological Communities

One Priority Ecological Community (PEC) was identified within 20 km of Study Area 1 as shown in Figure 2. This PEC is Priority 3 – “Banksia dominated woodlands of the Swan Coastal Plain

IBRA region". The PEC is currently mapped as occurring approximately 2 km south-east of the Study Area 1 (DPaW, 2015b).

3.4 Disease and Pathogens

Phytophthora cinnamomi (Dieback) disease is generally restricted to areas of the south west of the State, south of the 26th parallel of latitude, in areas receiving an average annual rainfall of greater than 400 mm.

The Study Areas are south of the 26th parallel and receive greater than 400 mm of rainfall per annum. The Study Areas are considered to be susceptible to the development of the *Phytophthora cinnamomi* pathogen.

A dieback assessment was not completed as part of this project.

3.5 Vegetation

3.5.1 Vegetation Mapping

Broad scale (1:1,000,000) vegetation mapping of the Perth and Moora and Hill River Areas was completed by Beard (1979) at an association level, which indicates that there are four Vegetation Associations present within the Study Areas (Table 10).

Table 10 Beard (1979) Vegetation Associations

Vegetation Association	Description	Location
7	Medium woodland; tuart and jarrah.	Southern portion of Study Area 3.
1030	Low woodland; <i>Banksia attenuata</i> & <i>B. menziesii</i> .	Southern portions of Study Areas 1 and 2; middle portion of Study Area 3.
1031	Mosaic: Shrublands; hakea scrub-heath/ Shrublands; dryandra heath.	Southern portions of Study Areas 2 and 3. All of Study Areas 4 and 5.
1035	Mosaic: Medium open woodland; marri/ Shrublands; dryandra heath.	Northern portion Study Area 2.

3.5.2 Vegetation Extent and Status

Beard mapping has been adapted and digitised by Shepherd *et al.* (2002). The extent of Beard's (1979) Vegetation Associations have been determined by the state-wide vegetation remaining extent calculations maintained by the DPaW (latest update 2014 – Government of Western Australia, 2015).

As indicated in Table 11, the remaining extent of the Vegetation Associations 7 and 1030 are greater than 30% of pre-European extent at a local government authority (LGA) level. In contrast, Vegetation Associations 1031 and 1035 have less than 30% of pre-European extent at an LGA and therefore are underrepresented.

Table 11 Vegetation Association Extent and Status

Vegetation Association	Scale	Pre-European Extent (ha)	Current Extent (ha)	% Current Extent in All DPaW Managed Lands	% Remaining
Geraldton Sandplains (GES)		3,136,037.83	1,404,375.00	40.33	44.78
Swan Coastal Plains (SWA)		1,501,221.93	580,697.31	37.35	38.68
Lesueur Sandplain (GES02)		1,171,775.19	502,918.10	41.89	42.92
Dandaragan Plateau (SWA01)		383,464.90	113,551.68	34.44	29.61
7	State	179,724.65	23,104.53	5.26	12.86
	IBRA (GES)	4,136.5	1,391.05	9.20	33.63
	Sub-IBRA (GES02)	4,136.50	1,391.05	9.20	33.63
	Shire of Dandaragan	4,192.64	1,402.98	9.13	66.78
1030	State	139,012.86	88,997.10	17.98	64.02
	IBRA (GES)	3,848.52	2,790.59	74.80	72.51
	IBRA (SWA)	134,788.56	86,061.30	16.11	63.85
	Sub-IBRA (GES02)	3,848.52	2,790.59	74.80	72.51
	Sub-IBRA (SWA01)	20,572.95	6,497.53	24.05	31.58
	Shire of Dandaragan	121,005.02	80,802.97	19.50	66.78
1031	State	269,490.91	88,606.05	42.30	32.88
	IBRA (GES)	241,349.97	83,155.02	44.13	34.45
	Sub-IBRA (GES02)	241,349.97	83,155.02	44.13	34.45
	Shire of Dandaragan	230,488.23	67,978.55	52.13	29.49
1035	State	5,018.34	494.12	53.65	9.85
	IBRA (GES)	241,349.97	83,155.02	7.35	34.45
	Sub-IBRA (GES02)	1,582.96	133.61	7.35	8.41
	Shire of Dandaragan	5,018.34	494.12	53.65	9.85

3.6 Flora

3.6.1 Flora Diversity

A search of the *NatureMap* database (DEC, 2007-) was undertaken for a buffer of 20 km around each of the Study Areas. The summary of the findings are provided in Table 12. The Project Area occurs within known biodiversity hotspots (Swan Coastal Plain, and Geraldton Sandplains), with *NatureMap* records indicating over 1000 flora taxa known within 20 km of the

majority of Study Areas. Study Areas are typically dominated by Heaths (Ericaceae), Banksias (Proteaceae), Myrtles (Myrtaceae), Peas and Wattles (Fabaceae), Kangaroo Paws and Catspaws (Haemodoraceae), Sedges (Cyperaceae), Triggerplants (Stylidiaceae), and Daisies (Asteraceae).

Table 12 NatureMap Search Results

Study Area 1	Dominant Families	Number of Taxa
Total Flora Taxa within 20 km: 964	Fabaceae	90
	Ericaceae	35
	Haemodoraceae	34
	Asteraceae	32
Study Area 2	Dominant Families	Number of taxa
Total Flora Taxa within 20 km: 1,078	Myrtaceae	131
	Proteaceae	120
	Fabaceae	100
	Haemodoraceae	43
	Cyperaceae	42
Study Area 3	Dominant Families	Number of taxa
Total Flora Taxa within 20 km: 1,241	Myrtaceae	158
	Proteaceae	141
	Fabaceae	107
	Eriaceae	41
	Cyperaceae	40
	Stylidiaceae	39
	Haemodoraceae	38
Study Area 4	Dominant Families	Number of taxa
Total Flora Taxa within 20 km: 1,194	Myrtaceae	162
	Proteaceae	145
	Fabaceae	122
	Eriaceae	43
Study Area 5	Dominant Families	Number of taxa
Total Flora Taxa within 20 km: 1,182	Myrtaceae	156
	Proteaceae	145
	Fabaceae	116
	Eriaceae	45

3.6.2 Conservation Significant Flora Taxa

A search of the EPBC Act PMST (DotE, 2015a) indicated the following number of EPBC Act listed flora taxa that are likely to occur within 20 km of the Study Areas:

- 29 taxa in Study Area 1;

- 31 taxa in Study Area 2;
- 34 taxa in Study Area 3;
- 34 taxa in Study Area 4; and
- 33 taxa in Study Area 5.

Desktop searches of the *NatureMap* database (DEC, 2007-) and the DPaW databases (20 km buffer) determined that Threatened (Declared Rare) Flora taxa declared under the WC Act are known to occur within 20 km of the Study Areas. The searches indicate that 195 conservation significant flora taxa (including Threatened (Declared Rare) and Priority Flora) have been previously recorded within 20 km of the Study Areas (Appendix C).

A desktop assessment of the likelihood of these conservation significant flora taxa occurring in the Study Areas indicates that 53 are “unlikely to occur”, 67 are considered “possible to occur” and 75 are “likely to occur” based on an understanding of their known range and habitat preferences. The likelihood of occurrence assessment is provided in Appendix C.

3.7 Fauna

3.7.1 Fauna Diversity

The search results of the *NatureMap* database (DPaW, 2007-) for each Study Area are provided in Table 13. Counts of species by fauna groups are stated.

Table 13 NatureMap Search Results with 20 km Buffer

Study Area	Amphibians	Birds	Mammals	Reptiles	Mollucs
Study Area 1	3	125	9	10	-
Study Area 2	10	116	1	38	-
Study Area 3	10	102	10	52	1
Study Area 4	9	92	10	51	-
Study Area 5	8	73	8	39	-

3.7.2 Conservation Significant Fauna

A summary of the search results of the EPBC PMST for Threatened and Migratory fauna taxa that could possibly occur within 20 km of the Study Areas is provided in Table 14.

A number of Marine-listed species including, fish, turtles and cetaceans were indicated in the EPBC Act PMST and NatureMap search results. As the survey was limited to terrestrial fauna these marine species were not considered for likelihood of occurrence assessment.

Table 14 EPBC Act-Listed Threatened and Migratory Species

Study Area	Listed Threatened Species	Listed Migratory Species
Study Area 1	4	5
Study Area 2	4	5
Study Area 3	4	5
Study Area 4	4	5
Study Area 5	3	5

A search of the *NatureMap* database (DPaW, 2007–) identified conservation significant fauna taxa (including Threatened or Migratory) that have been previously recorded within 20 km of the Study Areas. The findings include:

- 12 fauna taxa that hold a conservation status in Study Area 1;
- Eight fauna taxa that hold a conservation status in Study Area 2;
- Nine fauna taxa that hold a conservation status in Study Area 3;
- Five fauna taxa that hold a conservation status in Study Area 4; and
- Eight fauna taxa that hold a conservation status in Study Area 5.

Conservation significant fauna species are discussed further in Sections 4.5.4 and 4.5.5.

3.8 Hydrology

3.8.1 Wetlands

International and Nationally Important Wetlands

There are no mapped internationally or nationally important wetlands occurring within five kilometres of the Project Area.

Lakes Covered Under the Environmental Protection (Swan Coastal Plain Lakes) Policy

No Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 (EPP) Lakes registered boundaries or policy boundaries intercept the Study Areas. The closest EPP Lake is located two kilometres south of Study Area 1, on the other side of the Moore River.

Geomorphic Wetlands

Study Area 1 occurs within the limit of the mapping completed for the Swan Coastal Plain geomorphic wetlands study. Study Area 3 occurs within the mapping completed for the Geomorphic Wetlands Cervantes South. The locations of the geomorphic wetlands noted within these areas have been mapped in Figure 2 and summarised in Table 15.

Table 15 Geomorphic Wetlands within or Adjacent to the Study Areas

Study Area	Geomorphic Wetland
Study Area 1	One unranked dampland intercepts Study Area 1
Study Area 2	None identified
Study Area 3	None identified
Study Area 4	None identified
Study Area 5	None identified

3.8.2 Watercourses

The search results from the Department of Water (DoW) watercourses within the Study Areas are provided in Table 16 (DoW, 2000).

Table 16 DoW Search Results

Study Area	Hydrography - DoW
1	None
2	None
3	Swamp-perennial (Two swamps - 250 m east and west from Study Area)
4	None
5	None

3.8.3 Public Drinking Water Source

The hydrology and hydrogeology aspects proclaimed under the *Rights in Water and Irrigation Act 1914* (RIWI Act) within the Project Area are provided in Table 17.

Table 17 DoW Geographic Data Atlas Query Results

Aspect	Detail	Result
RIWI Groundwater Areas	Groundwater areas proclaimed under the RIWI Act.	Study Areas 1 and 2 – Gingin. Study Areas 3, 4 and 5 – Jurien.
Groundwater Sub-areas	Groundwater areas proclaimed under the RIWI Act.	Study Areas 1 – Namming Lake. Study Area 2 – Wedge Island. Study Areas 3, 4 and 5 – Badgingarra.
RIWI Watercourses	Watercourses proclaimed under the RIWI Act.	The Project does not cross any RIWI watercourses.
RIWI Surface Water Area	Surface water areas proclaimed under the RIWI Act.	Study Area 1, 2 and 3 – Lower Moore. Study Area 4 – Nambung/Catuby Coastal Tributaries. Study Area 5 – Hill River and Tributaries.
Public Drinking Water	PDWSAs is a collective term	The Project is not within a

Aspect	Detail	Result
Source Areas (PDWSA)	used for the description of Water Reserves, Catchment Areas and Underground Pollution Control Areas declared (gazetted) under the provisions of the <i>Metropolitan Water Supply, Sewage and Drainage (MWSSD) Act 1909</i> or the <i>Country Area Water Supply (CAWS) Act 1947</i> .	PDWSA. The nearest is 750 m east of Study Area 5 (Priority 3 - Badgingarra Water Reserve).

4. Field Results

4.1 Hydrology

4.1.1 Ephemeral Drainage Lines

GHD recorded two ephemeral drainages lines from Study Area 3. The ephemeral drainage lines were dry at the time of the survey and impacted by weeds, predominately introduced grass species. However, some native shrubs were present.

4.1.2 Wetlands

The field findings are consistent with the desktop assessment with a geomorphic wetland recorded within Study Area 1 (Figure 6). This wetland was recorded on either side of the Brand Highway and was rated Condition 2 (*Excellent*) to Condition 3 (*Very Good*) at the location of the surveyed quadrat. On the eastern side of the Brand Highway the geomorphic wetland was in Condition 5 (*Degraded*) and was impacted by introduced plants including Arium Lily (**Zantedeschia aethiopica*) and Olive Tree (**Olea europaea*).

4.2 Vegetation

4.2.1 Vegetation Types

Eight vegetation types, including one described as “Cleared and Degraded”, were recorded from the Study Areas. The eight vegetation types were delineated within the Study Areas using 25 non-permanent quadrats, relevés, transects and a review of aerial photography.



The dominant Vegetation Types were the Mixed Heath on White Sands (with underlying laterite) covering an extent of 165.7 ha (Vegetation Type 6); and Low Open *Banksia* Woodland, covering an extent of 195.2 ha (Vegetation Type 7).



The description of Vegetation Types, location, extant, condition and equivalent Vegetation Associations is shown in Table 18 and mapped in Figure 3.



4.2.2 Vegetation Extent and Status



Vegetation Types recorded within the Study Areas are considered to be equivalent to the mapped pre-European (Beard 1979) Vegetation Associations known from the local and regional area. The Vegetation Types are well represented at an LGA level, with greater than 30% remaining, with the exception being Vegetation Type 6 (Beard's Vegetation Association 1031 and 1035) and Vegetation Type 8 which are under-represented.

Table 18 Vegetation Types Recorded within the Study Areas

Number	Short Description	Long Description	Photo	Location	Vegetation Condition	Extent	Vegetation Association
1	Banksia Woodland on White Sand	<p>Low Open Woodland dominated by <i>Banksia attenuata</i>, <i>B. menziesii</i> with <i>Eucalyptus todtiana</i> over Scattered Shrubs of <i>B. attenuata</i>, <i>Jacksonia floribunda</i> over Low Shrubland to Open Shrubland of <i>Melaleuca urceolaris</i> and <i>Eremaea pauciflora</i> over Sedgeland of <i>Desmocladius subterranea</i>, <i>Xanthorrhoea priessii</i> over herbs <i>Trachymene pilosa</i>, <i>Podotheca angustifolia</i>, <i>Burchardia congesta</i>, <i>Pterostylis dilatata</i> on White Sand.</p> <p>Portion of this vegetation type represents a Priority 3 Ecological Community, the Banksia dominated woodlands of the Swan Coastal Plain IBRA.</p>		Study Area 1 (Q1, Q2)	Condition 3 to Condition 2 (<i>Excellent to Very Good</i>)	11.7 ha	1030 - Well represented greater than 30%
2	Cleared/ Degraded	Includes existing clearing road reserve, gravel pits, tracks and firebreaks. Often comprises Scattered Shrubs over Scattered Bunch introduced grass and Scattered Herbs.		All Study Areas	Condition 6 (<i>Completely Degraded</i>)	59.1 ha	N/A

Number	Short Description	Long Description	Photo	Location	Vegetation Condition	Extent	Vegetation Association
3	Geomorphic Wetland	Trees of <i>Corymbia calophylla</i> , <i>Melaleuca priessiana</i> over Shrubs of <i>M. priessiana</i> , <i>M. incana</i> , <i>Hypocalymma angustifolium</i> over Sedgeland of <i>Lepidosperma squamatum</i> , * <i>Cyperus congestus</i>		Study Area 1 (Q3)	Condition 4 to Condition 2 (<i>Good to Excellent</i>)	2.0 ha	1030 - Well represented greater than 30%
4	Marri Banksia Woodland	Woodland of <i>Corymbia calophylla</i> over Low Woodland of <i>Banksia attenuata</i> , <i>Banksia prionotes</i> over High Open Shrubland of <i>Allocasuarina humilis</i> , <i>Nuytsia floribunda</i> over Scattered Shrubs of <i>Jacksonia horrida</i> , <i>Hibbertia hypericoides</i> over Low Shrubland of <i>Calothamnus sanguineus</i> , <i>Acacia pulchella</i> var. <i>glaberrima</i> , <i>Banksia nivea</i> over Open Sedgeland of <i>Caustis dioica</i> , <i>Mesomelaena pseudostygia</i> over Scattered Herbs of <i>Cassytha flava</i> , <i>Haemodorum brevisepalum</i> .		Study Area 1 (Q4)	Condition 4 to Condition 3 (<i>Good to Very Good</i>)	3.3 ha	1030 - Well represented greater than 30%

Number	Short Description	Long Description	Photo	Location	Vegetation Condition	Extent	Vegetation Association
5	Heath and Emergents	Sattered Low Trees of <i>Banksia attenuata</i> , <i>Eucalyptus todtiana</i> over Scattered Heath of <i>Leucopogon oldfieldii</i> , <i>Astroloma xerophyllum</i> , <i>Hibbertia aurea</i> , <i>Hakea obliqua</i> , <i>H. ruscifolia</i> , <i>Melaleuca trichophylla</i> over Low Shrubland of <i>Conostylis</i> , <i>Calothamnus sanguineus</i> over Very Open Sedgeland of <i>Mesomelaena pseudostygia</i> , <i>Desmocladius subterranea</i> , <i>Lyginia barbartia</i> over Scattered Herbs of <i>Drosera spp.</i> and <i>Burchardia congesta</i> .		Study Areas 1 and 3 (Q5, Q15, Q17)	Condition 4 to Condition 2 (Good to Excellent)	14.4 ha	1030 - Well represented greater than 30%
6	Mixed Heath on White Sand (with Laterite)	Open Heathland of <i>Leucopogon oldfieldii</i> , <i>Conostephium sanguineus</i> , <i>Hibbertia hypercoides</i> , <i>H. subvaginata</i> , <i>Leucopogon oldfieldii</i> , <i>Stirlingia incrassata</i> over Low Open Shrubland <i>Banksia shuttleworthiana</i> , <i>Hakea conchifolia</i> , <i>Jacksonia floribund</i> over Sedgeland of <i>Dasypogon bromeliifolius</i> , <i>Mesomelaena pseudostygia</i> , <i>Xanthorrhoea priessii</i> , <i>Desmocladius subterranea</i> over Scattered Herbs of <i>Drosea citrina</i> , <i>D. bulbosa</i> subsp. <i>bulbosa</i> , <i>Stylidium miniatum</i> , on White Sand with Laterite.		Study Areas 2, 3, 4 and 5 (Q7, Q8, Q9, Q10, Q11, Q12, Q22, Q23, Q24, Q25)	Condition 3 to Condition 1 (Very Good to Pristine or Nearly so)	165.7 ha	1031, 1035 - Less than 30%

Number	Short Description	Long Description	Photo	Location	Vegetation Condition	Extent	Vegetation Association
7	Low Open Banksia Woodland	Low Open Woodland of <i>Eucalyptus todtiana</i> , <i>Bankia menziesii</i> , <i>B. attenuata</i> , over Shrubland of <i>Hakea obliqua</i> over Low Open Shrubland of <i>Banksia shuttleworthiana</i> , <i>Jacksonia floribunda</i> , <i>Conostylis setigera</i> subsp. <i>setigera</i> , <i>Stirlingia latifolia</i> , <i>Calothamnus sanguineus</i> , <i>Hakea prostrata</i> over Open Sedgeland of <i>Schoenus rigens</i> , <i>Dasyopogon bromeliifolius</i> , <i>Desmocladius subterranea</i> , <i>Lyginia barbata</i> , <i>Mesomelaena pseudostygia</i> over Very Open Herbs of <i>Phyllangium divergens</i> , <i>Burchardia congesta</i> , <i>Drosera citrina</i> , <i>Stylidium miniatum</i> .		Study Areas 2, 3 and 4 (Q13, Q14, Q15, Q16, Q19)	Condition 6 to Condition 1 (Completely Degraded to Pristine or Nearly so)	195.2 ha	1030, 7- Well represented greater than 30%
8	Heath on Gravel	Scattered Shrubs of <i>Petrophile macrostachya</i> , <i>Allocasuarina humilis</i> over Low Open Heath of <i>Leucopogon oldfieldii</i> , <i>Gastrolobium polystachyum</i> , <i>Eremaea pauciflora</i> , <i>Astroloma glaucescens</i> over Sedgeland of <i>Mesomelaena tetragona</i> over Scattered Herbs of <i>Stylidium cygnorum</i> , <i>Drosera porrecta</i> .		Study Area 4 (Q21)	Condition 6 to Condition 2 (Completely Degraded to Excellent)	7.6 ha	1031 – Under-represented less than 30%

4.2.1 Vegetation Condition

Vegetation condition throughout the Study Areas ranged from *Completely Degraded* (Condition 6) to *Excellent* (Condition 2). The lower condition vegetation was associated with the road maintenance zone, firebreaks, gas pipeline easement and ephemeral drainage lines.

The vegetation condition ratings determined during the field survey have been mapped in Figure 4 and detailed in Table 19.

Table 19 Extent of Vegetation Condition Rating within the Study Areas

Vegetation Condition Rating (Keighery 1994)	Extent Mapped within the Project Area (ha)
<i>Pristine or Nearly so to Excellent</i> (Conditions 1- 2)	9.7 ha
<i>Excellent</i> (Condition 2)	301.6 ha
<i>Excellent to Very Good</i> (Conditions 2-3)	67.6 ha
<i>Very Good</i> (Condition 3)	20.5 ha
<i>Very Good to Good</i> (Conditions 3-4)	3.1 ha
<i>Good</i> (Condition 4)	0.9 ha
<i>Degraded</i> (Condition 5)	1.9 ha
<i>Completely Degraded</i> (Condition 6)	55.7 ha

4.3 Significant Ecological Communities

4.3.1 Threatened Ecological Communities

No ecological communities were recorded from the Study Areas that are considered to represent examples of known Threatened Ecological Communities to those identified in Section 3.3.

4.3.2 Priority Ecological Community

One DPaW-listed PEC was recorded; the 'Swan Coastal Plain *Banksia attenuata*-*Banksia menziesii* woodlands' (Priority 3). Vegetation Type 1 'Banksia Woodland on White Sand' recorded in Study Area 1 was considered representative of this PEC. 7.5 hectares of this vegetation type was mapped within the Study Area (Figure 6). Discussion with the DPaW (J. Pryde, 29 March 2016) confirms that "based on the quadrat data and flora species present at the site the area is likely to align with the Priority 3 ecological community Banksia dominated woodlands of the Swan Coastal Plain IBRA region."

GHD notes that this PEC is currently being considered for listing under the EPBC Act.

4.3.3 Other Significant Vegetation

The field survey did not identify vegetation that may be considered as "other significant" as defined in Desmond (2001a and 2001b).

4.4 Flora

4.4.1 Recorded Flora Diversity

Four hundred and forty flora taxa from 67 families were recorded from the Study Areas during the GHD field surveys. This total comprised 375 native taxa (85 %) and 65 introduced taxa (15%). A summary of the dominant families and genera recorded within each Study Area is provided in Table 20 and a flora list for the Study Areas is provided in Appendix C.

The recorded diversity compares well with the number of known flora taxa recorded within 20 km of the Study Areas, considering the areas surveyed as part of this Biological Assessment are small compared with the areas covered by the results of desktop searches as indicated in Section 3.4.1.

Table 20 Summary of Flora Statistics

Study Area 1	Study Area 2	Study Area 3	Study Area 4	Study Area 5
Dominant Families				
Fabaceae (24 taxa)	Proteaceae (37 taxa)	Proteaceae (31 taxa)	Proteaceae (41 taxa)	Proteaceae (31 taxa)
Myrtaceae (19 taxa)	Myrtaceae (28 taxa)	Myrtaceae (27 taxa)	Myrtaceae (27 taxa)	Myrtaceae (25 taxa)
Poaceae (18 taxa)	Fabaceae (22 taxa)	Fabaceae (20 taxa)	Fabaceae (26 taxa)	Fabaceae (14 taxa)
Proteaceae (18 taxa)				
Dominant Genera				
<i>Melaleuca</i> (6 taxa)	<i>Banksia</i> (12 taxa)	<i>Banksia</i> (8 taxa)	<i>Banksia</i> (13 taxa)	<i>Banksia</i> (11 taxa)
<i>Banksia</i> (5 taxa)	<i>Acacia</i> (7 taxa)	<i>Hakea</i> (8 taxa)	<i>Hakea</i> (10 taxa)	<i>Hakea</i> (6 taxa)
<i>Stylidium</i> (5 taxa)	<i>Shoenus</i> (7 taxa)	<i>Hibbertia</i> (7 taxa)	<i>Schoenus</i> (7 taxa)	<i>Verticordia</i> (6 taxa)
<i>Conostylis</i> (5 taxa)	<i>Hakea</i> (7 taxa)	<i>Stylidium</i> (7 taxa)	<i>Stylidium</i> (6 taxa)	
<i>Hakea</i> (5 taxa)				

4.4.2 Conservation Significant Flora Taxa

EPBC Act and WC Act

No conservation significant flora taxa listed under the EPBC Act or WC Act were recorded from the Study Areas.

DPaW Listed Priority Flora Taxa

Thirteen Priority Flora taxa were recorded from the Project Area including:

- *Onychosepalum microcarpum* (Priority 2);
- *Allocasuarina ramosissima* (Priority 3);
- *Grevillea makinsonii* (Priority 3);
- *Hypocalymma serrulatum* (Priority 3);
- *Phlebocarya pilosissima* subsp. *pilosissima* (Priority 3);
- *Stylidium hymenocraspedum* (Priority 3);
- *Tetratheca angulata* (Priority 3);
- *Conostephium magnum* (Priority 4);
- *Desmocladius elongatus* (Priority 4);
- *Eucalyptus macrocarpa* subsp. *elachantha* (Priority 4);
- *Grevillea rudis* (Priority 4);
- *Hypolaena robusta* (Priority 4); and
- *Schoenus griffinianus* (Priority 4).

Brief descriptions of these taxa are provided below and the locations were mapped, shown in Figure 5. GHD is in the process of organising collected specimens for submission to the Western Australian Herbarium. Accession numbers will be provided to Main Roads on completion of the task.

***Onychosepalum microcarpum* (Priority 2)**

Onychosepalum microcarpum is a rhizomatous, tufted perennial herb, which grows to a height of between 0.07 to 0.15 metres and flowers from August to October. This species occupies white or yellow sand often associated with dry heath or low woodland (DPaW, 1998-). *NatureMap* indicates that 13 records of this species are known within Western Australia and six within 20 km of the Study Areas.



Plate 3 *Onychosepalum microcarpum*

In 2015, GHD recorded an individual plant was recorded from Study Area 5.

***Allocasuarina ramosissima* (Priority 3)**

Allocasuarina ramosissima is a dioecous, divaricate shrub, which grows to a height of 0.3 to 1.2 metres. This species occupies lateritic soils often with gravel (DPaW, 1998-). *NatureMap* indicates that 53 records of this species are known in Western Australia, with the majority occurring within 20 km of the Study Areas.



Plate 4 *Allocasuarina ramosissima*

In 2015, GHD recorded an individual plant within Study Area 5.

***Grevillea makinsonii* (Priority 3)**

Grevillea makinsonii is an erect shrub to 1.6 metres high. It flowers yellow or cream to yellow between July and October. It occupies white, grey or yellow sand over laterite, loam, gravel or clay on rocky hills and sandplains (DPaW, 1998-). *NatureMap* indicates that 21 records of this species is known in Western Australia and no records within 20 km of the Study Areas. The nearest record is 56 km west of Study Area 1.



Plate 5 *Grevillea makinsonii*

In 2015, GHD recorded four individual plants from Study Areas 2 and 4.

***Hypocalymma serrulatum* (Priority 3)**

Hypocalymma serrulatum is an erect shrub that grows to a height ranging from 0.45 to 1.7 m. This taxon flowers white to pink between April and May. It prefers grey or white sands generally along drainage lines (DPaW, 1998-). *NatureMap* indicates that 25 records are known in Western Australia and within 20 km of the Study Areas.



Plate 6 *Hypocalymma serrulatum*

In 2015, GHD recorded three individual plants from Study Areas 3 and 4.

***Phlebocarya pilosissima* subsp. *pilosissima* (Priority 3)**

Phlebocarya pilosissima subsp. *pilosissima* is a shortly rhizomatous, compactly tufted perennial to 0.4 m high. This species occurs on the Swan Coastal Plain and Lesueur sandplains in white or grey sand and lateritic gravel. *NatureMap* indicates that 28 records are known from Western Australia and majority of records within 20 km of the Study Areas.



Plate 7 *Phlebocarya pilosissima* subsp. *pilosissima*

In 2015, GHD recorded an individual plant from Study Area 2, growing in a disturbed road maintenance zone.

***Stylidium hymenocraspedum* (Priority 3)**

Stylidium hymenocraspedum is a rosetted perennial herb to 0.7 m high. The leaves are adpressed to the soil and spatulate. It flowers yellow from September to October. This species occurs in sand over laterite often on hillslopes or heath, *Banksia* and *Eucalyptus* low open woodland (DPaW, 1998-). *NatureMap* indicates 21 records are known in Western Australia and all records located with 20 km of the Study Areas.



Plate 8 *Stylidium hymenocraspedum*

In 2015, GHD recorded 20 plants from five locations in Study Areas 2 and 4.

***Tetratheca angulata* (Priority 3)**

Tetratheca angulata is a lax to erect, slender shrub to 0.3 metres high. It occurs in sandy to gravelly laterite soils on low hill crests, breakaways with massive laterite boulders (DPaW, 1998-). *NatureMap* indicates that 15 records of this species are known in Western Australia and all within 20 km of the Study Areas.



Plate 9 *Tetratheca angulata*

In 2015, GHD recorded three individual plants from Study Area 4.

***Conostephium magnum* (Priority 4)**

Conostephium magnum is an erect, compact many-stemmed shrub which grows to two metres high. This species flowers pink to purple between July and September. It occupies a variety of habitats including white to grey sands sometimes associated with laterite gravel, Sand dunes, swampland, disturbed roadside, drainage channels and open woodlands (DPaW, 1998-). *NatureMap* indicates that 34 records occur within Western Australia and the majority within 20 km of the Study Areas.



Plate 10 *Conostephium magnum*

In 2015, GHD recorded 239 plants from 58 locations within Study Areas 2, 3 and 5.

***Desmocladus elongatus* (Priority 4)**

Desmocladus elongatus is rhizomatous, perennial sedge-like herb that grows a height of between 0.25 to 0.5 m. This species flowers between August and December. It occupies white and grey sands often associated with dry kwongan (DPaW, 1998-). *NatureMap* indicates that 63 records of this species are known in Western Australia and the majority within 20 km of the Study Areas.

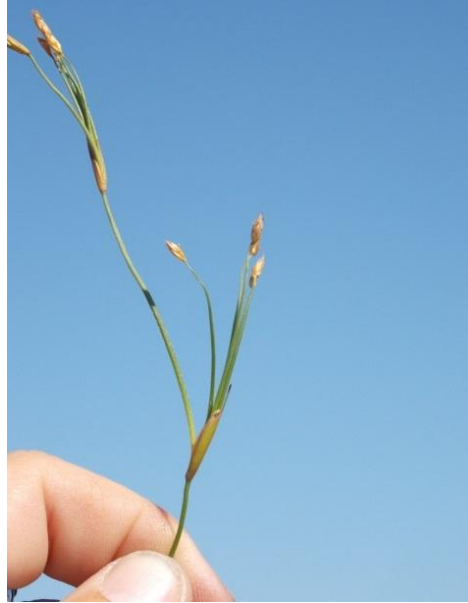


Plate 11 *Desmocladus elongatus*

In 2015, GHD recorded eight individual plants in Study Areas 4 and 5.

***Eucalyptus macrocarpa* subsp. *elachantha* (Priority 4)**

Eucalyptus macrocarpa subsp. *elachantha* is a spreading or sprawling mallee, which grows to a height of 0.8 to four metres. It has smooth grey over salmon pink bark and flowers red to pink between August and September or sometime November to December. This species occupies white and grey sand over laterite often associated with hillslopes, ridges or on sandplains (DPaW, 1998-). *NatureMap* indicates that 92 records of this species is known in Western Australia and more than half of known records occur within 20 km of the Study Areas.



Plate 12 *Eucalyptus macrocarpa* subsp. *elachantha*

In 2015, GHD recorded five plants from four locations within Study Areas 4 and 5.

***Grevillea rudis* (Priority 4)**

Grevillea rudis is a loose, spreading to erect shrub to 1.2m high. This species has white-cream flowers and grows in white, grey, yellow or red sand, often with gravel and over laterite (DPaW, 1998). *NatureMap* indicates that 90 records occur within Western Australia and the majority within 20 km of the Study Areas.



Plate 13 *Grevillea rudis*

In 2015, GHD recorded six individual plants with Study Areas 4 and 5.

***Hypolaena robusta* (Priority 4)**

Hypolaena robusta is a dioecious rhizomatous perennial herb, which grows to 0.5 metres high. It flowers from September to October and occupies sandplains (DPaW, 1998-). *NatureMap* indicates that 57 records of this species are known in Western Australia and eight records within 20 km of the Study Areas.



Plate 14 *Hypolaena robusta*

In 2015, GHD recorded three individual plants within Study Areas 3 and 4.

***Schoenus griffinianus* (Priority 4)**

Schoenus griffinianus is small, tufted perennial sedge that grows to a height of 0.1 metres high. It flowers from September to October and occupies white sand (DPaW, 1998-). *NatureMap* indicates 50 records are known in Western Australian and six records within 20 km of the Study Areas.



Plate 15 *Schoenus griffinianus*

In 2015, GHD recorded three individual plants from Study Areas 1, 2 and 4.

4.4.3 Other Significant Flora

The flora species recorded during the field surveys were assessed to determine whether any were regarded as other 'significant flora' as defined by the EPA (2004a). A large number of species were recorded that are either regional endemics (endemic to the Lesueur subregion or endemic to the Swan Coastal or are occurring at the outer extent of their range. Only one taxon – a weed, **Coriandrium sativum* (Coriander), was recorded 80 to 120 km north of its nearest known record.

4.4.4 Likelihood of Occurrence Assessment Following Results of Field Survey

The review of the desktop "likelihood of occurrence" assessment of conservation significant flora taxa following field assessment indicates the following:

- 137 unlikely to occur;
- 11 possible to occur; and
- 38 likely to occur.

A summary of the flora taxa that are "likely to occur" or "possible to occur" within the Study Areas is provided in Table 21.

Table 21 Summary of Likelihood Assessment

Species Name	Status	Assessment Outcome
<i>Catacolea enodis</i>	P2	This species was not recorded during the field survey; however there is suitable habitat within the Study Areas. This taxon prefers deep white sand over laterite with tall heath, which is associated with Vegetation Type 6 – Mixed Heath on White Sand (with laterite).
<i>Lyginia excelsa</i>	P1	This species was not recorded during the field survey; however there is suitable habitat within the Study Areas. This taxon prefers dry heath and Banksia woodland, which is associated with Vegetation Type 7 – Low Open <i>Banksia</i> Woodland and Vegetation Type 1 - <i>Banksia</i> Woodland on White Sand.
<i>Onychosepalum microcarpum</i>	P2	This species was not recorded during the field survey; however there is suitable habitat within the Study Areas. This taxon prefers dry heath in low woodland, which is associated with Vegetation Type 7 – Low Open <i>Banksia</i> Woodland.
<i>Chordifex reseminans</i>	P2	This species was not recorded during the field survey; however there is suitable habitat within the Study Areas. This taxon prefers dry sand, Heath, which is associated with vegetation 5 – Heath and Emergents, and Vegetation Type 6 – Mixed Heath on White Sand (with laterite).
<i>Baeckea</i> sp. Moora (R. Bone 1993/1)	P3	This species was not recorded during the field survey; however there is suitable habitat within the Study Areas. This taxon prefers gravelly soils, which is associated with Vegetation Type 6 – Mixed Heath on White Sand (with laterite).
<i>Banksia chamaephyton</i>	P4	These species were not recorded during the field survey; however there is suitable habitat within the Study Areas. These taxa prefer grey or white sand over laterite, which is associated with Vegetation Type 6 – Mixed Heath on White Sand (with laterite), Vegetation Type 7 - Low Open <i>Banksia</i> Woodland and Vegetation Type 8 – Heath on gravel.
<i>Calothamnus accedens</i>	P4	
<i>Stylidium inversiflorum</i>	P4	
<i>Eucalyptus pendens</i>	P4	
<i>Thysanotus anceps</i>	P3	
<i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i>	P3	
<i>Beaufortia bicolor</i>	P3	
<i>Calytrix eneabbensis</i>	P4	
<i>Isopogon drummondii</i>	P3	

Species Name	Status	Assessment Outcome
<i>Persoonia rudis</i>	P3	
<i>Banksia subulata</i>	P3	
<i>Persoonia filiformis</i>	P2	
<i>Leucopogon</i> sp. Badgingarra (R. Davis 421)	P2	This species was not recorded during the field survey; however there is suitable habitat within the Study Areas. This taxon prefers grey sand, dry white sand, Hills, plains, which is associated with Vegetation Type 5 – Heath and Emergent, Vegetation Type 6 – Mixed Heath on White Sand (with laterite), Vegetation Type 7-Low Open <i>Banksia</i> Woodland and Vegetation Type 8 – Heath on gravel.
<i>Anigozanthos humilis</i> subsp. Badgingarra (S.D. Hopper 7114)	P2	Grey-white sand, rich brown sandy loam, sandy clay, alluvial soils. Low plains, river-banks, winter-wet swamps.
<i>Asterolasia drummondii</i>	P4	This species was not recorded during the field survey; however there is suitable habitat within the Study Areas. This taxon prefers lateritic gravel and sand or loam. Lateritic hills and sandplains, breakaways. These habitat types are associated with Vegetation Type 6 Mixed Heath on White Sand (with Laterite).
<i>Lepidobolus quadratus</i>	P3	This species was not recorded during the field survey; however there is suitable habitat within the Study Areas. This taxon prefers lateritic gravel, grey/white sand, with dry kwongan. This habitat is associated with Vegetation Type 6 Mixed Heath on White Sand (with Laterite).
<i>Banksia dallanneyi</i> subsp. <i>pollostata</i>	P3	These species were not recorded during the field survey; however there is suitable habitat within the Study Areas. These taxa prefer lateritic gravel, which associated with Vegetation Type 6 Mixed Heath on White Sand (with Laterite) and Vegetation Type 8 - Heath on gravel.
<i>Banksia splendida</i> subsp. <i>macrocarpa</i>	P3	
<i>Banksia kippistiana</i> var. <i>paenepeccata</i>	P3	
<i>Xanthosia tomentosa</i>	P4	
<i>Banksia nobilis</i> subsp. <i>fragrans</i>	P3	This species was not recorded during the field survey; however there is suitable habitat within the Study Areas. This taxon prefers lateritic rises, which is associated with Vegetation Type 6 Mixed Heath on White Sand (with Laterite) and Vegetation Type 8 Heath on gravel.
<i>Eucalyptus absita</i> x <i>loxophleba</i>	P1	This species was not recorded during the field survey; however there is suitable habitat within the Study Areas. This taxon prefers lateritic sand, which is associated with Vegetation Type 6 Mixed Heath on White Sand (with Laterite) and Vegetation Type 8 Heath on gravel.
<i>Hakea neurophylla</i>	P4	These species was not recorded during the field survey; however there is suitable habitat within the Study Areas. These taxa prefer lateritic sandy soils on hillsides or slopes, which associated with Vegetation Type 6 Mixed Heath on White Sand (with Laterite) and Vegetation Type 8 Heath on gravel.
<i>Beaufortia eriocephala</i>	P3	
<i>Verticordia insignis</i> subsp. <i>eomagis</i>	P3	

Species Name	Status	Assessment Outcome
<i>Leucopogon squarrosus</i> subsp. <i>trigynus</i>	P2	Primarily occurs on the Bassendean Sands of the Swan Coastal Plain. This species was not recorded during the field survey but restricted to possibly occur in Study Area 1. The habitat is broadly represented throughout the local area and associated with all vegetation types recorded within Study Areas 1, with the exception being Vegetation Type 3 – Geomorphic Wetland.
<i>Verticordia rutilastra</i>	P3	This species was not recorded during the field survey; however there is suitable habitat within the Study Areas. This taxon prefers sand and lateritic gravel on hills, which is associated with Vegetation Type 6 - Mixed Heath on White Sand (with Laterite) and Vegetation Type 8 - Heath on gravel.
<i>Grevillea thyrsooides</i> subsp. <i>pustulata</i>	P3	These species were not recorded during the field survey; however there is suitable habitat within the Study Areas. These taxa prefer sand or sandy gravel, which is associated with Vegetation Type 6 - Mixed Heath on White Sand (with Laterite) and Vegetation Type 8 - Heath on gravel.
<i>Grevillea thyrsooides</i> subsp. <i>thyrsooides</i>	P3	
<i>Thysanotus glaucus</i>	P4	
<i>Allocasuarina grevilleoides</i>	P3	These species were not recorded during the field survey; however there is suitable habitat within the Study Areas. These taxon prefer sand over laterite, gravel, sometimes on hills which is associated with Vegetation Type 6 - Mixed Heath on White Sand (with Laterite) and Vegetation Type 8 - Heath on gravel.
<i>Patersonia spirifolia</i>	En	
<i>Arnocrinum gracillimum</i>	P2	
<i>Hypocalymma linifolium</i>	P1	These species were not recorded during the field survey; however there is suitable habitat within the Study Areas. These taxon prefer sand, which is associated with Vegetation Type 1 - Banksia Woodland on White Sand, Vegetation Type 5 – Heath + Emergent and Vegetation Type 7 - Low Open Banksia Woodland.
<i>Onychosepalum nodatum</i>	P3	
<i>Guichenotia alba</i>	P3	This species was not recorded during the field survey; however there is suitable habitat within the Study Areas. This taxon prefers sandy and gravelly soils in low-lying flats, depressions, which is associated with Vegetation Type 6 – Mixed heath on White Sand (with Laterite) low lying areas generally east side of the Brand Highway.
<i>Comesperma rhadinocarpum</i>	P2	These species were not recorded during the field survey; however there is suitable habitat within the Study Areas. These taxon prefer sandy soils, which likely to be associated with Vegetation Type 5 – Heath + Emergent, Vegetation Type 7 - Low Open Banksia Woodland and Vegetation Type 1 - Banksia Woodland on White Sand. However, there is limited information on sand type for these taxa and therefore they may possibly occur.
<i>Platysace ramosissima</i>	P3	
<i>Goodenia xanthotricha</i>	P2	
<i>Eucalyptus annuliformis</i>	P1	

Species Name	Status	Assessment Outcome
<i>Eucalyptus absita</i>	En	This taxon was not recorded during the field survey. It prefers white lateritic sand, which is associated with north-eastern portion Vegetation Type 6 - Mixed Heath on White Sand (with Laterite) and mapped in Figure 6.
<i>Desmocladius elongatus</i>	P4	These species were not recorded during the field survey; however there is suitable habitat within the Study Areas. These taxon prefer white or grey sand, which is associated with Vegetation Type 1 - Banksia Woodland on White Sand, Vegetation Type 5 – Heath + Emergent and Vegetation Type 7 - Low Open Banksia Woodland.
<i>Jacksonia anthoclada</i>	P3	
<i>Beyeria cinerea</i> subsp. <i>cinerea</i>	P3	

4.4.5 Introduced Flora

Sixty-five introduced flora taxa were recorded from the Study Areas (Appendix C). The majority of weed species recorded were widespread and often associated with disturbed areas or agricultural practices.

No Weeds of National Significance were recorded. One pest organism Declared under the BAM Act was recorded from six locations within Study Area 1: *Zantedeschia aethiopica* (Arum Lily).



4.5 Fauna

4.5.1 Habitat Types

A total of five habitat types were identified within the Study Area during the field survey, based on the predominant landforms, soils and vegetation structure. These fauna habitat types are closely aligned with the vegetation types outlined in Section 4.2.1 and include:

- Banksia woodland;
- Geomorphic Wetland;
- Marri-Banksia woodland;
- Heath Shrubland; and
- Cleared or Degraded.

Table 22 Project Area Habitat Types

Habitat Type and Extent	Indicative Photograph
<p>Banksia woodland (11.7 ha)</p> <p>The Banksia woodland habitat type was observed in Study Areas 1. The flora species identified within this habitat is consistent with the Banksia Woodland on White Sand vegetation type. These woodlands vary in density and fire age, and include scattered <i>Eucalyptus tottiana</i> trees over diverse mixed shrubs, grasses, herbs and sedges.</p> <p>The Banksia woodlands are both structurally and floristically diverse and contain a wide variety of habitat resources for fauna. Structurally, the vegetation varies throughout the Study Area from very dense to more open woodlands, with some areas comprising very dense patches of <i>Banksia</i> shrubs. Throughout this habitat there are also several micro-habitat features such as logs, branches and thick leaf litter.</p> <p>The Banksia woodland provides suitable foraging habitat for the Carnaby's Black-Cockatoo. This habitat type is also suitable for the Western Brush Wallaby; however, due to the patch size it is unlikely to be essential habitat for this taxon. This habitat type also offers suitable habitat for the Carpet Python (<i>Morelia spilota</i> subsp. <i>imbricata</i>) and Black-striped Snake (<i>Neelaps calonotos</i>).</p>	
<p>Marri Banksia woodland (3.3 ha)</p> <p>This habitat type was recorded within Study Area 1 and consisted of Marri trees and banksias. The habitat was in Very Good to Good condition. The habitat consisted of a canopy, shrub layer and groundwater. The canopy was relatively open, 10 to 30% cover, similarly for the shrub layer and ground cover. Impacts from historical fire were evident; however, this habitat type was rated a Good to Very Good vegetation condition.</p> <p>Similarly to the Banksia woodland habitat type, this habitat type was structurally diverse and provided a range of habitat resource for fauna. The presence of leaf litter, wood litter and some logs provides microhabitat for fauna. However, the trees were absent of hollows and unlikely to provide suitable breeding habitat, but could be suitable roosting habitat for the Carnaby's Black-Cockatoo. Similarly, the presence of the tall Marri trees provides suitable foraging habitat for the Carnaby's Black-Cockatoo. This habitat type also offers suitable habitat for the Carpet Python (<i>Morelia spilota</i> subsp. <i>imbricata</i>) and Black-striped Snake (<i>Neelaps calonotos</i>).</p>	

Habitat Type and Extent

Heath Shrubland (187.7 ha)

The Heath Shrubland was one of the most dominant habitat types within the Study Area, covering a total area of 187.7 ha. The Heath Shrubland comprised a rich diversity of the flora taxa including Myrtaceae, heath, Proteaceae, rushes, sedges and many grasses, sometimes with emergent *Eucalyptus tottiana*.

This habitat type lack structure and mostly consisted of a shrub layer. Similarly, the Heath Shrubland lacked microhabitats such as logs, wood and leaf litter.

GHD recorded approximately 15 Carnaby's Black-Cockatoos flying over Study Areas 2 and 4. GHD observed the birds exhibiting foraging behaviour on *Eucalyptus tottiana* immediately adjacent to Study Area 4.

This habitat type also provides suitable habitat for the Woma (*Aspidites ramsayi*), Carpet Python (*Morelia spilota* subsp. *imbricate*) and Black-striped Snake (*Neelaps calonotos*).

Indicative Photograph



Low Open Banksia Woodland (195.2 ha)

The Low Open Banksia Woodland habitat type was the most dominant throughout Study Areas 2, 3 and 4, covering an extent of 195.2 ha. This habitat type comprised of Proteaceous shrubs dominated by *Banksia* and with Heath.

This habitat type lack structure and mostly consisted of a shrub layer. Similarly, this habitat type lacked microhabitats such as logs, wood and leaf litter.

This habitat type provides suitable foraging habitat for Carnaby's Black-Cockatoo. This habitat type also offers suitable habitat for the Carpet Python (*Morelia spilota* subsp. *imbricata*) and Black-striped Snake (*Neelaps calonotos*).



Habitat Type and Extent

Geomorphic Wetland (2.0 ha)

This habitat type is a permanently inundated wetland which forms part of the Swan Coastal Plain Geomorphic Wetland system. The wetland consisted of dense vegetation, predominately rushes and sedges.

The habitat type provides a water source for many fauna species and habitat for amphibians. The surrounding land use to the west of this habitat is broadacre agriculture. As a result, much of the western side of the wetland was disturbed, with evidence of introduced flora species.

Indicative Photograph



Cleared or Degraded (59.1 ha)

The cleared or degraded habitat was recorded in all Study Areas. This habitat was often associated with the road maintenance zone, tracks, firebreaks, parking bays and historical gravel pits, as indicated in the photograph. These areas offer very little habitat resources for fauna and are generally devoid of native vegetation.



4.5.2 Habitat Connectivity and Linkages

Habitat linkages are important to allow animals to move between areas of resource availability. Habitat linkage is important for ground and aerial fauna, providing cover, resources and linking areas for rest and reproduction.

Fragmentation of habitat limits the resources available to species, particularly sedentary species, which means they may be more vulnerable to natural disasters (such as fire events) or habitat change overtime. Fragmentation of habitat can also lead to edge effects, leading to degradation of the habitat. Where the distance between habitat fragments is small, species may still be able to move between these habitat areas, but may be more exposed to predation pressures in the cleared areas.

The habitat within the Study Areas is typically well connected both locally and regionally to larger areas of remnant vegetation to the west and east. These vegetated corridors provide an important regional linkage for native fauna, and connect the large tracts of native vegetation, approximately 385,099 ha within 20 km of the Study Areas, which is associated with the Badgingarra National Park (and various nature reserves in the west including Namming Nature Reserve and South Mimegarra Nature Reserve), through to the remnants of native vegetation forming patches in the largely agricultural landscape of the Wheatbelt to the east.

At a local scale, Study Area 1 is immediately surrounded by broadacre agricultural land and patches of remnant vegetation. The western portion of Study Areas 2, 3, 4 and 5 forms part of large tracts of vegetation associated with conservation areas. The eastern side of the Study Areas is adjacent to broad acre agriculture, which provides a barrier for the movement of ground dwelling fauna to the surrounding area.

4.5.3 Recorded Fauna Diversity

The field survey recorded 45 fauna species from the Study Areas. A summary of fauna records and comparison with desktop findings are provided in Table 23. GHD recorded low fauna diversity, between 5% and 19% of records known within 20 km of Study Areas, provided in Section 3.6.1. The lower diversity is due to relatively small and narrow corridor surveyed during the field assessment as compared with the desktop assessment, including a large buffer overlapping the Badgingarra National Park and other relatively undisturbed habitat. A list of the fauna species recorded during the survey is provided in Appendix D.

Table 23 Recorded Fauna Diversity

Study Area	Amphibians	Birds	Mammals	Reptiles	*%
Study Area 1	1	22	4	1	19%
Study Area 2	-	14	1	3	11%
Study Area 3	-	10	3	1	8%
Study Area 4	-	18	1		12%
Study Area 5	-	7	-	-	5%

*%Recorded in field survey compared to Desktop Assessment.

4.5.4 Conservation Significant Fauna

During the field survey two conservation significant fauna species were recorded:

- The Rainbow Bee-eater (*Merops ornatus*); and
- The Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*).

Rainbow Bee-eater

The Rainbow Bee-eater was recorded from Study Area 2 (Figure 5). Study Area 2 is considered suitable non-breeding habitat for the Rainbow Bee-eater. Its habitat is broadly represented in the local region, with 385,099 ha of potential habitat with 20 km of the Study Areas.

Carnaby's Black-Cockatoo

Carnaby's Black-Cockatoo is listed as Endangered under the EPBC Act and under Schedule 1 (Threatened) of the WC Act.

Approximately fifteen birds were observed exhibiting foraging behaviour on a *Eucalyptus todtiana* tree immediately outside Study Area 4 (Plate 16 and Figure 5).



Plate 16 Carnaby's Black-Cockatoo foraging on *Eucalyptus todtiana*

Throughout the duration of the survey small flocks of the species were also observed flying over Study Areas 2 and 4 (Plate 17). No suitable nesting habitat (trees containing hollows) were recorded from the Study Areas. However, potentially suitable trees (non-hollow trees) were observed in Study Area 1.



Plate 17 Carnaby's Black-Cockatoo over Study Area 4

Description and Ecology

In the south-west of Western Australia the Carnaby's Black-Cockatoo mostly occurs in the Wheatbelt, where the species breeds between July/August to January/February. The Carnaby's Black-Cockatoo is highly mobile and displays a seasonal migratory pattern that is linked to breeding, with the majority of birds moving to the higher rainfall coastal areas to forage during the non-breeding season (DSEWPaC 2012).

The Study Areas are located within the known breeding range of Carnaby's Black-Cockatoo (DSEWPaC 2012), and there is suitable habitat for the species within the Study Area. The field survey was carried out during the breeding season of Carnaby's Black-Cockatoo.

Habitat

A description of the extent of the foraging, potential breeding and roosting habitat for the species within the Study Areas is summarised in Table 24.

Overall, there are approximately 202.7 ha of remnant vegetation within the Study Areas that provides habitat for the Carnaby's Black-Cockatoo, which includes Marri Banksia woodland, Banksia woodland, Low Banksia Woodland and Heath Shrubland. This remnant vegetation provides foraging, roosting and potential breeding habitat for the species. The 59.1 ha of completely Cleared and Degraded habitat in the Study Areas is not included in the extent of Carnaby's Black-Cockatoo habitat as it does not provide any foraging, roosting or nesting resources for the species.

This habitat can be summarised as:

- **Foraging:** Overall there is approximately total of 202.7 ha of suitable foraging habitat for Carnaby's Black-Cockatoo within the Study Areas (the majority). This habitat comprises Marri Banksia woodland, Banksia woodland, Low Banksia Woodland and Heath Shrubland, which provide high value foraging resources for the species, including Marri nuts and a diversity of proteaceous species (Groom, 2011).

- **Breeding:** The habitat assessment identified four potential breeding trees with a suitable Diameter at Breast Height (DBH) throughout the Study Area 1; however, did not contain any hollows.
- **Roosting:** An approximate area of 3.3 ha of suitable roosting habitat occurs within Study Area 1 (Figure 6), however, there was no evidence of roosting recorded during the survey.

Table 24 Summary and Extent of Carnaby's Black-Cockatoo Habitat within the Study Areas

Habitat Type	Presence within the Study Area	Evidence
Foraging habitat	202.7 ha, the majority of the Study Areas.	None
Actual breeding habitat	None	None
Potential breeding habitat	Four potential breeding habitat trees with a DBH \geq 500 mm, none contained hollows: <ul style="list-style-type: none"> • Three Marri trees with no hollows; and • One <i>Eucalyptus tottiana</i> tree with no hollows. 	
Roosting habitat	3.3 ha Marri Banksia Woodland, which would provide suitable roosting habitat	No roosting sites were recorded

Local and Regional Context

The two records of Carnaby's Black-Cockatoo breeding are considered to be significant. Regans Ford is a known breeding site for the species (Johnstone *et al.* 2011, DEC, 2012), and previous DPaW nesting records have indicated that small numbers of the species breed in the area (DEC, 2012). GHD (2016) in a study at Regan's Ford confirmed that Carnaby's Black-Cockatoo are breeding in the location. Study Area 1 is also important as it provides foraging resources in close proximity to known breeding habitat, which is very important for the species breeding success. Success in breeding is dependent on the quality and proximity of feeding habitat within 12 km of nesting sites (Johnstone *et al.* 2011, DEC, 2012), and abundant suitable feeding habitat adjacent to breeding sites is necessary to provide food for the survival of the chick. Therefore, the foraging habitat within the Study Area 1 would support both individuals breeding within the Study Area 1 as well as in the local area.

The Study Areas are located in region where a number of areas are recognised as providing important breeding habitat for the Carnaby's Black-Cockatoo. These include:

- A 314 ha tract of land two kilometres south of Cataby is recognised as an Important Bird Area because it supports up to 24 breeding pairs of Carnaby's Black-Cockatoo (Dutson *et al.*, 2009) – located approximately 10 km south of the Study Area 2;
- A 8,287 ha area of land at Gillingarra which is recognised as an Important Bird Area supporting up to 20 breeding pairs of Carnaby's Black-Cockatoo which nesting in Marri trees and feeding the surrounding shrublands (Dutson *et al.*, 2009) – located approximately 70 km east of the Study Area 1;
- An area of vegetation around Cataby Brook has been identified as supporting Carnaby's Black-Cockatoo breeding and feeding habitats (EPA, 2014) – located approximately 12 km south of the Study Area 2; and

- There have been numerous breeding records in the northern Swan Coastal Plain region in more recent years, including Gingin, Bindoon, Mooliabeenee, Badgingarra and the Boonanarring Nature Reserve (9,250 ha) (Johnstone et al., 2011).

Therefore, these Study Areas is located within a region that is known to be important to support Carnaby's Black-Cockatoo breeding. On a local scale, there are limited suitable nesting resources for the species (i.e. hollow-bearing trees), with broadscale clearing for agriculture and large patches of remnant vegetation which largely comprise of shrublands.

4.5.5 Likelihood of Occurrence Assessment following Results of Field Survey

A likelihood of occurrence assessment was conducted for all conservation significant fauna species identified in the desktop assessment (Section 3.7.2). This assessment is based on species biology, habitat requirements, the quality and availability of suitable habitat as determined during the field survey and records of the species in the Study Areas.

The assessment concluded that in addition to the two species present (Carnaby's Black-Cockatoo and Rainbow Bee-eater), five other species are considered "likely to occur", four species are "unlikely to occur" and three species are "highly unlikely to occur" within the Study Areas.

The five conservation significant fauna species considered likely to occur in the Study Areas include:

- *Asphidites ramsayi* (Woma) – Schedule 4 (WC Act);
- *Dasyurus geoffroii* (Chuditch) – EPBC Act (Vulnerable) and Schedule 1 (WC Act);
- *Macropus irma* (Western Brush Wallaby) – Priority 4 (DPaW status);
- *Morelia spilota* subsp. *imbricata* (Carpet Python) – Schedule 4 (WC Act); and
- *Neelaps calonotos* (Black-striped Snake) – Priority 3 (DPaW Status).

All of these species are all generally wide ranging, are known to utilise the habitats available in the Study Areas, and have been recorded in proximity to the Study Areas. A description of each species and their associated habitat within the Study Areas is provided in Table 25.

Table 25 Description of Habitat for Conservation Significant Fauna Species Considered Likely to Occur within the Study Areas

Species	Extent and Location of Suitable Habitat	Description of Suitable Habitat
<i>Dasyurus geoffroii</i> (Chuditch)	Study Area 1, including all habitat types. Entire Study Areas 2, 3, 4 and 5.	<ul style="list-style-type: none"> The Chuditch occurs in low densities throughout the southwest and is known to utilise rural landscapes; The Chuditch has previously been recorded as roadkill within 20 km of the Study Area, near the bridge across the Moore River in 2001; The rate of occupancy of the Chuditch in Study Area 1 is likely to be low given the fragmentation of the habitat by the existing highway and extent of cleared agricultural land in the surrounding area; and Habitat with Study Areas 2, 3, 4 and 5 are likely to provide prey resource; however, no records of this species are known and therefore uncertainty whether this habitat is important to the Chuditch exists.
<i>Macropus irma</i> (Western Brush Wallaby)	Study Area 1, <i>Banksia</i> Woodland habitat type.	<ul style="list-style-type: none"> There are multiple records of the Brush Wallaby in proximity to the Study Area 1 and the species is known to utilise rural landscapes. It is likely that the Wallaby would utilise the <i>Banksia</i> Woodland habitat type within Study Area 1; and It is possible that the Wallaby would utilise the Study Area occasionally for refuge and foraging.
<i>Morelia spilota</i> subsp. <i>imbricate</i> (Carpet Python)	Study Area 5.	<ul style="list-style-type: none"> There is suitable habitat available in all Study Areas and the nearest record is 20 km north-east of Study Area 5.
<i>Neelaps calonotos</i> (Black-striped Snake)	Study Areas 2, 3, 4 and 5.	<ul style="list-style-type: none"> There is suitable habitat available in Study Areas 2, 3, 4 and 5 and the nearest record is three kilometres west of Study Area 3.
<i>Asphidites ramsayi</i> (Woma)	Study Area 5.	<ul style="list-style-type: none"> There is suitable habitat available in all Study Area and the nearest record is 17 km north-east of Study Area 5.

5. Referral to State and Australian Governments

This section details the requirements for environmental approvals for the Project.

5.1 Referral to the Department of the Environment

Matters of National Environmental Significance (MNES) are factors that require legislated protection in order to conserve biodiversity, protect world and national heritage places and comply with international treaties. An assessment of the occurrence of the biological MNES within the Study Area is provided in Table 26, including recommendations for further assessment once the project footprint has been determined.

Table 26 Assessment of the Project against Matters of National Environmental Significance

MNES	Presence/Absence	Recommendation
World Heritage Properties	None – nearest 10 km west of Study Area 4.	Not applicable
National Heritage Properties	None – nearest 46 km west of Study Area 3.	Not applicable
Ramsar Wetlands	None – nearest 350 km southwest of Study Area 3.	Not applicable
Nationally Threatened Species and Ecological Communities	None (TEC 31 km S). Carnaby's Black-Cockatoo present and foraging habitat present.	Uncertainty (See Table 24) Carnaby's Black-cockatoo recorded. Suitable roosting and foraging habitat present. Uncertainty exists with regard to the clearing extent and therefore significance of impact unknown; however, referral is recommended. Further assessment of the potential impacts to the Carnaby's Black-Cockatoo will be required.
	Badgingarra Box habitat present that is considered important habitat covering an extent of 3.42 ha as defined by DotE (2009) was recorded in the north-eastern portion of vegetation type 6.	Once the road realignment and bridge location have been confirmed, further assessment of the potential impacts to the Badgingarra Box habitat will be required.
	<i>Patersonia spirifolia</i> potential suitable habitat present.	Not required as none expected – potential suitable habitat identified but known records within the Study Area. This habitat is not considered critical to its survival.

MNES	Presence/Absence	Recommendation
	Chuditch are considered likely to occur within Study Area 1; However, suitable habitat is unlikely to offer important habitat to the Chuditch due to the fragmentation of remnant vegetation and the entirety of the Study Area being surrounded by broad acre agriculture; however, it may form part of an ecological linkage between larger reserves, in particular the conservation reserve south and south-west of this Study Area.	Once the road realignment and bridge location have been confirmed, further assessment of the potential impacts to the Chuditch will be required.
Listed Migratory Species	One recorded – Potential Rainbow Bee-eater habitat recorded.	Not required as none expected – Entire Project Area is considered suitable non-breeding habitat for the Rainbow Bee-eater. Its habitat is broadly represented in the local region, with 385, 099 ha of potential habitat with 20 km of the Study Areas.
Commonwealth Marine Areas	None – 65 km west of Study Area 3.	Not applicable
The Great Barrier Reef Marine Park	Not applicable – Great Barrier Reef Marine Park is located in Queensland.	Not applicable
Nuclear Actions	Not applicable.	Not applicable
A water resource (in relation to coal seam gas and/or large coal mining development)	Not applicable.	Not applicable

***Eucalyptus absita* – Badgingarra Box (Endangered)**

Eucalyptus absita was not recorded within the Study Areas; however records of this taxon are located xx km north of Study Area 5 and the Vegetation Type 6 (north-eastern portion) forms part of the tract of vegetation associated with these locations of the Badgingarra Box records. This portion of Vegetation Type 6 is situated in the lower part of the landscape and meets the habitat requirements for this species, which covers an extent of 3.42 ha. As defined DotE (2009), the area identified by GHD are important because they provide potential habitat for natural range extension and/or allowing pollinators or biota essential to the continued existence of the species to move between populations.

***Dasyurus geoffroi* - Chuditch (Vulnerable)**

Chuditch was not recorded during within the Study Areas; however suitable habitat is present. The Chuditch is present in a vast variety of habitat, with some key features required for their survival including adequate den resource (i.e. hollow logs, burrows or rock crevices), sufficient prey recourse (particularly large invertebrates) and sizeable area (>20,000 ha). Chuditch requires large intact natural areas due to their large home ranges and resource requirements. Chuditch are rarely found where habitat is severely fragmenting from agriculture. Furthermore, corridors of retained vegetation such as road reserves are important to chuditch as links

between larger reserves (DEC, 2012). Study Area 1 is unlikely to offer important habitat to the Chuditch due to the fragmentation of remnant vegetation and the entirety of the Study Area being surrounded by broad acre agriculture; however, it may form part of an ecological linkage between larger reserves, in particular the conservation reserve south and south-west of this Study Area.

Carnaby's Black-Cockatoo

Referral to the DotE is recommended for the proposed Project, due to uncertainty with regards to final design and clearing extent. The decision process to determine if referral is required is provided in Table 27.

Table 27 Risk Referral Table for Black-Cockatoos

Risk Type	Referral Trigger
Uncertainty: Referral to DSEWPAC is Recommended or Contact the Department	
Clearing of any known nesting tree.	Referral may not be required No known nesting trees were recorded within the Study Area.
Clearing of any part or degradation of breeding habitat in a woodland or forest within a species' known breeding range.	Referral is not triggered No potential breeding habitat was identified within the Study Areas; however, the project occurs within known breeding areas.
Clearing of more than one hectare of quality foraging habitat.	Referral recommended There is approximately 202.7 ha of foraging habitat present within the Study Areas. Project design is yet to be finalised and therefore there is uncertainty in clearing extent.
Creating a gap of greater than four kilometres between patches of Black-Cockatoo habitat (breeding, foraging or roosting).	Referral recommended At a local scale, Study Area 1 is immediately surrounded by a broadacre agricultural land and patches of remnant vegetation. The western portion of Study Areas 2, 3, 4 and 5 forms part of large tracts of vegetation associated with conservation areas. The eastern side of the Study Areas are adjacent to broad acre agriculture. Project design is yet to be finalised and therefore there is uncertainty in clearing extent.
Clearing or degradation (including pruning of top canopy) of a known roosting site.	Referral recommended Project design is yet to be finalised and therefore there is uncertainty in clearing extent. Potential roosting habitat was also recorded within Study Area 1.
Degradation (such as through altered hydrology or fire regimes) of more than one hectare of foraging habitat. Significance will depend on the level and extent of degradation and the quality of the habitat.	Referral recommended Project design is yet to be finalised. Approximately 202 ha of foraging habitat and 11 ha of roosting habitat was recorded from the Study Areas.

Risk Type	Referral Trigger
Clearing or disturbance in areas surrounding Black-Cockatoo habitat that has the potential to degrade habitat through introduction of invasive species, edge effect, hydrological changes, increase human visitation or fire.	<p>Referral recommended</p> <p>Project design is yet to be finalised and therefore there is uncertainty in clearing extent</p>
Actions that do not directly affect the listed species but that have the potential for indirect impacts such as increasing competitors for nest hollows.	<p>Referral is not triggered</p> <p>No trees containing hollows were recorded from the Study Areas.</p>
Actions with the potential to introduce known plant diseases such as <i>Phytophthora</i> spp.	<p>Referral recommended</p> <p><i>Phytophthora</i> is likely to be present in this soil type and location.</p>

5.2 Referral to the Environmental Protection Authority

Significant proposals must be referred to the EPA under Section 38 of the EP Act.

In deciding whether a proposal will be subject to the formal environmental impact assessment process, the EPA takes into account the environmental significance of any potential impacts that may result from the implementation of the scheme or proposal.

With consideration of the biological values discussed in this report, it is considered may be that the Project would require referral to the EPA under Section 38 of the EP Act, pending the outcome of the finalisation of clearing envelop for the Project.

5.3 Department of Environment Regulation

A preliminary assessment of the project against the Ten Clearing Principles has been undertaken and has determined that the Project is likely to be **at variance** with Principles (a), (b), (c) and (e). The Project **maybe at variance** with Principles (d) and (h) due to uncertainty with regard to the clearing extent. The Project is **not likely to be at variance** with Principles (f) and (i) if Main Roads develop a buffer zone for the geomorphic wetland to avoid clearing such vegetation in Study Area 1. GHD also recommends Main Roads avoid clearing of vegetation within and along the ephemeral drainage line in Study Area 3. The Project is **not likely to be at variance** with Principles (j). An assessment of the Ten Clearing Principles is provided in Table 28.

Table 28 Assessment Against the Ten Clearing Principles

Principle	Assessment	Data sources
<p>(a) – Native vegetation should not be cleared if it comprises a high level of biological diversity.</p>	<p>Vegetation Type and Condition</p> <p>Pre-European vegetation mapping of the area (Beard 1979) identified four Vegetation Associations within the Study Areas:</p> <ul style="list-style-type: none"> • 7 “Medium woodland, tuart & jarrah”; • 1030 “Low woodland; <i>Banksia attenuata</i> & <i>B. menziesii</i>”; • 1031 “Mosaic: Shrublands; hakea scrub-heath/Shrublands; dryandra heath”; and • 1035 “Mosaic: Medium open woodland; marri/Shrublands; dryandra heath.” <p>Eight vegetation types were identified within the Study Areas during the field survey. The dominant vegetation types were Mixed Heath on White Sands (with laterite) covering an extent of 165.7 ha (Vegetation Type 6) and Low Open <i>Banksia</i> Woodland, covering an extent of 195.2 ha (Vegetation Type 7). The vegetation condition was rated between <i>Pristine or Nearly So</i> to <i>Completely Degraded</i>.</p> <ul style="list-style-type: none"> • Conditions 1 to 2 (<i>Pristine or Nearly So</i> to <i>Excellent</i>) 9.7 ha; • Condition 2 (<i>Excellent</i>) 301.6 ha; • Conditions 2-3 (<i>Excellent</i> to <i>Very Good</i>) 67.7 ha; • Condition 3 (<i>Very Good</i>) 20.5 ha; • Conditions 3 - 4 (<i>Very Good</i> to <i>Good</i>) 3.1 ha; • Condition 4 (<i>Good</i>) 0.9 ha; • Conditions 4-5 (<i>Good</i> to <i>Degraded</i>) • Condition 5 (<i>Degraded</i>) 1.9 ha; • Condition 5 – 6 (<i>Degraded</i> to <i>Completely Degraded</i>) and • Condition 6 (<i>Completely Degraded</i>) 55.7 ha. <p>Total Vascular Plant Taxa</p> <p>The project occurs in an area which has been undersurveyed, within the Murchison IBRA and Gascoyne IBRA regions. A total of 372 flora taxa, from 51 families, were recorded in the Study Areas during the field survey. This total comprised 355 native</p>	<p>GHD Survey (2015); DPaW (2007-); Threatened and Priority Flora Databases; The WA Herbarium database (WAHerb); and EPBC Protected Matters (2015).</p>

Principle	Assessment	Data sources
	<p>species (95%) and 17 introduced taxa (5%).</p> <p>Flora Likelihood Assessment</p> <p>A likelihood assessment was undertaken for conservation significant species identified in the desktop assessment. The assessment indicated that 137 are 'unlikely' to occur, 11 are 'possible' to occur and 37 'likely' occur.</p> <p>The following species were considered as likely or possible:</p> <ul style="list-style-type: none"> • <i>Allocasuarina grevilleoides</i> (Study Areas 4 and 5); • <i>Arnocrinum gracillimum</i> (Study Areas 4 and 5); • <i>Asterolasia drummondii</i> (Study Area 2); • <i>Baeckea</i> sp. Moora (R. Bone 1993/1) (Study Area 1); • <i>Banksia chamaephyton</i> (Study Area 1); • <i>Banksia kippistiana</i> var. <i>paenepeccata</i> (Study Areas 1); • <i>Banksia nobilis</i> subsp. <i>fragrans</i> (Study Areas 4 and 5); • <i>Banksia splendida</i> subsp. <i>macrocarpa</i> (Study Areas 4 and 5); • <i>Banksia subulata</i> (Study Areas 4 and 5); • <i>Beaufortia bicolor</i> (Study Areas 2, 3, 4 and 5); • <i>Beaufortia eriocephala</i> (Study Areas 2, 4 and 5); • <i>Beyeria cinerea</i> subsp. <i>cinerea</i> (Study Area 1); • <i>Calothamnus accedens</i> (Study Areas 4 and 5); • <i>Calytrix eneabbensis</i> (Study Areas 3 and 4); • <i>Catacolea enodis</i> (Study Areas 3, 4 and 5); • <i>Chordifex reseminans</i> (Study Areas 1, 3 and 5); • <i>Comesperma rhadinocarpum</i> (Study Areas 3, 4, and 5); 	

Principle	Assessment	Data sources
	<ul style="list-style-type: none"> • <i>Desmocladius elongatus</i> (Study Areas 2, 3, 4 and 5); • <i>Eucalyptus absita</i> (Study Areas 4 and 5); • <i>Eucalyptus absita x loxophleba</i> (Study Areas 3, 4 and 5); • <i>Eucalyptus annuliformis</i> (Study Areas beyond range but may occur); • <i>Eucalyptus pendens</i> (Study Areas 2, 3, 4 and 5); • <i>Goodenia xanthotricha</i> (Study Areas 4 and 5); • <i>Grevillea thyrsoides</i> subsp. <i>pustulata</i> (Study Areas 3 and 5); • <i>Grevillea thyrsoides</i> subsp. <i>thyrsoides</i> (Study Areas 3 and 4); • <i>Guichenotia alba</i> (Study Areas 2, 3, 4 and 5); • <i>Hakea neurophylla</i> (Study Areas 4 and 5); • <i>Hypocalymma linifolium</i> (Study Areas 3, 4 and 5); • <i>Isopogon drummondii</i> (Study Areas 2, 3 and 4); • <i>Jacksonia anthoclada</i> (Study Areas 3, 4 and 5); • <i>Lepidobolus quadratus</i> (Study Areas 3, 4 and 5); • <i>Leucopogon</i> sp. Badgingarra (R. Davis 421) (Study Areas 2, 3, 4 and 5); • <i>Leucopogon squarrosus</i> subsp. <i>trigynus</i> (Study Area 1); • <i>Lyginia excelsa</i> (Study Areas 2, 3 and 4); • <i>Malleostemon</i> sp. Cooljarloo (B. Backhouse s.n. 16/11/88) (Study Areas 1, 2 and 3); • <i>Onychosepalum microcarpum</i> (All Study Areas); • <i>Onychosepalum nodatum</i> (Study Areas 2, 3 and 4); • <i>Patersonia spirifolia</i> (Study Areas 4 and 5); 	

Principle	Assessment	Data sources
	<ul style="list-style-type: none"> • <i>Persoonia filiformis</i> (Study Areas 3, 4 and 5); • <i>Persoonia rudis</i> (Study Areas 3, 4 and 5); • <i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i> (Study Areas 2, 3, 4 and 5) • <i>Platysace ramosissima</i> (Study Area 1); • <i>Stylidium inversiflorum</i> (Study Areas 3, 4 and 5); • <i>Thysanotus anceps</i> (Study Area 5); • <i>Thysanotus glaucus</i> (Study Area 2, 3, 4 and 5); • <i>Verticordia insignis</i> subsp. <i>eomagis</i> (Study Areas 2, 3, 4 and 5); • <i>Verticordia rutilastra</i> (Study Areas 2, 3, 4 and 5); and • <i>Xanthosia tomentosa</i> (Study Areas 4 and 5). <p>Priority Flora</p> <p>13 Priority Flora taxa were recorded from the Project Area including:</p> <ul style="list-style-type: none"> • <i>Onychosepalum microcarpum</i> (Priority 2); • <i>Allocasuarina ramosissima</i> (Priority 3); • <i>Grevillea makinsonii</i> (Priority 3); • <i>Hypocalymma serrulatum</i> (Priority 3); • <i>Phlebocarya pilosissima</i> subsp. <i>pilosissima</i> (Priority 3); • <i>Stylidium hymenocraspedum</i> (Priority 3) • <i>Tetratheca angulata</i> (Priority 3); • <i>Conostephium magnum</i> (Priority 4); • <i>Desmocladus elongatus</i> (Priority 4); 	

Principle	Assessment	Data sources
	<ul style="list-style-type: none"> • <i>Eucalyptus macrocarpa</i> subsp. <i>elachantha</i> (Priority 4); • <i>Grevillea rudis</i> (Priority 4); • <i>Hypolaena robusta</i> (Priority 4); • <i>Schoenus griffinianus</i> (Priority 4); <p>Total Fauna Taxa</p> <p>The Study Areas recorded a relatively low diversity in comparison desktop findings within 20 km of each Study Area as a result of adverse weather conditions (i.e. wind, rain) and small extent of habitat. A summary of the survey findings is provided:</p> <ul style="list-style-type: none"> • One amphibian, 22 birds, four mammals and one reptile from Study Area 1, representing 19% of the fauna species known within 20 km of the Study Area; • 14 birds, one mammal and three reptiles from Study Area 2, representing 11% of the number of species known within 20km of the Study Area; • 10 birds, three mammals and one reptile from Study Area 3, representing eight per cent of fauna species known within 20 km of the Study Area; • 18 birds and one mammal from Study Area 4, representing 12% of fauna species known within 10 km of the Study Area; and • Seven birds were recorded from Study Area 5, representing five per cent of the fauna species known within 20 km of the Study Area. <p>The habitat within the Study Areas is well connected both locally and regionally to larger areas of remnant vegetation to the west and east. These vegetated corridors provide an important regional linkage for native fauna and connect the large tracts of native vegetation, 385,099 ha within 20 km of the Study Areas, which is associated with the Badgingarra National Park (and various nature reserves in the west (including Namming Nature Reserve and South Mimegarra Nature Reserve), through to the remnants of native vegetation forming patches in the largely agricultural landscape of the Wheatbelt to the east.</p> <p>At a local scale, the Study Area 1 is immediately surrounded by a broad acre agricultural land and patches of remnant vegetation. The western portion of Study Areas 2, 3, 4 and 5 are form part of large tracts of vegetation associated with conservation areas. The eastern side of the Study Areas are adjacent to broad acre agriculture, which provides a barrier for the movement of ground dwelling fauna to the</p>	

Principle	Assessment	Data sources
	<p>surrounding area.</p> <p>Conservation Significant Species or Communities</p> <p>No TECs were recorded within the Study Areas; however, GHD recorded one DPaW-listed PEC: the 'Swan Coastal Plain <i>Banksia attenuata</i>- <i>Banksia menziesii</i> woodlands' (Priority 3). Vegetation Type 1 'Banksia Woodland on White Sand' recorded in Study Area 1 was considered representative of this PEC. 7.5 ha of this vegetation was mapped within the Study Area 1.</p> <p>Outcome</p> <p>The Project clearing footprint has not yet been designed; however if habitat for Priority flora, fauna or ecological communities is to be directly or indirectly impacted, then the proposed clearing is at variance to this Principle.</p>	
<p>(b) – Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.</p>	<p>Threatened and Priority Fauna</p> <p>GHD recorded Carnaby's Black-Cockatoo (<i>Calyptorhynchus latirostris</i>) foraging on a <i>Eucalyptus todtiana</i> tree, immediately outside Study Area 4. There is approximately 202.7 ha of foraging habitat present within the Study Areas. An approximate area of 3.3 ha of suitable roosting habitat occurs within Study Area 1, however there was no evidence of roosting recorded during the survey.</p> <p>A likelihood assessment indicated that the Chuditch listed as Endangered under the EPBC Act is likely to occur within the Study Areas, due to suitable habitat.</p> <p>Furthermore, corridors of retained vegetation such as road reserves are important to Chuditch as links between larger reserves.</p> <p>Study Area 1 is unlikely to offer important habitat to the Chuditch due to the fragmentation of remnant vegetation, and the entirety of the Study Area is surrounded by broad acre agriculture. However, it may form part of an ecological linkage between larger reserves in particular the conservation reserve south and south-west of this Study Area. The remaining Study Areas form part of vast tracts of remnant vegetation, however do not comprise of suitable denning habitat. Habitat within Study Areas 2, 3, 4 and 5 is likely to provide prey resource, however no records of this species are known and therefore uncertainty whether this habitat is important to the Chuditch exists (DPaW, 2007-).</p> <p>Other Significant Fauna</p>	<p>GHD Survey (2015); NatureMap (2015); and EPBC Protected Matters (2015).</p>

Principle	Assessment	Data sources
	<p>One other significant fauna species was recorded from Study Area 2, the Rainbow Bee-eater (<i>Merops ornatus</i>). Study Area 2 is considered suitable non-breeding habitat for the Rainbow Bee-eater. Its habitat is broadly represented in the local region, with 385, 099 ha of potential habitat with 20 km of the Study Areas.</p> <p>The likelihood assessment indicated that a number of Schedule 4 and DPaW listed fauna taxa are likely to occur within the Study Areas because suitable habitat is present. The taxa and location for likely occurrences and these include:</p> <ul style="list-style-type: none"> • <i>Asphidites ramsayi</i> (Woma) – Schedule 4 (WC Act) – All Study Areas; • <i>Macropus irma</i> (Western Brush Wallaby) – Priority 4 (DPaW status) – Study Area 1; • <i>Morelia spilota</i> subsp. <i>imbricata</i> (Carpet Python) – Schedule 4 (WC Act) – Study Area 5; and • <i>Neelaps calonotos</i> (Black-striped Snake) – Priority 3 (DPaW Status) – Study Areas 2, 3, 4 and 5. <p>Study Area 2, 3, 4 and 5 are surrounded by large tracts of vegetation (385, 099 ha within 20 km) associated with conservation reserves (i.e. Badgingarra National Park). There habitat is likely to be represented within surrounding area.</p> <p>Habitat Extent, Retention and Ecological Corridors</p> <p>A total of five habitat types were identified within the Study Area during the field survey, based on the predominant landforms, soils and vegetation structure. These fauna habitat types are closely aligned with the vegetation types.</p> <p>The habitat within the Study Areas is well connected both locally and regionally to larger areas of remnant vegetation to the west and east. These vegetated corridors provide an important regional linkage for native fauna and connect the large tracts of native vegetation approximately 385, 099 ha within 20 km of the Study Areas, which is associated with the Badgingarra National Park (and various nature reserves in the west (including Namming Nature Reserve and South Mimagarra Nature Reserve), through to the remnants of native vegetation forming patches in the largely agricultural landscape of the Wheatbelt to the east.</p> <p>At a local scale, the Study Area 1 is immediately surrounded by a broad acre agricultural land and patches of remnant vegetation. The western portion of Study</p>	

Principle	Assessment	Data sources
	<p>Areas 2, 3, 4 and 5 are form part of large tracts of vegetation associated with conservation areas.</p> <p>The eastern side of the Study Areas are adjacent to broad acre agriculture, which provides a barrier for the movement of ground dwelling fauna to the surrounding area.</p> <p>Outcome</p> <p>The clearing extent is yet to be finalised but based on the potential impacts to Carnaby's high quality foraging and roosting habitat, the potential clearing is at variance with this Principle.</p>	
<p>(c) – Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.</p>	<p>Presence</p> <p>Desktop searches of the EPBC Act PMST database (DotE 2014a), NatureMap database (DPaW 2007–), DPaW Threatened and Priority Flora database (TPFL) and Western Australian Herbarium database (WAHERB) identified Threatened flora listed under the EPBC Act and/or WC Act within 20 km of the Study Areas. No Threatened Flora was recorded from the Study Areas.</p> <p>Habitat</p> <p>The likelihood assessment indicated that two rare flora are likely to occur within the Study Areas. These taxa were not recorded during the field survey, however their habitat was present.</p> <p>Important habitat for the Endangered <i>Eucalyptus absita</i> (Badgingarra Box) was recorded within Study Area 5 and associated with the north-eastern portion of Vegetation Type 6.. If the proposed clearing impacts directly or indirectly on suitable habitat for Threatened flora, then it is likely to be at variance with this Principle.</p>	<p>GHD Survey (2015); NatureMap (2015); EPBC Protected Matters (2015); and The WA Herbarium database (WAHerb).</p>
<p>(d) – Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological</p>	<p>Desktop searches identified no TECs within 20 km of the Study Areas. No vegetation associated with an Australian Government or State listed TEC was identified within the Study Areas.</p> <p>Outcome</p> <p>The project is maybe at variance with this Principle.</p>	<p>GHD Survey (2015); NatureMap (2015); EPBC Protected Matters (2015); and Beard, J. (1979).</p>

Principle	Assessment	Data sources
community.		
(e) – Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.	<p>Four Vegetation Associations have been mapped within the Study Areas (Beard 1976). Vegetation Associations 1031 and 1035 are considered under-represented, with less than 30% remaining at an LGA level. These are detailed below:</p> <ul style="list-style-type: none"> • 12.9% of Beard Vegetation Association 7 remains at a State level, 33.6% remains at a bioregion level (GES) and a sub-bioregion level (GES02) and 66.8% at a LGA level; • 64.0% of Beard Vegetation Association 1030 remains at a State level and bioregion level (SWA). 72.5% remains at a bioregion level (GES) and sub-bioregion level (GES02). 31.6% remains at a sub-bioregion level (SWA01) and 66.8 at a LGA level. • 32.9% of Beard Vegetation Association 1031 remains at a State level. At a bioregion (GES) and sub-bioregion level (GES02), 34.4 remains. At a LGA level 29.5 remains. • 9.85% of Beard Vegetation Association 1035 remains at a State level. At a bioregion level (GES) 34.45% remains. At a sub-bioregion level (GES02) 8.41% remains. 9.8% remains at a LGA level. <p>Outcome</p> <p>The clearing extent is yet to be finalised; is clearing occurs withn areas mapped as having less than 30% of the pre-European extent remainiing, then the proposed clearing is likely to be at variance with this Principle.</p>	<p>GHD Survey (2015); Statewide Vegetation Statistics (Government of Western Australia, 2012); and GIS Database: IBRA WA (Regions – Sub regions); Pre-European Vegetation.</p>
(f) – Native vegetation should not be cleared if it is growing in, or in association with, an	Two ephemeral drainages lines were observed in Study Area 3 during the field survey. The ephemeral drainage lines were dry at the time of the survey and impacted by weeds, predominantly introduced grass species.	GHD Survey (2015); The WA Herbarium database (WAHerb);

Principle	Assessment	Data sources
<p>environment associated with a watercourse or wetland.</p>	<p>A geomorphic wetland was recorded within Study Area 1. This wetland was recorded on either side of the Brand Highway and was Excellent to Very Good condition at the location of the quadrat. However, on the eastern side of the Brand Highway the Geomorphic wetland was in a degraded condition and was impacted by introduced plants including Arum Lily (<i>Zantedeschia aethiopica</i>) and Olive Tree (<i>Olea europaea</i>).</p> <p>Any clearing of riparian or wetland vegetation, or clearing within the buffer of a wetland will result in the proposed clearing likely to be at variance to this Principle.</p> <p>Outcome</p> <p>Main Roads to avoid clearing vegetation within proposed buffer of wetland the Project is not likely to be at variance with this Principle.</p>	<p>and NRM SLIP database.</p>
<p>(g) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.</p>	<p>Soil Erosion</p> <p>The amount of vegetation required to be cleared is likely to be minimal because the project is restricted to road improvement works along the Brand Highway.</p> <p>Although there is uncertainty in relation to the clearing extent, it will not cause “appreciable land degradation”. Appropriate management during clearing is likely to minimise the risks of soil erosion.</p> <p>The Study Areas’ soil type’s risks The Study Areas’ soil type’s risks to water and wind erosion and salinity were mapped by NRM INFO portal. A summary of the risk for each Study Area is provided below.</p> <p>Water Erosion</p> <ul style="list-style-type: none"> • Study Area 1: 10 -30% chance of high to extreme water erosion risks; • Study Areas 2, 3 and 4: <3% and 3-10% chance of high to extreme water erosion risks; and • Study Area 5: <3% chance of high to extreme water erosion risks. <p>Wind Erosion</p> <ul style="list-style-type: none"> • Study Area 1: 30 - 50% and >70% chance of high to extreme wind erosion risk; 	<p>GHD Survey (2014); CSIRO ASRIS (2015); and NRM SLIP database.</p>

Principle	Assessment	Data sources
	<ul style="list-style-type: none"> • Study Area 2: Between 10 to >70% chance of high to extreme wind erosion risk; • Study Areas 3 and 4: >70% chance of high to extreme wind erosion risk; and • Study Area 5: <3% to >70% chance of high to extreme wind erosion risk. <p>Soil Acidity The Study Areas have an Extremely Low Probability/Very Low Confidence of ASS occurring.</p> <p>Salinity The Study Areas have a 30 - 50% chance of moderate to high salinity risk or presently saline. The clearing of vegetation is not considered to significantly alter the hydrological balance and cause a change in the salinity in the Study Areas.</p> <p>Outcome Due to the linear clearing required adjacent to the existing Brand Highway, and the construction management measures to be put in place; the proposed clearing is not likely to be at variance to this Principle.</p>	
(h) – Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.	<p>A desktop search was undertaken on <i>NatureMap</i>, which indicated that two conservation areas are located within the vicinity of Study Areas 2, 3, 4 and 5. An additional conservation area was identified which is located 1.6 km west of Study Area 1.</p> <p>The Badgingarra National Park also an ESA runs adjacent to the road reserve along an extent of Study Areas 4 and 5. The Namming Nature Reserve is located 1.6 km to the west of Study Area 1.</p> <p>An Unnamed Conservation Park (Reserve 41986), south of Badgingarra National Park, runs adjacent to the western road reserve along an extent of Study Areas 2 and 3.</p> <p>The habitat within the Study Areas is well connected both locally and regionally to</p>	GHD Survey (2015); NatureMap (2015); EPBC Protected Matters (2015); and DPaW Tenure.

Principle	Assessment	Data sources
	<p>larger areas of remnant vegetation to the west and east. These vegetated corridors provide an important regional linkage for native fauna, and connect the large tracts of native vegetation (approximately 385, 099 ha within 20 km of the Study Areas) which is associated with the Badgingarra National Park (and various nature reserves in the west (including Namming Nature Reserve and South Mimegarra Nature Reserve), through to the remnants of native vegetation forming patches in the largely agricultural landscape of the Wheatbelt to the east.</p> <p>At a local scale, the Study Area 1 is immediately surrounded by a broad acre agricultural land and patches of remnant vegetation. The western portion of Study Areas 2, 3, 4 and 5 are form part of large tracts of vegetation associated with conservation areas. The eastern side of the Study Areas are adjacent to broad acre agriculture, which provides a barrier for the movement of ground dwelling fauna to the surrounding area.</p> <p>Outcome</p> <p>The amount of vegetation required to be cleared is likely to be minimal because the project is restricted to road improvement works along the Brand Highway. However, there is uncertainty in relation to the extent of clearing exists; therefore the Project maybe at variance with this Principle.</p>	
<p>(i) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.</p>	<p>Catchment Areas</p> <p>The Project does not occur within a proclaimed Drinking Water Supply Catchment.</p> <p>Groundwater</p> <p>The clearing of vegetation is not considered to cause an alteration to the quality of groundwater in or adjacent to the Study Areas.</p> <p>Surface Water</p> <p>A Geomorphic wetland was recorded within Study Area. GHD recommends a wetland buffer is developed prior to finalising the clearing extent and thus preventing the clearing of vegetative areas that if cleared would cause deterioration to surface water. Where possible clearing should be avoided within or along the two ephemeral drainages lines from Study Area 3. If clearing cannot be avoided within or immediately adjacent to riprain and wetland areas; then it will be at variance to this Principle.</p>	<p>GHD Biological Survey (2015); NRM SLIP database; and Public Drinking Water Source Areas (PDWSAs).</p>

Principle	Assessment	Data sources
	<p>Outcome</p> <p>Main Roads to avoid clearing vegetation within proposed buffer of wetland the Project is not likely to be at variance with this Principle.</p>	
<p>(j) – Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding.</p>	<p>The Study Areas 1,2 and 3 lies in the Lower Moore Surface Water Area. Study Area 4 lies within the Nambung/Cataby Coastal Tributaries and Study Area 5 within the Hill River and Tributaries.</p> <p>The Study Areas comprise a small extent of this catchment and are not likely to influence the potential flooding and waterlogging of catchment areas.</p> <p>Outcome</p> <p>Project not likely to be at variance with this Principle.</p>	<p>GHD Biological Survey (2015);</p> <p>DoW Databases; and</p> <p>NRM SLIP soil erosion considerations.</p>

6. Conclusions and Recommendations

6.1 Key Constraints

6.1.1 Vegetation

The Study Areas comprised eight vegetation types and equivalent to the mapped pre-European (Beard, 1979) Vegetation Associations. The vegetation types are well represented at a LGA level with greater than 30% remaining, with the exception being Vegetation Type 6 (Equivalent to Beard's Vegetation Association 1031 and 1035) and Vegetation Type 8 (Equivalent to Beard's Vegetation Association 1031). Vegetation Types 6 and 8 are under-represented with less than 30% remaining at a LGA level. One vegetation type (Vegetation Type 1) 'Banksia Woodland on White Sand' recorded in Study Area 1 was considered representative of this PEC. This vegetation type covers an extent of 7.5 ha of Study Area 1. A geomorphic wetland was recorded within the Study Area 1, a buffer is recommended to protect vegetation associated and dependant on the wetland.

6.1.2 Flora

No EPBC Act or WC Act listed Threatened flora was recorded within the Study Areas. However, 13 DPaW-listed Priority flora taxa were recorded. In addition, the likelihood of occurrence assessment post-field survey concluded that two flora taxa listed under the EPBC and WC Act that are likely to occur and 46 Priority flora taxa that are likely or possible to occur. The remaining 137 flora taxa are unlikely to occur within the Study Area.

6.1.3 Fauna

Two conservation significant fauna were recorded from the Study Area including the Carnaby's Black-Cockatoo (listed Endangered) and the Rainbow Bee-eater (Marine and Migratory).

There is approximately total of 202.7 ha of suitable foraging habitat for Carnaby's Black-Cockatoo within the Study Areas (the majority). This habitat comprises Marri Banksia woodland, Banksia woodland, Low Banksia Woodland and Heath Shrubland, which provide high value foraging resources for the species, including Marri nuts and a diversity of proteaceous species (Groom, 2011). The habitat assessment identified four potential breeding trees with a suitable DBH throughout the Study Area 1; however, did not contain any hollows. An approximate area of 3.3 ha of suitable roosting habitat occurs within Study Area 1 (Figure 6), however, there was no evidence of roosting recorded during the survey.

The Rainbow Bee-eater was recorded from Study Area 2 and is considered suitable non-breeding habitat for the Rainbow Bee-eater. Its habitat is broadly represented in the local region, with 385,099 ha of potential habitat with 20 km of the Study Areas.

The likelihood of occurrence assessment post-field survey concluded that one fauna listed under the EPBC and WC Act that is likely to occur and four other conservation significant fauna taxa that are likely or possible to occur. The remaining are considered unlikely to occur within the Study Areas.

6.1.4 Soils

The amount of vegetation required to be cleared is likely to be minimal because the project is restricted to road improvement works along the Brand Highway. Main Roads designs roads and road reserves reserves to retain surface water and runoff within the road reserve and it will not cause "appreciable land degradation"..

6.2 Recommendations

There are several key recommendations that should be incorporated in to the design and impact area refinement for the project including:

- GHD recommends Main Roads develop an appropriate buffer for the Geomorphic Wetland prior to finalising the clearing extent;
- Main Roads avoid the PEC identified within Study Area 1;
- Main Roads avoid the clearing of vegetation within or along the two ephemeral drainages lines from Study Area 3;
- The Study Areas are relatively weed free with the exception of the cleared/degraded areas. GHD recommends Main Roads implement relevant weed management plans to prevent the spread of introduced flora within the Study Areas; and
- Water/erosion management should be implemented to minimise alteration to hydrology and erosion of susceptible landscapes.
- The Department for Planning and Infrastructure (DPI) (DPI, 2005) provides a “Guideline for the Determination of Wetland Buffer Requirements” to assist landowners, developers, planners and architects to identify an appropriate buffer between wetlands and landuses that will enhance or maintain the significant attributes and values of the wetland. When planning a buffer, the separation distance between the wetland and proposed Project should be established. For the wetland in Study Area 1, the separation distance will be measured from the boundary of the wetland function area up to dryland vegetation (Banksia Woodlands). GHD recommends Main Roads develop an appropriate buffer for this geomorphic wetland prior to finalising the clearing extent.

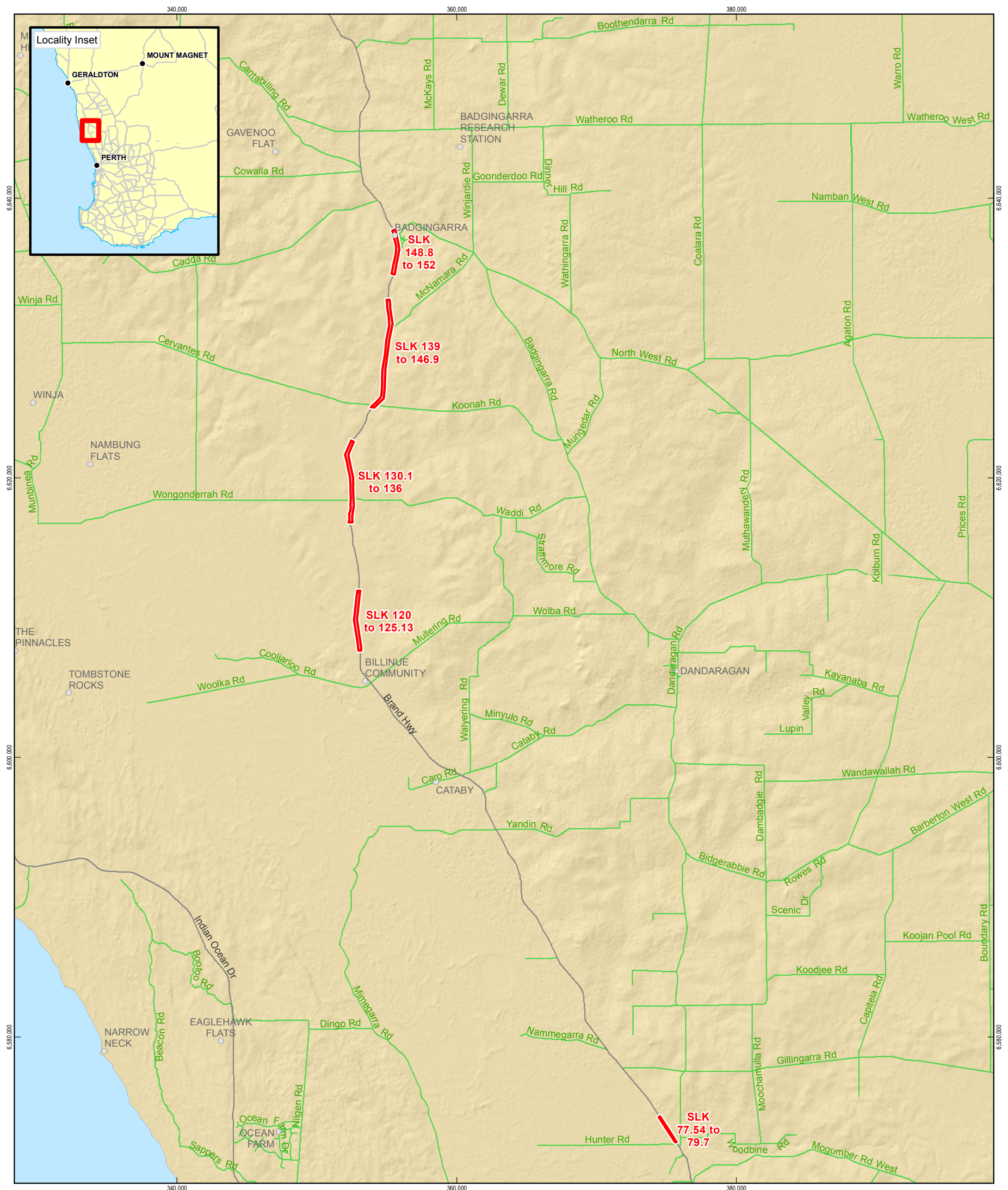
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Figures

Figure 1	Locality
Figure 2	Environmental Constraints
Figure 3	Vegetation type
Figure 4	Vegetation condition
Figure 5	Recorded Flora and Fauna Constraints
Figure 6	Recorded Conservation Significant Habitat and Communities

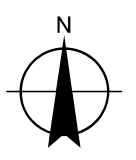


LEGEND

- State Road
- Local Road
- Study Area

Paper Size A3
 0 1 2 4 6 8 10
 Kilometres

Map Projection: Transverse Mercator
 Horizontal Datum: Geocentric Datum of Australia
 Grid: Map Grid of Australia 1994, Zone 50

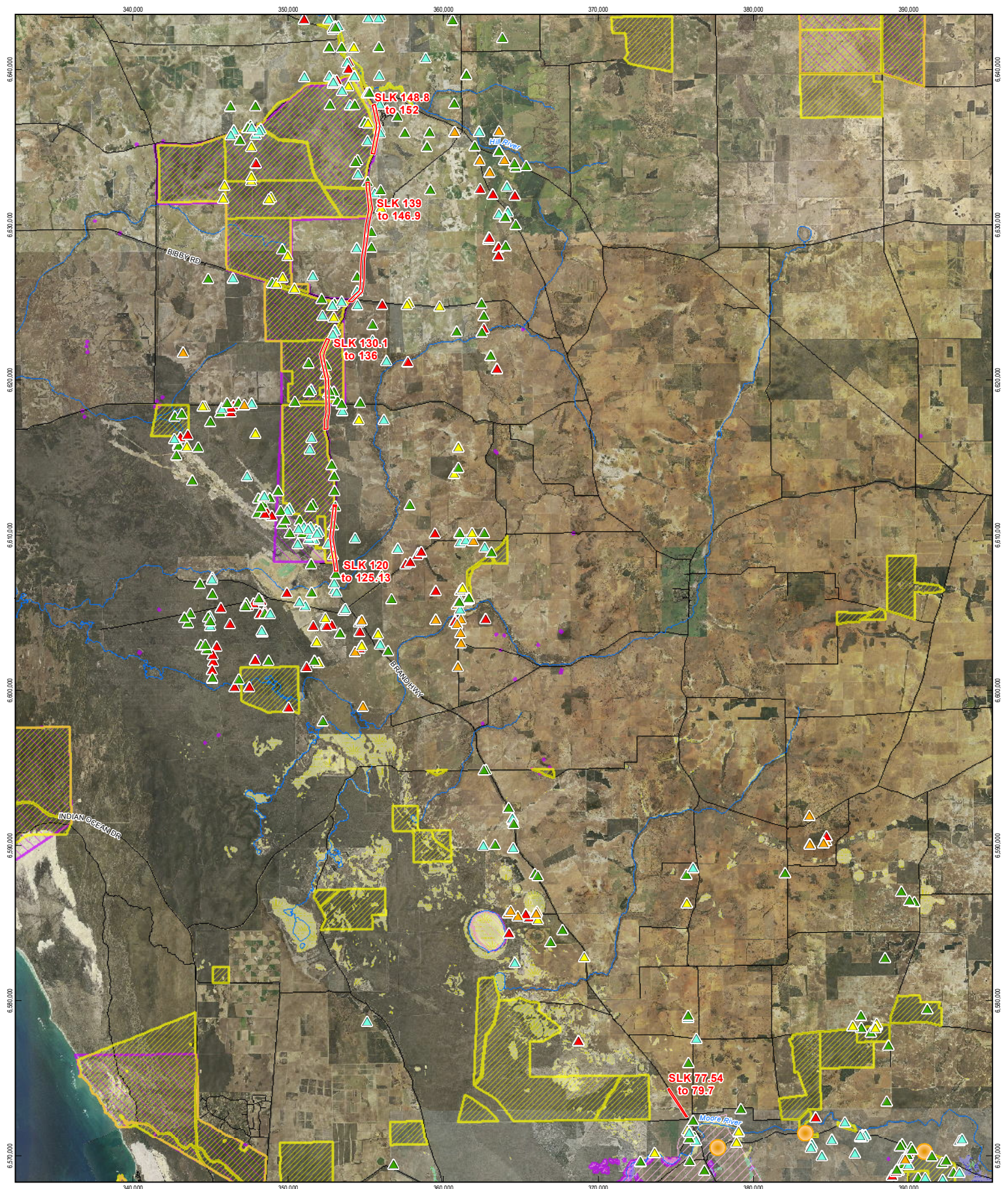


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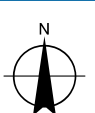
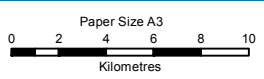
Location

Figure 1



LEGEND

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|---|--|--|---|--|
| <ul style="list-style-type: none"> ▲ (T) Threatened Rare Flora - Extant Taxa ▲ Priority 1 - Poorly Known Taxa ▲ Priority 2 - Poorly Known Taxa | <ul style="list-style-type: none"> ▲ Priority 3 - Poorly Known Taxa ▲ Priority 4 - Rare Taxa ▲ Priority 5 - Conservation Dependent Taxa | <ul style="list-style-type: none"> — River — Road DPaW Estate Study Area Environmentally Sensitive Area | <ul style="list-style-type: none"> Geomorphic Wetlands, Swan Coastal Plain Conservation Resource Enhancement Multiple Use Not Assessed | <ul style="list-style-type: none"> Threatened and Priority Ecological Areas SCP Lakes Register boundaries SCP Lakes Policy boundary |
|---|--|--|---|--|



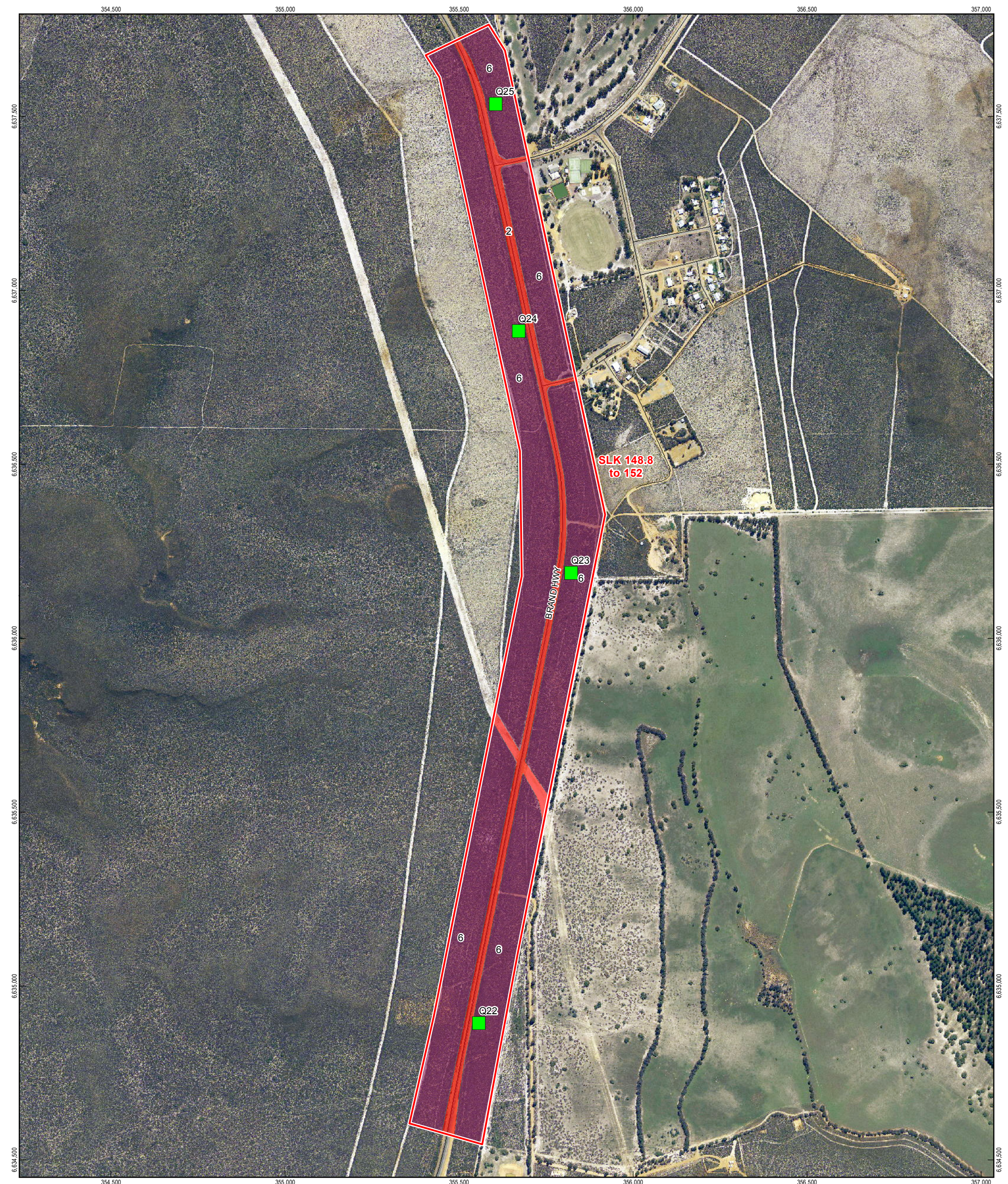
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Environmental Constraints

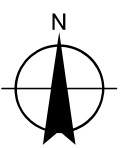
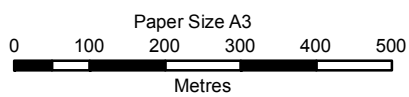
Figure 2

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 Data source: EPA: SCP Lakes boundaries - 20150909; Landgate: Imagery (Virtual Mosaic), Road - 20150908; DER: Environmentally Sensitive Area - 20141008; DPaW: Geomorphic wetlands - 20150909; DPaW Estate - 20141008; Threatened (Declared Rare) and Priority Flora - 20150901; Threatened and Priority Ecological Communities - 20151006; DoW: River - 20141006; GHD: Study Area - 20150908. Created by: RB & ML



LEGEND

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|--|--|---|
|  Quadrat | Vegetation Type |  5 - Heath + Emergents |
|  River |  1 - Banksia Woodland on White Sand |  6 - Mixed Heath on White Sand (with Laterite) |
|  Road |  2 - Cleared / Degraded |  7 - Low Open Banksia Woodland |
|  Study Area |  3 - Geomorphic Wetland |  8 - Heath on Gravel |
| |  4 - Marri Banksia Woodland | |

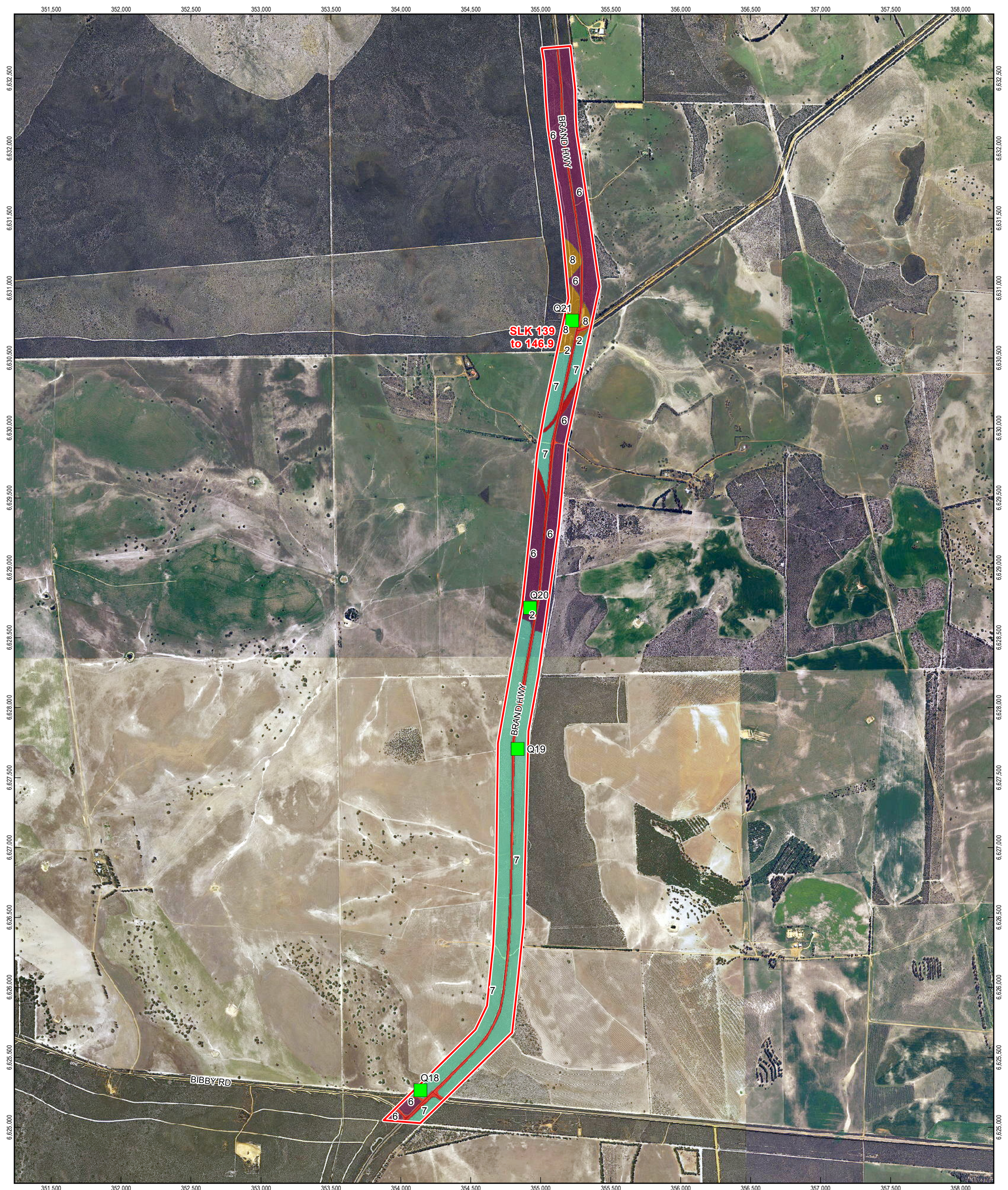


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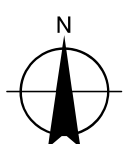
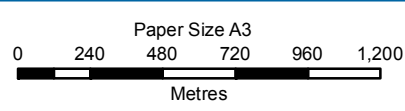
Vegetation Type

Page 1 of 5
Figure 3



LEGEND

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|  Quadrat | Vegetation Type |  5 - Heath + Emergents |
|  River |  1 - Banksia Woodland on White Sand |  6 - Mixed Heath on White Sand (with Laterite) |
|  Road |  2 - Cleared / Degraded |  7 - Low Open Banksia Woodland |
|  Study Area |  3 - Geomorphic Wetland |  8 - Heath on Gravel |
| |  4 - Marri Banksia Woodland | |

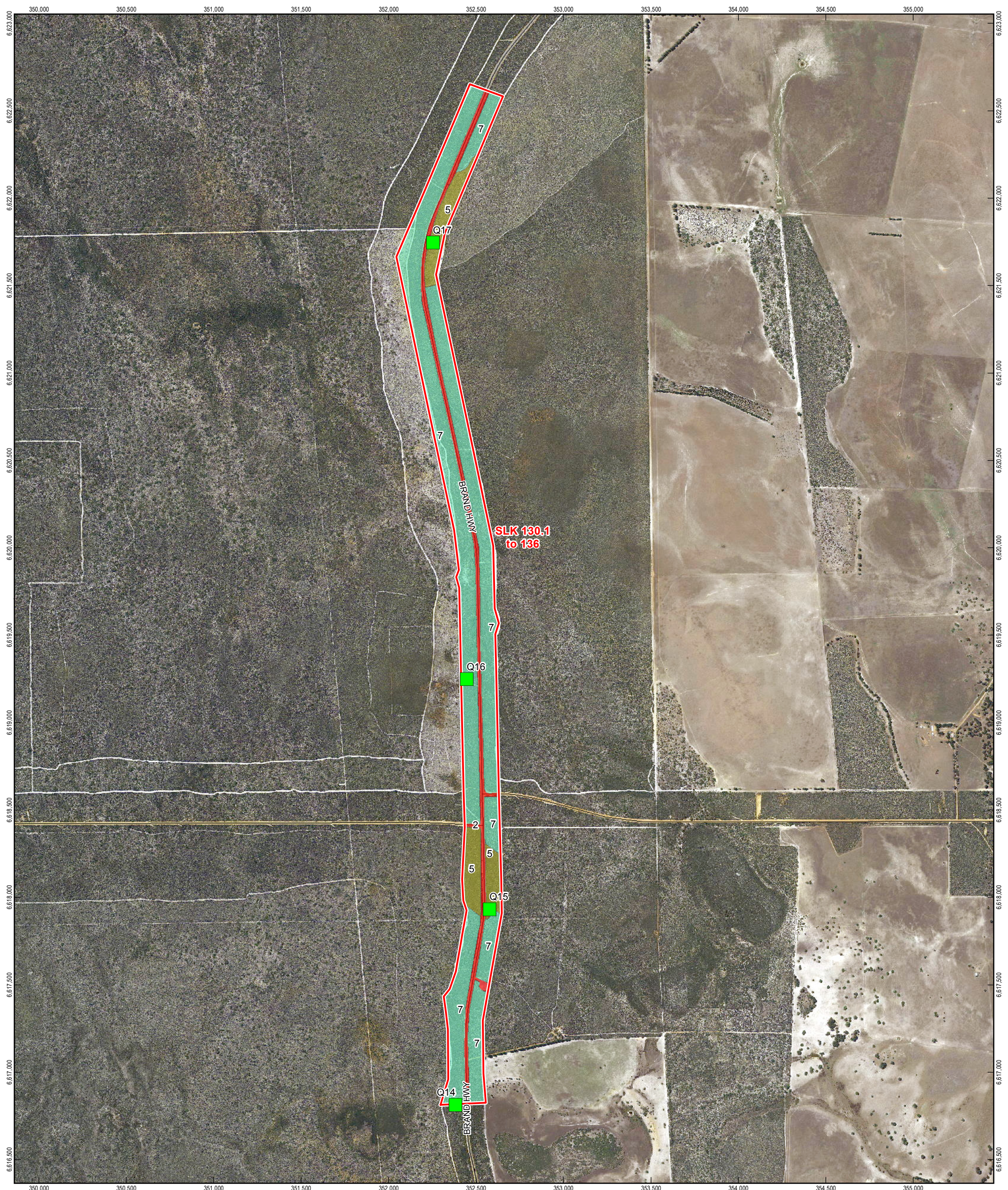


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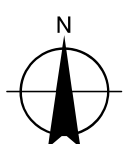
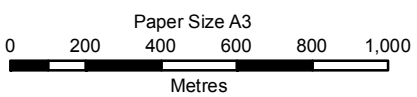
Vegetation Type

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LEGEND

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|  Quadrat | Vegetation Type |  5 - Heath + Emergents |
|  River |  1 - Banksia Woodland on White Sand |  6 - Mixed Heath on White Sand (with Laterite) |
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|  Study Area |  3 - Geomorphic Wetland |  8 - Heath on Gravel |
| |  4 - Marri Banksia Woodland | |

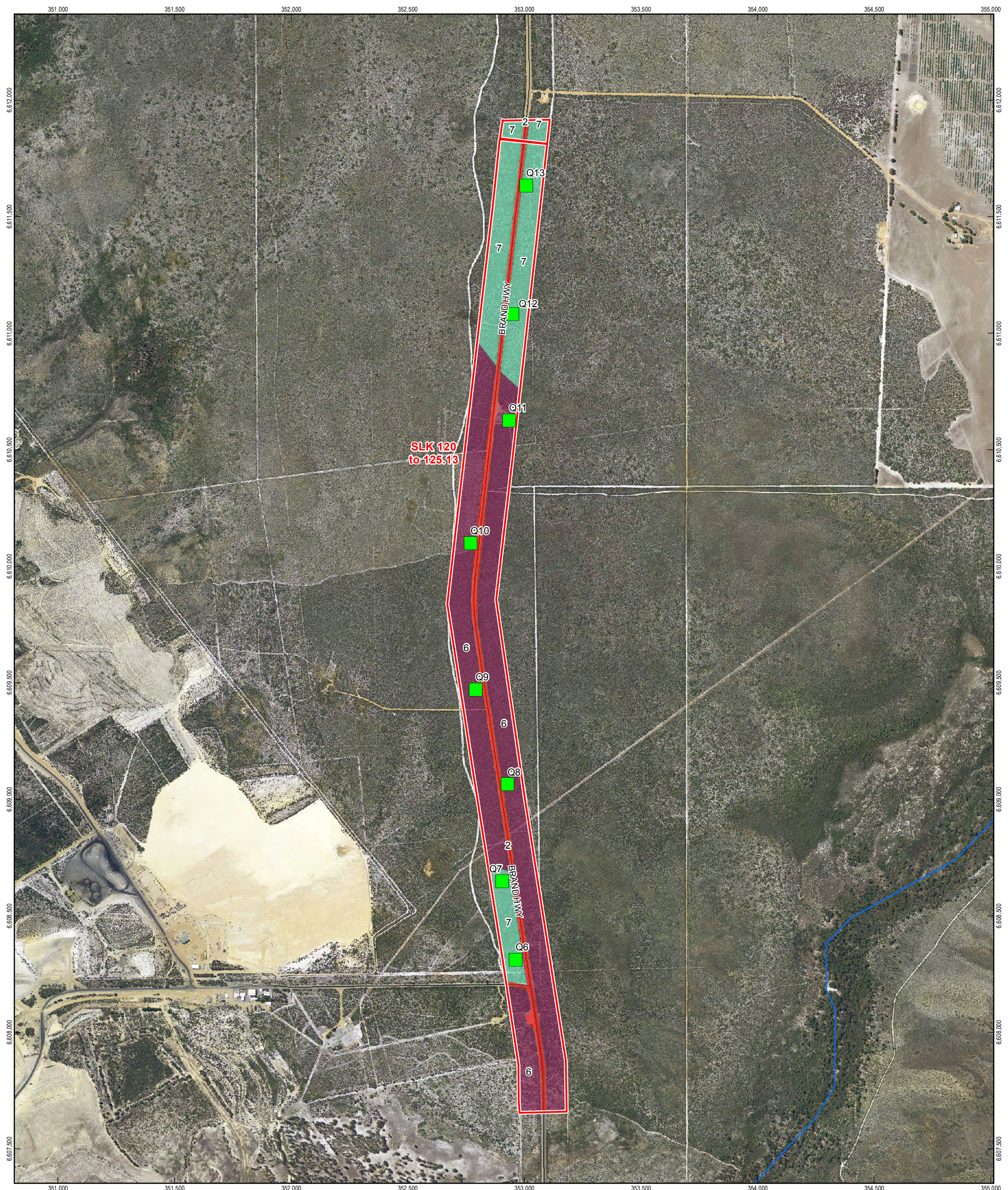


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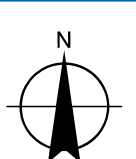
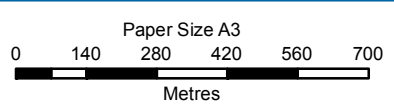
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LEGEND

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|------------|------------------------------------|---|
| Quadrat | Vegetation Type | 5 - Heath + Emergents |
| River | 1 - Banksia Woodland on White Sand | 6 - Mixed Heath on White Sand (with Laterite) |
| Road | 2 - Cleared / Degraded | 7 - Low Open Banksia Woodland |
| Study Area | 3 - Geomorphic Wetland | 8 - Heath on Gravel |
| | 4 - Marri Banksia Woodland | |



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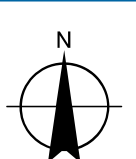
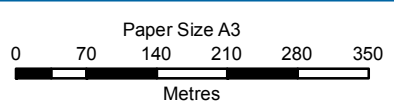
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LEGEND

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|--|------------|------------------------|------------------------------------|-----------------------|---|
| | Quadrat | Vegetation Type | | 5 - Heath + Emergents | |
| | River | | 1 - Banksia Woodland on White Sand | | 6 - Mixed Heath on White Sand (with Laterite) |
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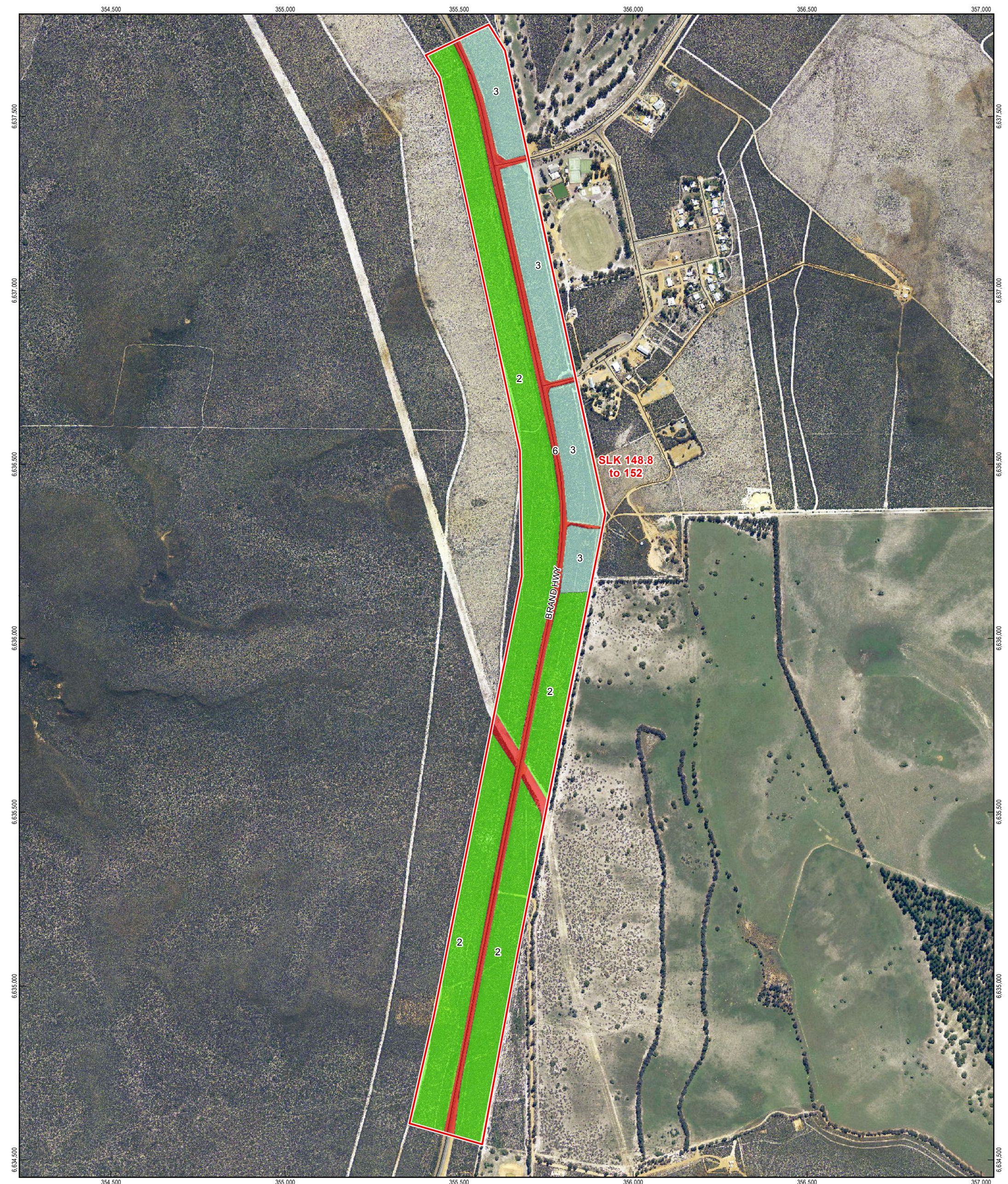


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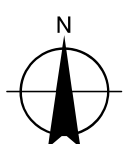
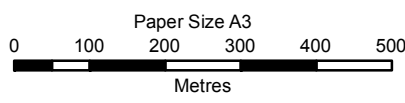
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LEGEND

- River
 - Road
 - Study Area
- | Vegetation Condition | |
|--|--|
| ■ 1 - Pristine or Nearly so | ■ 3 - Very Good |
| ■ 1-2 - Excellent to Pristine | ■ 3-4 - Good to Very Good |
| ■ 2 - Excellent | ■ 4 - Good |
| ■ 2-3 - Very Good to Excellent | ■ 5 - Degraded |
| | ■ 6 - Completely Degraded |

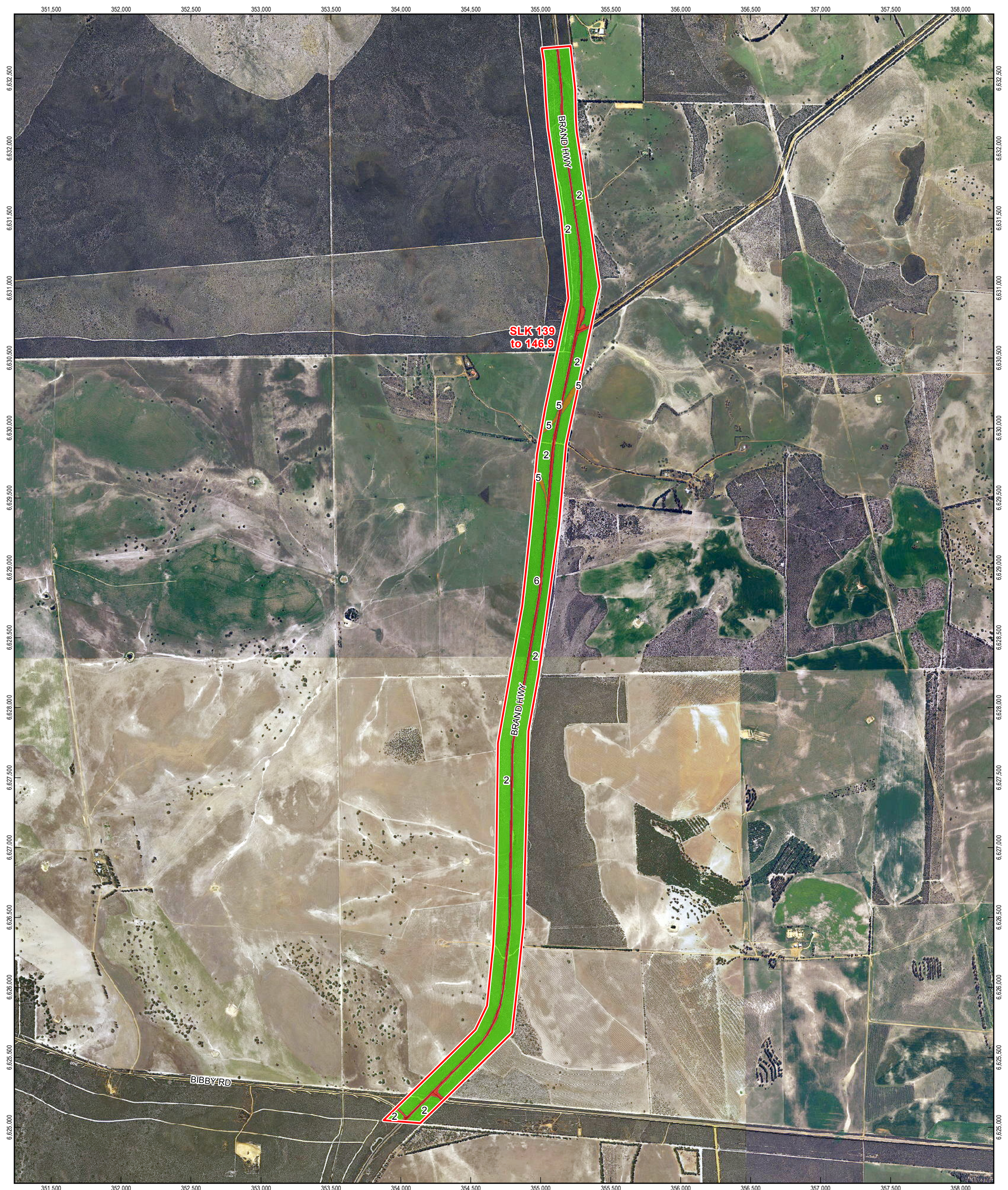


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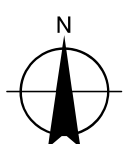
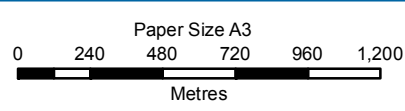
Vegetation Condition

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LEGEND

- River
 - Road
 - Study Area
- | | | |
|---|--|--|
| Vegetation Condition | | |
| 1 - Pristine or Nearly so | 3 - Very Good | 4 - Good |
| 1-2 - Excellent to Pristine | 5 - Degraded | 6 - Completely Degraded |
| 2 - Excellent | | |
| 2-3 - Very Good to Excellent | | |

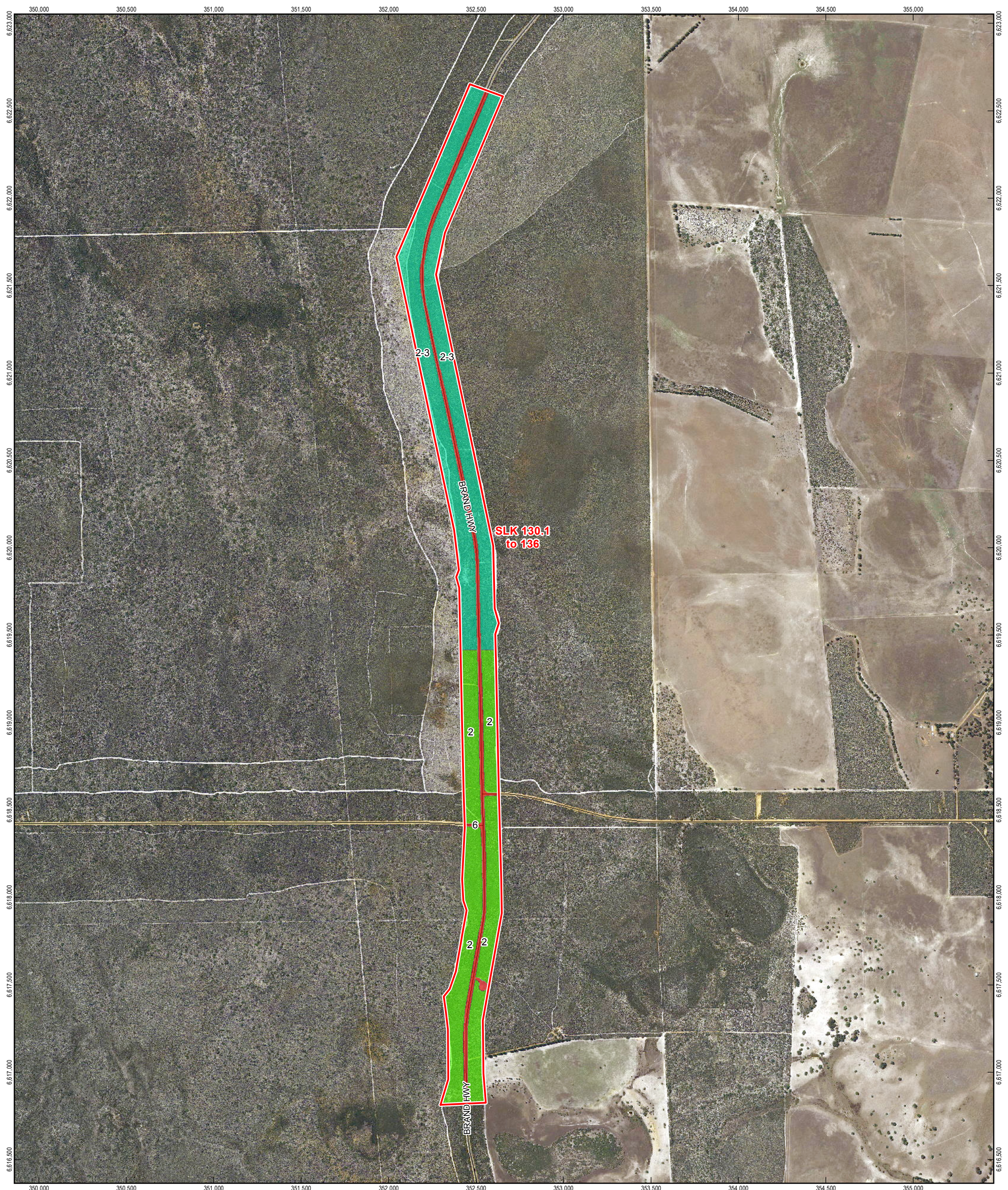


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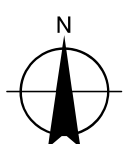
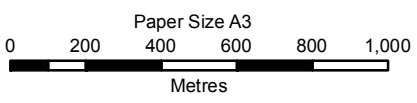
Vegetation Condition

Page 2 of 5
Figure 4



LEGEND

- River
 - Road
 - Study Area
- | Vegetation Condition | |
|---|---|
| <ul style="list-style-type: none"> 1 - Pristine or Nearly so 1-2 - Excellent to Pristine 2 - Excellent 2-3 - Very Good to Excellent | <ul style="list-style-type: none"> 3 - Very Good 3-4 - Good to Very Good 4 - Good 5 - Degraded 6 - Completely Degraded |



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Vegetation Condition

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