# Main Roads Western Australia

## Perth-Darwin National Highway - Tonkin Highway Link

## Environmental Impact Assessment and Biological Survey

September 2013

# Abbreviations

| | |
|---|---|
| ASRIS | Australian Soil Resource Information |
| BAM Act | *Biosecurity and Agriculture Management Act 2007* |
| BoM | Bureau of Meteorology |
| CEMP | Construction Environmental Management Plan |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| DAFWA | Department of Agriculture and Food Western Australia |
| DEC | Department of Environment and Conservation |
| DEFL | DEC Threatened and Priority Flora database |
| DoW | Department of Water |
| DRF | Declared Rare Flora |
| DSEWPaC | Department of Sustainability, Environment, Water, Population and Communities |
| EP Act | *Environmental Protection Act 1986* |
| EPA | Environmental Protection Authority |
| EPBC Act | *Environment Protection and Biodiversity Conservation Act 1999* |
| GPS | Global Positioning System |
| IBRA | Interim Biogeographic Regionalisation of Australia |
| MNES | Matters of National Environmental Significance |
| OEPA | Office of the Environmental Protection Authority |
| PEC | Priority Ecological Community |
| RIWI Act | *Rights in Water and Irrigation Act 1914* |
| TEC | Threatened Ecological Community |
| WC Act | *Wildlife Conservation Act 1950* |
| WoNS | Weed of National Significance |

# Executive summary

GHD Pty Ltd (GHD) has been commissioned by Main Roads Western Australia (Main Roads) to undertake detailed environmental and heritage investigations to support alignment definition planning for the preferred long term alignment for the Perth-Darwin National Highway (PDNH) between Tonkin/Reid Highway and Maralla Road, Ellenbrook (the PDNH–Tonkin Link).

This Environmental Impact Assessment (EIA) has been built upon desktop investigations and includes findings from field work investigations, including:

- Spring biological flora survey;
- Fauna survey;
- Dieback survey (observations only);
- Wetland field investigation;
- Potentially contaminated site assessment (Preliminary Ste Investigation); and
- European and Indigenous heritage assessments.

This report is presented in two parts, namely the:

- Environmental Impact Assessment (sections 4 to section 7); and
- Environmental Management Plan (section 8).

The Study Area includes a corridor along the preferred EWNSR alignment from just south of the planned Hepburn Avenue interchange on Tonkin Highway to north of Gnangara Road, and a corridor along the future PDNH – Tonkin Link alignment from the EWNSR to the planned PDNH north of Ellenbrook. The desktop and field assessments were undertaken for the entire Study Area which comprises of 1658.76 hectares (ha) (presented in Figure 1).

The environmental impact assessment and management plan for the project have been based on the proposed road alignment (Project Area) (presented in Figure 2). The Project Area comprises of approximately 272.14 ha.

The physical setting and construction footprint have been assessed in terms of their environmental values and the requirement for either preservation or management of those values. Further consideration has been given to the broader landscape surrounding the proposal in terms of the requirement for environmental management as a consequence of the proposal.

**Environmental Impact Assessment**

The key environmental issues identified and assessed for the proposal are:

- The presence of suitable feeding habitat and potential breeding and roosting habitat for the Endangered Carnaby's Black Cockatoo
- The presence of the Priority 4 listed flora species, *Verticordia lindleyi* subsp. *lindleyi* and the Threatened *Caladenia huegelii* within one kilometre of the Project area
- The potential occurrence of the Priority Ecological Community (PEC) 'Low lying B*anksia attenuata* woodlands or shrublands', which is listed as Priority 3.
- Clearing within a conservation category wetland
- Clearing within a Priority 1 Public Drinking Water Source Area (PDWSA)

- Clearing within four Bush Forever sites and the Gnangara State Forest (including identified “ecological corridors”)
- Water quality

The referral guidelines for black cockatoo species, published by the Department of Sustainability Environment Water Population and Communities (DSEWPaC) indicates that referral of the action to DSEWPaC will be required. This is because the proposal poses a high risk of significant impact as it will clear more than 1 hectare (ha) of suitable foraging habitat as well as removing potential breeding and roosting habitat for Carnaby’s Black Cockatoo (*Calyptorhynchus latirostris*).

The project is considered to require referral under the *Environmental Protection Act 1986* (EP Act) given the project involves the construction of a new road and will impact on a number of environmental factors (as listed above).

An assessment of the project against the 10 Clearing Principles considered the project to be at variance or significantly at variance to principles (b), (f) and (h) and may be at variance to principles (a), (c), (g), (i) and (j).

**Environmental Management Plan**

The EMP addresses specific issues that were identified during the EIA. The project management measures identified within the EMP are in addition to the standard environmental management contract specifications. Main Roads’ standard environmental contract specifications (Specifications 203, 204, 301, 302 and 304) are to be adhered to where appropriate.

The areas that require special management are addressed in terms of:

- The timing of the various management actions;
- The topic (e.g. vegetation);
- The objectives for each area;
- The actions that are necessary to minimise the impact;
- The responsible party for implementing the action; and
- Whether the action arose from external advice or is a Main Roads requirement.

Prior to the commencement of the Project, specific management plans that address the following issues will be prepared:

- Offsets (Bush Forever, Conservation Category Wetlands and Carnaby’s Black Cockatoo habitat);
- Rehabilitation;
- Vegetation and flora;
- Weeds and dieback;
- Fauna;
- Acid sulphate soils;
- Wetlands;
- Surface water and drainage;
- Erosion;
- Air quality;

- Visual amenity;
- Noise and vibration; and
- Hazardous materials.

This report is subject to, and must be read in conjunction with, the limitations set out in section 2.3 and the assumptions and qualifications contained throughout the Report.

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# Appendices

# 1. Introduction

GHD Pty Ltd (GHD) has been commissioned by Main Roads Western Australia (Main Roads) to undertake detailed environmental and heritage investigations to support alignment definition planning for the preferred long term alignment for the Perth-Darwin National Highway (PDNH) between Tonkin/Reid Highway and Maralla Road, Ellenbrook (the PDNH–Tonkin Link).

## 1.1 Background

The Great Northern Highway (GNH) from Roe Highway, Middle Swan to Brand Highway, Muchea, forms part of the PDNH route. Previous planning studies have been completed which support the need to plan for a future PDNH alignment west of the existing highway alignment. The planned PDNH reservation between Reid Highway and Maralla Road is protected in the Metropolitan Region Scheme (MRS). The highway reservation north of Maralla Road has been submitted to the Department of Planning for inclusion in the MRS.

Key stakeholders in the North East Corridor have lobbied Government to construct the planned PDNH alignment to remove regional traffic, particularly large heavy vehicles, from GNH through the Swan Valley. The State Government allocated funding over 2011/12, 12/13, 13/14 to progress planning and project development investigations for the PDNH between Reid Highway and Muchea, which is also referred to as the Swan Valley Bypass.

More recent regional structure planning for the North West Corridor identified and confirmed the need to plan for a future, high standard, regional road route in the East Wanneroo area from Tonkin Highway to Yanchep, generally in a north-west direction along the western edge of the Gnangara Priority 1 Underground Water Pollution Control Area (P1 UWPCA). This East Wanneroo North-South route (EWNSR) has in-principle approval from the Western Australian Planning Commission (WAPC).

In light of this planning decision the need for a more direct connection of the planned PDNH alignment to Tonkin Highway has been reviewed. Main Roads completed a strategic road network review in 2012 to confirm the preferred, long term, PDNH alignment and network configuration between Reid Highway and Maralla Road, Ellenbrook. The study included a review of previous planning, traffic modelling and analysis, preliminary desktop analysis of environmental, social, engineering and economic aspects and assessment of road network options and stakeholder consultation to assist in determining the preferred network.

The area is underlain by the Gnangara Mound, a strategically important water resource, and much of the area is classified as a Priority 1 Underground Water Pollution Control Area (P1 UWPCA). A network of public drinking water supply bores, owned and operated by Water Corporation, exist within the area. Where impact on the buffer zone surrounding these bores cannot be avoided, consideration must be given to controlled drainage to divert potentially contaminated water. Water Corporation has indicated that where all other options have been exhausted, the relocation of bores would be considered on a case by case basis.

Other significant constraints include Conservation Category Wetlands, Bush Forever areas, Aboriginal heritage sites, and the Gnangara Park primary recreational node north of Gnangara Road which has been recently rehabilitated and upgraded by the Department of Environment and Conservation (DEC) to create a popular public facility.

Two main network options were assessed (Plate 1):

**Network A**

This network includes the preferred alignment for the EWNSR and the planned PDNH alignment along Drumpellier Drive and Lord Street. A connection to Lord Street south of Reid Highway is not provided.

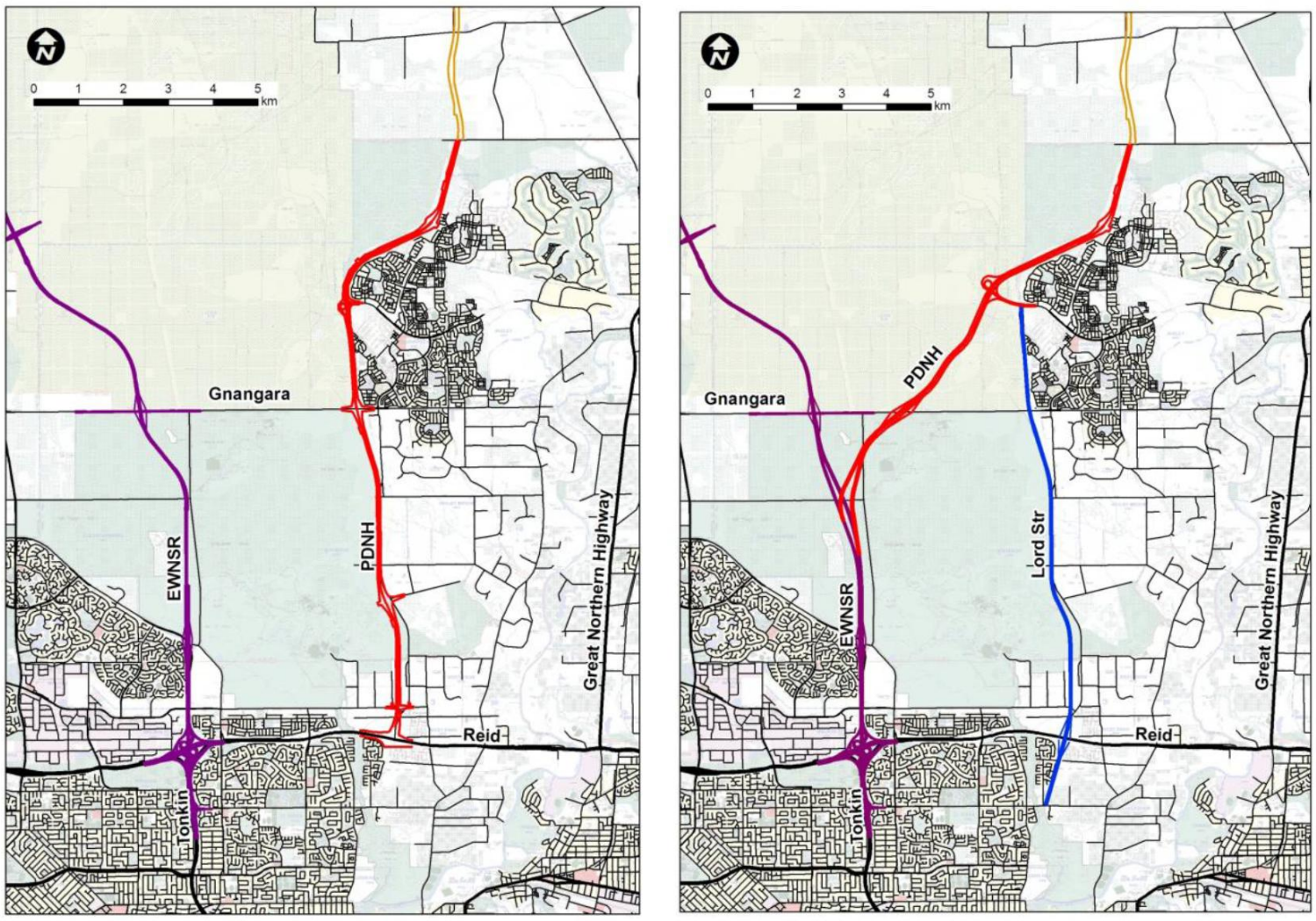
**Network B**

This network includes the preferred alignment for the EWNSR and an indicative western PDNH alignment which ties in with the EWNSR south of Gnangara Road and then links with Tonkin Highway. Drumpellier Drive and Lord Street are included as 4-lane local arterials to provide north – south connectivity to Reid Highway. Lord Street continues south of Reid Highway as a 2-lane road.

The assessment of options indicated that a more direct connection of the future PDNH to Tonkin Highway would provide significant benefits, including:

- Providing a more logical and functional transport network.
- Providing a more effective transport link.
- A high percentage of all total traffic (78%) and freight traffic (84%) travelling on the PDNH north of Ellenbrook would use the proposed link to Tonkin Highway.
- Providing a more direct route from the PDNH to most major industrial areas, including Balcatta and Malaga to the west, Landsdale and Wangara to the north west, and Bassendean, Kewdale, Welshpool, Forrestfield, Perth Airport and Canning Vale to the south.
- Achieving the lowest network operating cost (combination of vehicle operating cost and person time costs).
- Construction costs would be lower, excluding the cost of the proposed East Wanneroo North South Road and Tonkin / Reid systems interchange which is common to all options, and costs for local road network upgrades.
- Achieving lower social impact on existing and future residential areas.
- Allowing the currently planned PDNH alignment, south of Ellenbrook, to function as an arterial road (not freeway standard) and to service residential developments from Ellenbrook to Caversham without the likely significant conflicts with heavy vehicles.
- Providing for the Lord Street south connection to Reid Highway with a conventional grade separated diamond interchange.

The study results are summarised in the PDNH Strategic Network Review – PDNH Tonkin Link, March 2012, prepared by Main Roads.




**Network A** **Network B**

Plate 1 Network options considered

## 1.2 Study area

The Study Area includes a corridor along the preferred EWNSR alignment from just south of the planned Hepburn Avenue interchange on Tonkin Highway to north of Gnangara Road, and a corridor along the future PDNH – Tonkin Link alignment from the EWNSR to the planned PDNH north of Ellenbrook. The desktop and field assessments were undertaken for the entire Study Area which comprises of approximately 1658.76 hectares (ha).

The location of the Study Area is shown in Figure 1, Appendix A.

## 1.3 Project area

The environmental impact assessment and management plan for the project have been based on the proposed road alignment (Project Area) shown in Figure 2, Appendix A. The Project Area comprises of approximately 272.14 ha.

# 2. Project scope and survey methodology

## 2.1 Project scope

This Environmental Impact Assessment (EIA) has been built upon desktop investigations and includes findings from field work investigations, including:

- Spring biological flora survey;
- Fauna survey;
- Dieback survey (observations only);
- Wetland field investigation;
- Potentially contaminated site assessment (Preliminary Ste Investigation); and
- European and Indigenous heritage assessments.

This report is presented in two parts, namely the:

- Environmental Impact Assessment (sections 4 to section 7); and
- Environmental Management Plan (section 8).

### 2.1.1 Environmental impact assessment

The EIA for the proposed Project includes an examination of the following items:

- Identification of legislation relevant to the proposed works;
- Description and assessment of the existing environment, including physical, biological, social, aesthetic, heritage, noise and site contamination;
- Determination of key environmental aspects and scope of any additional site investigations required;
- Appropriate physical and biological field investigations;
- Impact assessment that describes the proposed works and their potential impact on the existing environment;
- Assessment of the Project against the *Environmental Protection Act 1986* (EP Act) 10 Clearing Principals in accordance with the *Department of Environment and Conservation's (DEC's) Guide to Assessment – Clearing of Native Vegetation*;
- Provision of necessary information to assist the Main Roads Project Manager in applying for, and obtaining, clearances, permits and licences which may be required under various Acts and regulations relevant to the Project; and
- Assessment of whether the Project is likely to have a significant environmental impact which may trigger referral to either the Environmental Protection Authority (EPA) or the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC).

### 2.1.2 Environmental management plan

The EMP addresses the following items:

- Provision of environmental management actions to minimise potential environmental impacts identified in the EIA;

- Identification of those responsible for the implementation of management actions; and
- A monitoring and reporting program to assess implementation.

## 2.2 Biological survey methodology

The biological survey included field investigations to verify the environmental attributes present within the Study Area. The biological survey included the following:

- Level 2 flora and vegetation survey;
- Visual evidence of disease status or other existing impacts on vegetation. The *Phytophthora* (dieback) assessment considered the presence and health of key indicator species, but was not a formal dieback assessment consistent with DEC requirements;
- Level 1 fauna assessment; and
- Wetland field assessment.

The results of the biological survey have been combined with the existing environment section (section 4). A detailed description of the methodology of the survey is provided below.

### 2.2.1 Flora and vegetation assessment

The field survey was undertaken with regards to the Environmental Protection Authority (EPA) Guidance Statement No. 51, *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004a) and *Terrestrial Biological Surveys as an Element of Biodiversity Protection*, Position Statement No. 3 (EPA, 2002). GHD undertook a flora and vegetation assessment of the Study Area between the 24th and 27th of September 2012.

Field assessment methodology involved sampling using quadrats located in representative vegetation types and recording of plant species present (visible) at the time of the survey in the Study Area. Grid-based searches allowed for targeted searches of Threatened and Priority flora and other flora of local or taxonomic significance in areas of suitable habitat.

The boundaries of potentially different vegetation types were identified by means of a combination of aerial photography interpretation, topographical features, previous mapping (Beard 1979 and Heddle *et al.* 1980) and field observations. Quadrat sampling sites involved areas of 10 m × 10 m and the position of each site was recorded using a GPS unit. The information presented in Table 1 was recorded for each quadrat. During the field assessment 24 quadrats were assessed.

**Table 1 Quadrat data recorded during the field survey**

| Aspect | Measurement |
|---|---|
| Physical Features | Aspect, soil attributes. Percentage cover by: rocks, logs and branches, leaf litter, bare ground. |
| Location | Coordinates recorded in GDA94 datum using a hand-held Global Positioning System (GPS) tool and PDA (Trimble Nomad), to accuracy approximately ± 5 m and ± 2 m respectively. |
| Vegetation Condition | Vegetation condition was assessed using the condition rating scale devised by Keighery (1994). |
| Disturbance | Level and nature of disturbances (e.g. weed presence, fire – and time since last fire, impacts from grazing, exploration activities). |
| Flora | List of dominant flora from each structural layer.<br>Cover class for each structural layer. |

The locations of quadrats are provided in Figure 4, Appendix A.

## Flora species Identification

Species that were well known to the survey botanists were identified in the field, while species that were unknown were collected and assigned a unique number to facilitate tracking. Plant species were identified by the use of local and regional flora keys and by comparison with the named species held at the Western Australian Herbarium. Plant taxonomists who are considered to be an authority on a particular plant group were consulted when necessary.

The conservation status of all recorded flora was compared against the current lists available on FloraBase (WA Herbarium, 1998) and the EPBC Act Threatened species database provided by DSEWPaC (2010).

## Vegetation condition

The vegetation condition of the Study Area was assessed using the vegetation condition rating scale developed by Keighery (1994) that 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 2.

Table 2 Vegetation condition rating scale

| Vegetation condition rating | Vegetation condition | Description |
|---|---|---|
| 1 | Pristine or Nearly So | No obvious signs of disturbance. |
| 2 | Excellent | Vegetation structure intact, disturbance affecting individual species, and weeds are non-aggressive species. |
| 3 | Very Good | Vegetation structure altered, obvious signs of disturbance. |
| 4 | Good | Vegetation structure significantly altered by very obvious signs of multiple disturbances, retains basic vegetation structure or ability to regenerate it. |
| 5 | Degraded | Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not in a state approaching good condition without intensive management. |
| 6 | Completely Degraded | The structure of the vegetation is no longer intact and the area is completely or almost without native species. |

A preliminary assessment for *Phytophthora cinnamomi* (dieback) based on the presence/absence and health of typical indicator species was undertaken. This is not a formal dieback assessment consistent with DEC requirements.

## PATN Analysis

PATN analysis (furthest neighbour analysis on Bray–Curtis dissimilarity) was used to generate an estimate of association between vegetation types by comparing species present within representative quadrats. The PATN classifies the quadrats into groups, condenses the information into three dimensions and displays the patterns in graphically.

All GHD quadrat data was analysed using PATN to assist in the determination of vegetation types, with those quadrats grouped together in PATN being typically assigned to the same vegetation type. The results of the PATN analysis were verified against field observations to

derive the final vegetation types. As PATN compares the species present in each quadrat (and GHD has not included dominance) occasionally quadrats are grouped together due to similarities in the species complex although may appear distinctly different in the field (either based on dominance of key species, soils, landform or presence of disturbance factors); a degree of discretion is required when interpreting PATN outputs. In these instances, GHD has assigned the vegetation type based on field assessment not PATN results.

PATN analysis was used to compare the GHD quadrats to existing data (where available) for TECs/PECs of the Swan Coastal Plain. PATN is limited in use for this purpose as analysis is based on all species recorded in quadrats, includes introduced species and does not take into account dominance of species. Further interpretation of PATN results, coupled with field and desktop information is needed to determine whether the vegetation types are representative of a TEC or PEC.

Information from the Swan Coastal Plain dataset (Gibson *et al.* 1994) was extracted for each of the TECs/PECs identified during desktop searches. These TECs/PECs align with Floristic Community Types (FCT) described and surveyed by Gibson *et al.* (1994). A representative sample of the TEC/PEC potentially found in the area was selected. The quadrats shown in Table 3 were used for each of the relevant FCT.

**Table 3 List of the Gibson *et al*. (1994) quadrats used in the PATN analysis**

| Floristic Community Type | Quadrats |
|---|---|
| FCT10a | C58-4, FISH-3, FISH-4, FL-2, agosn11 |
| FCT11 | AUSTB-3, beel03, BULL-12, C71-1, CARAB-3 |
| FCT20 | 5C03, activ01, activ02, activ03, ACTIV-1 |
| FCT21c | 5C07, BULLER-3, dillo01, ELE02, ELE22 |
| FCT22 | 5F01, BANK-1, BNR27, BNR29, BNR32 |
| FCT23a | BANK-2, BANK-3, beel02, bibra01, BULL-3 |
| FCT23b | 5A01, 5C02, 5C04, 5C06, 5D01 |
| FCT3c | Duck1, Duck2, Ellen6, Pearce2, Talb1 |
| FCT4 | AMBR-3, C58-1, CAPEL-3, cas01, cas04 |
| FCT5 | AUSTB-4, AUSTB-5, AUSTB-6, BULL-5, BULL-7 |
| FCT6 | card10, card11, card4, ELLEN-7, much02 |
| FCT7 | AUSTB-1, AUSTB-2, AUSTB-7, AUSTB-8, BAMBUN-1 |
| FCT8 | airf01, airf02, BRIX-1, BRIX-3, BRIX-4 |
| FCT9 | brick4, BYRD-1, DUCK-3, MANEA-1, Pind02 |

### 2.2.2 Fauna and habitat assessment

The fauna assessment was consistent with a Level 1 survey (reconnaissance survey) in regard of the requirements of the EPA Guidance Statement No. 56 *Assessment of Environmental Factors for Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004b) and the DEC and EPA's *Technical Guide Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA 2010).

Nomenclature used in the report follows that used by the Western Australian Museum 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. However birds follow Christidis and Boles (2008).

The methodology used to undertake the fauna assessment included:

- Opportunistic searches across all habitat types within the Study Area. This ensured the maximum suite of species potentially occurring at the Study Area was observed. 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 area.
- Searching for tracks, scats, bones, diggings and feeding areas for both native and feral fauna.
- Habitat assessments were conducted and included targeting the known habitat preferences of threatened vertebrate species listed under the relevant Commonwealth and State Acts, including DEC listed Priority fauna, which are suspected to occur in the general area. The aim of the habitat assessment was to determine the likelihood of any threatened species utilising the areas that will be impacted upon as a consequence of the proposed works.

### 2.2.3 Survey methodology limitations

The limitations surrounding the flora and fauna survey are provided in Table 4.

**Table 4 Survey limitations**

| Variable | Impact on survey outcomes |
|---|---|
| Access | The majority of the Study Area was easily accessed via walking transects. Some sections of the Study Area could not be surveyed as access to some private properties was restricted, including Cyrenian House and Cullacabardee settlement. However, much of the vegetation and condition types within these areas could be interpreted by visual observation and aerial imagery. |
| Experience levels | The survey ecologists are practitioners suitably qualified in their respective fields. |
| Timing, weather & season | The GHD survey was undertaken in spring (September) which is considered the dominant flowering period for the Swan Coastal Plain bioregion. Furthermore, the field survey occurred during or close to peak flowering period for all conservation significant flora species identified in the desktop search (Naturemap), therefore increasing the species visibility and improving the potential of successfully recording them on site.<br>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.<br>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. |
| Intensity of survey — flora & vegetation | The flora and vegetation survey was conducted in accordance with the EPA Guidance Statement 51, Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004a) and Terrestrial Biological Surveys as an Element of Biodiversity Protection, Position Statement No. 3 (EPA, 2002), with a combination of quadrats located in representative vegetation types and meandering transects of the Study Area on foot. The plant species present (visible) at the time of the survey were recorded. |
| Intensity of survey — fauna | The fauna assessment conducted was a reconnaissance (Level 1) survey only and thus only sampled those species that can be easily seen, heard or have distinctive signs, such as tracks, scats, diggings etc. Many cryptic 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. |

| Variable | Impact on survey outcomes |
|---|---|
| | The fauna assessment was aimed at identifying habitat types and terrestrial vertebrate fauna utilising the Study Area. No sampling for invertebrates or aquatic species occurred. The information available on the identification, distribution and conservation status of invertebrates is generally less extensive than that of vertebrate species. |
| Determination | The taxonomy and conservation status of the Western Australian flora and fauna is dynamic. This report was prepared with reliance on taxonomy and conservation current at the time issuing, but it should be noted this may change. |

## 2.3 Limitations

This Report has been prepared by GHD for Main Roads and may only be used and relied on by Main Roads for the purpose agreed between GHD and the Main Roads as set out in section 2.1 of this Report, as provided in the project brief.

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 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, in part, 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 (including the presence of species and communities of conservation significance) 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.

### 2.3.1 Assumptions

This report assesses both the Study Area and Project Area as defined in Section 1.2 and 1.3 and shown in Figure 1 and Figure 2 (Appendix A). Any change to the area of impact may change the results of this assessment.

# 3. Legal framework and background

## 3.1 Relevant legislation

Key Commonwealth and State (WA) environmental legislation that may be relevant to the Project is outlined in Table 5.

### Table 5 Key Environmental Legislation Relevant to the Project

| Legislation | Responsible Government Agency | Aspect |
|---|---|---|
| **Commonwealth Legislation** | | |
| *Environment Protection and Biodiversity Conservation Act 1999* | Department of Sustainability, Environment, Water, Population and Communities | Rare flora and fauna |
| *Native Title Act 1993* | National Native Title Tribunal | Native title |
| **State Legislation** | | |
| *Aboriginal Heritage Act 1972* | Department of Indigenous Affairs | Archaeological and ethnographic sites |
| *Agricultural and Related Resources Protection Act 1976* | Department of Agriculture | Weeds and feral animals |
| *Conservation and Land Management Act 1984* | Department of Environment and Conservation | Use, protection and management of public lands and waters and its flora and fauna. |
| *Contaminated Sites Act 2003* | Department of Environment and Conservation | Management of contaminated sites |
| *Environmental Protection Act 1986* | Department of Environment and Conservation | Environmental impact assessment and management |
| *Environmental Protection (Noise) Regulations 1997* | Department of Environment and Conservation | Noise standards |
| *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* | Department of Environment and Conservation | Clearing of native vegetation |
| *Heritage of Western Australia Act 1990* | Heritage Council of Western Australia | European heritage protection |
| *Land Administration Act 1997* | Department of Regional Development and Lands | Administration of State Land |
| *Rights in Water and Irrigation Act 1914* | Department of Water | Access to and use of water resources; protection and management of river flows and drainage |
| *Soil and Land Conservation Act 1945* | Department of Agriculture | Protection of soil and prevention/management of soil erosion |
| *Wildlife Conservation Act 1950* | Department of Environment and Conservation | Protection of native wildlife |

## 3.2 Background and legal framework

### 3.2.1 Threatened and priority ecological communities

Ecological communities are defined as ‘naturally occurring biological assemblages that occur in a particular type of habitat’ (English and Blythe 1997). Threatened Ecological Communities (TECs) are ecological communities that have been assessed and assigned to one of four

categories related to the status of the threat to the community, i.e. Presumed Totally Destroyed, Critically Endangered, Endangered, Endangered and Vulnerable.

The DEC maintains a list of TECs which have been endorsed by the Minister for the Environment (August 2010) however they are not formally protected under the State *Wildlife Conservation Act 1950* (WC Act). Some of these TECs are protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). DEC listed ecological communities are given special consideration in environmental impact assessments and have special status under the land clearing regulations of the *Environmental Protection Act 1986* (EP Act). The EPA's position on TECs states that proposals that result in the direct loss of TECs are likely to require formal assessment.

Possible TECs that do not meet survey criteria are added to the DEC's Priority Ecological Community (PEC) Lists under Priorities 1, 2 and 3. These are ecological communities that are adequately known; are rare but not threatened, not meet criteria for Near Threatened. PECs that have been recently removed from the threatened list are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5. A description of the conservation categories for TECs and PECs is provided in Appendix B.

### 3.2.2 Conservation significant flora

Flora taxa of conservation significance are protected under both State and Commonwealth Acts. The EPBC Act provides a legal framework to protect and manage nationally important flora and communities.

The WC Act is the primary wildlife conservation legislation in the State. The WC Act enables the Minister for the Environment to declare taxa as "Threatened" or "Rare Flora" if they are considered to be in danger of extinction, rare or otherwise in need of special protection.

The DEC also produces a supplementary list of Priority Flora, for species that are not considered Threatened under the WC Act but for which the DEC feels there is cause for concern. These species have no special legislative protection, but their presence would normally be considered relevant to an assessment of the conservation status of an area. These taxa need further survey and evaluation of conservation status before consideration can be given to declaration as Threatened flora.

A description of the relevant conservation categories is detailed in Appendix B.

### 3.2.3 Conservation significant fauna

The Federal conservation level of fauna species and their significance status is currently assessed under the EPBC Act. The significance levels for fauna used in the EPBC Act are those recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994).

The EPBC Act also protects migratory species that are listed under the following International Agreements:

- Appendices to the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals) for which Australia is a Range State under the Convention;
- The Agreement between the Government of Australia and the Government of the Peoples Republic of China for the Protection of Migratory Birds and their Environment (CAMBA);

- The Agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (JAMBA); and
- The Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds (ROKAMBA).

The State conservation level of fauna species and their significance status is currently assessed under the WC Act (*Wildlife Conservation (Specially Protected Fauna) Notice 2010(2)*). The WC Act uses a set of Schedules but also classifies species using some of the IUCN categories. Schedule 3 fauna species are those which are subject to agreements between the government of Australia and the governments of Japan, China and the Republic of Korea relating to the protection of migratory birds and are declared to be fauna that is in need of special protection.

The DEC also produces a supplementary list of Priority Fauna, these being species that are not considered Threatened under the WC Act but for which the Department feels there is a cause for concern. Such taxa need further survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna. These species have no special legislative protection, but their presence would normally be considered relevant to an assessment of the conservation status of an area.

A description of relevant conservation categories is detailed in Appendix B.

### 3.2.4 Public drinking water source area

Public Drinking Water Source Areas (PDWSAs) is a collective term used for the description of Water Reserves, Catchment Areas and Underground Pollution Control Areas declared (gazetted) under the provisions of the *Metropolitan Water Supply, Sewage and Drainage Act 1909* or the *Country Areas Water Supply Act 1947*.

### 3.2.5 Wetlands

Wetlands include not only lakes with open water, but areas of seasonally, intermittently or permanently waterlogged soil. Approximately 25% of the Swan Coastal Plain between Moore River and Mandurah is classified as wetland (Hill *et al*., 1996).

Though extensive in area, not all wetlands retain significant ecological values due to the concentration of urban and agricultural development in the region. Most wetlands have been cleared, filled or developed over, leaving only 20% of all the wetlands that were present on the Swan Coastal Plain prior to European settlement. Of these, an estimated 15% of the wetland area has retained high ecological values (Hill *et al.,* 1996).

#### Ramsar wetlands

The Convention on Wetlands of International Importance, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international co-operation for the conservation and wise use of wetlands and their resources.

The EPBC Act enhances the management and protection of Australia's Ramsar wetlands. A 'declared Ramsar wetland' is an area that has been designated under Article 2 of the Ramsar convention or declared by the Minister to be a declared Ramsar wetland under the EPBC Act. Ramsar wetlands are recognised as a matter of national environmental significance under the EPBC Act. Consequently, an action that has, will have, or is likely to have, a significant impact on the ecological character of a Ramsar wetland must be referred to the Minister and undergo an environmental assessment and approval process (DSEWPaC 2013c).

### Lakes covered under the *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992*

The *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992* (EPP Lakes) protects the environmental values of selected wetlands on the Swan Coastal Plain.

### Geomorphic wetlands

Categorisation of wetlands has been undertaken by Hill, *et al.* (1996), delineating Swan Coastal Plain into levels of protection and management categories. Conservation Category Wetlands are wetlands that support high levels of attributes and functions. Resource Enhancement Wetlands are those that have been partly modified but still support substantial functions and attributes. Multiple Use Wetlands are classified as those wetlands with few attributes that still provide important wetland functions. Multiple Use wetlands have few important ecological attributes and functions remaining.

The Geomorphic Wetlands Swan Coastal Plain dataset displays the location, boundary, geomorphic classification (wetland type) and management category of wetlands on the Swan Coastal Plain.

## 3.2.6 Acid sulfate soils

The DEC (2012) describes Acid Sulfate Soils (ASS) as naturally occurring soil and sediments containing sulphide minerals, predominantly pyrite (an iron sulphide). In an undisturbed state below the water table ASS are benign and not acidic.

However, if the ASS is drained, excavated or exposed by lowering of the water table, the sulphides will react with oxygen to form sulphuric acid. The resulting sulphuric acid can break heavy metal bonds, releasing metals such as aluminium, iron, and arsenic into the groundwater. Flushing of acidic leachate to groundwater and surface waters can cause offsite impacts including:

- Ecological damage to aquatic and riparian ecosystems;
- Effects on estuarine fisheries and aquaculture projects;
- Reduction in agricultural productivity through:
  - Contamination of groundwater with arsenic, aluminium and heavy metals;
  - Metal contamination of soils; and
  - Damage to infrastructure through the corrosion of concrete and steel pipes, bridges and other sub-surface assets.

Projects which disturb potential ASS must be assessed to determine associated risks and management measures put in place to avoid and mitigate environmental harm.

## 3.2.7 Bush forever

Bush Forever, which was released in December 2000 and proclaimed in 2010, is a Government initiative to retain and protect regionally significant bushland on the Swan Coastal Plain within the Perth Metropolitan Region. Bush Forever aims to protect more than 51,000 hectares of regionally significant bushland within 287 sites across the metropolitan portion of the Swan Coastal Plain (Government of Western Australia, 2000).

## 3.2.8 Environmentally sensitive areas

- A declared World Heritage property as defined in Section 13 of the EPBC Act.

- An area that is registered on the Register of the National Estate (RNE), because of its natural values, under the *Australian Heritage Commission Act 1975* of the Commonwealth (the RNE was closed in 2007 and is no longer a statutory list).
- A defined wetland and the area within 50 m of the wetland.
- The area covered by vegetation within 50 m of rare flora, to the extent to which the vegetation is continuous with the vegetation in which the rare flora is located.
- The area covered by a TEC.
- A Bush Forever Site.
- The areas covered by the following policies:
  - The *Environmental Protection (Gnangara Mound Crown Land) Policy 1992.*
  - The *Environmental Protection (Western Swamp Tortoise Habitat) Policy 2002.*
- The areas covered by the lakes to which the *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992* (SCPL) (EPP Lakes) applies.
- Protected wetlands as defined in the *Environmental Protection (South West Agricultural Zone Wetlands) Policy 1998*.
- Areas of fringing native vegetation in the policy area as defined in the *Environmental Protection (Swan and Canning Rivers) Policy 1997*.

# 4. Existing environment

## 4.1 Climate

The Study Area experiences a Mediterranean climate, with mild wet winters and hot dry summers. The closest Bureau of Meteorology (BoM) weather station to the Study Area is located 15 km away at Perth Airport (station number 9021). A summary of the climatic data (BoM 2012) for this weather station is below and is graphed in Plate 2:

- Mean maximum temperature: 17.9 °C to 31.9 °C.
- Mean minimum temperature: 8.0 °C to 17.5 °C.
- Rainfall: 774.4 mm.
- Mean number of days of rain ≥ 1 mm: 86.3.

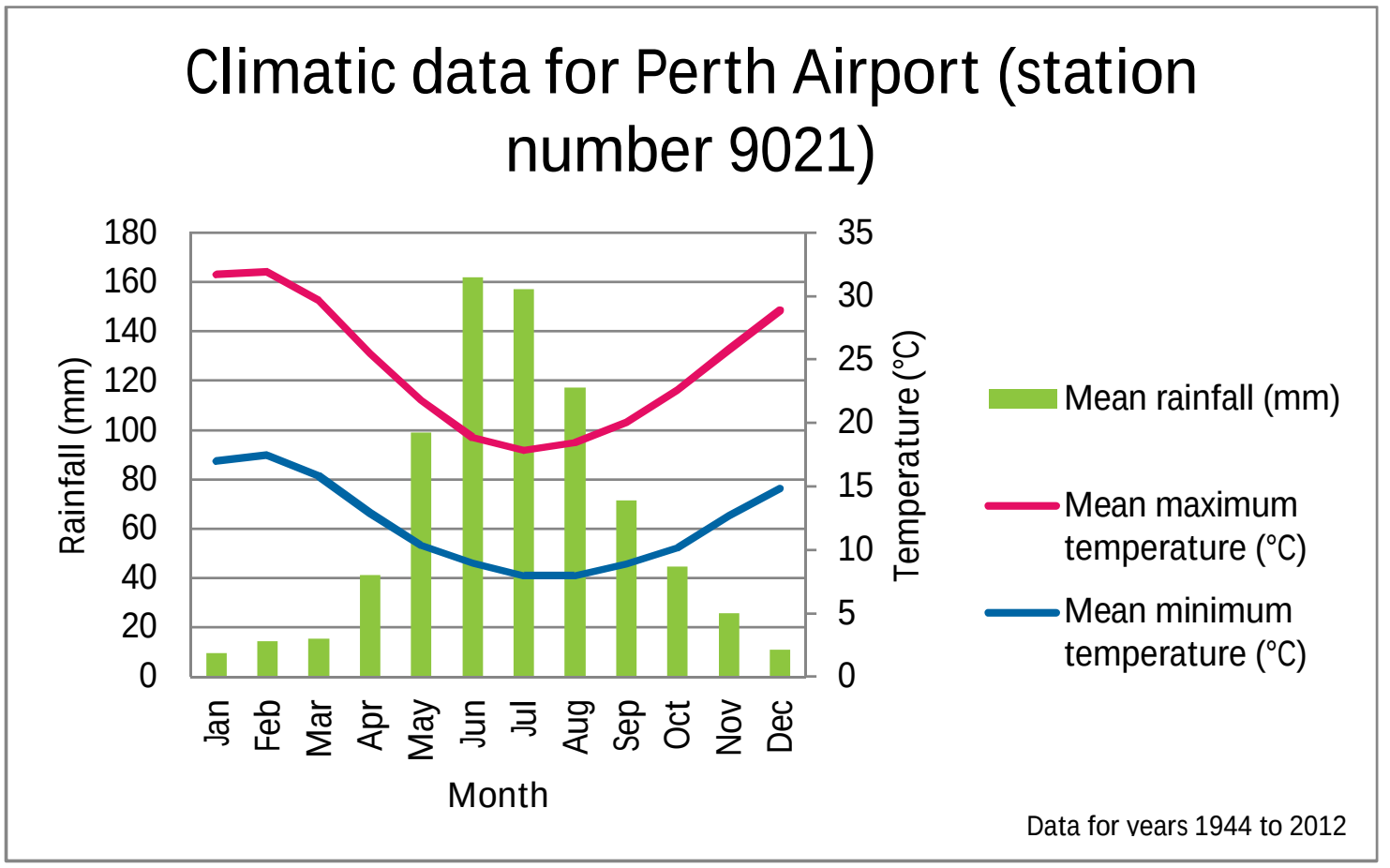



Plate 2 Climatic data for Perth Airport (station 9021) (BoM 2012)

## 4.2 Geology and soils

The Study Area is situated on aeolian deposits of the Swan Coastal Plain. The geology of the area consists of Bassendean sand, white and grey quartz sand (Department of Mines 1978).

According to the soils and landform mapping undertaken by Churchwood and McArthur (1978), the Study Area is situated on:

- Bassendean: sandplains with low dunes and occasional swamps; iron or humus podzols.
- Southern River: Sandplain with low dunes and many intervening swamps; iron and humus podzols, peats, and clays.

The Bassendean dunes are the oldest of the three aeolian dune systems and so are the most leached, infertile and acidic. The sands contain little silt or clay, and very low levels of nutrient elements, with any nutrient content being associated with organic matter. The dunes of the Bassendean system are generally of low relief often with broad swales or relatively flat sand sheets between the low dunes, which are poorly drained. The Bassendean unit with peaty podzols in the swamps is separated from the Southern River unit which occurs where sand

appears to have been blown over the alluvial soils and so the swamps often have a clay base (Department of Conservation and Environment 1980).

## 4.3 Flora and vegetation

The following section includes information gathered during a spring flora and vegetation survey of the Study Area undertaken by GHD in September 2012.

A detailed description of the methodology of this survey is provided in section 2.2 and a summary of the results is provided in Appendix D.

### 4.3.1 Bioregion

The Study Area is located within the Swan Coastal Plain Interim Biogeographic Regionalisation of Australia (IBRA) Region, Swan Coastal Plain Sub-Region. This sub-region is dominated by woodlands of Banksia and Tuart on sandy soils, sheoak on outwash plains, and paperbark in swampy areas. The colluvial and aeolian sand areas represent three phases of Quaternary marine sand dune development (which provide relief), and include a complex series of seasonal fresh water wetlands, alluvial river flats, coastal limestones and several off-shore islands. Younger sandy areas and limestones are dominated by heath and/or Tuart woodlands, while Banksia and Jarrah–Banksia woodlands are found on the older dune systems (Mitchell *et al*., 2002).

### 4.3.2 Broad vegetation mapping

Broad scale vegetation mapping of the area undertaken by Beard (1979) indicates the following two vegetation associations present in the Study Area:

- Medium very sparse woodland; jarrah, with low woodland; banksia & casuarina (association 1001) – occurs over the majority of the Study Area (1538.4 ha present within the Study Area)
- Low woodland; banksia (association 949) – present in the northern-most tip of the Study Area (120.3 ha present within the Study Area)

Heddle *et al.* (1980) mapped the Perth area at a finer scale than Beard. The Heddle *et al*. (1980) mapping identified the following vegetation complexes on Aeolian Deposits of the Swan Coastal Plain within the Study Site:

<u>Bassendean Dunes:</u>

- Bassendean complex – north: vegetation ranges from a low open forest and low open woodland of *Banksia* species *Eucalyptus todtiana* to low woodland of *Melaleuca* species and sedgelands which occupy the moister sites. (137.5 ha present within the Study Area).
- Bassendean complex – north – transition vegetation complex: a transition complex of low open forest and low woodland of *Banksia* species – *E. todtiana* on a series of high sand dunes. The understory species reflect similarities with both the Bassendean – north and Karrakatta – north vegetation complexes. (94.7 ha present within the Study Area).
- Bassendean complex – central and south: Vegetation ranges from woodland of *E. marginata –Allocasuarina fraseriana – Banksia* spp. to low woodland of *Melaleuca* species, and sedgelands on the moister sites. This area includes the transition of *E. marginata* to *E. todtiana* in the vicinity of Perth. (1199.2 ha present within the Study Area).

<u>Combinations of Bassendean Dunes/Pinjarra Plain:</u>

- Southern River complex: open woodland of *E. calophylla* [now *Corymbia calophylla*] – *E. marginata – Banksia* species with fringing woodland of *E. rudis – M. rhaphiophylla* along creek beds. (227.4 ha present within the Study Area).

### 4.3.3 Site vegetation types

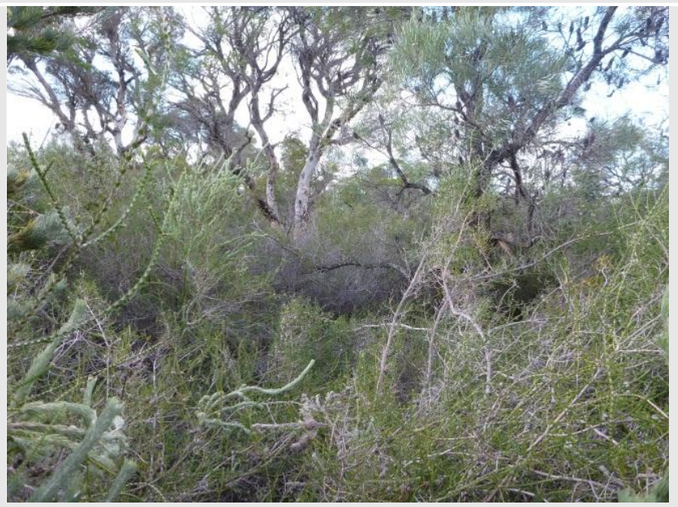
Nine native vegetation types (not including highly modified areas) were identified within the Study Area. Native vegetation remaining within the Study Area consisted predominantly of a mix of *Eucalyptus marginata* (jarrah) – *Corymbia calophylla* (marri) – *Banksia* woodlands.

The majority of the Study Area north of Gnangara Road consists of pine plantations (a portion of which has been clear-felled). There are patches of remnant native vegetation remaining in the north-east of the Study Area, which consists predominantly of mixed *Banksia* woodlands. There is also an area which was previously cleared for sand mining which has since undergone rehabilitation, and is in various stages of growth.

A large portion of the Study Area south of Gnangara Road has previously been 'parkland cleared' and used for grazing, however there are significant areas of remnant vegetation remaining. These areas consist of a mosaic of woodlands of jarrah, marri, and banksia, *Melaleuca* damplands/wetlands and heathlands. The vegetation types in this area are largely associated with the underlying groundwater table and drainage features of the surrounding landscape.

The vegetation types are described in further detail in Table 6 and mapped in Figure 4, Appendix A.

Table 6 Vegetation types recorded in the Study Area

| No. | Broad Vegetation Type | Vegetation Association | Representative Quadrats | Site Photo | Total area (ha) in Study Area by vegetation condition |
|---|---|---|---|---|---|
| 1 | *Banksia* Woodland | Mixed Low Woodland of *Banksia menziesii, B. ilicifolia, B. attenuata* and *Nuytsia floribunda* with Scattered *Melaleuca preissiana* in lower-lying areas over Tall Shrubland to Scattered Tall Shrubs of *Xanthorrhoea preissii, Macrozamia fraseri* and *Adenanthos cygnorum* over Low Shrubland of *Hibbertia* spp., *Lysinema ciliatum* and *Regelia inops* over Herbland of *Dasypogon bromeliifolius, Patersonia occidentalis, Stylidium* spp., *Lyginia imberbis, Trachymene pilosa* and *Conostylis* spp. on low undulating grey sand dunes. | Q1, Q2, Q3, Q6, and Q20. |  | 2-3 = 25.82<br>3 = 64.97<br>3-4 = 2.79<br>4 = 6.64<br><br>Total = 100.22 ha |
| 2 | Closed Tall Scrub | Low Open Woodland of *Melaleuca preissiana* over Closed Tall Scrub of *Regelia ciliata, Adenanthos cygnorum* and *Banksia attenuata* in winter-wet depressions. | Q4 and Q5. |  | 2-3 = 2.24<br>3 = 1.93<br><br>Total = 4.17 ha |

| No. | Broad Vegetation Type | Vegetation Association | Representative Quadrats | Site Photo | Total area (ha) in Study Area by vegetation condition |
|---|---|---|---|---|---|
| 3 | Open Paddock | Woodland to Scattered Trees of *Eucalyptus marginata*, *Corymbia calophylla* and *Eucalyptus todtiana* with *Eucalyptus rudis* dominant along drainage lines over Low Woodland to Scattered Low Trees of *Nuytsia floribunda, Banksia attenuata, B. menziesii, B. ilicifolia* and *Melaleuca preissiana* over Open Scrub to Scattered Shrubs of *Xanthorrhoea preissii, Jacksonia furcellata* and *Hypocalymma angustifolium* over a predominantly cleared understorey dominated by introduced grasses and herbs including **Ehrharta longifolia, *Arctotheca calendula, *Hypochaeris glabra*, **Ursinia anthemoides, *Carpobrotus edulis, *Bromus diandrus* and **Ehrharta calycina* on grey sandy flats. | Q7, Q10, Q11 and T1. |  | 4-5 = 65.81<br>5 = 7.21<br>5-6 = 415.90<br>6 = 5.40<br><br>Total = 494.32 ha |
| 4 | *Melaleuca* Low Woodland | Low Woodland to Low Closed Woodland of *Melaleuca preissiana* over Scattered Shrubs of *Xanthorrhoea preissii, Astartea scoparia* and *Hypocalymma angustifolium* over predominantly cleared understorey dominated by introduced grasses and herbs including **Arctotheca calendula, *Hypochaeris glabra, *Ursinia anthemoides, *Brassica tournefortii*, *Carpobrotus edulis, *Galium murale* with Scattered Sedges of *Lepidosperma pubisquameum* and *Lepidosperma longitudinale* in winter-wet depressions and drainage lines. | Q8, Q9 Q12 and Q16. |  | 2-3 = 3.56<br>5-6 = 56.40<br><br>Total = 59.96 ha |

| No. | Broad Vegetation Type | Vegetation Association | Representative Quadrats | Site Photo | Total area (ha) in Study Area by vegetation condition |
|---|---|---|---|---|---|
| 5 | *Banksia* Low Open Forest | Scattered Trees to Low Open Woodland of *Corymbia calophylla* and *Eucalyptus marginata* over Low Open Forest of *Banksia attenuata*, *Allocasuarina fraseriana, B. menziesii* and occasional *B. ilicifolia* over Shrubland of *Xanthorrhoea preissii* and *Calytrix fraseri* over Low Shrubland of *Hibbertia hypericoides, Hibbertia subvaginata* and *Hypocalymma robustum* over Open Herbland of *Dasypogon bromeliifolius, Patersonia occidentalis, Drosera erythrorhiza* and *Stylidium* spp. on dark grey-brown sand flats. | Q14, Q21 and Q22. |  | 2-3 = 57.74<br>3-4 = 32.07<br><br>Total = 89.81 ha |
| 6 | Mixed Open Heath | Scattered Low Trees to Low Open Woodland of *Melaleuca preissiana, Allocasuarina fraseriana* and *Nuytsia floribunda* over Open Heath of *Calytrix fraseri, Melaleuca seriata, Pericalymma ellipticum* and *Xanthorrhoea preissii* over Low Shrubland of *Verticordia* spp., *Hypocalymma angustifolium* and *Scholtzia involucrata* over Open Herbland of *Patersonia occidentalis*, *Dasypogon bromeliifolius, Stylidium calcaratum*, **Ursinia anthemoides* and *Waitzia suaveolens* over Open to Very Open Sedgeland of *Lepidosperma* spp. and *Lyginia imberbis* on grey sand in lower-lying depressions. | Q13, Q15 and Q24. |  | 2-3 = 13.90<br>3-4 = 2.66<br><br>Total = 16.56 ha |

| No. | Broad Vegetation Type | Vegetation Association | Representative Quadrats | Site Photo | Total area (ha) in Study Area by vegetation condition |
|---|---|---|---|---|---|
| 7 | Jarrah-Marri-Banksia Woodland | Woodland of *Corymbia calophylla* and *Eucalyptus marginata* over Low Woodland of *Banksia menziesii, B. attenuata* and *B. ilicifolia* over Open Heath of *Xanthorrhoea preissii*, *Gompholobium scabrum*, *Jacksonia furcellata* and *Macrozamia fraseri* over Low Shrubland of *Hibbertia subvaginata, Hibbertia hypericoides* and *Hypocalymma robustum* over Open Herbland of *Patersonia occidentalis*, *Dasypogon bromeliifolius, *Hypochaeris glabra* and *Drosera erythrorhiza* on undulating dark grey-brown sand. | Q17, Q18 and Q19. |  | 2-3 = 73.02<br>3 = 5.93<br><br>Total = 78.56 ha |
| 8 | *Verticordia* Low Open Heath | Scattered Tall Shrubs of *Banksia menziesii* over Open Low Heath of *Verticordia* sp. and *Melaleuca seriata* over Open Herbland of *Lyginia imberbis, Cassytha* sp., *Stylidium calcaratum* and **Ursinia anthemoides* on white-grey sandy flats. | Q23 |  | 2-3 = 4.15<br><br>Total = 4.15 ha |

| No. | Broad Vegetation Type | Vegetation Association | Representative Quadrats | Site Photo | Total area (ha) in Study Area by vegetation condition |
|---|---|---|---|---|---|
| 9. | Rehabilitation | The return of previously cleared or disturbed land to remnant native vegetation. | N/A |  | 3-4 = 9.25<br>4 = 7.08<br>4-5 = 41.45<br>5-6 = 6.79<br>6 = 2.05<br><br>Total = 66.62 ha |
| 10 | Plantation | *Pinus* sp. plantations. Large areas have been clear-felled, leaving them devoid of vegetation. Some scattered native vegetation occurs within this vegetation type. | N/A |  | **included within the cleared/highly modified calculation below.* |

| No. | Broad Vegetation Type | Vegetation Association | Representative Quadrats | Site Photo | Total area (ha) in Study Area by vegetation condition |
|---|---|---|---|---|---|
| 11 | Cleared / Highly Modified | Areas where clearing or other activities have fundamentally altered the composition of native vegetation. These areas are completely or almost completely without native species. Some scattered native or planted trees (*Eucalyptus* spp.) and shrub species may remain with an understorey dominated by introduced grasses (or crop species) and herbs. | N/A |  | 5-6 = 50.74<br>6 = 618.89<br><br>Total = 669.63 |

### 4.3.4 Vegetation condition

Based on the Keighery (1994) condition rating scale (Appendix D) the vegetation condition of the study area ranged from Excellent (2) to Completely Degraded (6).

A large proportion of the Study Area occurs on predominantly cleared or highly altered land such as roads, grazed farmland, powerline easements, sand mine, building infrastructure, access tracks and plantations. These areas are generally considered to be in Degraded (5) to Completely Degraded (6) condition with little to no native vegetation remaining. Where vegetation is present in these areas, it generally comprises of common weed or crop species, with isolated native trees or shrubs. Vegetation adjacent to cleared or disturbed areas are subject to weed edge effects.

In areas where remnant patches of relatively intact vegetation remains, the vegetation is considered to range from Excellent (2) to Good (4) condition. The vegetation structure in these areas is generally intact, with some obvious signs of anthropogenic disturbance, including weeds, adjacent clearing, fire, historical logging and/or grazing.

The vegetation condition of the Study Area has been mapped on Figure 5, Appendix A.

### 4.3.5 Dieback

Dieback is spread by the movement of infected soil, plant material or water. The disease spreads naturally in sloping areas where surface water movements may result in contamination of areas downslope of an infected area. Dieback is also commonly spread via human activities, such as earth moving, vehicle movement and movement on foot.

GHD undertook a preliminary assessment for Dieback (*Phytophthora cinnamomi*) as part of the vegetation condition assessment. This was based on the presence/absence and health of typical indicator species, such as *Banksia* species. The Study Area can be considered as in an area susceptible to the development of the pathogen.

One strip of remnant vegetation on the eastern side of Beechboro Road, south of Bennett Brook, contains patches of dead banksias, which are suspected as relating to dieback. Dieback has previously been recorded in Whiteman Park. No further evidence for the presence of dieback was recorded in the Study Area.

Potentially dieback infected areas are shown in Plates 3 and 4.

Plate 3 Patch of dead *Banksia* species

Plate 4 Small patch of dead *Banskia* species

### 4.3.6 Threatened and priority ecological communities

A search of the DEC's TEC database did not identify any TECs within the Study Area. However, the desktop assessment did identify the presence or potential occurrence of the following four TECs within 10 km of the Study Area:

- *Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands of the Swan Coastal Plain (community type 3c) (*Endangered*. Also *Critically Endangered* under the DEC TEC database).
- Assemblages of plants and invertebrate animals of tumulus (organic mound) springs of the Swan Coastal Plain (no community type listed) (*Endangered*. Also *Critically Endangered* under the DEC TEC database).
- Claypans of the Swan Coastal Plain (community types 07, 08, 09 and 10a) (*Critically Endangered*. Also *Vulnerable* – 07, 08 and 09 – and *Endangered* – 10a).
- Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain (no community type listed) (*Endangered*. Also *Endangered* under the DEC TEC database).

The DEC search identified the buffers of the following two PECs within the Study Area:

- Low lying *Banksia attenuata* woodlands or Shrublands (community type 21c) (Priority 3).
- *Banksia ilicifolia* woodlands, southern Swan Coastal Plain (community type 22) (Priority 3).

The location of theTECs and PECs identified in the desktop assessment are provided in Figure 3A, Appendix A.

The species information from the quadrats completed during the survey has been compared using PATN analysis to the data from *A Floristic Survey of the Swan Coastal Plain* (Gibson, *et al.* 1994), which is a detailed analysis of vegetation types occurring on the Swan Coastal Plain. The Gibson, *et al*. (1994) study used the floristic data from 509 plots on the Swan Coastal Plain to define major regional community types, known as Floristic Community Types (FCTs).

Based on field observations and the PATN analysis, vegetation within the Study Area is closely associated with floristic community type (FCT) 21c. FCT 21c is listed as a Priority 3 PEC identified as 'Low lying B*anksia attenuata* woodlands or shrublands' (Priority 3 PEC). None of the quadrats recorded in the Study Area showed similarities to any TECs or other PECs identified as potentially occurring within the Study Area.

**Priority 3 - Low lying *Banksia attenuata* woodlands or shrublands (FCT 21c)**

This community type occurs sporadically between Gingin and Bunbury, and is largely restricted to the Bassendean system. The type tends to occupy lower lying wetter sites and is variously dominated by *Melaleuca preissiana*, *Banksia attenuata*, *B. menziesii*, *Regelia ciliata*, *Eucalyptus marginata* or *Corymbia calophylla*. Structurally, this community type may be either a woodland or occasionally a shrubland (DEC 2012a).

The entire Study Area occurs on the Bassendean system. A large majority of the remnant vegetation within the Study Area is dominated by *Banksia* woodlands of varying species composition and structure. The PATN Analysis identified 15 quadrats which showed similarity to this PEC based on species presence, with five quadrats (3, 18, 19, 20, and 21) displaying a greater than 65% similarity in species presence. Although the vegetation present within Quadrats 3, 18, 19 and 20 is associated with *Banksia* woodlands which have affinities to FCT 21c, none of these quadrats are located in, or associated with low-lying or wetter land features. The vegetation associated with these quadrats has been recorded from low, undulating sandy dune systems. As such, these sites are not considered to be representative of this PEC as they do not occur in the correct landscape.

The vegetation within Quadrat 21 consists of *Banksia* low open forest on sandy flats. This vegetation type occurs immediately adjacent to, and as a mosaic with, the Mixed Open Heath vegetation type which is associated with low lying depressions. The species recorded within Quadrat 21 had a 69% similarity to species present in quadrats associated with FCT21c. Quadrat 21 is located within the DEC buffer area of a known location of this PEC and this site is therefore considered to be representative of the PEC. The location of Quadrat 21 is shown on Figure 4, Appendix A. A targeted vegetation survey is required to accurately assess the presence and occurrence of this PEC within the Study Area.

It should be noted that many of the species associated with this PEC are common to *Banksia* woodlands across the Swan Coastal Plain (such as *B attenuata, B. menziesii, Corymbia calophylla, Eucalyptus marginata, Gompholobium tomentosum, Burchardia congesta, Trachymene pilosa, Caladenia flava, Dasypogon bromeliifolius, Drosera erythrorhiza, Patersonia occidentalis, *Briza maxima, *Hypochaeris glabra* and *Trachymene pilosa*, to name a few) and were recorded throughout the Study Area. The PATN analysis is limited in its use for comparing quadrat data as the analysis is based on all species recorded in the quadrats, including introduced species, and does not take into account dominance of species. This is likely to be the reason that 15 of the 24 quadrats recorded during the survey show affinity to FCT 21c.



### 4.3.7 Flora diversity

A NatureMap search identified 1198 flora species collected within 10 km of the Study Area; of which 261 are naturalised (introduced) species.

A total of 248 plant taxa (including subspecies and varieties) representing 58 families and 160 plant genera were recorded in the survey area. This total is comprised of 178 native species and 74 introduced (exotic) and/or planted species.

Dominant families recorded from the Study Area are:

- Myrtaceae 34 taxa;
- Fabaceae 33 taxa; and
- Asteraceae 21 taxa.

A total of 25 native taxa and 10 introduced taxa could not be identified to species level due to the absence of adequate flowering parts and/or fruiting bodies. None of these specimens

matched descriptions of any conservation significant species previously recorded from the vicinity of the Study Area.

A flora species list is provided in Appendix D.

### 4.3.8 Conservation significant flora

Desktop queries of the EPBC Act Protected Matters Search, NatureMap Database, DEC Rare Flora Databases and Western Australian Herbarium (WAHERB) (Appendix C) were undertaken over a 10 km radius from the Study Area, which identified the following:

- 17 species listed under the EPBC Act
- 16 species listed under the WC Act
- 40 DEC Priority species.

Of these, two plant taxa have been previously recorded within the Study Area (DEC 2012b). There is one record of the listed Threatened species *Caladenia huegelii* and one record of a Priority 4 listed species, *Verticordia lindleyi* subsp. *lindleyi*, both on the eastern side of Beechboro Road, within Whiteman Park.

A list of conservation significant flora identified in the desktop review is provided in Appendix C. The location of the DEC Threatened and Priority flora records within the Study Area is provided in Figure 3A, Appendix A.

The spring survey included a targeted search for Threatened and Priority flora within the Study Area at the locations recorded on DEC's database and in areas considered to contain suitable habitat for these species. No Threatened flora species listed under the EPBC Act or WC Act were recorded in the Study Area.

Two Priority plant species were recorded from the Study Area (Figure 6, Appendix A):

- *Eucalyptus caesia* (Priority 4)
- *Verticordia lindleyi subsp. lindleyi* (Priority 4)

A single *Eucalyptus caesia* tree was recorded in the Study Area in remnant vegetation north of Gnangara Road. *Eucalyptus caesia* is a mallee with 'minni-ritchi' bark which grows from 1.8 to 14 m tall. It has pink-red flowers, flowering in May to September and is known to occur on loam and granite outcrops. This species is known from the Avon Wheatbelt, Coolgardie and Mallee IBRA regions and does not naturally occur in the Swan Coastal Plain. Given the location of this single tree in remnant vegetation showing minimal signs of disturbance, it is unlikely to have been planted. However it is likely that seed was transported into the area (usually by birds) from a nearby planted species. The location of this species within the Study Area is not considered significant.

Four records of *Verticordia lindleyi subsp.* cf. *lindleyi* were recorded at two separate locations within the Study Area. None of the specimens collected during the survey were flowering therefore a definitive identification cannot be given, however these specimens were all found to closely resemble *Verticordia lindleyi subsp. lindleyi* and are likely to be this subspecies. *Verticordia lindleyi subsp. lindleyi* is an erect shrub which grows from 0.2 to 0.75 m high with pink flowers. It flowers in May or November to December or January. It occurs on sand and sandy clay soils in winter-wet depressions.

It is recommended a targeted survey for this species is undertaken during its known flowering period (May or late spring/early summer) to confirm its identification and to confirm the population size and extent of the species within the proposed alignment. This will assist in determining the level of impact the proposed construction footprint will have on this species.

Based on the DEC database, there is one record (recorded in 2005) of the Threatened species *Caladenia huegelii* within the Study Area. *Caladenia huegelii* occurs in areas of mixed woodland of *Eucalyptus marginata*, *Banksia attenuata*, *B. ilicifolia* and *B. menziesii* with scattered *Allocasuarina fraseriana* and *Corymbia calophylla* over dense shrubs of *Stirlingia latifolia*, *Hypocalymma robustum*, *Hibbertia hypericoides*, *H. subvaginata*, *Xanthorrhoea preissii*, *Adenanthos cuneatus* and *Conostylis* species. It occurs from just north of Perth to the Busselton area, usually within 20 km of the coast. Throughout its range the species tends to favour areas of dense undergrowth. Soil is usually deep grey-white sand usually associated with the Bassendean sand-dune system (DEC 2009).

*Caladenia huegelii* was not recorded during the field survey despite targeted searches during its known flowering period (September-October) and the presence of suitable habitat within the Study Area. However, it is thought that this species does not flower every year and the tubers can lie dormant until disturbance such as fire or partial clearing occurs (DSEWPaC 2013b). For this reason surveys over a number of years are generally required to confirm the presence of this species. Additional targeted surveys in suitable habitat for *Caladenia huegelii* (including the *Banksia* Woodland, *Banksia* Low Open Forest and Jarrah-Marri-*Banksia* Woodland) are recommended to confirm the presence/absence of this species within the proposed alignment and assist in determining the level of impact (if any) the proposed construction footprint will have on this species.

### Likelihood of occurrence

In addition to the flora species recorded during the field survey, a number of conservation significant flora species were identified as potentially occurring within the Study Area during the desktop investigation. An assessment on the likelihood of these species occurring in the Study Area was undertaken. This assessment is based on species habitat requirements, availability of suitable habitat and records of the species in the area. The assessment is provided in Appendix E.

The assessment concluded that two species are present or have previously been recorded, 15 species have potential to occur, 34 species are unlikely to occur and two species are highly unlikely to occur in the Study Area. Additionally the likelihood of occurrence of three species could not be assessed as there is currently little to no information available on the habitat requirements of them. A summary of the flora species considered to be present or have the potential to occur in the Study Area is provided in Table 7.

Table 7 Summary of flora species considered to occur or have potential to occur in the Study Area

| Known to occur | Potential to occur |
|---|---|
| *Caladenia huegelii* | *Acacia benthamii* |
| *Verticordia lindleyi* subsp. *lindleyi* | *Amperea protensa* |
| | *Dampiera triloba* |
| | *Dasymalla axillaris* |
| | *Drosera occidentalis* subsp. *occidentalis* |
| | *Drosera x sidjamesii* |
| | *Hypolaena robusta* |
| | *Isopogon drummondii* |
| | *Jacksonia sericea* |
| | *Pimelea calcicola* |
| | *Schoenus griffinianus* |
| | *Schoenus natans* |
| | *Schoenus* sp. Waroona (G.J. Keighery 12235) |

| Known to occur | Potential to occur |
|---|---|
| | *Stylidium trudgenii* |

### 4.3.9 Introduced flora

Weeds may lead to the degradation of the environment by competing with native vegetation for resources. A total of 74 introduced (exotic) plant species were recorded from the Study Area. Introduced grasses and herb species are common throughout the understorey of much of the Study Area, and particularly dominant within highly modified areas. The areas of native vegetation considered to be in excellent to very good condition contain minimal weed invasion of generally non-aggressive weed species.

No weed species recorded in the Study Area are listed as Weeds of National Significance (WONS) listed by the Federal Government or are classified as Declared Pests by the *Biosecurity and Agriculture Management Act 2007* (BAM Act).

## 4.4 Fauna

The following section includes information gathered during a spring fauna survey of the Study Area undertaken by GHD in September 2012.

### 4.4.1 Fauna habitat types

Six broad fauna habitat types have been identified in the Study Area based on the predominant landforms, soil and vegetation structure in the area. These habitat types closely correspond to the vegetation types outlined in section 5.2.1 and are as follows:

- *Banksia* woodlands/forests
- Eucalypt Woodlands
- Winter-wet depressions/minor drainage lines (Tall scrublands and *Melaleuca* woodlands)
- Heathlands
- Pine plantations

The *Banksia* and Eucalypt woodlands are the dominant habitat types throughout the Study Area. These habitat types contain an overstorey dominated by *Banksia* spp., *Eucalyptus marginata* (jarrah), *Corymbia calophylla* (marri), *Allocasuarina fraseriana* (sheoak) and *Nuytsia floribunda* and are generally associated with grey sandy soils on plains and low dune systems. The Banksia woodlands range from good to excellent condition and provide particularly high habitat value for fauna species due to the variety of microhabitats and various resource niches available. The woodlands would be expected to support a high diversity of bird species. Across these woodlands are areas of loose sands that are particularly suitable for burrowing reptiles. The woodlands range from an open to closed canopy with a relatively sparse mid-storey and thick ground cover in some areas. This ground cover would provide foraging opportunities and refuge areas for ground-dwelling mammals such as the Southern Brown Bandicoot/Quenda and Western Brush Wallaby and reptiles such as goannas and skinks. Micro-habitat features such as tree hollows and cavities provide habitat for a number of birds, reptiles and small mammal species. The presence of banksia, jarrah, marri and other eucalypt and proteaceous species provides feeding habitat for the conservation significant black cockatoo species. Some of the larger eucalypts also provide potential breeding and roosting habitat.

There are patches of *Melaleuca* woodlands and tall scrublands associated with winter-wet depressions and minor drainage lines throughout the Study Area. During the wet winter months the soils in these areas are likely to be waterlogged or partially inundated. The density of the tall scrublands and canopy of the Melaleuca woodlands provide good habitat for bird species.

However the majority of the Melaleuca woodlands in the Study Area have been highly modified and contain little to no native understorey species, reducing the habitat value for ground dwelling fauna species.

The heathlands in the Study Area are generally associated with grey sandy flats and low-lying depressions. The vegetation was generally open and consisted of a mid-storey of mixed shrubs with a very open upper-storey of scattered trees over an open ground layer of sedges, herbs and low shrubs. This habitat would be utilised by ground-dwelling mammals and reptiles and some smaller bird species.

The majority of the Study Area north of Gnangara Road consists of pine plantations or recently cleared land. Pine plantations provide very limited habitat for most fauna species as the understorey is completely devoid of vegetation. However they do provide some habitat for bird species. Pines have become one of the main food sources for Carnaby's Black Cockatoo within the Gnangara Sustainability Strategy area during the non-breeding season (January-June) (Finn *et al*. 2009). The Gnangara pine plantations are considered to have high value as a food source for Carnaby's Black Cockatoo. Additionally most of the pines along Gnangara Road have well-developed canopies that provide good roost sites for the cockatoos. Saunders (1974) noted that birds in the Gnangara plantation bred locally and it's possible that they may have done so in the marri woodland areas.

### Habitat linkages

Habitat linkages are important to allow animals to move between areas of resource availability. They are important for ground and aerial fauna, providing cover, resources, and linking areas suitable 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 or habitat changes over time. 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 majority of the Study Area south of Gnangara Road, particularly to the west and east, is surrounded by remnant native vegetation or partially cleared farmland. The areas of remnant vegetation in and immediately surrounding the Study Area are part of a regionally significant fragmented bushland/wetland linkage, with a large proportion of this vegetation currently protected as a series of Bush Forever sites (Government of Western Australia 2000). The existing Beechboro Road dissects the remnant vegetation in a north-south direction and Gnangara Road dissects vegetation in an east-west direction. North of Gnangara Road the remaining remnant vegetation is already highly fragmented due to historical and current clearing activities such as sand mining, pine plantations, roads, tracks and urban development.

## 4.4.2 Fauna diversity

A NatureMap search identified records of 452 fauna species within 10 km of the Study Area; of which 20 are naturalised (introduced) species. These records consisted of 190 bird, 81 reptile, 36 mammal, 14 amphibian, 45 fish and 86 invertebrate species. Errors were identified within these search results where a number of the fauna species listed in the results are outside their known distribution. In these cases the information provided within the database may have been incorrectly recorded or entered, or the species incorrectly identified (DEC 2013). Therefore this list of species does not accurately capture the true diversity of the search area.

The spring field survey recorded a total of 51 fauna species, consisting of 37 birds, seven reptiles and seven mammals. Of these, 47 are native and four species are introduced.

A list of the fauna species recorded during the survey is provided in Appendix D.

### 4.4.3 Conservation significant fauna

Desktop queries of the EPBC Act Protected Matters Search and NatureMap Database were undertaken over a 10 km radius of the Study Area, which identified the presence of the following:

- 15 threatened species listed under the EPBC Act
- 13 species listed as Migratory under the EPBC Act
- 20 species listed under the WC Act
- 11 DEC Priority species

A list of the conservation significant species identified in the desktop review is provided in Appendix C.

During the field survey one species listed as Endangered under the EPBC Act and Threatened under the WC Act, two species listed Priority by the DEC and one species listed Migratory under the EPBC Act were recorded. The species are listed as follows:

- Carnaby's Black Cockatoo (*Calptorhynchus latirsotris*) – Endangered/Threatened
- Western Brush Wallaby (*Macropus irma*) – Priority 4
- Quenda/Southern Brown Bandicoot (*Isoodon obesulus fusciventer*) – Priority 5
- Rainbow Bee-eater (*Merops ornatus*) – Migratory

A brief description of each of these species and their associated habitat types are described below.

**Carnaby's Black Cockatoo (*Calptorhynchus latirsotris*)**

The Carnaby's Black Cockatoo is listed Endangered under the EPBC Act and Threatened (Schedule 1) under the WC Act. It is distributed across the south-west of Western Australia in uncleared or remnant areas of *Eucalyptus* woodland and shrubland of kwongan heath. Carnaby's Cockatoo breeds in the semi-arid and sub-humid interior ("wheatbelt") and some locations along the south and west coasts. From late January/early February most interior-breeding birds leave their breeding areas, moving west, south and east towards the coast. The movement back to breeding sites in the interior occurs in July/August, and September/October to breeding areas on the Swan Coastal Plain (DSEWPaC 2012b).

***Foraging Habitat***

The Carnaby's Black Cockatoo is known to feed in native shrubland, kwongan heathland and woodland dominated by proteaceous plant species such as *Banksia* spp., *Hakea* spp. and *Grevillea* spp. This species is known to forage in pine plantations (*Pinus* spp.) and eucalypt woodland and forest that contain foraging species. They also feed on individual trees and small stands of these species. Common food items include seeds, flowers and nectar of native proteaceous plant species, eucalypts, and Callistemon and seeds of introduced species including *Pinus* pp., *Erodium* spp., wild radish, canola, almonds and pecan nuts (DSEWPaC 2012b).

The majority of the vegetation in the Study Area contain suitable foraging species for the Carnaby's Black Cockatoo. This includes banksia woodlands (including *Banksia attenuata*, *B. menziesii*, *B. ilicifolia*, *B. grandis, and Hakea* spp.), mixed eucalypt woodlands (containing *Eucalyptus marginata, Corymbia calophylla, E. rudis, E. gomphocephala, E. todtiana* and *Banksia* spp.), and pine plantations (*Pinus* sp.), all of which contain plant species which are regarded as high value foraging species.

***Breeding Habitat***

The Study Area is located within the known breeding range for the Carnaby's Black Cockatoo (DSEWPaC 2012b). This species generally breeds in woodland or forest, but also breeds in former woodland or forest now present as isolated trees. It nests in hollows in live or dead trees of *E. salmonophloia* (salmon gum), *E. wandoo* (wandoo), *E. gomphocephala* (tuart), *E. marginata* (jarrah), *E. rudis* (flooded gum), *E. loxophleba* subsp. *loxophleba* (York gum), *E. accedens* (powderbark), *E. diversicolor* (karri) and *Corymbia calophylla* (marri). Of these species, tuart, jarrah, flooded gum and marri were all recorded from the Study Area.

There is suitable breeding habitat for the Carnaby's Black Cockatoo within the Study Area.

***Roosting Habitat***

The Carnaby's Black Cockatoo will roost in a suitable tree or group of trees, usually close to an important water source (riparian environments or natural and artificial permanent water sources) and within an area of quality foraging habitat. This species is known to roost *Eucalyptus occidentalis* (flat-topped Yate), *E. salmonophloia* (salmon gum), *E. wandoo* (wandoo), *Corymbia calophylla* (marri), *E. diversicolor* (karri), *E. patens* (blackbutt), *E. gomphocephala* (tuart) and introduced eucalypts (for example blue gum) and introduced pines (DSEWPaC 2012b). Of these species, marri, tuart and pine trees were recorded in the Study Area.

According to mapping provided by the Department of Planning Western Australia (2011) there is a known roosting site in the Study Area, north of Gnangara Road, with a number of other sites recorded nearby.

There is suitable roosting habitat for the Carnaby's Black Cockatoo within the Study Area.

**Western Brush Wallaby (*Macropus irma*)**

The Western Brush Wallaby is listed Priority 4 by the DEC and is endemic to the south-west of Western Australia. Its optimum habitat is open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets. It is also found in some areas of mallee and heath and is uncommon in wet sclerophyll forest and absent from the true Karri forests that have dense undergrowth (Van Dyck and Strahan 2008).

Within the Study Area, the eucalypt forests, mixed eucalypt and *Banksia* woodlands and mixed open heathlands provide suitable habitat for this species. This species was observed in the Jarrah-Marri-*Banksia* woodland east of Beechboro Road, near the WA Archery centre which is outside the clearing footprint for the Project. This species is known to occur within Whiteman Park.

**Quenda / Southern Brown Bandicoot (*Isoodon obesulus fusciventer*)**

The Quenda, also known as the Southern Brown Bandicoot, is listed Priority 5 by the DEC. It is widely distributed near the south-west coast from Guilderton north of Perth to east of Esperance, patchy distribution through the Jarrah and Karri forest and on the Swan Coastal Plain, and inland as far as Hyden. Its optimum habitat includes scrubby, often swampy, vegetation with dense cover up to one metre high, often feeds in adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and cropland lying close to dense cover. On the Swan Coastal Plain, Quendas are often associated with wetlands (Van Dyck and Strahan 2008).

Within the Study Area, the forest, woodlands and scrubby heathland habitats, particularly those closely associated with the seasonal damplands and contain a dense understorey, provide suitable habitat for Quenda. A number of bandicoot diggings were observed in the Study Area on the eastern side of Beechboro Road in the *Banksia* low open forest and mixed open heath

vegetation types. This area is outside the clearing footprint of the proposed project. This species is known to occur within Whiteman Park.

**Rainbow Bee-eater (*Merops ornatus*)**

The Rainbow Bee-eater is listed Migratory under the EPBC Act. The Rainbow Bee-eater is distributed across much of mainland Australia, and occurs on several near-shore islands. It is a breeding migratory bird to the south-west, arriving in September to October and departing the south-west from January to March/April (DSEWPaC 2013b). They occur mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation (DSEWPaC 2013b).

The entire Study Area provides suitable habitat for the Rainbow Bee-eater, in particular the open paddocks, open forests and woodlands. A number of individuals were observed throughout the Study Area during the field survey.

### Likelihood of occurrence

In addition to the fauna species recorded during the field survey, a number of conservation significant fauna species were identified as potentially occurring within the Study Area during the desktop investigation. An assessment on the likelihood of these species occurring in the Study Area was undertaken. This assessment is based on species biology, habitat requirements, the quality and availability of suitable habitat and records of the species in the area. The assessment is provided in Appendix E.

The assessment concluded that four species are known to occur, four species are likely to occur, five species could possibly occur and 27 species are unlikely to occur in the Study Area. A summary of the fauna species considered to be present, likely to occur or possibly occur in the Study Area are listed in Table 8.

Table 8 Summary of the likelihood of occurrence assessment

| Known to occur | Likely to occur | Could possibly occur |
|---|---|---|
| Carnaby's Black Cockatoo | Peregrine Falcon | Fork-tailed Swift |
| Rainbow Bee-eater | Black-striped Snake | Eastern Great Egret |
| Western Brush Wallaby | Carpet Python | Cattle Egret |
| Quenda / Southern Brown Bandicoot | *Ctenotus gemmula* | Graceful Sun-moth |
| | | *Hylaeus globuliferus* (Bee) |

## 4.5 Hydrology

Hydrology and hydrogeology aspects in the Study Area are provided in Table 9. The Study Area is located within two proclaimed groundwater areas and one proclaimed surface water area under the *Rights in Water and Irrigation Act 1914* (RIWI Act), and a Priority 1 Public Drinking Water Source Area (PDWSA).

Table 9 Department of Water Geographic Data Atlas Queries (DoW 2012)

| Aspect | Details | Results |
|---|---|---|
| RIWI Groundwater Areas | Groundwater areas proclaimed under the *Rights in Water and Irrigation Act 1914*. | Gnangara and Mirrabooka |
| RIWI Surface Water Areas | Surface water areas proclaimed under the *Rights in Water and Irrigation Act 1914*. | Swan River System |
| RIWI Irrigation District | Irrigation Districts proclaimed under the *Rights in Water and Irrigation Act 1914*. | None present |
| RIWI Rivers | Rivers proclaimed under the *Rights in Water and Irrigation Act 1914*. | None present |

| Aspect | Details | Results |
|---|---|---|
| Public Drinking Water Source Areas (PDWSA) | PDWSAs is a collective term used for the description of Water Reserves, Catchment Areas and Underground Pollution Control Areas declared (gazetted) under the provisions of the *Metropolitan Water Supply, Sewage and Drainage (MWSSD) Act 1909* or the *Country Area Water Supply (CAWS) Act 1947*. | Gnangara Underground Water Pollution Control Area (P1) |
| Waterway Management Areas | Areas proclaimed under the *Waterway Conservation Act 1976*. | None present |

### 4.5.1 Groundwater

Typically the groundwater within the Bassendean Sand ranges from surface level (interdune areas) to in excess of 30 m deep. The water table fluctuates seasonally.

The Study Area is located within the Gnangara Mound which is the largest and most important source of fresh groundwater in the Perth region. It also supports a variety of significant environmental features such as wetlands, shallow cave streams, springs and seepages, and native vegetation dependent on groundwater (Western Australian Planning Commission 2001).

Based on the Perth groundwater Atlas, the local groundwater flow at the Site was anticipated to flow in a south to south-east direction towards the Swan River. Regionally, the groundwater flow direction was influenced by the Gnangara Mound to the North of Perth. The groundwater flows in a radial direction from the mound towards to the Swan River and Indian Ocean.

A search of the Department of Water (DoW) WIN (Water Information Systems) registered bores database identified a total of 237 bores within a 1 km buffer zone of the site boundary. A total of 130 of the 237 registered bores were listed as being “abandoned” or “not operating” The remaining 107 registered bores still in use were registered for a variety of uses including: 2 as domestic/household bores, 11 as Groundwater Assessment Network bores, 5 as investigation bores, 4 as irrigation bores, 21 as monitoring bores, 11 as observation bores, 22 as production bores, 1 as a project bore and 6 as WRL linked bores. The remaining bores did not provide information regarding registered use (GHD 2013).

Depth to groundwater reportedly ranged from 13.5 mbgl (41.238 mAHD) to 14.64 mbgl (40.098 mAHD) in the north of the site to 1.505 mbgl (30.8 mAHD) to 2.7 mbgl (29.605 mAHD) in the south of the site in September and October 2009 (GHD 2013). Further details on the locations of groundwater bores are provided in the Preliminary Site Investigation (PSI) conducted by GHD (2013) (Appendix F).

A search of the DoW Geographic Data Atlas (DoW 2012) identified the Study Area as being within both the Gnangara and Mirrabooka RIWI groundwater areas.

The groundwater salinity in the Study Area ranges from 0 to 1000 mg/L TDS (DoW 2012).

### 4.5.2 Public drinking water source areas

A search of the DoW Geographic Data Atlas (2012) indicates that the Study Area is within the Gnangara Underground Water Pollution Control Area which is a Priority 1 Protection Zone. P1 classification areas are defined to ensure that there is no degradation of the water source.

### 4.5.3 Surface hydrology and wetlands

The Study Area is located within the Swan River System RIWI surface water area. No RIWI rivers were identified in the area.

There is one significant stream in the Study Area, Bennett Brook. Bennett Brook originates in the Study Area in Whiteman Park as a superficial aquifer. Rain fills the aquifer, causing it to rise and fill the wetlands during the winter months. The Brook flows through Mussel Pool and runs south to join the Swan River at Bassendean (Whiteman Park 2013).

The entire Study Area lies within the Bennett Brook Catchment. Under the Healthy Rivers Action Plan (HRAP), the Bennett Brook Catchment is identified as one of eight priority catchments in the Swan Canning river system. The catchment has an area of 217 $km^2$ and just over half is covered by the Gnangara pine plantation and Whiteman Park. Bennett Brook was once a natural creek system; however its tributaries to the west have been modified to deeply incised drains to allow development. The amount of water entering Bennett brook from the catchment is important to maintain environmental and recreational values in the brook (Government of Western Australia 2011).

The EPBC Act Protected Matters Search did not identify any Ramsar listed wetlands within 10 km of the Study Area. The search did however identify three Nationally Important Wetlands in the search area:

- Ellen Brook Swamps System
- RAAF Caversham
- Swan-Canning Estuary

None of these wetlands are within the Study Area.

There are no EPP Lakes within or immediately adjacent to the Study Area.

Two types of geomorphic wetlands have been identified within the Study Area, palusplain (seasonally waterlogged flats) and damplands (seasonally waterlogged basin). Within the Study Area there are five Conservation Category Wetlands, twelve Multiple Use Wetlands and one Resource Enhancement Wetland. A list of the geomorphic wetlands present within the Study Area is provided in Table 10. The location of these wetlands and their associated identification number is presented on Figure 3A, Appendix A.

Table 10 Geomorphic wetlands present within the Study Area.

| UFI | Wetland Classification | Management Category | Wetland Name |
|---|---|---|---|
| 15260 | Palusplain | Conservation | Unknown |
| 8439 | Palusplain | Conservation | Unknown |
| 8404 | Palusplain | Conservation | Unknown |
| 12965 | Palusplain | Conservation | Unknown |
| 8416 | Palusplain | Conservation | Unknown |
| 13381 | Dampland | Resource Enhancement | Unknown |
| 8412 | Dampland | Multiple Use | Unknown |
| 8411 | Dampland | Multiple Use | Unknown |
| 8413 | Dampland | Multiple Use | Unknown |
| 8254 | Dampland | Multiple Use | Unknown |
| 8438 | Dampland | Multiple Use | Unknown |
| 8255 | Palusplain | Multiple Use | Unknown |
| 8440 | Palusplain | Multiple Use | Unknown |
| 8442 | Palusplain | Multiple Use | Unknown |
| 8444 | Palusplain | Multiple Use | Unknown |
| 15175 | Palusplain | Multiple Use | Unknown |
| 8454 | Palusplain | Multiple Use | Unknown |
| 15029 | Palusplain | Multiple Use | Unknown |

### 4.5.4 Wetland field assessment

An assessment of the wetlands and creeks was undertaken concurrently with the spring flora and fauna survey. This assessment considered all wetlands within the Study Area. A summary of the findings of these investigations is provided in Table 11.

Table 11 Geomorphic wetlands present within the Study Area.

| UFI | Management Category | Site description | Vegetation Condition | Photograph |
|---|---|---|---|---|
| 15260 | Conservation | Mosaic of heathlands and *Banksia* low open forest on sandy flats. Dominant species include *Banksia menziesii, Verticordia* spp., *Melaleuca seriata, M. preissiana, Allocasuarina fraseriana, Calytrix fraseri, Pericalymma ellipticum,* and *Hypocalymma angustifolium*. Soils may potentially be seasonally waterlogged. | Excellent (2) to Very Good (3) |   |
| 8439 | Conservation | This wetland is associated with Bennett Brook. The ground cover along the creek predominantly consists of weedy grasses and herbs. The vegetation consists of *Melaleuca* low woodland along an ephemeral creekline and seasonally waterlogged flats. Dominant species include *Melaleuca preissiana, Hypocalymma angustifolium, Nuytsia floribunda, Pericalymma ellipticum* and *Xanthorrhoea preissii.* | Very Good (3) to Good (4) |  |

| UFI | Management Category | Site description | Vegetation Condition | Photograph |
|---|---|---|---|---|
| 8404 | Conservation | Mosaic of *Banksia* low open forest and mixed open heath on sandy flats. Dominant species include *Banksia attenuata, Allocasuarina fraseriana, B. menziesii* and occasional *B. ilicifolia, Xanthorrhoea preissii, Calytrix fraseri, Hibbertia* spp., *Hypocalymma* spp., *Melaleuca preissiana, Nuytsia floribunda, Melaleuca seriata, Pericalymma ellipticum,* and *Verticordia* spp. over herbs and scattered sedges. | Excellent (2) to Very Good (3) |  |
| 12965 | Conservation | This site is on private property that was fenced off and unable to be surveyed. However vegetation appeared to consist of *Eucalyptus – Banksia* woodland with scattered sheoaks over low shrubs. No species associated with a wetland were observed. | Excellent (2) to very Good (3) |  |

| UFI | Management Category | Site description | Vegetation Condition | Photograph |
|---|---|---|---|---|
| 8416 | Conservation | *Melaleuca preissiana* Low Woodland on seasonally waterlogged soils. Understorey is predominantly cleared and dominated by weedy grasses and herbs. Some native shrubs including *Astartea scoparia* and *Hypocalymma angustifolium* over sedges *Lepidosperma pubisquameum* and *L. longitudinale* remain. | Good (4) to Degraded (5) |  |
| 13381 | Resource Enhancement | Vegetation predominantly cleared; land previously used for agricultural (grazing) purposes. Vegetation consists of scattered eucalypts, melaleucas and grass trees over weeds (herbs and grasses). The vegetation structure is longer intact. | Completely Degraded (6) |  |
| 8412 | Multiple Use | This site consists of a driveway entering an equestrian centre (private property). The area is predominantly cleared and consists of scattered native and introduced trees. The vegetation structure of the site is no longer | Completely Degraded (6) | No Photo |

| UFI | Management Category | Site description | Vegetation Condition | Photograph |
|---|---|---|---|---|
| | | intact. | | |
| 8411 | Multiple Use | Vegetation predominantly cleared; land previously used for agricultural (grazing) purposes. Vegetation consists of scattered eucalypts, melaleucas and grass trees over weeds (herbs and grasses). The vegetation structure is longer intact. | Completely Degraded (6) |   |
| 8413 | Multiple Use | Site has been completely cleared. A large aerial is situated in the middle of the site. | Completely Degraded (6) | No Photo |
| 8254 | Multiple Use | Vegetation predominantly cleared; land previously used for agricultural (grazing) purposes. Beechboro Rd runs through the site. West of Beechboro Rd vegetation consists of scattered small clumps of *Melaleuca preissiana* with scattered Jarrah, Marri, melaleucas, *Nuytsia floribunda* and grass trees over weeds. Vegetation structure is no longer intact.<br>The small area of vegetation east of Beechboro Rd consists of Jarrah-Marri-Banksia Woodland and is generally in very good condition. | Degraded (5) to Completely Degraded (6) and in bushland east of Beechboro Rd Excellent (2) to Very Good (3) |   |

| UFI | Management Category | Site description | Vegetation Condition | Photograph |
|---|---|---|---|---|
| 8438 | Multiple Use | Vegetation predominantly cleared; land previously used for agricultural (grazing) purposes. Scattered small clumps of Melaleuca preissiana with scattered individual eucalypts, melaleucas and grass trees over weeds. Vegetation structure is no longer intact. | Completely Degraded (6) |  |
| 8255 | Multiple Use | Parkland cleared; land previously used for agricultural (grazing) purposes. Scattered *Melaleuca preissiana*, eucalypts and grass trees over weeds. Vegetation structure is no longer intact. | Completely Degraded (6) |  |
| 8440 | Multiple Use | Vegetation predominantly cleared; land previously used for agricultural (grazing) purposes and currently an equestrian centre. Contains some scattered eucalypts and grass trees of weed. The vegetation structure | Completely Degraded (6) | No Photo |

| UFI | Management Category | Site description | Vegetation Condition | Photograph |
|---|---|---|---|---|
| | | is no longer intact. | | |
| 8442 | Multiple Use | Predominantly cleared land previously used for agricultural (grazing) purposes, tracks, fenceline and for the existing Beechboro Road. Some scattered eucalypts, acacias, melaleucas and grass trees over weedy grasses and herbs. Vegetation structure is no longer intact. | Degraded (5) to Completely Degraded (6) |  |
| 8444 | Multiple Use | Predominantly cleared land previously used for agricultural (grazing) purposes, tracks, fenceline and the existing Beechboro Road. Some scattered eucalypts, melaleucas, grass trees and other low trees and tall shrubs over weedy grasses and herbs. Vegetation structure is no longer intact. | Degraded (5) to Completely Degraded (6) |  |

| UFI | Management Category | Site description | Vegetation Condition | Photograph |
|---|---|---|---|---|
| 15175 | Multiple Use | The land is predominantly parkland cleared, previously used for agricultural purposes (grazing) and contains scattered trees and shrubs including eucalypts, melaleucas, grass trees over weeds. Basic vegetation structure is severely impacted by disturbance. | Degraded (5) to Completely Degraded (6) |   |
| 8454 | Multiple Use | Predominantly cleared land previously used for agricultural (grazing) purposes. Some scattered eucalypts, melaleucas and grass trees over weedy grasses and herbs. Numerous tracks. Vegetation structure is no longer intact. | Completely Degraded (6) |  |
| 15029 | Multiple Use | Predominantly cleared land previously used for agricultural (grazing) purposes, roads and housing. Some scattered eucalypts and melaleucas over weedy grasses and herbs. Vegetation structure is no longer intact. | Completely Degraded (6) |   |

## 4.6 Acid sulfate soils

The Australian Soil Resource Information System (ASRIS, 2012) contains an Atlas of Australian Acid Sulfate Soils (prepared by CSIRO, Fitzpatrick and Shand, 2008) for use in hazard assessment.

The ASRIS (2012) database and associated CSIRO guidance (Fitzpatrick and Shand, 2008) states the following for the Study Area:

- The majority of the Study Area is within the National Acid Sulphate Soils Group B4;
  - Low Probability/Very Low Confidence of Occurrence.
- Small areas within the Study Area are within the National Acid Sulphate Soils Group A3 and A4;
  - High Probability/Low Confidence of Occurrence.

Based on the above, ASRIS (2012) mapping shows the majority of the Study Area to have a low probability of having ASS impact, with smaller portions of site having a high probability of ASS impact. However, this was inferred from other datasets and consequently is subject to uncertainty i.e. 'Very Low Confidence'.

ASS mapping of the Study Area is provided in Figure 3B, Appendix A

## 4.7 Heritage

### 4.7.1 Aboriginal heritage

Main Roads commissioned detailed heritage investigations to support alignment definition planning for the preferred long term alignment for the PDNH between Tonkin-Reid Highway and Maralla Road in Ellenbrook. R. & E. O'Connor Pty Ltd carried out the Aboriginal heritage surveys of the Study Area which included an anthropological survey and Aboriginal consultative process, which were carried out in November and December 2012. John B. Cecchi carried out the archaeological survey on behalf of R. & E. O'Connor Pty Ltd in November 2012.

A search of the Register of Aboriginal Sites for the Study Area and immediate surrounds was carried out as part of this survey. Two Aboriginal sites and one "Other Heritage Place" have been previously recorded within the search area (Figure 3C, Appendix A). These are:

- Site Number 3692, "Bennett Brook In Toto", a mythological site held under Closed Access without gender restrictions.
- Site Number 3426, "South Ballajura Camp", a camping site held under Closed Access without gender restrictions.
- Other Heritage Place Listing Number 3618, "Whitemans Cutting", an artefact scatter site held under Open Access without gender restrictions.

Site Number 3426 is outside the area of proposed works.

The ethnographic survey identified that the proposed Project will impact indirectly upon one Aboriginal site, namely Site Number 3692, "Bennett Brook In Toto". The impact will be indirect, in that the project crosses a small seasonal drain which, when flowing, carries run-off into the headwaters of Bennett Brook in Whiteman Park. That impact has the potential to be damaging to the Aboriginal values of the site, as noted by four of the Aboriginal groups, as there is a possibility of pollutants from road construction entering the waters of the Bennett Brook system (O'Connor 2012). If strict control over run-off is enforced, then the possibility of impact on the site can be avoided. It is noted that three of the Aboriginal groups recommended that monitors

from their community should be appointed to observe and oversee those controls (O'Connor 2012).

Other Heritage Place Listing Number 3618, "Whitemans Cutting", an artefact scatter site held under Open Access without gender restrictions, is also within the survey area. However, the Site File in this case records that the artefacts have been collected from the site in the past. The proposed works cannot therefore impact upon those artefacts, as they are no longer in place (O'Connor 2012).

No archaeological sites of Aboriginal heritage or isolated artefacts were identified during the field survey undertaken by Cecchi (2012).

The ethnographic and archaeological survey reports undertaken by O'Connor (2012) and Cecchi (2012) respectively are provided in Appendix G.

### 4.7.2 Native title

The Study Area has no determined native title holders. However the Study Area is included within the lands and waters claimed by the Swan River #2 People and the Whadjuk People applications for determination of native title. The latter claim has satisfied the conditions of Section 190A of the *Native Title Act 1993* and is therefore listed on the Register of Native Title Claims. As such, the claimant group enjoys the statutory Right to Negotiate under the Future Act provisions of that legislation. The Swan River People's claim is unregistered (O'Connor 2012).

### 4.7.3 European heritage

Dr Gaye Nayton was commissioned by GHD on behalf of Main Roads to undertake an assessment of european heritage sites within the PDNH-Tonkin Link Study Area in December 2012. The purpose of the study was to investigate and make recommendations for managing identified non-indigenous heritage issues that may be affected by the highway in accordance with the requirements of the Heritage Council of WA. The results of the assessment are summarised below.

The Heritage Council of Western Australia's register of heritage Places was searched through the on-line database called *Inherit*. The database was searched for known heritage places within the suburbs of Whiteman, Lexia, Cullacabardee and Gnangara with the following results:

- Lexia and Cullacabardee: No heritage places.
- Whiteman: two trains on the Whiteman Park railway which is located outside of the Study Area.
- Gnangara: Gnangara Lake and East Wanneroo School site, both of which are outside of the Study Area.

The local government municipal inventories for the City of Wanneroo and the City of Swan were also searched with no further results as was the National Trust classified list (Nayton 2012). The Australian Heritage Commission was also searched. This database contained only the Ellenbrook National Estate Area of bushland which has Maralla Road as it southern boundary. This is outside the current Study Area (Nayton 2012).

The survey of the Study Area undertaken by Nayton (2012) identified no heritage listed non-indigenous places. An extensive desktop survey and information search identified only one potential heritage place which could create issues. This is the Forestry Department's divisional headquarters' and fire lookout, much of which would be an archaeological site. The history of the place indicates heritage potential at the state level however no archaeological survey has been undertaken to determine whether this archaeological potential is still largely intact (Nayton

2012). Nayton (2012) recommended that an archaeological and heritage survey is carried out on this place if the planned construction works are likely to impact on or close to this site to determine the extent and nature of surviving archaeological and built heritage features.

It should be noted that during the flora and fauna survey undertaken by GHD in spring 2012, this area was traversed and there were no buildings remaining on site. However this area had been highly disturbed and scattered building rubble, concrete slabs, rubbish and introduced vegetation was observed which indicated that there was once a building/structure in the area.

Nayton (2012) also identified that the former Santa Rosa farmhouse within the Rick Hamersley Centre may also be a low level heritage issue if impacted. It is recommended that if either the Santa Rosa farmhouse or the Cottage at the Rick Hamersley Centre is required to be demolished than an archival survey is undertaken of both houses prior to demolition (Nayton 2012).

The European heritage assessment report undertaken by Nayton (2012) is provided in Appendix H.

## 4.8 Land use and social setting

The Study Area is located within land classified as State Forests, Parks and Recreation (including Whiteman Park), Primary and Other Regional Roads, Rural, Urban, and PP-Special Uses and Water Catchment Reserve (Department of Planning Western Australia 2013).

The area north of Gnangara Road is predominantly pine plantation (classified as State Forest) with pockets of remnant native vegetation concentrated on the north-eastern potion of the Study Area. The main road entering this area (Gaskell Avenue) provides private access to an active sand quarry which is situated north of the Study Area. The mine site office, an old rehabilitated sand quarry and future sand mining areas are located within the Study Area along Gaskell Avenue.

The majority of the Study Area south of Gnangara Road is classified as Parks and Recreation, and is known as Whiteman Park. Within Whiteman Park, on the eastern side of Beechboro Road there is a gun club, bowhunters club and an equestrian centre. Two private properties exist on the western side of Beechboro Road, they include Cyrenian House and Cullacabardee settlement.

## 4.9 Reserves and conservation areas

A large proportion of the Study Area north of Gnangara Road is within DEC estate classified as the Gnangara-Moore River State Forest. This area largely consists of pine plantation. As part of the Gnangara State Forest concept plan, the DEC have advised that an area west of Centre Way is a trail bike area while east of Centre Way is planned for passive recreation area.

### 4.9.1 Bush forever

Five Bush Forever sites occur within the boundaries of the Study Area. The details of these bush forever sites are listed in Table 12. The locations of these bush forever sites are shown on Figure 3A, Appendix A.

Table 12 Details of the Bush Forever sites located within the Study Area

| Site number | Site name | Size (ha) | Landscape features | Selection criteria met | Bush Forever recommendation | Linkagesi |
|---|---|---|---|---|---|---|
| 399 | Melaleuca Park and Adjacent Bushland, Bullsbrook/Lexia | 4150.9 | Tall dune, open water, vegetated wetland, creek, vegetation uplands. | Providing a representation of ecological communities, Diversity, Rarity, Maintaining ecological processes or natural systems, Scientific or evolutionary importance, General criteria for the protection of wetland, streamline and estuarine fringing vegetation and coastal vegetation. | Part A: Site with some existing Protection; the existing care, control and management of this Site is endorsed (Proposed 'Gnangara Park' – Cabinet 1996). Part B: Rural Commentary Mechanism. | Adjacent native vegetation to the north (Site 462), east (sites 6, 298 and 300) and west (Site 398); part of Greenways 40, 41, 36; part of a regionally significant contiguous and fragmented bushland/wetland linkage. |
| 192 and 195 | Wetherell Road Bushland, Lexia/Ellenbrook | 40.7 | Vegetated uplands. | Providing a representation of ecological communities, criteria not relevant to determination of regional significance but which may be applied when evaluating areas having similar values | Sites with Some Existing Protection; the existing care, control and management of these Sites are endorsed (Proposed 'Gnangara Park' – Cabinet 1996). | No adjacent native vegetation (Site 399 across road to north); part of Greenway 40; part of contiguous ii and fragmented iii bushland/wetland linkages. |
| 198 | Beechboro Road Bushland, Cullacabardee/Ballajura | 431.4 | Vegetated wetland, vegetated uplands. | Providing a representation of ecological communities; and general criteria for the protection of wetland, streamline and estuarine fringing vegetation and coastal vegetation. | Proposed Parks and Recreation Reservation. | Adjacent native vegetation to the north (Site 196 across road), south and east (Site 304 across road); part of a regionally significant fragmented iii bushland/wetland linkage. |
| 304 (Parts A and B) | Whiteman Park, Whiteman/West Swan | 1547.9 | Vegetated wetland, creek, vegetated uplands. | Providing a representation of ecological communities; Diversity; Rarity; Scientific or evolutionary importance; General criteria for the protection of wetland, streamline and estuarine fringing vegetation and coastal vegetation; Criteria not relevant to determination of regional significance, but which may be applied when evaluating areas having similar values. | Part A: Site with Some Existing Protection; the existing purpose, care, control and management of this Site is endorsed. Part B: Proposed Parks and Recreation Reservation. | Adjacent native vegetation to the south (Site 305) and west (Site 198 across road); part of Greenways 32, 39, 21, 40, 38; part of a regionally significant fragmented iii bushland/wetland linkage. |

## 4.10 Environmental sensitive areas

A search of the DEC's Native Vegetation Viewer identified that the entire Study Area is located within an Environmentally Sensitive Area (ESA). ESAs are declared by a notice under Section 51B of the EP Act.

The ESA identified over the Study Area is associated with the following aspects:

- The entire Study Area is covered by the *Environmental Protection (Gnangara Mound Crown Land) Policy 1992*;
- Bush Forever sites; and
- Defined wetlands and the area within 50 m of the wetland.

## 4.11 Contaminated sites

The search of the DEC Contaminated Sites Database identified five (5) contaminated sites within a 1 km radius of the Study Area. This database only identifies known contaminated sites which are related to existing or historical land uses. Therefore there is the potential for unreported contaminated sites to exist within the study area. Table 13 summarises the identified contaminated sites.

### Table 13 Summary of identified contaminated sites

| Address/Location | Classification | Historical Land Use | Nature and extent of Contamination |
|---|---|---|---|
| 779 Gnangara Road, Lexia.(also referred to as the former Ampol service station at Lot 27)<br>Within site boundary. | Remediated for restricted use.<br>**Restricted Use:** superficial aquifer is not suitable for potable use without treatment. | Service Station. | Upper portion of groundwater beneath the site is impacted by nitrates.<br>Remediation works involved the excavation and disposal of hydrocarbon impacted soils and has been considered to be successfully remediated (groundwater free from hydrocarbon impacts). |
| 11 Cascarilla Road, Beechboro.<br>15 Cascarilla Road, Beechboro.<br>14 Bittern Way, Beechboro.<br>16 Bittern Way, Beechboro. | Contaminated restricted use.<br>**Restricted Use:** groundwater is not to be extracted until it can be demonstrated that the groundwater is chemically suitable for the intended use. | Steel Fabrication Workshop (industrial estate) | Arsenic contamination is present in groundwater beneath all four sites. The extent and direction of the plume has not been appropriately determined. |

GHD undertook an inspection of the Study Area on 22 November 2012 to observe the general condition and identify any potential sources of contamination. Due to the size of the site and time constraints, the site inspection was conducted by vehicle with only major and minor public roads accessed. As such, large portions of the site could not be accessed including the south western and north eastern portions of the site due to a combination of the presence private properties and native reservation containing no access roads and/or locked gates, and the presence of active sand mining operations. The key observations from the inspection are summarised below:

- The inspection noted that the Site was predominantly used as a recreation and conservation reserve (Whiteman Park);

- An aboriginal reserve was located in the southern portion of the site at the western end of Baal Street (access to the reserve was restricted);
- The Western Australian Gun Club rifle range was located in Jules Steiner Memorial Drive. Suspected asbestos service pits were observed at the rifle range;
- A decommissioned service station (former Ampol service station) was located at Lot 27 Gnangara Road, Lexia. Fragments of suspected asbestos sheeting, spilt oil and a waste oil UST were observed. It appeared that the underground storage tanks and above ground liquid petroleum gas tanks had been removed from site;
- An operating sand quarry is located in the north eastern portion of the site in Gaskell Avenue (access to the quarry was restricted);
- A large area (approximately 1 ha) of disturbed soils was located on the south western side of the Beechboro Road and Hepburn Avenue intersection. Building rubble including fragments of suspected asbestos sheeting and piping, treated timber, concrete, plastics and steel were observed within the disturbed soils;
- Soil stockpiles (approx. 50 $m^3$) containing bitumen, road base and concrete were located at the southern end of Beechboro Road. Fly-tipping of televisions was also observed at this location;
- Isolated soil stockpiles (approx. 50 $m^3$) containing building rubble including bonded fragments of suspected asbestos containing materials, bricks, concrete and plastics were located at the entrance to the access track to Whiteman Park on the western side of Beechboro Road North;
- Fly-tipping of suspected asbestos containing material, televisions, domestic rubbish and car tyres was observed along both sides of Baal Street; and
- Fly-tipping was observed at the intersection of Gnangara Road and Centre Way in the high voltage power line corridor.

The result of the Preliminary Site Investigation conducted by GHD (2013) is provided in Appendix F.

## 4.12 Air quality

At present there is minimal air pollution within the Study Area as the majority of the area consists of bushland or semi-rural land. There is moderate traffic in the area, with Gnangara Road currently serving as a freight route for vehicles travelling between Perth's north-east corridor and various industrial areas in the north-west metropolitan area, including Landsdale and Wangara (Main Roads 2012). The increase of urban development in the surrounding area has also put pressure on the existing roads and has resulted in increased traffic. Dust emissions north of Gnangara Road may occur as a result of excavations at the nearby sand quarry and from vehicle movements along unsealed roads.

No air quality monitoring has been carried out as part of this assessment.

## 4.13 Noise and vibration

No acoustic assessment of the proposal has been completed and therefore there is no quantitative information available with respect to the existing noise environment.

## 4.14 Visual amenity

There is little topographic relief in the Study Area which predominantly consists of low undulating dunes and a series of low-lying damplands. The existing amenity of the Study Area

comprises of native bushland, agricultural land, pine plantations, existing roads, cleared land and to a lesser extent, housing estates.

It is likely that the proposed alignment will require large amounts of fill, particularly in low-lying areas. The proposed road is likely to be visible to a number of neighbouring properties, such as Cullacabardee settlement, Cyrenian House, parts of Whiteman Park, and housing in Ellenbrook and Ballajura. The majority of the alignment is however surrounded by vegetation which provides high scenic quality and some visual screening from surrounding land uses.

# 5. Environmental impacts and recommendations

The Study Area has a long history of vegetation clearing, grazing and other disturbances which have resulted in significant losses of native vegetation, suppression of natural regeneration and weed invasion. Despite the general disturbance, there are areas of native vegetation ranging from good to excellent condition remaining in conservation reserves, road reserves, private properties and parklands.

This section assesses the potential impacts of the proposed alignment option which is referred to as the 'Project Area' (Figure 1, Appendix A). The potential direct and indirect project impacts are discussed throughout this section, along with recommendations for further assessments or management.

The Environmental Management Plan (EMP) (Section 8) provides further mitigation measures for each of the potential impacts identified.

## 5.1 Flora and vegetation

**Potential impacts**

Clearing of native vegetation will be required for construction of the proposed highway. Potential impacts on flora and vegetation are not only restricted to loss of native vegetation within the clearing areas but also to impacts on the vegetation adjacent to the disturbance, due to the edge effects, changes in hydrology and potential fragmentation of the remaining vegetation.

The National Objectives and Targets for Biodiversity Conservation 2001-2005 (Commonwealth of Australia 2001) recognise that the retention of 30 per cent or more of the pre-clearing extent of each ecological community is necessary if Australia's biological diversity is to be protected. This threshold level below which species loss appears to accelerate exponentially and loss below this level should not be permitted. This level of recognition is in keeping with the targets recommended in the review of the *National Strategy for the Conservation of Australia's biological Diversity* (ANZECC 2000) and in *EPA Position Statement No. 2* on environmental protection of native vegetation in Western Australia (EPA 2000).

From a purely biodiversity perspective and taking no account of any other land degradation issues, there are a number of key criteria now being applied to the clearing of native vegetation in Western Australia (EPA 2000).

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

Within the Swan Coastal Plain, EPA Position Statement No.9 identifies vegetation complexes with 30 per cent or less or their pre-clearing extent remaining in a bioregion, or 10 per cent or less of their pre-clearing extent remaining in constrained areas (i.e. areas of urban development in cities and major town) on the Swan Coastal Plain, to be critical assets.

The extent of remnant native vegetation has been assessed by Shepherd *et al.* (2002) and the Government of Western Australia (2013), based on vegetation association mapping undertaken by Beard (1979). The remaining extent of the vegetation associations present within the Study Area for the State, Bioregion (Swan Coastal Plain) and Local Government Area (LGA) is detailed in Table 14. Based on the current extent of these vegetation associations, association 1001 has less than 30% remaining at the State, IBRA region and LGA scale and is therefore considered to be a critical asset. Vegetation association 949 is regarded as having more than 50% remaining at the three scales and is therefore considered of least concern.

The EPA Guidance Statement No. 10 (Environmental Protection Authority 2006) assesses the extent of Heddle *et al.* (1980) vegetation complexes currently present against predicted pre-European extents. These are shown in

Table 15.

Based on the current extent of these vegetation complexes, both the Bassendean complex – north and Bassendean complex – north – transition vegetation complex have more than 50% remaining in the System 6/part System 1 area. The Bassendean complex – central and south and the Southern River complex have less than 30% remaining and therefore would be considered a critical asset.

The Project Area may however be considered to be within a constrained area of the Swan Coastal Plain. In this case, all vegetation types listed in Table 14 and

Table 15 have more than 10% remaining of their pre-clearing extents and would therefore not be considered critical assets.

Table 14 Extent and status of Beard (1979) vegetation associations within the Project Area

| Vegetation association | Vegetation description | Total within Project Area | Region | Pre-European extent (ha) | Current extent (ha) | % remaining | % current extent protected (IUCN Class I-IV) for conservation (proportion of pre-European extent) | % of the current extent within the Project Area |
|---|---|---|---|---|---|---|---|---|
| 1001 | Medium very sparse woodland; jarrah, with low woodland; banksia & casuarina | 240 ha | State | 57410.23 | 14151.90 | 24.65 (Vulnerable) | 1.14 | 1.7% |
| | | | IBRA Bioregion | 57410.23 | 14151.90 | 24.65 (Vulnerable) | 1.14 | 1.7% |
| | | | LGA | 8868.66 | 2393.76 | 26.99 (Vulnerable) | 0.02 | 10% |
| 949 | Low woodland; banksia | 32.03 ha | State | 218193.94 | 124116.74 | 56.88 (Least Concern) | 13.77 | 0.03% |
| | | | IBRA Bioregion | 184475.82 | 105107.74 | 56.98 (Least Concern) | 14.88 | 0.03% |
| | | | LGA | 16235.17 | 8266.44 | 50.92 (Least Concern) | 2.76 | 0.38% |

Table 15 Extent and status of Heddle *et al*. (1980) within the Study Area

| Vegetation complex | Total within Project Area | Total pre-1750 extent (ha) | Present extent (1997/98) in the System 6/part System 1 area (ha) | % of each remaining (1997/98) in the System 6/part System 1 area (ha) | % of each remaining of pre-1750 extent in secure tenure (2002) | % of the current extent within the Project Area |
|---|---|---|---|---|---|---|
| Bassendean complex – north | 38.54 ha | 74,147 | 53,384 | 72.0 (Least Concern) | 27.5 | 0.072% |
| Bassendean complex – north – transition vegetation complex | 9.32 ha | 17,675 | 16,308 | 92.3 (Least Concern) | 57.8 | 0.057% |
| Bassendean complex – central and south | 184.09 | 87,477 | 23,624 | 27.0 (Vulnerable) | 0.7 | 0.78% |
| Southern River complex | 40.19 | 57,979 | 11,501 | 19.8 (Vulnerable) | 1.5 | 0.35% |

According to the proposed design, the total amount of native vegetation that may need to be cleared as a result of construction of the Project is estimated at around 166.2 ha (including parkland cleared paddocks). This is based on the clearing extent of the vegetation types mapped within the Project Area, excluding the plantations and cleared/highly modified areas (see Table 16). The amount of clearing however could vary is some areas, due to cut and fill requirements, interchanges and retention of roadside vegetation. The area to be cleared for the proposed project by vegetation type and condition is represented in Table 16.

### Table 16 Amount of clearing required within the Project Area by vegetation type and condition

| GHD Vegetation Type | Vegetation Condition | Clearing Extent (ha) | Proportion of total clearing (%) |
|---|---|---|---|
| Banksia Woodland | 2-3 | 0.34 | 0.12 |
| | 3 | 11.43 | 4.2 |
| | 4 | 1.42 | 0.52 |
| Closed tall Scrub | 3 | 0.03 | 0.011 |
| Open Paddock | 4-5 | 31.91 | 11.73 |
| | 5 | 0.21 | 0.077 |
| | 5-6 | 82.72 | 30.4 |
| | 6 | 0.11 | 0.04 |
| Melaleuca Low Woodland | 5-6 | 0.47 | 0.17 |
| Banksia Low Open Forest | 2-3 | 10.76 | 3.95 |
| | 3-4 | 12.21 | 4.49 |
| Mosaic Banksia Low Open Forest and Mixed Open Heath | 2-3 | 9.86 | 3.62 |
| Jarrah-Marri-Banksia Woodland | 2-3 | 0.25 | 0.092 |
| Rehabilitation | 3-4 | 2.09 | 0.77 |
| | 4 | 0.6 | 0.22 |
| | 4-5 | 0.34 | 0.12 |
| | 6 | 1.45 | 0.53 |
| Plantations | 6 | 20.25 | 7.44 |
| Cleared/Highly Modified | 6 | 36.83 | 13.53 |
| Plantations and Cleared/Highly Modified | 5-6 | 22.13 | 8.13 |
| | 6 | 26.73 | 9.82 |
| **Total** | | **272.14 ha** | **100%** |

The proposed alignment is predominantly located within parkland cleared farmland and pine plantations.The total area of vegetation affected by the proposed alignment is summarised in Table 17.

### Table 17 Area of vegetation affected by the proposed road alignment

| Impact area | Area (ha) | Proportion of proposed alignment (%) |
|---|---|---|
| Remnant native vegetation | 51.25 | 18.83 |
| Parkland cleared farmland (open paddock contains remnant vegetation) | 114.95 | 42.24 |
| Pine Plantations/Cleared | 69.11 | 25.40 |
| Completely Cleared | 36.83 | 13.53 |
| **Total** | **272.14 ha** | **100%** |

Approximately 49 ha of native vegetation in good or better condition is present within the proposed alignment, which is approximately 18% of the entire alignment.

The proposed alignment does not traverse any vegetation associated with or within a buffer area of a known TEC or PEC. However the *Banksia* Low Open Forest vegetation type located near the Cullacabardee settlement was identified as having vegetation closely associated with the Priority 3 PEC Low lying *Banksia attenuata* woodlands or Shrublands (community type 21c). A targeted flora survey would be required to accurately assess the presence and occurrence of this PEC within the Project Area.

There are no known records of any Threatened or Priority flora species within the Project Area. However there are records of the Threatened *Caladenia huegelii* and the Priority 4 listed *Verticordia lindleyi* subsp. *lindleyi* within 1 km of the Project Area. Further targeted searches would be required for these species within the Project Area and immediately adjacent areas to identify any potential impacts to these species.

Clearing and construction activities within the proposed construction footprint have a number of actual and potential impacts on vegetation, including:

- Loss of flora biodiversity;
- Loss of suitable habitat for conservation significant flora;
- Increased erosion and runoff;
- Changes to existing drainage and hydrology;
- Loss of visual appeal;
- Potential loss of vegetation associated with a PEC;
- Fragmentation of remnant bushland;
- Introduction and/or spread of dieback and weeds; and
- Increase risk of fire.

Soil moving activities such as those associated with clearing vegetation and construction operations have a high risk of introducing and spreading dieback. This risk is further increased in wet soil conditions. In addition, if the Project Area is infected, there is potential for construction activities to result in the spread of dieback to off-site areas.

**Recommendations**

1. Main Roads to prepare and implement a Revegetation and Landscape Plan for the project.
2. It is recommended a dieback assessment by an experience dieback interpreter would need to be undertaken to confirm the presence of dieback in the area. Based on the results of the dieback assessment and mapping, a Dieback Management Plan should be prepared and implemented prior to clearing and construction.
3. Weed management will be necessary through the development of a Topsoil Management Plan.
4. A targeted vegetation survey would be required to accurately assess the presence and occurrence of the 'Low lying *Banksia attenuata* woodlands and shrublands' PEC within the Project Area.
5. A targeted survey to be undertaken for the Priority 4 listed *Verticordia lindleyi* subsp. *lindleyi* during its known flowering period (May or late spring/early summer) to confirm its identification and to confirm the population size and extent of the species within the Project Area. This will assist in determining the level of impact the proposed construction footprint will have on this species.

6. Additional targeted surveys to be undertaken for the Threatened *Caladenia huegelii* during its known flowering period (September-October) is recommended to confirm the presence/absence of this species in the Project Area and assist in determining the level of impact (if any) the proposed project will have on this species.

## 5.2 Fauna

**Potential impacts**

Clearing for the construction of the project may have an impact on a number of the conservation significant fauna species identified in the field survey and desktop assessment. Table 18 identifies the potential impacts the project clearing is expected to have on fauna species identified during the survey and those identified as likely to or possible to occur within the Project Area.

Table 18 Potential impacts on conservation significant fauna identified as present, likely to occur or possibly occurring within the Project Area

| Species | Conservation Status | Potential impacts (areas are approximate in size and based on vegetation mapping) |
|---|---|---|
| Carnaby's Black Cockatoo | Endangered; Threatened | There is approximately 233.25 ha of suitable feeding habitat (including pine plantations) within the Project Area.<br>Suitable roosting and breeding habitat was identified in the area during the field survey. A targeted black cockatoo habitat assessment would be required to identify the amount of suitable breeding and roosting habitat within the Project Area.<br>Potential impacts on Carnaby's Black Cockatoo's are discussed in further detail in section 6.1.1. |
| Western Brush Wallaby | Priority 4 | Loss of suitable habitat, habitat connectivity and fragmentation. Given the linear nature of the project and limited suitable habitat within the Project Area, impacts to this species are considered minimal. |
| Quenda / Southern Brown Bandicoot | Priority 5 | Loss of suitable habitat, habitat connectivity and fragmentation. By including good management practices such as the installation of underpasses, rehabilitation of areas and fauna clearance prior to vegetation clearing, impacts to the species would be minimal. |
| Rainbow bee-eater | Migratory | Loss of suitable habitat, however this species is common and widespread and would not be significantly impacted by the proposed project. |
| Forest Red-tailed Black | Vulnerable; | There is approximately 233.25 ha of suitable |

| Species | Conservation Status | Potential impacts (areas are approximate in size and based on vegetation mapping) |
|---|---|---|
| Cockatoo | Threatened | feeding habitat within the Project Area.<br><br>Suitable roosting and breeding habitat was identified in the area during the field survey. A targeted black cockatoo habitat assessment would be required to identify the amount of suitable breeding and roosting habitat within the Project Area.<br><br>However the Project Area is outside the currently known distribution of this species and therefore this species is not considered to be significantly impacted by the project. |
| Peregrine Falcon | Schedule 4 | The Project Area does not contain prime habitat for this species and is likely to only occur as an occasional visitor. Impacts to this species are considered negligible. |
| Black-striped Snake | Priority 3 | Loss of suitable habitat and habitat fragmentation. |
| Carpet Python | Schedule 4; Priority 4 | Loss of suitable habitat, habitat degradation and fragmentation. |
| *Ctenotus gemmula* | Priority 3 | Loss of suitable habitat and habitat fragmentation. |
| Fork-tailed Swift | Migratory | An aerial species which rarely utilises a terrestrial environment, no expected impacts. |
| Eastern Great Egret | Migratory | Limited available habitat, no expected impacts. |
| Cattle Egret | Migratory | Limited available habitat, no expected impacts. |
| Graceful Sunmoth | Priority 4 | Loss of suitable habitat. |
| *Hylaeus globuliferus* | Priority 3 | Loss of suitable habitat. |

Clearing and construction activities within the proposed construction footprint have a number of actual and potential impacts on fauna, including:

- Loss of/damage to fauna habitat, particularly for species of conservation significance;
- Loss of habitat linkages and fragmentation;
- Hydrological changes;
- Changes to habitat caused from the spread of dieback and weeds;
- Fauna injury and mortality: through entrapment and vehicle strike during and post construction;
- Disruption of movement of fauna across the highway alignment, especially for terrestrial species such as small mammals and reptiles; and

- Removal of suitable foraging habitat and potential roosting and breeding habitat for the endangered Carnaby's Black Cockatoo.

**Recommendations**

7. A targeted black cockatoo field assessment of the alignment is required to determine the level of impacts of the project on the Carnaby's Black Cockatoo as per the EPBC Act referral documentation requirements (DSEWPaC 2012b). This includes the identification and mapping of suitable breeding, roosting and feeding habitat within the Project Area.
8. Based on the results of the targeted black cockatoo field assessment prepare a mitigation and offsets management plan to address impacts on the Carnaby's Black Cockatoo.
9. A targeted threatened fauna survey is recommended to identify the presence of conservation significant fauna identified in the fauna assessment as likely to or potentially occurring within the Project Area. This will assist in determining the level of impact the proposed construction footprint may have on these species and assist in the development of a significant fauna management plan.
10. Prepare and implement a Significant Fauna Management Plan.

## 5.3 Groundwater

**Potential impacts**

The Project Area is situated within both the Mirrabooka Groundwater Area and the Gnangara Groundwater Area. These groundwater areas are protected under the RIWI Act. The Act gives the DoW the power to manage ground and surface areas and use of land that may impact upon these water sources.

The proposed alignment is also within the Gnangara Underground Water Pollution Control Area which is a Priority 1 Protection Zone. Priority 1 (P1) classification areas are managed to ensure that there is no degradation of the drinking water source by preventing the development of potentially harmful activities in these areas.

Activities associated with the project have a number of actual and potential impacts on groundwater, including:

- Groundwater contamination as a result of leakage or spills of stored fuels and chemicals;
- Changes to existing hydrology;
- Impacts on groundwater as a result of acid sulphate soils; and
- Dewatering (if required).

**Recommendations**

11. Best practice design and management techniques need to be incorporated into the planning, design and construction of the road to manage stormwater disposal and avoid the risk of pollution.
12. Undertake a detailed risk assessment assessing the risks of the project on public drinking water source areas.
13. Prepare and implement a drainage and nutrient management plan and prepare an emergency response action plan.

## 5.4 Surface water and drainage

**Potential impacts**

The proposed alignment is situated within the Swan River System Surface Water Area. Surface water areas are protected under the RIWI Act. The Act gives the DoW the power to manage ground and surface areas and use of land that may impact upon these water sources. Construction of the project has the potential to generate water runoff and pollution issues. As the highway is likely to be built up in some areas due to seasonal waterlogging, there is potential for alterations to localised sheet flows. This alteration may result in ponding, new areas of waterlogging or changes to water levels in 'downstream' swamps and damplands.

Activities associated with the project have a number of actual and potential impacts on surface water and drainage, including:

- Increased stormwater runoff;
- Increases in scour and turbidity;
- Changes to existing hydrology;
- Obstruction of flows, or further impediment of flows;
- Contamination due to spills or releases of hydrocarbons or waste; and
- Changes to ecosystem function as a result of changes in water quality.

**Recommendations**

14. Design and construction of the project will need to be managed to ensure that there will be no significant or long-term impacts on water quality or surface hydrology and will improve runoff and drainage systems.

15. Prepare and implement a surface water management plan.

## 5.5 Wetlands

**Potential impacts**

Wetlands provide important functions with regard to hydrological function and linkage, water purification flora biodiversity and fauna habitat. The Project Area intersects one Conservation category wetland, one Resource Enhancement wetland and three Multiple Use wetlands. The construction of the alignment would, in some places, involve the filling and clearing of parts of these wetlands.

The EPA urges that all Conservation category wetlands and appropriate buffers are fully protected. Projects that are likely to lead to a significant adverse impact on these wetlands are likely to be formally assessed by the EPA. The EPA also urges that all reasonable measures are taken to minimise the potential impacts on Resource Enhancement wetlands and appropriate buffers. These wetlands have the potential to be restored to Conservation category, and rehabilitation is encouraged. In the case of Multiple Use wetlands, the EPA urges that all reasonable measures are taken to retain the wetland's hydrological functions (including on-site water infiltration and flood detention) and, where possible, other wetland functions.

Within the proposed alignment there is approximately 4.81 ha mapped as Conservation Category Wetland, 20.53 ha mapped as Multiple Use Wetland and 4.07 ha mapped as Resource Enhancement Wetland.

Any proposal that is likely to have an impact on a Conservation category wetland is a 'significant proposal' under section 38 of the EP Act.

**Recommendations**

16. Where possible, wetland areas should be avoided but where that is not possible approval to disturb the areas will require detailed management commitments with regard to vegetation removal, soil movement, hydrological function and pollution.

17. It is important that there be ongoing consultation with DEC for the assessment of impacts on wetlands and the determination of management measures and impacts on Conservation and Resource Enhancement wetlands. The DEC should be consulted with regard to drainage design and their requirements for the protection of specific wetlands.

18. Hydrological modelling should be carried out to determine the areas where surface flow may be affected by the road design and to provide management systems, such as culverts and drainage lines, to prevent ponding near the road or erosion due to heavy flows through culverts.

19. Prepare an environmental offset package to counterbalance adverse impacts to conservation category wetlands, having regard for the EPA's Position Statement No. 9 Environmental Offsets.

## 5.6 Acid sulfate soils

**Potential impacts**

It is possible that works in some sections of the alignment may disturb soils with acid generating potential. ASS will be an environmental issue for the project where these soils will need to be disturbed in earth-working activities such as footings for bridges and culverts or areas of cut.

The DEC's preferred approach is to characterise ASS materials *in situ* prior to commencement of development works. This is to enable an effective management and treatment plan to be developed before the commencement of earthworks.

**Recommendations**

20. Due to uncertainty concerning the classification of the site with respect to ASS, if soils greater than 3 metres in depth are to be disturbed, an ASS investigation should be undertaken to determine the soil status.

21. Works in areas suspected of containing ASS require an acid sulphate soil investigation to be undertaken and a comprehensive acid sulphate soil management plan to be developed and implemented.

## 5.7 Heritage

### 5.7.1 Aboriginal heritage

**Potential impacts**

Two Aboriginal sites and one "Other Heritage Place" have been previously recorded within the search area. The ethnographic survey identified that the proposed project will impact indirectly upon one Aboriginal site, namely Site Number 3692, "Bennett Brook In Toto". The impact will be indirect, in that the project crosses a small seasonal drain which, when flowing, carries run-off into the headwaters of Bennett Brook in Whiteman Park. That impact has the potential to be damaging to the Aboriginal values of the site, as noted by four of the Aboriginal groups, as there is a possibility of pollutants from road construction entering the waters of the Bennett Brook system (O'Connor 2012). If strict control over run-off is enforced, then the possibility of impact on the site can be avoided. It is noted that three of the Aboriginal groups recommended that

monitors from their community should be appointed to observe and oversee those controls (O'Connor 2012).

**Recommendations**

22. An application pursuant to Section 18 of the *Aboriginal Heritage Act 1972* should be made by the owner of the land upon which the proposed works will take place and Ministerial consent should be obtained for those works before they commence, on the grounds they will have indirect impact upon one Aboriginal site, as detailed above.

23. Personnel working on the project should be informed as to the provisions and sanctions of the *Aboriginal Heritage Act 1972*. All sites of Aboriginal heritage are protected under the Act, whether previously registered, reported or not. Further archaeological and ethnographic consultation may be required should any archaeological material be uncovered during the project.

24. Personnel should be aware that if quartz, dolerite, chert, quartzite, silcrete, mylonite or granite are uncovered, these may possibly represent Aboriginal artefacts, and Recommendation 1 may apply. For the purpose of preventing unwarranted disturbances to sites, Aboriginal people may be employed, and would be of significant advantage should Aboriginal skeletal material be unearthed.

25. Should skeletal material be uncovered during earth work, all works in the area should cease and the WA Police should be contacted.

26. A monitoring program conducted by an archaeologist during works that are undertaken in areas where land integrity is moderate to high, such as within Whiteman Park Reserve, or in areas where the proposed road will intersect landscape features such as creeks, sand ridges or swamps, may serve to identify previously concealed or underground archaeological deposits within the Study Area.

### 5.7.2 European heritage

**Potential impacts**

The survey of the Study Area undertaken by Nayton (2012) identified no heritage listed non-indigenous places. An extensive desktop survey and information search identified only one potential heritage place which could create issues. This is the Forestry Department's divisional headquarters' and fire lookout, much of which would be an archaeological site. The history of the place indicates heritage potential at the state level however no archaeological survey has been undertaken to determine whether this archaeological potential is still largely intact (Nayton 2012). Nayton (2012) also identified that the former Santa Rosa farmhouse within the Rick Hamersley Centre may also be a low level heritage issue if impacted. This site will not be impacted by the proposed alignment.

**Recommendations**

27. An archaeological and heritage survey is recommended to be carried out at the Forestry Department site if the planned construction works are likely to impact on or close to this site to determine the extent and nature of surviving archaeological and built heritage features.

## 5.8 Reserves and conservation areas

**Potential impacts**

The proposed alignment will have a direct impact on four Bush Forever sites. The proposed alignment will involve the clearing of approximately 22.24 ha of Bush Forever Site 399; 1.24 ha of Bush Forever Site 192; 83.39 ha of Bush Forever Site 304; and 32.87 ha of Bush Forever Site 198. Bush Forever sites have been identified by the State Government as areas which should be protected for conservation purposes and any impacts on these sites are discouraged. Main Roads require a development approval for any woks within a Bush Forever site.

The alignment also requires 94.34 ha of clearing within the Gnangara-Moore River State Forest. The proposed alignment will impact on recreation areas currently being proposed by DEC as part of the Gnangara State Forest Concept Plan, affecting both trail bike use areas and passive recreational use areas.

**Recommendations**

28. The DEC and WA Planning Commission (WAPC) will require detailed consultation and provision of a land offset package to replace lost bushland with Bush Forever sites.

## 5.9 Contaminated sites

**Potential impacts**

There are no DEC recorded contaminated sites within the proposed alignment. The site investigation identified a number of potential contamination sources throughout the Study Area, including uncontrolled rubbish dumping and soil stockpiles with building rubble. The risks of disturbance of contaminated soils or water within or adjoining these sites is low, due to the fact that the highway will be built above ground level over much of its length and because the possible contamination levels are likely to be low.

Any potential risks for highway construction are small. They may involve removal of contaminated soil to a more suitable location however, given the nature of the highway use, this is unlikely to be required. Relocation of contaminated soil is generally only required when the new landuse involves risks to residents or land users through direct contact with the soil or water. Although the construction and use of the highway will open up the land to more users, there is a very low risk of direct contact with the soil and some of the possible contamination would be ‘sealed’ under the road formation.

**Recommendations**

29. Where suspected or potential sources of contamination are located along the highway alignment, further investigations should be completed which may include targeted soil sampling to understand the impacts to human health and the environment during and following construction phases.

## 5.10 Noise and vibration

**Potential impacts**

Construction activities will result in temporarily increased noise levels due to earth works, construction activities and vehicle and machinery movement and operation. The proposed alignment is located within close proximity to residential premises which may be impacted by nuisance noise during construction.

Noise associated with the vehicle movement during the operational phase of the proposed road is anticipated to increase above current noise levels.

**Recommendations**

30. Main Roads is to manage traffic related noise impacts in accordance with WAPC State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Landuse Planning (WAPC 2009).

31. A road traffic noise assessment is recommended to be carried out to examine the likely noise impact from the proposed road to adjoining noise sensitive premises and determine the type and extent of noise control treatment required to satisfy Main Roads *Noise Level Objectives*.

32. Prepare and implement a noise and vibration management plan that fulfils the requirements of the DEC, noise regulations and local government authorities.

## 5.11 Air quality

**Potential impacts**

The construction of the proposed highway has the potential to generate dust as a result of vegetation clearing, earthworks, spillage of soil material and vehicle movement, which may be a nuisance to nearby residents and impact adjacent vegetation. The majority of the soil type in the area is loose sand with fine organic matter, which has potential for movement in strong breezes. Excessive dust emissions have the potential to impact on the health of the local community and surrounding vegetation, although amenity issues may occur in the localised area during construction activities.

**Recommendations**

33. An air quality management plan should be prepared prior to construction in order to assess and manage risks to sensitive areas.

34. Main Roads are required to undertake an air quality assessment for new roads.

## 5.12 Visual amenity

**Potential impacts**

Construction and operation of the project will have a significant impact on the amenity of the local area as a consequence of:

- Vegetation clearing
- Traffic noise exposure
- Changes to local road systems
- Visual amenity
- Visibility of the highway
- Changes to some property access where the road corridor will sever existing access.

Measures such as traffic noise management, service roads, and site landscaping will reduce this impact to some extent but residual amenity impacts can be expected in the long term.

**Recommendations**

35. Prior to detailed design and construction, a Landscape and Visual Impact Management Plan should be developed.

## 5.13 Public safety and risk

**Potential impacts**

Increased traffic volumes arising from the movement of construction and transport vehicles may result in some localised short-term adverse impacts on local and regional traffic movements. The following potential impacts have been identified:

- Risk of injury to road users due to construction vehicles and trucks operating within the local area; and
- Potential damage to roads and spillage of carted materials, particularly sand.

## 5.14 Waste and hazardous substances

**Potential impacts**

Demolition and construction works are likely to generate considerable waste materials. Waste management pertains to the controlled disposal of products that cannot be used onsite, and may include construction waste, general office waste, and hazardous waste. Poor management of waste materials may lead to litter or contamination of the project area and surrounds. This in turn may impact on the aesthetics of the area (e.g. visual amenity) and the health of terrestrial ecosystems.

The construction of the project is unlikely to require the use of hazardous substances other than fuels and oils for machinery. The storage and use of hazardous substances has the potential to impact wetlands or waterways if not carefully managed. Standard management procedures which minimise the risks at wetlands and other sensitive areas will be developed prior to construction and provided in a suitable management plan.

**Recommendations**

36. Prepare and implement a hazardous materials management plan.

# 6. Environmental approvals

## 6.1 Commonwealth approvals

Referral to DSEWPaC under the EPBC Act is triggered if a proposed action has/or potentially has a significant impact on any matter of National Environmental Significance (NES), including National Heritage values. An assessment against each of these issues is provided in Table 19.

Table 19 Assessment of the project against Matters of National Environmental Significance

| Matters of National Environmental Significance | Present | Impact |
|---|---|---|
| World Heritage Places | No | None |
| National Heritage Places | No | None |
| Ramsar Wetlands | No | None |
| Threatened Species and Ecological Communities | Yes | Removal of suitable foraging habitat and potential roosting and breeding habitat for Black Cockatoo species. |
| Listed Migratory Species | May be present | No significant impacts |
| Commonwealth Marine Areas | No | None |
| Nuclear Actions | No | None |

During the spring flora and fauna survey the endangered Carnaby's Black Cockatoo was identified in the Study Area. Additionally the Study Area is located within the modelled distribution for the Carnaby's Black Cockatoo and just outside the boundary for the Forest Red-tailed Black Cockatoo. The potential impacts on black cockatoo species is discussed in further detail below.

### 6.1.1 Risk referral table for threatened black cockatoos

In October 2012, DSEWPaC released the referral guidelines for the assessment of projects for potential impacts on black cockatoos (DSEWPaC, 2012b). These guidelines are for all black cockatoo species, and do not provide information relative to particular areas of the State, but provide information to decide whether a project may trigger referral.

Within these guidelines, DSEWPaC provides a risk table that gives guidance on what it views as risks/impacts to black cockatoos that will trigger referral. Risk is broken into three categories, high, uncertain and low, and primarily focuses on breeding, feeding and roosting areas as well as indirect impacts. If there is uncertainty in regards to risks on black cockatoos then DSEWPaC recommends referring the project or contacting the Department to ensure legal certainty.

The risk referral table is shown in Table 20 with an assessment of the Project against each of the potential risks.

Table 20 DSEWPaC risk referral table for black cockatoos

| Risk type | Referral Trigger |
|---|---|
| High risk of significant impacts: referral to DSEWPaC recommended | |
| Clearing of any known nesting tree. | Unknown. A targeted cockatoo field assessment of the preferred alignment will be required to provide a definitive result. |
| Clearing of any part or degradation of breeding habitat in a woodland or forest within a species' known breeding range. | Referral may be required as there are trees within the preferred alignment that meet the criteria of potential breeding trees. The Project Area is within the known |

| Risk type | Referral Trigger |
|---|---|
| | breeding range for the Carnaby's Black Cockatoo. A targeted cockatoo field assessment of the preferred alignment will be required to provide a definitive result. |
| Clearing of more than 1 ha of quality foraging habitat. | Yes, referral will be triggered. Greater than 1 ha of quality foraging habitat is proposed to be cleared. |
| Creating a gap or greater than 4 km between patches of black cockatoo habitat (breeding, foraging or roosting). | Referral is not triggered, the site is within a highly modified environment and the project will not impact on current levels of fragmentation. There are areas of suitable cockatoo habitat in adjacent bushland and pine plantations. |
| Clearing or degradation (including pruning of top canopy) of a known roosting site. | Referral is likely to be triggered. There is a known roosting site within the pine plantations, north of Gnangara Road. A targeted cockatoo field assessment of the preferred alignment will be required to provide a definitive result. |
| **Uncertainty: referral recommended or contact the DSEWPaC** | |
| Degradation (such as through altered hydrology or fire regimes) of more than 1 ha of foraging habitat. Significance will depend on the level and extent of degradation and the quality of the habitat. | Yes referral will be triggered. The project will impact on more than 1 ha of good quality foraging habitat. |
| 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. | Referral is not triggered; much of the site and surrounding area is already highly modified due to various external impacts (such as introduced species, edge effect, grazing, human visitation, etc.). The project is unlikely to impact on the current levels of habitat degradation. |
| Actions that do not directly affect the listed species but that have the potential for indirect impacts such as increasing competitors for nest hollows. | Referral may be triggered. The clearing of suitable nesting hollows would reduce the amount of available nesting habitat, increasing competition for remaining hollows in the area. |
| Actions with the potential to introduce known plant diseases such as *Phytophthora* spp. | Referral is unlikely to be triggered; *Phytophthora* is known to occur widely in the region and may already be present at the site. Much of the Study Area is already highly degraded.<br>Management measures should be implemented to reduce the risk of introduction and spread of *Phytophthora*. |
| **Low risk of significant impacts: referral may not be required but may refer to DSEWPaC for legal certainty** | |
| Actions that do not affect black cockatoo habitat or individuals. | Not applicable |
| Actions whose impacts occur outside the modelled distribution of the three black cockatoos. | Not applicable |

As detailed in Table 20, based on the potential impact of the Project on the Carnaby's Black Cockatoo, referral will be required. A targeted black cockatoo field assessment of the proposed alignment is recommended to determine the level of impacts of the project on the Carnaby's Black Cockatoo as per the EPBC Act Referral documentation requirements (DSEWPaC 2012b). This would include identifying the following features within the project footprint:

- Recording and mapping of suitable breeding habitat (suitable trees with a diameter at breast height (DBH) greater than 500 mm (or >300 mm for Wandoo)
- Recording and mapping of suitable roosting habitat

- Recording and mapping of suitable foraging habitat
- Evidence of current activity and any other signs of use (including suitable nest hollows, feeding signs or feeding debris, and sightings) by the Carnaby's Black Cockatoo.

### 6.1.2 Offsets

Offsets are defined as measures that compensate for the residual adverse impacts of an action on the environment. Offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures. These remaining, unavoidable impacts are termed 'residual impacts'. For assessments under the EPBC Act, offsets are only required if residual impacts are significant (DSEWPaC 2012a).

Based on this assessment, the residual impacts on the Carnaby's Black Cockatoo are likely to be considered significant due to the proposed clearing of approximately 233.25 ha of foraging habitat. Unless the proposed impacts can be further avoided or mitigated appropriately then it is likely that an offset package would be required.

Offsets should be tailored specifically to the attribute of the protected matter that is impacted in order to deliver a conservation gain (DSEWPaC 2012a).

## 6.2 Western Australian State Government approvals

### 6.2.1 Referral to Environmental Protection Authority (EPA)

Significant proposals (e.g. subdivision and development applications) must be referred to the EPA under Section 38 of the *Environmental Protection Act 1986* (EP Act).

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

The EPA considers that environmental significance is a function of:

- The extent and consequence of impacts on biophysical aspects;
- The environmental values of the areas affected;
- The extent of emissions and their potential to unreasonably interfere with the health, welfare, convenience, comfort or amenity of people;
- The extent and rigour to which potential impacts have been investigated and described in the referral, and the confidence in the reliability of predicted impacts;
- The extent to which the proposal implements the principles of sustainability;
- The ability of decision-making authorities to place conditions on the proposals to ensure required environmental outcomes are achieved; and
- The likely level of public interest and the extent to which the proponent has consulted with interested and affect people and responded to issues raised.

Regardless of the above factors, Main Roads must refer a project if it triggers the following:

- It is likely to have a significant effect on the environment;
- There is a high level of public interest; or
- A new road or a major realignment is involved.

The project will require referral under this Act given the project involves the construction of a new road. Additionally, the project will impact on the following environmental factors:

- Significant habitat for threatened fauna (Carnaby's Black Cockatoo);
- Conservation category wetland;
- P1 Public Drinking Water Source Area (PDWSA);
- Water Quality;
- Bush Forever sites; and
- Gnangara State Forest (including identified "ecological corridors").

### 6.2.2 Department of Environment and Conservation

The clearing of vegetation in Western Australia is covered under the EP Act. Main Roads has been granted a Statewide vegetation clearing permit (Purpose Permit CPS 818-8), under section 51E of the EP Act, from the DEC. The Purpose Permit allows Main Roads to clear native vegetation for road realignment projects and associated construction activities (including pre-construction activities). Any clearing of native vegetation must be assessed against the "Ten Clearing Principles" outlined in the permit. The Permit does not authorise the clearance of native vegetation for project activities where:

- The clearing may be seriously at variance with the clearing principles; or
- Those project activities are incorporated in any proposal that is referred to and assessed under Part IV of the EP Act by the EPA.

An assessment of the project against the 10 Clearing Principles is provided in Table 21. The project is considered to be at variance or significantly at variance to principles (b), (f) and (h) and may be at variance to principles (a), (c), (g), (i) and (j).

Table 21 Assessment of the project against the Ten Clearing Principles

| Clearing Principle | | Assessment | Outcome |
|---|---|---|---|
| (a) | Native vegetation should not be cleared if it comprises a high level of biological diversity. | Nine native vegetation types (not including highly modified areas) were identified within the Study Area however only seven of these will be directly impacted by the proposed construction corridor. The majority of the proposed alignment north of Gnangara Road consists of pine plantations (a portion of which has been clear-felled). There are patches of remnant native vegetation remaining in the north-east of the Project Area, which consists predominantly of mixed *Banksia* woodlands. There is also an area which was previously cleared for sand mining which has since undergone rehabilitation, and is in various stages of growth.<br>A large portion of the proposed alignment south of Gnangara Road has previously been 'parkland cleared' and used for grazing, There is a section along the alignment adjacent to the Cullacabardee Settlement which consists of remnant native vegetation that remains in good to excellent condition. This area contains a mosaic of *Banksia* low open forest and mixed open heath on sandy flats and palusplain. The vegetation types in this area are largely associated with the underlying groundwater table and drainage features of the surrounding landscape.<br>The DEC search identified the buffers of two PECs within the Study Area: Low lying *Banksia attenuata* woodlands or Shrublands (community type 21c) (Priority 3) and *Banksia ilicifolia* woodlands, southern Swan Coastal Plain (community type 22) (Priority 3). During the 2012 spring flora and vegetation survey the vegetation type '*Banksia* low open forest' was identified as having close affinities to the Priority 3 PEC Low lying *Banksia attenuata* woodland or shrubland (FCT 21c). This vegetation was considered to range from excellent to good condition. A targeted flora survey would be required to accurately assess the presence and occurrence of this PEC within the Project Area.<br>The 2012 spring flora survey recorded a total of 248 plant taxa representing 58 families and 160 plant genera within the Study Area. This total comprised of 74 introduced (exotic) species.<br>The desktop assessment identified a large number of Priority plants as potentially occurring within the Study Area and immediate surrounds. There is one record of the Priority 4 listed species, *Verticordia lindleyi* subsp. *lindleyi* identified in the Study Area. During the spring flora survey two Priority 4 plant species were recorded, *Eucalyptus caesia* and *Verticordia lindleyi* subsp. *lindleyi*. One *Eucalyptus caesia* was recorded in the Study Area. This species does not naturally occur on the Swan Coastal Plain and is likely to have been introduced to the Study Area and is not considered as significant.<br>Four records of *Verticordia lindleyi* subsp. cf. *lindleyi* were recorded at two separate locations within the Study Area. None of the specimens collected during the survey were flowering therefore a definitive identification cannot be given, however these specimens were all found to closely resemble *Verticordia lindleyi* subsp. *lindleyi* and are likely to be this subspecies. None of these records were located within the proposed alignment however suitable habitat for this species is | The project may be at variance to this principle. |

| Clearing Principle | | Assessment | Outcome |
|---|---|---|---|
| | | present within the alignment. It is recommended a targeted survey for this species is undertaken during its known flowering period to confirm its identification and to confirm the population size and extent of the species within the proposed alignment. This will assist in determining the level of impact the proposed construction footprint will have on this species.<br>The desktop assessment identified a number of Priority fauna species as likely to or potentially occurring within the Study Area. During the 2012 spring fauna survey two Priority fauna species were recorded, the Western Brush Wallaby (Priority 4) and Quenda (Priority 5). Both these species were recorded from vegetation east of Beechboro Road, outside of the proposed alignment. However there is some suitable habitat for these species within the proposed alignment.<br>Although the majority of the proposed alignment is highly disturbed or cleared, there are patches of remnant native vegetation in very good condition which provide suitable habitat for conservation significant flora and fauna. Given that the proposed alignment contains vegetation potentially associated with a PEC, contains wetland dependent vegetation and provides habitat for conservation significant flora and fauna the project is considered as may be at variance to this principle. | |
| (b) | Native vegetation should not be cleared if it comprises the whole, or part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia. | During the spring field survey four species of conservation significance were recorded, including the Carnaby's Black Cockatoo, Western Brush Wallaby, Quenda and Rainbow Bee-eater.<br>In addition to these, there are a number of conservation significant fauna identified during the desktop assessment as likely to or may potentially occur within the Project Area.<br>A large proportion of the proposed alignment has previously been cleared or highly disturbed however where patches of remnant vegetation remain it is generally in very good condition. Much of this remnant vegetation provides suitable habitat for ground-dwelling fauna such as the conservation significant Black-striped Snake and Quenda.<br>The majority of the vegetation in the alignment contains suitable habitat for the Endangered Carnaby's Black Cockatoo, including the *Banksia* woodlands, *Banksia-Eucalyptus* woodlands, open paddock with scattered eucalypts and proteaceous species and pine plantations. The alignment contains approximately 233.25 ha of suitable feeding habitat and potential roosting and breeding habitat. A targeted black cockatoo field assessment of the alignment is required to identify and map the presence of suitable breeding and roosting habitat within the Project Area as per the EPBC Act referral documentation requirements (DSEWPaC 2012).<br>Given the presence of significant habitat for the Carnaby's Black Cockatoo and habitat suitable for a number of other conservation significant fauna potentially occurring within the Project Area, the project is considered to be significantly at variance to this principle. | The project is at variance to this principle. |
| (c) | Native vegetation should not be cleared if it includes, or is | The desktop assessment identified one record of the Threatened flora species *Caladenia huegelii,* in the Study Area. The record is located east of Beechboro Road, within the Whiteman Park | The project may be at |

| Clearing Principle | | Assessment | Outcome |
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| | necessary for the continued existence of, rare flora. | reserve. This record is outside the proposed road alignment.<br>The location of this record and other areas of suitable habitat within the Study Area were targeted during the 2012 spring survey. No Threatened flora species were recorded during the survey.<br>It is thought that the species *C. huegelii* does not flower every year and the bulbs can lie dormant until disturbance such as fire or partial clearing occurs (DSEWPaC 2013b). For this reason surveys over a number of years are generally required to confirm the presence of this species. Further targeted surveys in suitable habitat for *C. huegelii* are recommended to confirm the presence/absence of this species within the proposed alignment and assist in determining the level of impact (if any) the proposed construction footprint will have on this species.<br>Given that there are known records of *C. huegelii* in the area and suitable habitat for this species is present within the proposed alignment, the project may be at variance to this principle. | variance to this principle. |
| (d) | Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community. | There are no known records of TECs within the Study Area.<br>The spring 2012 flora and vegetation survey did not identify any TECs with the Study Area.<br>The project is considered unlikely to be at variance to this principle. | The project is unlikely to be at variance to this principle. |
| (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. | Heddle *et al.* (1980) defines the vegetation within the proposed alignment to consist of the Bassendean Complex – north, of which there is 72% pre-European extent remaining; Bassendean Complex – north – transitional vegetation complex, of which there is 92.3% pre-European extent remaining; Bassendean Complex – central and south, of which there is 27% pre-European extent remaining; and Southern River Complex, of which there is 19.8% of pre-European extent remaining (EPA 2006).<br>The vegetation within the proposed alignment is also described as Beard vegetation association 1001, of which there is 24.65% pre-European extent remaining; and vegetation association 949, of which there is 56.88% pre-European extent remaining (Government of Western Australia 2011).<br>The Study Area is located within the City of Swan, within which there is 43.7% of pre-European vegetation extent remaining. The State Government is committed to the National Objectives and Targets for Biodiversity Conservation which includes a target that prevents the clearance of ecological communities with an extent below 30% of that present pre-European settlement (Commonwealth of Australia 2001).<br>Although two of the vegetation complexes and one of the Beard vegetation associations identified within the Study Area have less than the recommended 30% threshold remaining, the Study Area is considered to be within a constrained area. The EPA (2006) recognises the Perth Metropolitan Region as a 'constrained area', providing for the variation of the minimum percentage of vegetation complexes remaining to 10% of the pre-European extent. | The project is unlikely to be at variance to this principle. |

| Clearing Principle | | Assessment | Outcome |
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| | | Therefore, the project is considered unlikely to be at variance to this principle. | |
| (f) | Native vegetation should not be cleared if it is growing in or in association with a watercourse or wetland. | There are numerous wetlands and seasonal damplands located in the local area (5 km radius) and within the Study Area. Within the Project Area there is approximately 4.81 ha mapped as Conservation Category Wetland, 20.53 ha mapped as Multiple Use Wetland and 4.07 ha mapped as Resource Enhancement Wetland.<br>The wetlands within the Study Area were assessed during the spring 2012 flora and vegetation survey. The vegetation in the Conservation Category Wetland located within the proposed alignment consists of a mosaic of predominantly mixed open heath and *Banksia* low open forest on sandy flats. Dominant species include *Banksia menziesii, Verticordia* spp., *Melaleuca seriata, M. preissiana, Allocasuarina fraseriana, Calytrix fraseri, Pericalymma ellipticum,* and *Hypocalymma angustifolium*. The area was predominantly lower-lying and the soils may potentially be seasonally waterlogged.<br>There are no permanent watercourses or wetlands within the proposed alignment or within the immediate vicinity. There is one significant stream in the Project Area named Bennett Brook. Bennett Brook originates within the proposed alignment (west of Beechboro Road) as a superficial aquifer. Rain fills the aquifer, causing it to rise and fill the wetlands during the winter months, flowing in a south-east direction. The Brook flows through Mussel Pool and runs south to join the Swan River at Bassendean (Whiteman Park 2013). The existing Beechboro Road already traverses through Bennett Brook.<br>Given the proposed alignment is located within a mapped Conservation Category wetland and there is vegetation associated with seasonally waterlogged areas, it is considered that the project is at variance to this principle. | The project is at variance to this principle. |
| (g) | Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation. | The soils within the Project Area are part of the Bassendean Dune System and comprise leached sands, which are considered to have high risk of wind erosion. It is considered that the removal of vegetation from the site will further expose the soils and may result in wind erosion. The high wind erosion potential is due to the sandy nature of the topsoil and without appropriate ground cover, or adequate dust suppression on exposed surfaces the project would be likely to cause land degradation. However, given the thin, linear nature of the project and the eventual sealing of exposed surfaces, the risk of wind erosion will be reduced.<br>It is considered that the proposed clearing is unlikely to result in an increase in salinity as there is a low salinity risk within the Project Area.<br>ASRIS (2012) mapping shows the majority of the Project Area as having low probability of having Acid Sulfate Soil (ASS) impact, with smaller portions of the area as having a high probability of ASS impact. However, this was inferred from other datasets and consequently is subject to uncertainty, i.e. 'Very Low Confidence'.<br>It is considered that the project may be at variance to this principle. | The project may be at variance to this principle. |

| Clearing Principle | | Assessment | Outcome |
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| (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. | The majority of the proposed alignment, north of Gnangara Road is within DEC estate classified as the Gnangara-Moore River State Forest (94.34 ha). This area largely consists of pine plantation and small patches of remnant native vegetation.<br>The proposed alignment traverses through four Bush Forever sites, including sites 198 (32.87 ha), 304 (83.39 ha), 399 (22.24 ha) and the edge of 192 (1.24 ha).<br>Given that the proposed alignment traverses through four Bush Forever sites and the Gnangara State Forest, the project is considered to be significantly at variance to this principle. | The project is significantly at variance to this principle. |
| (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. | There are numerous wetlands and seasonal damplands located in the local area (5 km radius) and within the Project Area. Within the proposed alignment there is approximately 4.81 ha mapped as Conservation Category Wetland, 20.53 ha mapped as Multiple Use Wetland and 4.07 ha mapped as Resource Enhancement Wetland.<br>There is one significant stream in the Project Area, Bennett Brook. Bennett Brook originates within the proposed alignment (west of Beechboro Road) as a superficial aquifer. Rain fills the aquifer, causing it to rise and fill the wetlands during the winter months, flowing in a south-east direction. The existing Beechboro Road already traverses through Bennett Brook.<br>It is considered that the proposed clearing is unlikely to result in an increase in salinity as there is a low salinity risk within the Study Area.<br>The Study Area is located within the Mirrabooka RIWI Groundwater Area south of Gnangara Road and east along Gaskell Road (north of Gnangara Road), and within the Gnangara RIWI Groundwater Area over the majority of the area north of Gnangara Road.<br>The proposed alignment is located within a Priority 1 protected Public Drinking Water Source Area (PDWSA). P1 classification areas are defined to ensure that there is no degradation of the water source.<br>The Study Area is located within the *Environmental Protection (Gnangara Mound Crown Land) Policy 1992* which states that 'person shall not clear, destroy or remove any vegetation on or from the policy area unless the person is authorised under the Act to do so and is acting in accordance with that authorisation'.<br>The proposed project may cause deterioration in the quality of surface water however it is unlikely to cause deterioration in the quality of groundwater. A CEMP will be prepared which includes management actions to address potential impacts to surface and underground water. Detail design should include consideration of water management such that there is no direct runoff to nearby water courses and wetlands.<br>The project may at variance to this principle. | The project may be at variance to this principle. |
| (j) | Native vegetation should not be cleared if the clearing of the | There are numerous wetlands and seasonal damplands located in the local area (5 km radius) and within the Study Area. The Proposed alignment is situated within the Bassendean Dune | The project may be at |

| Clearing Principle | | Assessment | Outcome |
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| | vegetation is likely to cause, or exacerbate, the intensity of flooding. | System. The dunes of the Bassendean system are generally of low relief often with broad swales or relatively flat sand sheets between the low dunes, which are poorly drained. The clearing of native vegetation may cause, or exacerbate the incidence or intensity of flooding due to increased runoff in localised areas, particularly in the low-lying poorly drained areas.<br>Therefore the project may be at variance to this principle. | variance to this principle. |

### 6.2.3 Department of Water

The DoW is responsible for managing the state's water resources. The RIWI Act covers the regulation, management, use and protection of water resources in Western Australia. RIWI licensing is active in all proclaimed areas and for all artesian groundwater wells throughout the state. Under the RIWI Act it is illegal to take water from a watercourse or groundwater aquifer without a licence.

The project is situated within the Mirrabooka and Gnangara RIWI Groundwater Areas and Swan River System RIWI Surface Water Area. Therefore any interference with bed and banks, dewatering and abstraction associated with the project will require licence applications from the DoW. Additional management plans may be required as part of the licensing conditions or policy requirements.

### 6.2.4 Department of Indigenous Affairs

Indigenous Affairs in Western Australia is protected under the *Aboriginal Heritage Act 1972*. Approval under Section 18 of the *Aboriginal Heritage Act 1972* will be required from the Minister of Indigenous Affairs if any heritage sites will be impacted by the Project.

The Project has the potential to have an indirect impact on one registered heritage site, "Bennett Brook In Toto". An application pursuant to Section 18 of the *Aboriginal Heritage Act 1972* should be made by Main Roads and Ministerial consent should be obtained for those works before they commence, on the grounds they will have indirect impact upon one Aboriginal site (as detailed in section 5.7.1).

# 7. Stakeholder consultation

Main Roads has consulted with a range of stakeholders during the development of the Tonkin-link alignment over the past 12 months, regarding the environmental and cultural impacts of the project.

A working group has been established for the Perth Darwin National Highway Planning Study (Reid Highway to Maralla Road). The group consists of representatives from Main Roads, Department of Planning, Department of Transport, Department of Environment and Conservation, Department of Water, Water Corporation, City of Swan, City of Wanneroo and Public Transport Authority.

Issues raised by these stakeholders have been addressed within this EIA and EMP where possible. It is understood that Main Roads will continue to consult with these, and other relevant stakeholders, throughout the development of the project.

# 8. Environmental management plan

The aim of this EMP is to minimise the environmental impacts associated with the proposed works as well as to identify areas of responsibilities required for the implementation of management strategies.

This EMP addresses specific issues that were identified during the EIA. The project management measures identified within this EMP are in addition to the standard environmental management contract specifications. Main Roads' standard environmental contract specifications (Specifications 203, 204, 301, 302 and 304) are to be adhered to where appropriate.

The areas that require special management will be addressed in terms of:

- The timing of the various management actions;
- The topic (e.g. vegetation);
- The objectives for each area;
- The actions that are necessary to minimise the impact;
- The responsible party for implementing the action; and
- Whether the action arose from external advice or is a Main Roads requirement.

Prior to the commencement of the Project, specific management plans that address the following issues will be prepared:

- Offsets (Bush Forever, Conservation Category Wetlands and Carnaby's Black Cockatoo habitat);
- Rehabilitation;
- Vegetation and flora;
- Weeds and dieback;
- Fauna;
- Acid sulphate soils;
- Wetlands;
- Surface water and drainage;
- Erosion;
- Air quality;
- Visual amenity;
- Noise and vibration; and
- Hazardous materials.

## 8.1 Communication plan

Environmental issues specific to the project will be communicated as follows:

| Method | Frequency | Participants | Reference | Record |
|---|---|---|---|---|
| Project Site | | | | |
| Induction | Prior to Work | All personnel and subcontractors | EMP and Contractor Environmental Policy | Induction Meeting |
| Toolbox Meetings | Weekly | Project Personnel | Contractor Safety Plan | Minutes of Meeting |
| Contract Meetings | Monthly | Main Roads' Project Manager and Contractor Project Manager | EMP | Minutes of Meeting |

## 8.2 External communication and complaints

A complaints register shall be maintained by the contractor. All complaints received shall be forwarded to the Main Roads' Project Manager for action. Serious complaints shall be investigated within 24 hours of the complaint being received.

| ENVIRONMENTAL MANAGEMENT PLAN | | | | | |
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| **Timing** | **Topic** | **Objective** | **Action** | **Responsible Party** | **Advice** |
| Design | Loss of vegetation and fauna habitats | Minimise direct loss of vegetation and fauna habitats. | Selection of design that minimises direct and indirect impacts on native vegetation and habitat in the Project area. | Main Roads | Main Roads |
| | | | Plan and develop storage sites, laydown areas, hardstands and other areas which require clear space to occur within areas which are already cleared or otherwise disturbed. | | |
| | | | Avoid clearing known locations of priority flora species and communities (where possible). | | |
| | | | Restrict the extent of clearing in habitat considered to be significant for threatened fauna. | | |
| All phases of Construction | Vegetation Clearing<br>- Record-keeping | All projects should maintain the required records relating to clearing native vegetation under the purpose permit. | Clearing:<br>• a map showing the location where the clearing occurred;<br>• the size of the area cleared (in hectares); and<br>• the dates on which the clearing was done. | Project Manager | DEC |
| Pre-construction | Vegetation clearing – Revegetation | | A revegetation plan will be prepared that includes the following:<br>• A figure showing areas to be revegetated;<br>• Requirements for vegetation chipping and reuse;<br>• Requirements for topsoil use and/or soil preparation or treatment;<br>• Species lists and planting and/or seeding zones;<br>• Estimates of quantities and costs;<br>• Completion criteria for revegetation success. | Main Roads/Contractor | DEC |
| Pre-construction | Vegetation clearing – dieback and weed management | Prevent the introduction and/or spread of dieback and weeds | A dieback assessment by an experience dieback interpreter would need to be undertaken to confirm the presence and map the occurrence of dieback in the Project Area.<br>A Dieback and Weed Management Plan will be prepared including:<br>• All imported fill will be certified weed free;<br>• All machinery and plant will be cleaned down prior to arrival at the Project site.<br>• Weed monitoring and management.<br>• Where noxious weeds are observed, their location will be recorded and the area sprayed with a relevant herbicide prior to seed dispersal. | Contractor | DEC |
| Pre - Construction | Vegetation Clearing - CPS 818/7 management requirements | Compliance with management conditions of purpose permit. | If clearing is pursuant to Main Purpose Permit (CPS 818) ensure compliance with Section 14 of the permit relating to Dieback, other pathogen and weed control. | Contractor/Project Manager | DEC |

| ENVIRONMENTAL MANAGEMENT PLAN | | | | | |
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| **Timing** | **Topic** | **Objective** | **Action** | **Responsible Party** | **Advice** |
| Pre – Construction | Surface Water Drainage | Prevent damage to environment from changes to flood regime and maintain hydrological regime that exists prior to construction. | Maintain the hydrological balance between each side of the road. This will prevent ponding and scour during flood events, and with appropriate management structures in place (such as culverts) balance will be maintained. Stormwater drainage shall be treated and disposed of in accordance with DEC requirements. | Project Manager | Main Roads/ DEC |
| Pre-construction | Groundwater | To maintain the quality of groundwater so that existing and potential environmental values are protected. | If dewatering is required, Main Roads will gain approvals from DoW. A Dewatering Management Plan will be prepared including:<br>• If dewatering is required, the most appropriate method will be determined on site and dewatering kept to a minimum necessary for the safe construction;<br>• As far as practicable, infiltrate dewater back into the groundwater resource, close enough to the abstraction point that is does not create a 'recycle' effect; and<br>• The Construction Contractor will design, maintain and operate all necessary pumping equipment and temporary structures for dewatering. | Main Roads/Contractor | DoW |
| Construction | Noise, Vibration and Dust | Ensure that the construction of the proposal does not become a nuisance to the public. | Access to private property and appropriate traffic management measures should be planned and implemented prior to the construction of works. | Contractor | Main Roads |
| | | | • Vehicle speeds will be restricted to minimise dust.<br>• Water unsealed roads and construction site(s) during dry and windy conditions, as required.<br>• All surfaces temporarily disturbed as a result of construction activities will be revegetated or otherwise stabilised to reduce the potential for dust issues.<br>• Stockpiles will be stabilised against wind and rain if they are to be left for extended periods of time. | Contractor | Main Roads |
| | | | Pedestrian public access should be should be planned and implemented prior to the construction of works. | Contractor | Main Roads |
| | | | Any complaints regarding dust will be attended to as soon as possible. | Contractor/Project Manager | Main Roads |
| Construction | Waste | Inappropriate disposal of construction waste | Confirm that non-recyclable materials/wastes are disposed of at licensed landfill facilities or in accordance with Council regulations. | Contractor | Main Roads |
| Construction | Pollution and Litter | Ensure that the construction of the proposal is managed to a | The designated servicing area will be bunded to contain any spills or leaks and shall not be located in an area adjacent to any drainage areas or watercourses or will drain into a temporary sump. | Contractor | Main Roads |

| ENVIRONMENTAL MANAGEMENT PLAN | | | | | |
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| **Timing** | **Topic** | **Objective** | **Action** | **Responsible Party** | **Advice** |
| | | standard that minimises any adverse impacts on the environment. | Temporary storage of bitumen, asphalt, concrete or aggregate should only occur at designated depots or controlled hardstands. Precoating of aggregate will only occur in approved areas. | Contractor | Main Roads |
| | | | Emergency clean-up procedures shall be implemented in the case of any spillage. These will include control of spilled material and removal of contaminated soil to an approved site. The contractor shall ensure appropriate equipment is available at all times and shall notify the Superintendent's Representative of a spill. | Contractor | Main Roads |
| | | | Employees whose activities include the storage and handling of waste have been appropriately trained and are competent at undertaking tasks required. | Contractor | Main Roads |
| | | | All waste oil will be collected for recycling and any empty fuel/oil containers, used filters and waste hydraulic parts to be collected and stored in an allocated area then removed to an approved site. | Contractor | Main Roads |
| | | | The project areas will be kept in a tidy manner at all times. | Contractor | Main Roads |
| Construction | Fire | Ensure that the fire risk associated with the construction of the proposal is minimised. | No fires shall be lit within the project area. | Contractor | Main Roads |
| | | | Machinery will be fitted with approved spark arresting mufflers. | Contractor | Main Roads |
| Construction | Fauna | Avoid unnecessary impacts to fauna and damage to fauna habitat. | Fauna are not to be fed or intentionally harmed. | Contractor | Main Roads |
| | | | Timing of clearing should avoid the peak breeding period for threatened and priority fauna known to occur in the Study Area. | Main Roads | DEC |
| | | | No pets or firearms permitted on site. | Contractor | Main Roads |
| | | | The WILDCARE Helpline is to be contacted, 9474 9055, in the event of sick, injured or orphaned native wildlife on the site. | Contractor | Main Roads |
| | | | Any trenched or open excavations should be checked daily for fauna and any fauna will be removed as soon as possible. | Contractor | Main Roads |
| | | | • Removal of fauna from the Project area will only be undertaken by designated and trained personnel.<br>• Any logs or other material which has value as habitat for fauna is to be stockpiled and replaced on the revegetation area (where possible). | Contractor | Main Roads |
| | | | Minimise or restrict the movement and use of plant and vehicles at dusk and dawn and during night time hours. | Contractor | Main Roads |

| ENVIRONMENTAL MANAGEMENT PLAN | | | | | |
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| **Timing** | **Topic** | **Objective** | **Action** | **Responsible Party** | **Advice** |
| Construction | Aboriginal Heritage | Ensure that no new Aboriginal Heritage sites are impacted by construction. | Any suspected human skeletal material uncovered during the construction phase must be immediately reported to the Western Australian Police Service, DIA and the WA Museum. All Site personnel must be informed of this requirement and of the requirement for work to cease in the area if such material is uncovered. Work may only recommence once full clearance from the relevant Authority is obtained. | Contractor | Main Roads |
| | | | Any suspected new Aboriginal site identified during the construction phase must be reported to the DIA as soon as possible and works must cease until appropriate clearances have been obtained. | Contractor | Main Roads |
| Construction | Site Management | Ensure that the site is managed to ensure that construction of the proposal will have minimal impact upon the surrounding environment. | Materials storage areas will be located on previously disturbed/ designated area. | Contractor | Main Roads |
| | | | All waste materials from the development are to be completely removed from the site upon completion of the project. Final clean-up shall be to the satisfaction of the Project Manager and the Site Superintendent. | Contractor | Main Roads |
| Construction | Traffic | Minimise the disturbance from traffic | Construction vehicles will travel along specifically designated routes that have been selected to minimise disturbance on other traffic and the community. | Contractor | Main Roads |
| Construction | Topsoil stripping and re-use | Determine adequate topsoil management in order to enhance revegetation success and minimise erosion and spread of weeds. | Topsoil stripping and management will be in accordance with the proposed treatments outlined in the Revegetation Plan, including<br>• Topsoil will be stripped to a maximum depth of 150 mm along all sections of work;<br>• Topsoil that is re-used will be stored as close as possible to the source of the area or target area for reuse. Topsoil will be stored in an area as free as possible from weeds an in windrows or heaps ideally 1 metre high (maximum of 2 m). It should be reused as soon as possible after stripping, and as close as possible to its source. | Contractor | Main Roads |
| Construction/Post construction | Weed Management | | Monitor the weeds in the Project Area as per the requirements of the revegetation plan. | Contractor | Main Roads |
| Construction | Environmental Monitoring | To confirm that environmental management measures have been complied with. | During Project construction phase, compliance with environmental management measures will be monitored. | Contractor | Main Roads |

# 9. Limitations

## 9.1 Assumptions and limitations

This report presents the results of desktop data searches undertaken in late 2012 and early 2013 for environmental aspects linked to the Project. The desktop assessment is supported by a field survey undertaken in Spring 2012. The conclusions of this report are based on the information gathered during these investigations and thus reflect the environment of the Study Area at the time.

This assessment should be viewed as an environmental review of the existing environmental conditions of the Project, and a high-level identification of potential environmental and social issues associated with the construction and operation of the Project.

Where previous reports, flora surveys and similar work have been performed and recorded by others the data is included and used in the form provided by others. The responsibility for the accuracy of such data remains with the issuing authority, not with GHD.

An understanding of site conditions depends on the integration of many pieces of information, some regional, some site specific, some structure specific and some experience based. Hence, this report should not be altered, amended or abbreviated, issued in part or incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances that arise from the issue of the report that has been modified in any way as outlined above. Proposed management measures recommended are based on information available at the time of preparation.

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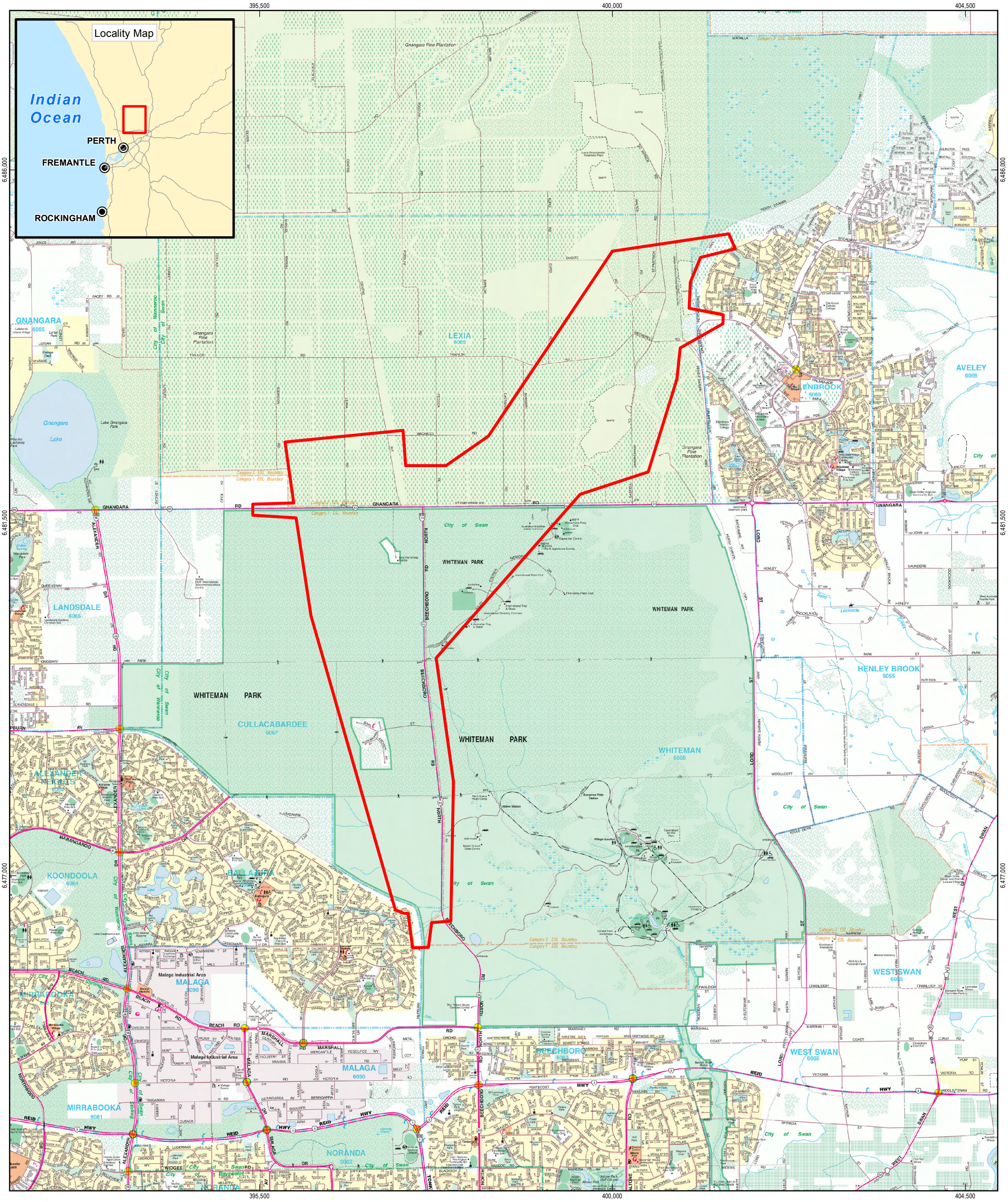
# Appendices

# Appendix A – Figures




LEGEND

Study Area

DRAFT

1: 45,000 (at A3)

0 225 450 900 1,350 1,800 2,250

Metres

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

N

Main Roads WA - ETS
PDNH Tonkin Link Environmental Impact Assessment

| | |
|---|---|
| Job Number | 61-28596 |
| Revision | B |
| Date | 04 Jun 2013 |

# Study Area: Locality

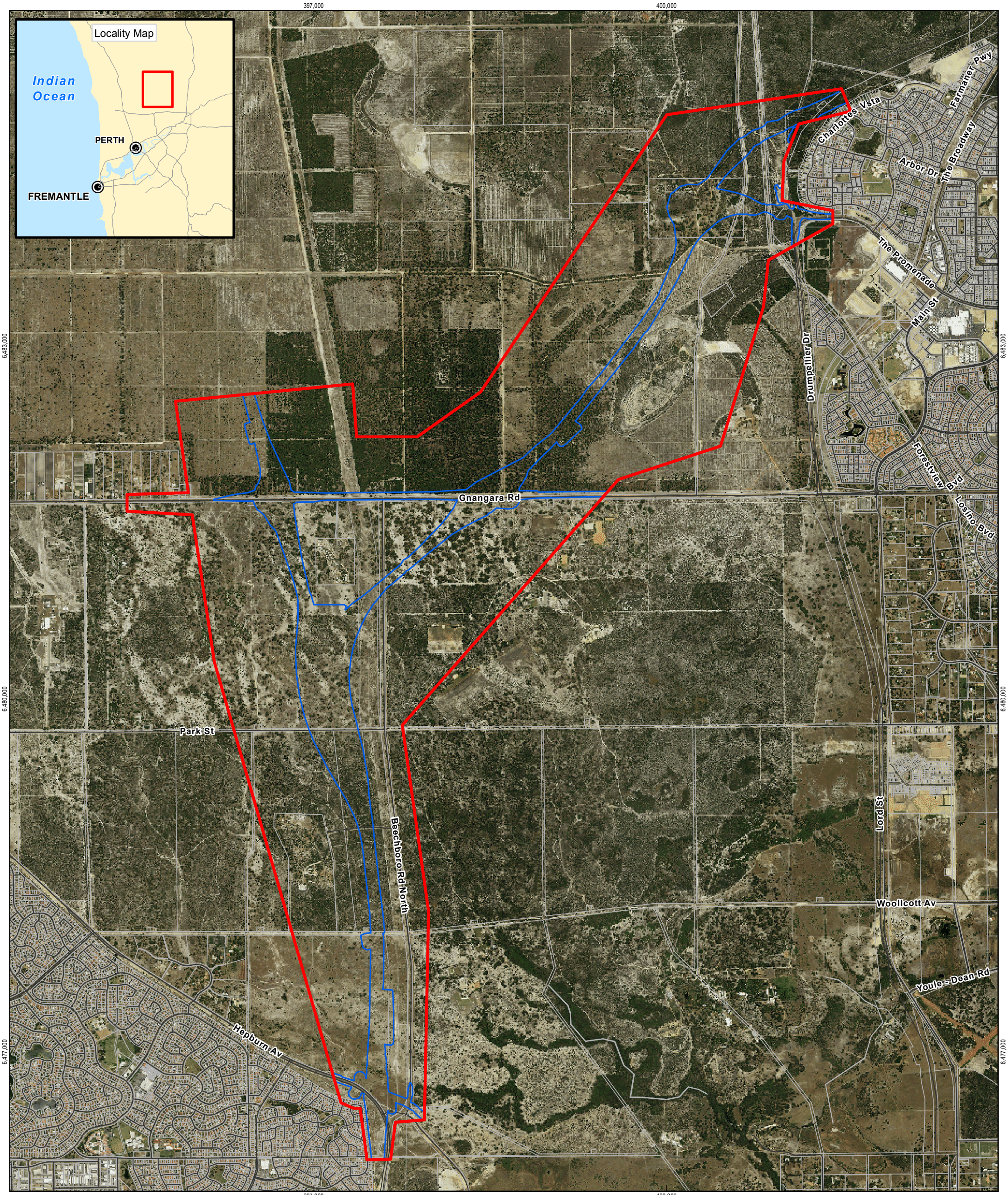
Figure 1


G:\61\28596\GIS\Maps\MXD\6128596_G001_Fig01_RevB.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au




Data source: Landgate: Streetsmart 2009 - 20121107; GHD: Study area - 20121010; GA: Geodata Topo 250k Series III - 2006. Created by: radeleon




LEGEND

- Road
- Cadastre
- Study Area
- Project Area

DRAFT

1: 30,000 (at A3)

0 150 300 600 900 1,200 1,500

Metres

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

N

Main Roads WA - ETS
PDNH Tonkin Link Environmental Impact Assessment

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|---|---|
| Job Number | 61-28596 |
| Revision | D |
| Date | 29 Aug 2013 |

# Project Area

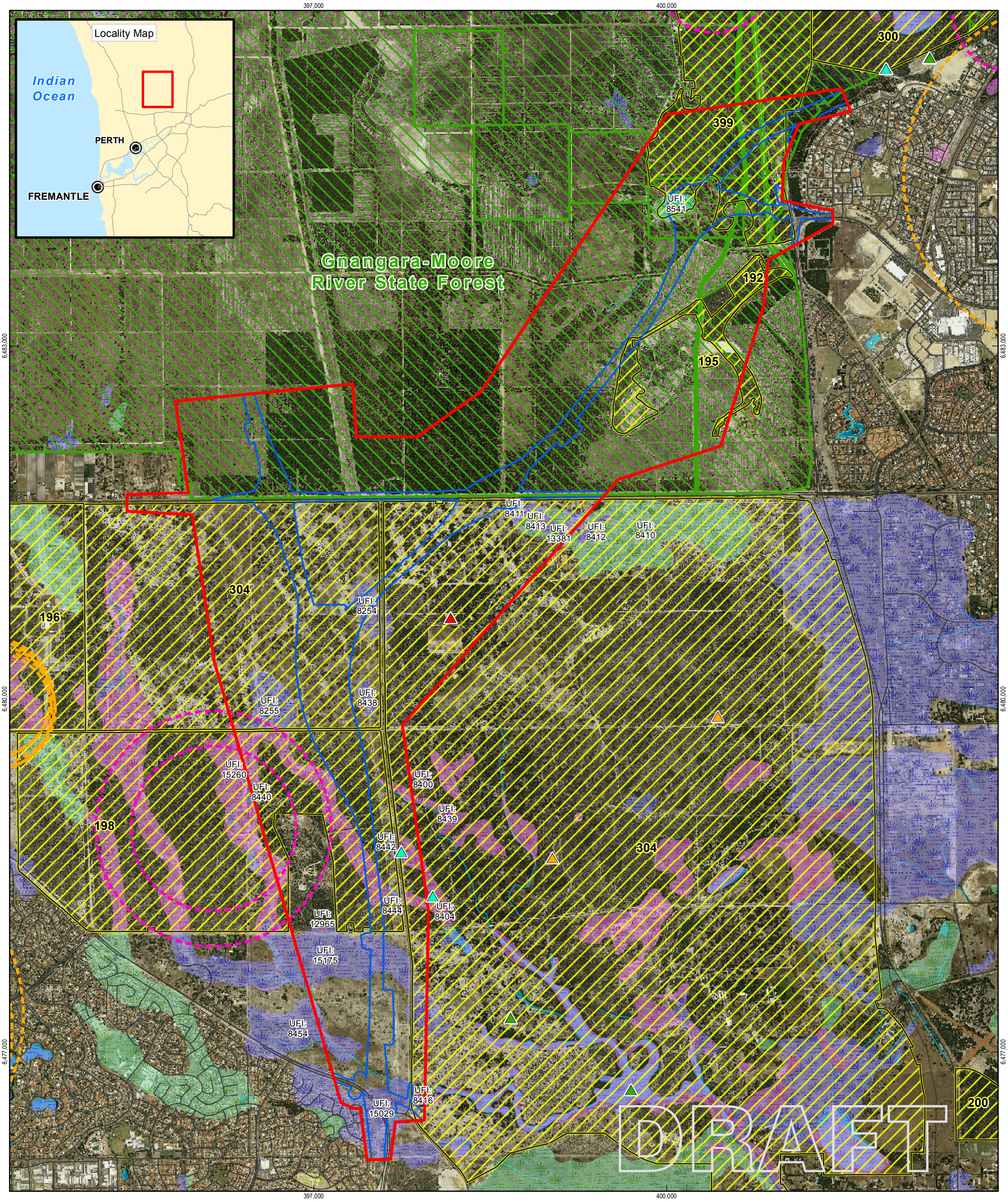
Figure 2

G:\61\28596\GIS\Maps\MXD\6128596_G001_Fig02_RevD.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au



Data source: Landgate: Metro Central Jan 2013 Mosaic - 20130604, Cadastre - 20121010, Hydrology - 20130408; MRWA: Road - 20120529; GHD: Study Area - 20121010, Project Area - 20130604; GA: Geodata Topo 250k Series III - 2006. Created by: cagilbert, radeleon




LEGEND

**Threatened (Declared Rare) & Priority Flora**
- (T) Threatened Rare Flora - Extant Taxa; T
- Priority 1 - Poorly Known Taxa
- Priority 2 - Poorly Known Taxa
- Priority 3 - Poorly Known Taxa
- Priority 4 - Rare Taxa
- Priority 5 - Conservation Dependent Taxa

- Road
- Sudy Area
- Project Area
- Hydrology
- DEC Estate
- Bush Forever Sites
- Priority Ecological Community
- Threatened Ecological Community

**Geomorphic Wetlands**
- Conservation
- Resource Enhancement
- Multiple Use
- Not Applicable

1: 30,000 (at A3)

0 150 300 600 900 1,200 1,500

Metres

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

N

Main Roads WA - ETS
PDNH Tonkin Link Environmental Impact Assessment

| | |
|---|---|
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| Revision | C |
| Date | 29 Aug 2013 |

# Environmental Context: Biological

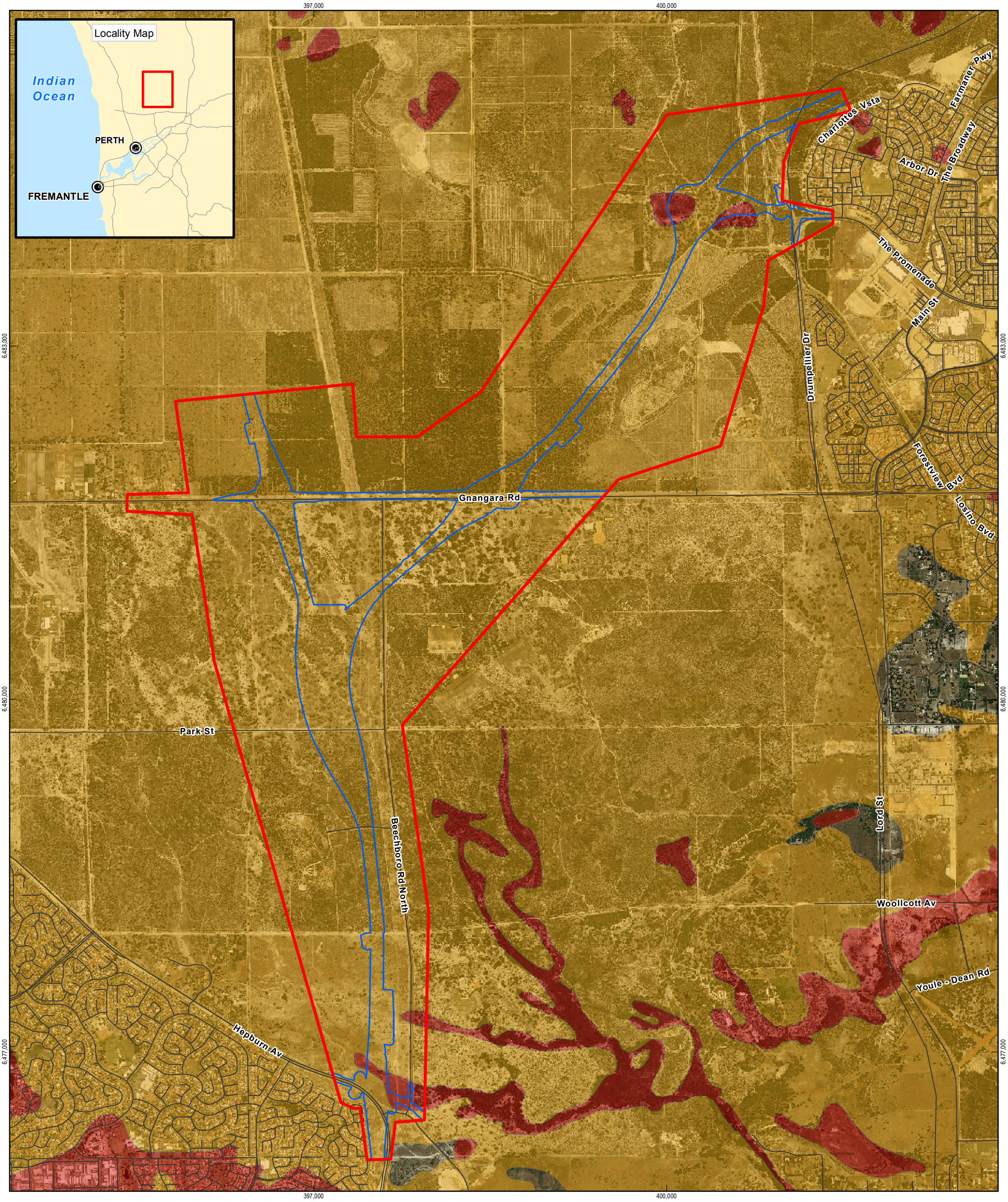
Figure 3A

G:\61\28596\GIS\Maps\MXD\6128596_G002_Fig03A_RevD.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au



Data source: Landgate: Metro Central Jan 2013 Mosaic - 20130604, Hydrology - 20130408; MRWA: Road - 20120529, Threatened Ecological Community - 20100323, Priority Ecological Community - 20100323; GHD: Study Area - 20121010, Project Area - 20130604; DEC: Threatened (Declared Rare) & Priority Flora - 20121205, Priority Ecological Community - 20120907, DEC Estate - 20130603, Geomorphic Wetlands - 20130630; DOP: Bush Forever Sites- 20120830; GA: Geodata Topo 250k Series III - 2006. Created by: cagilbert, radeleon




LEGEND

- Road
- Study Area
- Project Area

**Acid Sulphate Soils**

- High to moderate ASS disturbance risk (<3m from surface)
- Moderate to low ASS disturbance risk (<3m from surface)

DRAFT

1: 30,000 (at A3)

0 150 300 600 900 1,200 1,500

Metres

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

N

GHD

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# Environmental Context: Acid Sulphate Soil (ASS) Risk Mapping

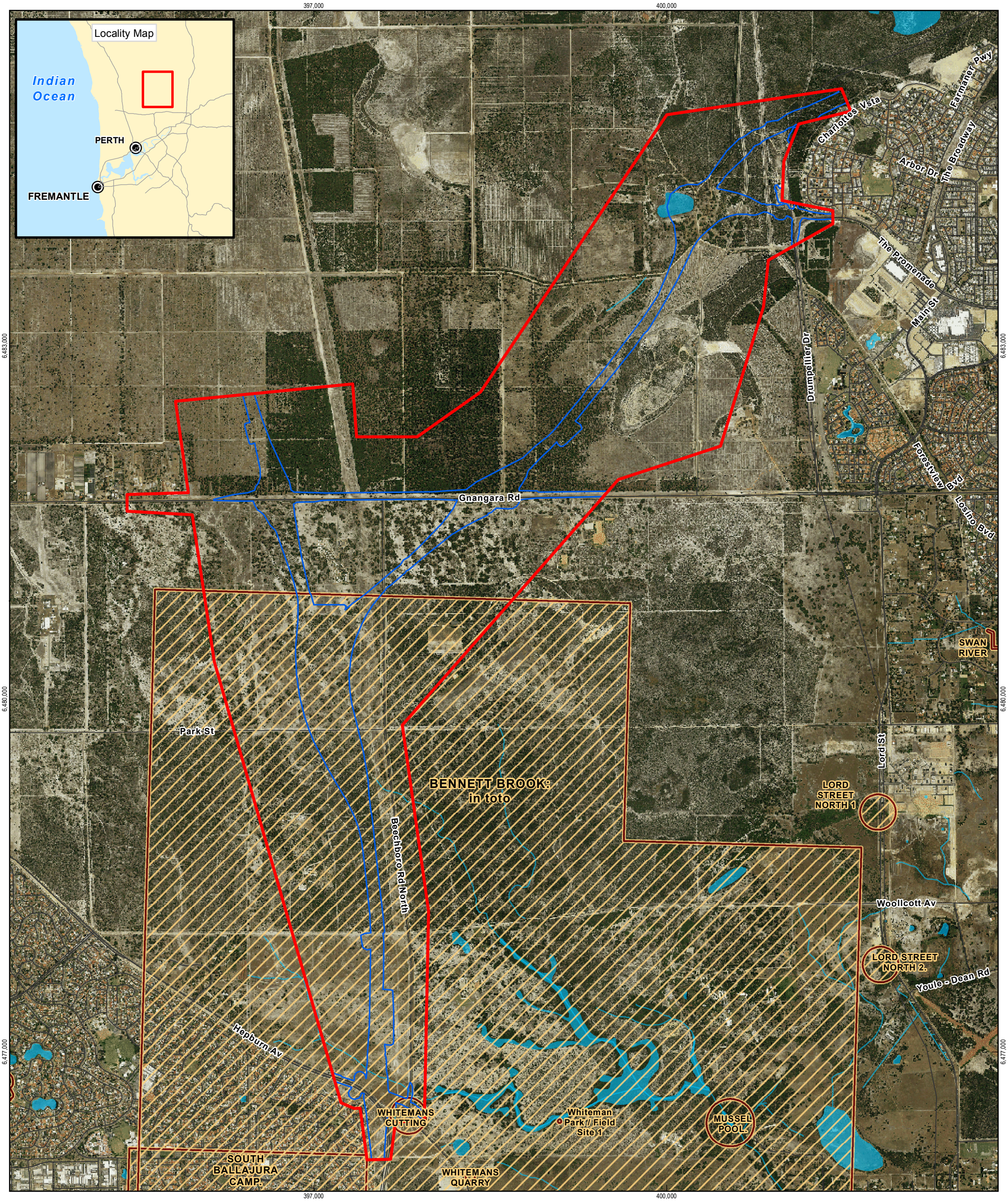
Figure 3B

G:\61\28596\GIS\Maps\MXD\6128596_G003_Fig03B_RevD.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au



Data source: Landgate: Metro Central Jan 2013 Mosaic - 20130604; MRWA: Road - 20120529; GHD: Study Area - 20121010, Project Area - 20130604; DEC: Acid Sulphate Soils - 20130630; GA: Geodata Topo 250k Series III - 2006. Created by: cagilbert, radeleon




LEGEND

- Road
- Study Area
- Project Area
- Aboriginal Heritage Sites
- Hydrology

DRAFT

1: 30,000 (at A3)

0 150 300 600 900 1,200 1,500

Metres

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

N

Main Roads WA - ETS
PDNH Tonkin Link Environmental Impact Assessment

Job Number 61-28596
Revision D
Date 29 Aug 2013

# Environmental Context: Aboriginal Heritage Sites

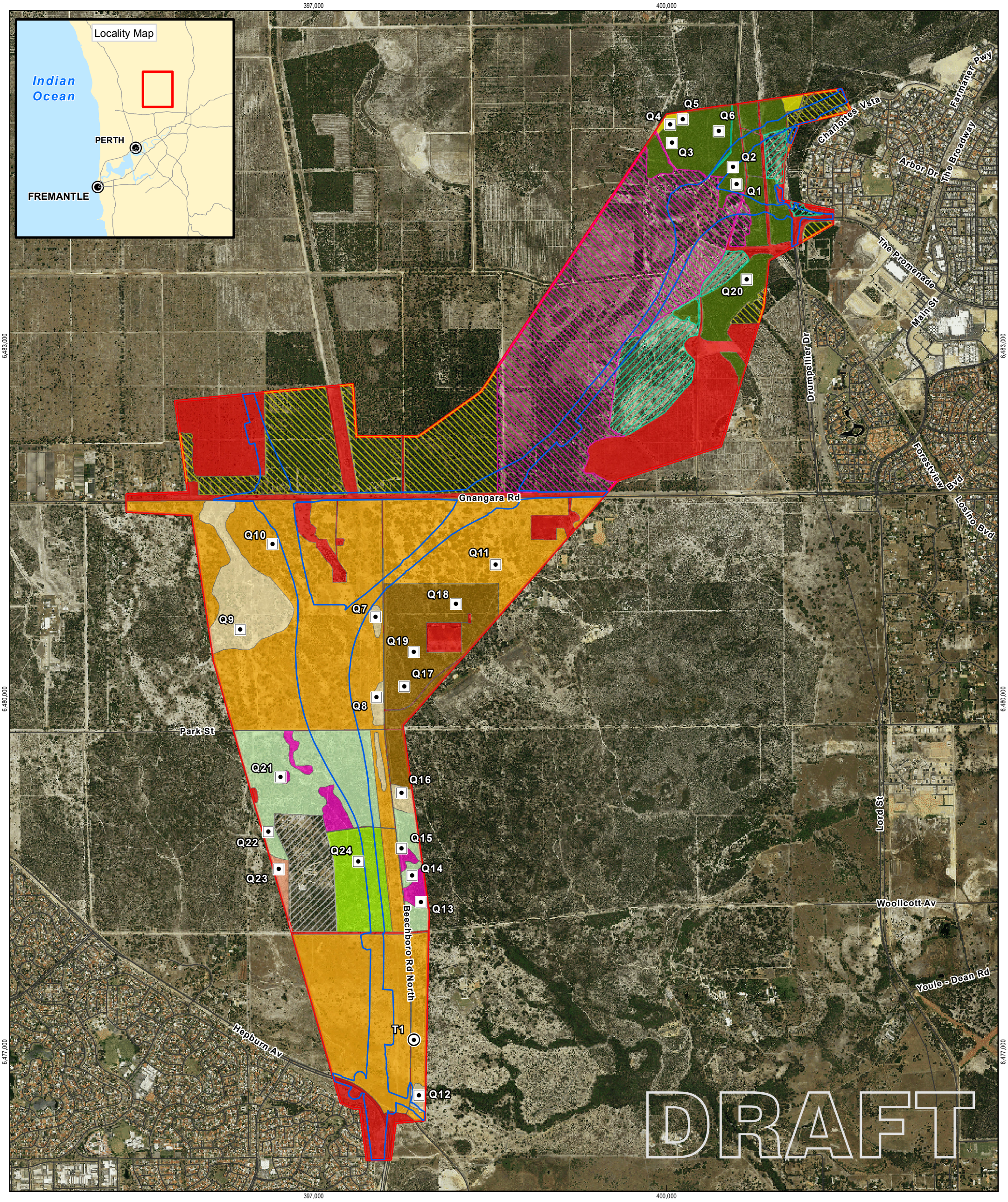
Figure 3C

G:\61\28596\GIS\Maps\MXD\6128596_G004_Fig03C_RevD.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au



Data source: Landgate: Metro Central Jan 2013 Mosaic - 20130604, Hydrology - 20130408; MRWA: Road - 20120529; GHD: Study Area - 20121010, Project Area - 20130604; DIA: Aboriginal Heritage Sites - 20130603; GA: Geodata Topo 250k Series III - 2006. Created by: cagilbert, radeleon




LEGEND

- Quadrat
- Transect
- Road
- Study Area
- Project Area

**Vegetation Type**

- *Banksia* Low Open Forest
- Mosaic of *Banksia* Low Open Forest and Mixed Open Heath
- *Banksia* Woodland
- *Melaleuca* Low Woodland
- *Verticordia* Low Open Heath
- Closed Tall Scrub
- Jarrah-Marri-*Banksia* Woodland
- Mixed Open Heath
- Open Paddock
- Cleared / Highly Modified
- Plantations
- Plantations and Cleared / Highly Modified
- Rehabilitation
- Unsurveyed

1: 30,000 (at A3)

0 150 300 600 900 1,200 1,500

Metres

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

N

GHD

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# Vegetation Type and Quadrat Locations

Job Number 61-28596
Revision F
Date 29 Aug 2013

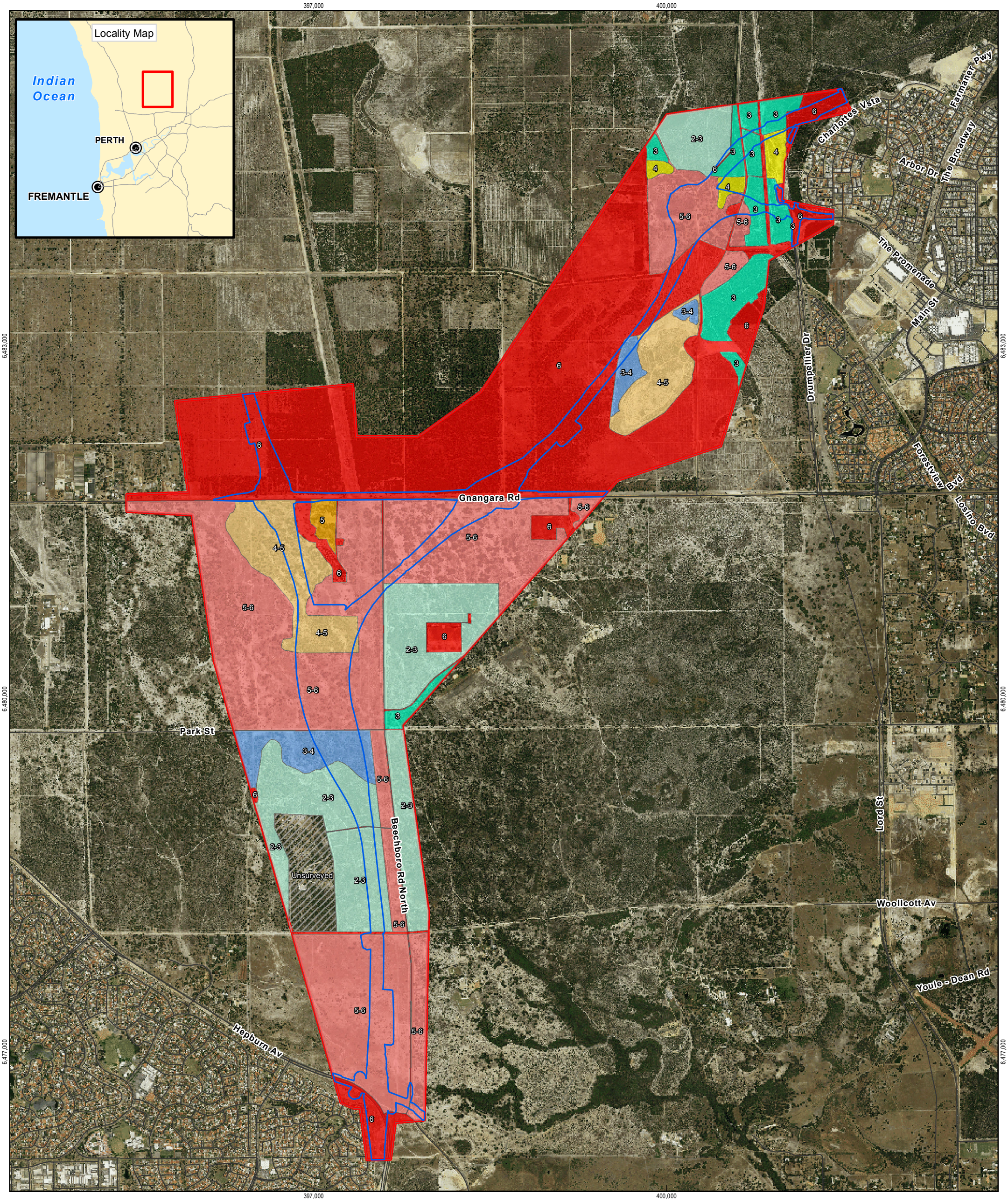
Figure 4

G:\61\28596\GIS\Maps\MXD\6128596_G005_Fig04_RevF.mxd

239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au



Data source: Landgate: Metro Central Jan 2013 Mosaic - 20130604; MRWA: Road - 20120529; GHD: Study Area - 20121010, Project Area - 20130604, Vegetation Type - 20130325, Quadrat - 20130325, Transect - 20130325; GA: Geodata Topo 250k Series III - 2006. Created by: cagilbert, radeleon




LEGEND

- Road
- Study Area
- Project Area

**Vegetation Condition (Keighery, 1994)**

- 2-3. Excellent - Very Good
- 3. Very Good
- 3-4. Very Good - Good
- 4. Good
- 4-5. Good - Degraded
- 5. Degraded
- 5-6. Degraded - Completely Degraded
- 6. Completely Degraded
- Unsurveyed

DRAFT

1: 30,000 (at A3)

0 150 300 600 900 1,200 1,500

Metres

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

N

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| Job Number | 61-28596 |
| Revision | E |
| Date | 29 Aug 2013 |

# Vegetation Condition

Figure 5

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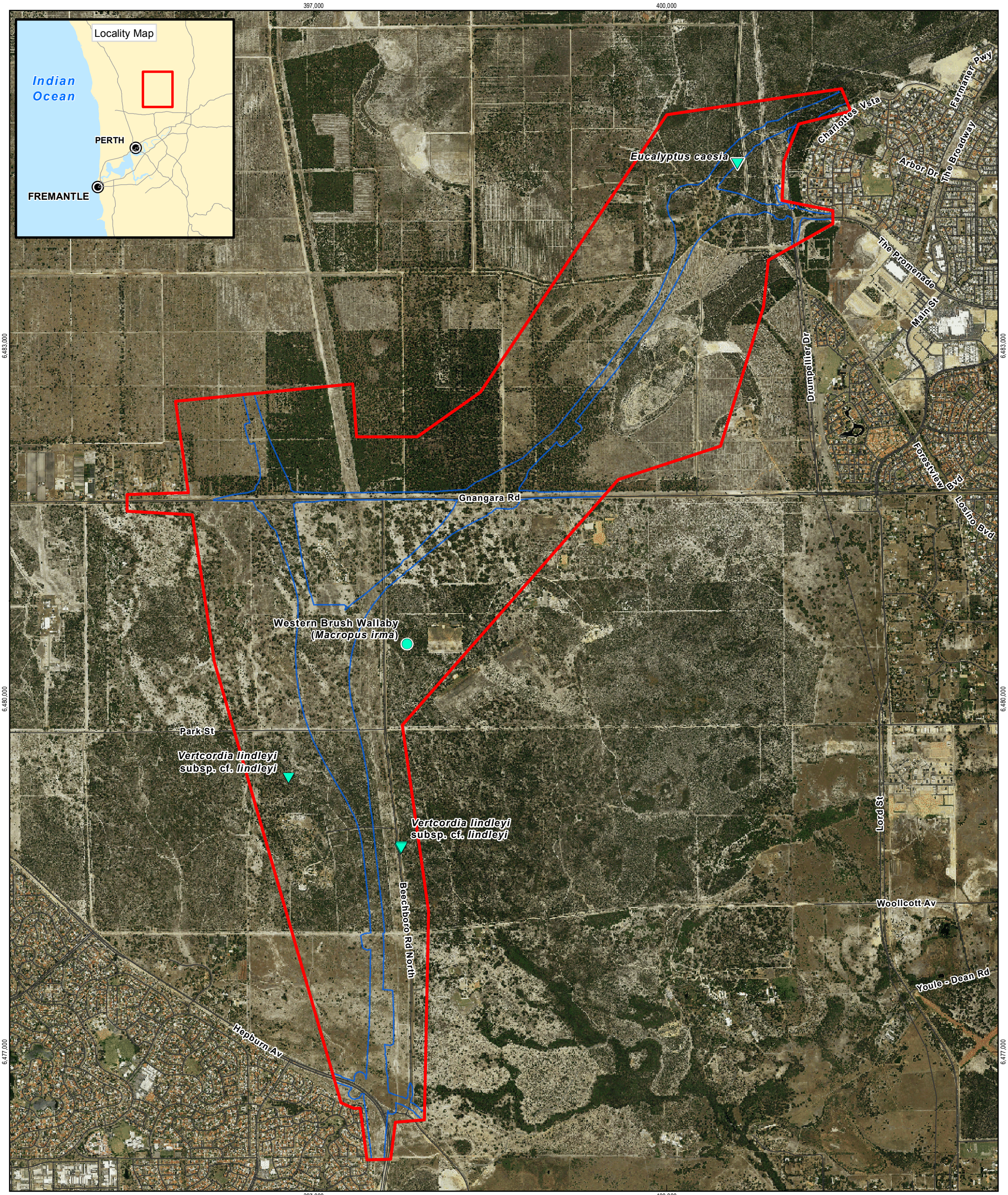
239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au



Data source: Landgate: Metro Central Jan 2013 Mosaic - 20130604; MRWA: Road - 20120529; GHD: Study Area - 20121010, Project Area - 20130604, Vegetation Condition (Keighery, 1994) - 20130325; GA: Geodata Topo 250k Series III - 2006. Created by: cagilbert, radeleon




LEGEND

**GHD Priority Fauna**

Priority 4

**GHD Priority Flora**

Priority 4

Road

Study Area

Project Area

DRAFT

1: 30,000 (at A3)

0 150 300 600 900 1,200 1,500

Metres

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

N

Main Roads WA - ETS
PDNH Tonkin Link Environmental Impact Assessment

Job Number 61-28596
Revision D
Date 29 Aug 2013

# GHD Significant Flora and Fauna Records

Figure 6

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239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au



Data source: Landgate: Metro Central Jan 2013 Mosaic - 20130604, Hydrology - 20130408; MRWA: Road - 20120529; GHD: Study Area - 20121010, Project Area - 20130604, GHD Priority Flora - 20130328, GHD Priority Fauna - 20130328; GA: Geodata Topo 250k Series III - 2006. Created by: cagilbert, radeleon

# Appendix B – Conservation Category Codes and Definitions

**Conservation categories and definitions for *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) listed flora and fauna species**

| Conservation Category | Definition |
|---|---|
| Extinct | Taxa not definitely located in the wild during the past 50 years |
| Extinct in the Wild | Taxa known to survive only in captivity |
| Critically Endangered | Taxa facing an extremely high risk of extinction in the wild in the immediate future |
| Endangered | Taxa facing a very high risk of extinction in the wild in the near future |
| Vulnerable | Taxa facing a high risk of extinction in the wild in the medium-term |
| Near Threatened | Taxa that risk becoming Vulnerable in the wild |
| Conservation Dependent | Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened. |
| Data Deficient (Insufficiently Known) | Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information. |
| Least Concern | Taxa that are not considered Threatened |

### Migratory Species listed under the EPBC Act

The EPBC Act protects lands and migratory species that are listed under International Agreements. The list of migratory species established under section 209 of the EPBC Act comprises:

- Migratory species which are native to Australia and are included in the appendices to the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals Appendices I and II);
- Migatory species included in annexes established under the Japan-Australia Migratory Bird Agreement (JAMBA) and the China-Australia Migratory Bird Agreement (CAMBA); and
- Native, migratory species identified in a list established under, or an instrument made under, an international agreement approved by the Minister, such as the republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

## Conservation codes and descriptions for Western Australian Flora and Fauna

| Code | Conservation category | Description |
|---|---|---|
| ***Wildlife Conservation Act 1950*** | | |
| T | Schedule 1 under the WC Act | Threatened Fauna (Fauna that is rare or is likely to become extinct<br><br>Threatened Flora (Declared Rare Flora – Extant)<br><br>Taxa that have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.<br><br>CR: Critically Endangered – considered to be facing an extremely high risk of extinction in the wild.<br>EN: Endangered – considered to be facing a very high risk of extinction in the wild.<br>VU: Vulnerable – considered to be facing a high risk of extinction in the wild. |
| X | Schedule 2 under the WC Act | Presumed Extinct Fauna<br><br>Presumed Extinct Flora (Declared Rare Flora – Extinct)<br><br>Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such. |
| IA | Schedule 3 under the WC Act | Birds protected under an international agreement.<br><br>Birds that are subject to an agreement between governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction. |
| S | Schedule 4 under the WC Act | Other specially protected fauna.<br><br>Fauna that is in need of special protection, otherwise than for the reasons mentioned in the above schedules. |
| **DEC Priority Listed** | | |
| 1 | Priority One: Poorly-known taxa | Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. |
| 2 | Priority Two: Poorly-known taxa | Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. |
| 3 | Priority Three: Poorly-known taxa | Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known |

| Code | Conservation category | Description |
|---|---|---|
| | | threatening processes exist that could affect them. |
| 4 | Priority Four: Rare, Near Threatened and other taxa in need of monitoring | (a) Rare. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.<br>(b) Near Threatened. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.<br>(c) Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy. |
| 5 | Priority 5: Conservation Dependent taxa | Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxon becoming threatened within five years. |

**Conservation codes for Threatened Ecological Communities (TECs) endorsed by the Western Australian Minister for the Environment and listed under the EPBC Act.**

| Western Australia Conservation Categories | | Federal Government Conservation Categories (EPBC Act) | |
|---|---|---|---|
| Presumed Totally Destroyed (PD) | The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. | Critically Endangered (CR) | If, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future |
| Critically Endangered (CR) | An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated | Endangered (EN) | If, at that time, it is not critically endangered and is facing a very high risk of extinction in the wild in the near future |
| Endangered (EN) | An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. | Vulnerable (VU) | If, at that time, it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future |
| Vulnerable (VU) | An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. | | |

## Conservation categories and definitions for Priority Ecological Communities (PECs) as listed by the DEC

| Category | Description |
|---|---|
| Priority 1 | Poorly known ecological communities.<br><br>Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤5 occurrences or a total area of ≤100ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range. |
| Priority 2 | Poorly known ecological communities.<br><br>Communities that are known from few occurrences with a restricted distribution (generally ≤10 occurrences or a total area of ≤200ha). At least some occurrences are not believed to be under immediate threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes. |
| Priority 3 | Poorly known ecological communities.<br><br>(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:<br>(ii) communities known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;<br>(iii) Communities made up of large, and/or widespread occurrences that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.<br>Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them. |
| Priority 4 | Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.<br><br>(i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.<br>(ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. |

| Category | Description |
|---|---|
| | (iii) Ecological communities that have been removed from the list of threatened communities during the past five years. |
| Priority 5 | Conservation Dependent ecological communities.<br><br>Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years. |

# Appendix C – Desktop Search Results

Conservation significant flora

Conservation significant fauna

## Conservation significant flora species identified in the desktop searches

| TAXON | Conservation Status | | | Database Source | | |
|---|---|---|---|---|---|---|
| | WC Act | EPBC Act | DEC | DEC Database | EPBC Act MNS | Naturemap |
| *Acacia benthamii* | | | Priority 2 | X | | X |
| *Acacia oncinophylla* subsp. *oncinophylla* | | | Priority 3 | | | X |
| *Acacia ridleyana* | | | Priority 3 | | | X |
| *Adenanthos cygnorum* subsp. *chamaephyton* | | | Priority 3 | | | X |
| *Andersonia gracilis* | Threatened | Endangered | | | X | |
| *Amperea protensa* | | | Priority 3 | X | | X |
| *Bolboschoenus medianus* | | | Priority 1 | | | X |
| *Byblis gigantea* | | | Priority 3 | | | X |
| *Caladenia huegelii* | Threatened | Critically Endangered | | X | | X |
| *Calectasia cyanea* | Threatened | Critically Endangered | | | | X |
| *Calectasia* sp. Pinjar (C. Tauss 557) | | | Priority 1 | X | | X |
| *Calothamnus rupestris* | | | Priority 4 | | | X |
| *Calytrix breviseta* subsp. *breviseta* | Threatened | Endangered | | | X | |
| *Carex tereticaulis* | | | Priority 1 | | | X |
| *Centrolepis caespitosa* | | Endangered | Priority 4 | | X | |
| *Chamelaucium* sp. Gingin (N.G. Marchant 6) | Threatened | Endangered | | | X | |
| *Cayanicula ixioides* subsp. *ixioides* | | | Priority 4 | | | X |
| *Cyathochaeta teretifolia* | | | Priority 3 | X | | X |
| *Dampiera triloba* | | | Priority 1 | X | | X |
| *Darwinia foetida* | Threatened | Critically Endangered | | | X | |
| *Darwinia pimelioides* | | | Priority 4 | | | X |
| *Dasymalla axillaris* | Threatened | | | X | | X |
| *Drosera occidentalis* subsp. *occidentalis* | | | Priority 4 | X | | X |

| TAXON | Conservation Status | | | Database Source | | |
|---|---|---|---|---|---|---|
| | WC Act | EPBC Act | DEC | DEC Database | EPBC Act MNS | Naturemap |
| *Drosera x sidjamesii* | | | Priority 1 | X | | X |
| *Eleocharis keigheryi* | Threatened | Vulnerable | | | | X |
| *Epiblema grandiflorum* var. *cyaneum (now Epiblema grandiflorum)* | | Endangered | | | X | |
| *Eryngium pinnatifidum* subsp. *palustre* | | | Priority 3 | X | | X |
| *Eucalyptus balanites* | Threatened | Endangered | | | X | |
| *Grevillea curviloba* subsp. *curviloba* | Threatened | Critically Endangered | | X | X | X |
| *Grevillea curviloba* subsp. *incurva* | Threatened | Endangered | | X | X | X |
| *Haemodorum loratum* | | | Priority 3 | X | | X |
| *Hibbertia helianthemoides* | | | Priority 3 | X | | X |
| *Hydrocotyle lemnoides* | | | Priority 4 | | | X |
| *Hydrocotyle striata* | | | Priority 1 | | | X |
| *Hypolaena robusta* | | | Priority 4 | X | | X |
| *Isopogon drummondii* | | | Priority 3 | | | X |
| *Jacksonia sericea* | | | Priority 4 | X | | X |
| *Lepidosperma rostratum* | Threatened | Endangered | | | X | |
| *Meionectes tenuifolia* | | | Priroity 3 | X | | X |
| *Myriophyllum echinatum* | | | Priority 3 | | | X |
| *Persoonia sulcata* | | | Priority 4 | | | X |
| *Phlebocarya pilosissima* subsp. *pilosissima* | | | Priority 3 | X | | X |
| *Pimelea calcicola* | | | Priority 3 | | | X |
| *Schoenus capillifolius* | | | Priority 3 | X | | X |
| *Schoenus griffinianus* | | | Priority 3 | | | X |
| *Schoenus natans* | | | Priority 4 | | | X |
| *Schoenus* sp. Busslbrook | | | Priority 2 | | | X |

| TAXON | Conservation Status | | | Database Source | | |
|---|---|---|---|---|---|---|
| | WC Act | EPBC Act | DEC | DEC Database | EPBC Act MNS | Naturemap |
| *Schoenus* sp. Waroona (G.J. Keighery 12235) | | | Priority 3 | X | | X |
| *Stachystemon* sp. Keysbrook (R. Archer 17/11/99) | | | Priority 1 | X | | X |
| *Stylidium longitubum* | | | Priority 3 | X | | X |
| *Stylidium trudgenii* | | | Priority 3 | X | | X |
| *Templetonia drummondii* | | | Priority 4 | | | X |
| *Thelymitra dedmaniarum* (previously *Thelymitra manginiorum*) | Threatened | Endangered | | | X | |
| *Thelymitra stellata* | Threatened | Endangered | | | X | |
| *Trithuria occidentalis* (previously *Hydatella dioica*) | Threatened | Endangered | | X | X | X |
| *Verticordia lindleyi* subsp. *lindleyi* | | | Priority 4 | X | | X |
| *Ornduffia calthifolia* (previously *Villarsia calthifolia*) | Threatened | Endangered | | | X | |

## Conservation significant fauna species identified in the desktop searches

| TAXON | Common Name | Conservation Status | | | Database Source | |
|---|---|---|---|---|---|---|
| | | WC Act | EPBC Act | DEC | EPBC Act MNS | Naturemap |
| **Birds** | | | | | | |
| *Actitis hypoleucos* | Common Sandpiper | | Migratory | | | X |
| *Anous tenuirostris* subsp. *melanops* | Australian Lesser Noddy | Threatened | Vulnerable | | | X |
| *Apus pacificus* | Fork-tailed Swift | Schedule 3 | Migratory | | X | X |
| *Ardea alba* subsp. *modesta* | Eastern Great Egret | Schedule 3 | Migratory | | X | X |
| *Ardea ibis* | Cattle Egret | Schedule 3 | Migratory | | X | X |
| *Botaurus poiciloptilus* | Australasian Bittern | Threatened | Endangered | | | X |
| *Burhinus grallarius* | Bush Stone-curlew | | | Priority 4 | | X |
| *Cacatua leadbeateri* | Major Mitchell's Cockatoo | Schedule 4 | | | | X |
| *Cacatua pastinator* subsp. *pastinator* | Muir's Corella (Western Corella SW WA) | Threatened | Vulnerable, Migratory | | | X |
| *Calidris acuminata* | Sharp-tailed Sandpiper | | Migratory | | X | |
| *Calidris ruficollis* | Red-necked Stint | | Migratory | | X | X |
| *Calyptorhynchus banksii* subsp. *naso* | Forest Red-tailed Black Cockatoo | Threatened | Vulnerable | | X | |
| *Calyptorhynchus baudinii* | Baudin's Black Cockatoo | Threatened | Vulnerable | | X | X |
| *Calyptorhynchus latirostris* | Carnaby's Black Cockatoo | Threatened | Endangered | | X | X |
| *Falco peregrinus* | Peregrine Falcon | Schedule 4 | | | | X |
| *Haliaeetus leucogaster* | White-bellied Sea-eagle | | Migratory | | X | |
| *Ixobrychus flavicollis* subsp. *australis* | Australian Black Bittern | | | Priority 3 | | X |
| *Ixobrychus minutus* subsp. *dubius* | Australian Little Bittern | | | Priority 4 | | X |
| *Leipoa ocellata* | Malleefowl | Threatened | Vulnerable, Migratory | | X | |

| TAXON | Common Name | Conservation Status | | | Database Source | |
|---|---|---|---|---|---|---|
| | | WC Act | EPBC Act | DEC | EPBC Act MNS | Naturemap |
| *Merops ornatus* | Rainbow Bee-eater | | Migratory | | X | X |
| *Plegadis falcinellus* | Glossy Ibis | | Migratory | | | X |
| *Rostratula australis* | Australian Painted Snipe | Threatened | Vulnerable | | X | |
| *Sterna nereis* subsp. *nereis* | Fairy Tern | Threatened | Vulnerable | | X | X |
| *Tringa glareola* | Wood Sandpiper | | Migratory | | X | X |
| *Tringa nebularia* | Common Greenshank | | Migratory | | | X |
| *Tringa stagnatilis* | Marsh Sandpiper | | Migratory | | | X |
| *Tyto novaehollandiae* subsp. *novaehollandiae* | Masked Owl (southern subspecies) | | | Priority 3 | | X |
| **Mammals** | | | | | | |
| *Bettongia penicellata* subsp. *ogilbyi* | Woylie, Brush-tailed Bettong | Threatened | Endangered | | | X |
| *Dasyurus geoffroii* | Chuditch, Western Quoll | Threatened | Vulnerable | | X | X |
| *Hydromys chrysogaster* | Water-rat | | | Priority 4 | | X |
| *Isoodon obesulus* subsp. *fusciventer* | Quenda, Southern Brown Bandicoot | | | Priority 5 | | X |
| *Macropus irma* | Western Brush Wallaby | | | Priority 4 | | X |
| *Macrotis lagotis* | Bilby | Threatened | Vulnerable | | | X |
| *Myrmecobius fasciatus* | Numbat | Threatened | Vulnerable | | | X |
| *Phascogale tapoatafa* subsp. *tapoatafa* | Southern Brush-tailed Phascogale | Threatened | | | | X |
| **Reptiles** | | | | | | |
| *Ctenotus gemmula (swan CP)* | | | | Priority 3 | | X |
| *Morelia spilota* subsp. *imbricata* | Carpet Python | Schedule 4 | | | | X |
| *Neelaps calonotos* | Black-striped Snake | | | Priority 3 | | X |
| *Pseudemydura umbrina* | Western Swamp Turtle/Tortoise | Threatened | Critically Endangered | | X | X |

| TAXON | Common Name | Conservation Status | | | Database Source | |
|---|---|---|---|---|---|---|
| | | WC Act | EPBC Act | DEC | EPBC Act MNS | Naturemap |
| **Invertebrates** | | | | | | |
| *Hylaeus globuliferus* | Bee | | | Priority 3 | | X |
| *Synemon gratiosa* | Graceful Sunmoth | | | Priority 4 | X | X |
| **Fish** | | | | | | |
| *Galaxiella nigrostriata* | Black-stripe Minnow | | | Priority 3 | | X |
| *Geotria australis* | Pouched Lamprey | | | Priority 1 | | X |

# Appendix D – Flora and Fauna Survey Results

Flora species list

Quadrat data

Fauna species list

## Flora species recorded within the Study Area during the Spring 2012 survey

| Family | Name | Status |
|---|---|---|
| Agapanthaceae | **Agapanthus* sp. | |
| Aizoaceae | **Carpobrotus edulis* | |
| Aizoaceae | *Carpobrotus* sp. | |
| Amaranthaceae | *Ptilotus polystachyus* | |
| Anacardiaceae | **Schinus terebinthifolius* | |
| Anarthriaceae | *Lyginia barbata* | |
| Anarthriaceae | *Lyginia imberbis* | |
| Apiaceae | *Xanthosia huegelii* | |
| Apocynaceae | **Gomphocarpus fruticosus* | |
| Apocynaceae | **Nerium oleander* | |
| Araliaceae | *Trachymene pilosa* | |
| Arecaceae | **Phoenix dactylifera* | |
| Asparagaceae | **Agave* sp. | |
| Asparagaceae | *Chamaescilla corymbosa* | |
| Asparagaceae | **Lachenalia aloides* | |
| Asparagaceae | *Laxmannia grandiflora* | |
| Asparagaceae | *Laxmannia ramosa* | |
| Asparagaceae | *Lomandra preissii* | |
| Asparagaceae | *Lomandra sericea* | |
| Asparagaceae | *Thysanotus patersonii/manglesianus* | |
| Asparagaceae | *Thysanotus* sp. | |
| Asparagaceae | **Yucca* sp. | |
| Asphodelaceae | **Trachyandra divaricata* | |
| Asteraceae | **Arctotheca calendula* | |
| Asteraceae | *Asteraceae* sp. | |
| Asteraceae | **Conyza* sp. | |
| Asteraceae | **Hypochaeris glabra* | |
| Asteraceae | **Hypochaeris radicata* | |
| Asteraceae | **Hypochaeris* sp. | |
| Asteraceae | *Lagenophora huegelii* | |
| Asteraceae | *Millotia* sp. | |
| Asteraceae | **Monoculus monstrosus* | |
| Asteraceae | *Podotheca chrysantha* | |
| Asteraceae | *Podotheca gnaphalioides* | |
| Asteraceae | *Rhodanthe citrina* | |
| Asteraceae | *Siloxerus humifusus* | |
| Asteraceae | **Sonchus oleraceus* | |
| Asteraceae | *Sonchus* sp. | |
| Asteraceae | **Tagetes minuta* | |
| Asteraceae | **Taraxacum officinale* | |
| Asteraceae | **Ursinia anthemoides* | |
| Asteraceae | *Waitzia nitida* | |
| Asteraceae | *Waitzia* sp. | |
| Asteraceae | *Waitzia suaveolens* | |
| Bigoniaceae | **Jacaranda mimosaefolia* | |
| Boraginaceae | **Echium plantagineum* | |
| Brassicaceae | **Brassica tournefortii* | |

| Family | Name | Status |
|---|---|---|
| Brassicaceae | **Heliophila pusilla* | |
| Campanulaceae | **Wahlenbergia capensis* | |
| Caryophyllaceae | **Petrorhagia dubia* | |
| Caryophyllaceae | *Silene gallica* | |
| Casuarinaceae | *Allocasuarina fraseriana* | |
| Casuarinaceae | *Allocasuarina humilis* | |
| Colchicaceae | *Burchardia congesta* | |
| Crassulaceae | *Crassula* sp. | |
| Cucurbitaceae | **Cucumis myriocarpus* | |
| Cyperaceae | *Cyperaceae* sp. | |
| Cyperaceae | *Isolepis* sp. | |
| Cyperaceae | *Lepidosperma longitudinale* | |
| Cyperaceae | *Lepidosperma pubisquameum* | |
| Cyperaceae | *Lepidosperma* sp. | |
| Cyperaceae | *Mesomelaena pseudostygia* | |
| Cyperaceae | *Schoenus curvifolius* | |
| Dasypogonaceae | *Calectasia narragara* | |
| Dasypogonaceae | *Dasypogon bromeliifolius* | |
| Dilleniaceae | *Hibbertia cf. huegelii* | |
| Dilleniaceae | *Hibbertia huegelii* | |
| Dilleniaceae | *Hibbertia hypericoides* | |
| Dilleniaceae | *Hibbertia racemosa* | |
| Dilleniaceae | *Hibbertia stellaris* | |
| Dilleniaceae | *Hibbertia subvaginata* | |
| Droseraceae | *Drosera erythrorhiza* | |
| Droseraceae | *Drosera menziesii subsp. penicillaris* | |
| Droseraceae | *Drosera pallida* | |
| Droseraceae | *Drosera* sp. | |
| Elaeocarpaceae | *Platytheca galioides* | |
| Ericaceae | *Astroloma pallidum* | |
| Ericaceae | *Astroloma xerophyllum* | |
| Ericaceae | *Conostephium pendulum* | |
| Ericaceae | *Leucopogon polymorphus* | |
| Ericaceae | *Leucopogon propinquus* | |
| Ericaceae | *Leucopogon sprengelioides* | |
| Ericaceae | *Lysinema ciliatum* | |
| Euphorbiaceae | **Euphorbia peplus* | |
| Euphorbiaceae | *Euphorbia sp.* | |
| Euphorbiaceae | **Euphorbia terracina* | |
| Euphorbiaceae | **Ricinus communis* | |
| Fabaceae | *Acacia huegelii* | |
| Fabaceae | **Acacia longifolia* | |
| Fabaceae | *Acacia pulchella* | |
| Fabaceae | *Acacia sessilis* | |
| Fabaceae | *Aotus procumbens* | |
| Fabaceae | *Bossiaea eriocarpa* | |
| Fabaceae | **Chamaecytisus palmensis* | |
| Fabaceae | *Daviesia divaricata subsp. divaricata* | |
| Fabaceae | *Daviesia physodes* | |

| Family | Name | Status |
|---|---|---|
| Fabaceae | *Daviesia triflora* | |
| Fabaceae | *Euchilopsis linearis* | |
| Fabaceae | *Fabaceae* sp. | |
| Fabaceae | *Gastrolobium capitatum* | |
| Fabaceae | *Gastrolobium ebracteolatum* | |
| Fabaceae | *Gompholobium confertum* | |
| Fabaceae | *Gompholobium scabrum* | |
| Fabaceae | *Gompholobium tomentosum* | |
| Fabaceae | *Hardenbergia comptoniana* | |
| Fabaceae | *Hovea chorizemifolia* | |
| Fabaceae | *Hovea pungens* | |
| Fabaceae | *Hovea trisperma* | |
| Fabaceae | *Isotropis cuneifolia* subsp. *cuneifolia* | |
| Fabaceae | *Jacksonia floribunda* | |
| Fabaceae | *Jacksonia furcellata* | |
| Fabaceae | *Jacksonia sternbergiana* | |
| Fabaceae | *Kennedia prostrata* | |
| Fabaceae | **Lupinus angustifolius* | |
| Fabaceae | **Lupinus cosentinii* | |
| Fabaceae | **Melilotus indicus* | |
| Fabaceae | **Ornithopus compressus* | |
| Fabaceae | **Ornithopus pinnatus* | |
| Fabaceae | **Trifolium hirtum* | |
| Fabaceae | **Trifolium* sp. | |
| Geraniaceae | *Erodium* sp. | |
| Geraniaceae | **Geranium dissectum* | |
| Geraniaceae | **Pelargonium capitatum* | |
| Geraniaceae | *Pelargonium* sp. | |
| Goodeniaceae | *Dampiera linearis* | |
| Goodeniaceae | *Lechenaultia biloba* | |
| Goodeniaceae | *Scaevola repens* var. *repens* | |
| Haemodoraceae | *Anigozanthos manglesii* | |
| Haemodoraceae | *Conostylis aculeata* | |
| Haemodoraceae | *Conostylis juncea* | |
| Haemodoraceae | *Conostylis* sp. | |
| Haemodoraceae | *Haemodorum* sp. | |
| Haemodoraceae | *Phlebocarya ciliata* | |
| Hemerocallidaceae | *Corynotheca micrantha* | |
| Hemerocallidaceae | *Hensmania turbinata* | |
| Iridaceae | **Freesia* sp. | |
| Iridaceae | **Gladiolus caryophyllaceus* | |
| Iridaceae | **Moraea flaccida* | |
| Iridaceae | *Patersonia occidentalis* | |
| Iridaceae | **Romulea rosea* | |
| Lauraceae | *Cassytha* sp. | |
| Loranthaceae | *Nuytsia floribunda* | |
| Molluginaceae | *Macarthuria australis* | |
| Moraceae | **Ficus carica* | |
| Myrtaceae | *Agonis flexuosa* | |

| Family | Name | Status |
|---|---|---|
| Myrtaceae | *Astartea scoparia* | |
| Myrtaceae | **Callistemon glaucus* | |
| Myrtaceae | *Calytrix fraseri* | |
| Myrtaceae | *Calytrix* sp. | |
| Myrtaceae | *Chamelaucium uncinatum* | |
| Myrtaceae | *Corymbia calophylla* | |
| Myrtaceae | *Eremaea asterocarpa* subsp. *asterocarpa* | |
| Myrtaceae | *Eremaea pauciflora* | |
| Myrtaceae | *Eucalyptus caesia* | Priority 4 (planted) |
| Myrtaceae | **Eucalyptus citridora* | |
| Myrtaceae | **Eucalyptus erythrocorys* | (planted) |
| Myrtaceae | *Eucalyptus gomphocephala* | |
| Myrtaceae | *Eucalyptus marginata* | |
| Myrtaceae | **Eucalyptus pyriformis* | |
| Myrtaceae | *Eucalyptus rudis* | |
| Myrtaceae | *Eucalyptus todtiana* | |
| Myrtaceae | *Hypocalymma angustifolium* | |
| Myrtaceae | *Hypocalymma robustum* | |
| Myrtaceae | *Hypocalymma* sp. | |
| Myrtaceae | *Kunzea glabrescens* | |
| Myrtaceae | *Kunzea micrantha* | |
| Myrtaceae | **Leptospermum laevigatum* | |
| Myrtaceae | *Melaleuca preissiana* | |
| Myrtaceae | *Melaleuca seriata* | |
| Myrtaceae | *Melaleuca spathulata* | |
| Myrtaceae | *Pericalymma ellipticum* | |
| Myrtaceae | *Regelia ciliata* | |
| Myrtaceae | *Regelia inops* | |
| Myrtaceae | *Scholtzia involucrata* | |
| Myrtaceae | *Verticordia cf. densiflora* | |
| Myrtaceae | *Verticordia densiflora* | |
| Myrtaceae | *Verticordia lindleyi* subsp. *cf. lindleyi* | Priority 4 |
| Myrtaceae | *Verticordia* sp. | |
| Onagraceae | **Oenothera* sp. | |
| Orchidaceae | *Caladenia discoidea* | |
| Orchidaceae | *Caladenia flava* | |
| Orchidaceae | *Caladenia latifolia* | |
| Orchidaceae | **Disa bracteata* | |
| Orchidaceae | *Elythranthera brunonis* | |
| Orchidaceae | *Leporella fimbriata* | |
| Orchidaceae | *Microtis media* | |
| Orchidaceae | *Pyrorchis nigricans* | |
| Orchidaceae | *Pyrorchis* sp. | |
| Orchidaceae | *Thelymitra crinita* | |
| Orobanchaceae | **Orobanche minor* | |
| Oxalidaceae | **Oxalis pes-caprae* | |
| Papaveraceae | **Fumaria capreolata* | |
| Phytolaccaceae | **Phytolacca octandra* | |
| Poaceae | **Aira caryophyllea* | |

| Family | Name | Status |
|---|---|---|
| Poaceae | **Aira cupaniana* | |
| Poaceae | **Aira* sp. | |
| Poaceae | *Austrostipa compressa* | |
| Poaceae | **Avena barbata* | |
| Poaceae | **Briza maxima* | |
| Poaceae | **Briza minor* | |
| Poaceae | **Bromus diandrus* | |
| Poaceae | **Ehrharta calycina* | |
| Poaceae | **Ehrharta longiflora* | |
| Poaceae | **Lolium rigidum* | |
| Poaceae | *Neurachne alopecuroidea* | |
| Poaceae | **Pentaschistis airoides* | |
| Poaceae | **Pentaschistis* sp. | |
| Poaceae | *Poaceae* sp. | |
| Primulaceae | **Lysimachia arvensis* | |
| Proteaceae | *Adenanthos cygnorum* | |
| Proteaceae | *Banksia attenuata* | |
| Proteaceae | *Banksia dallanneyi* | |
| Proteaceae | *Banksia grandis* | |
| Proteaceae | *Banksia ilicifolia* | |
| Proteaceae | *Banksia menziesii* | |
| Proteaceae | *Conospermum stoechadis* | |
| Proteaceae | *Grevillea crithmifolia* | |
| Proteaceae | *Hakea lissocarpha* | |
| Proteaceae | *Hakea prostrata* | |
| Proteaceae | *Hakea varia* | |
| Proteaceae | *Persoonia saccata* | |
| Proteaceae | *Petrophile brevifolia* | |
| Proteaceae | *Petrophile linearis* | |
| Proteaceae | *Stirlingia latifolia* | |
| Restionaceae | *Desmocladus fasciculatus* | |
| Restionaceae | *Desmocladus flexuosus* | |
| Restionaceae | *Hypolaena exsulca* | |
| Restionaceae | *Lepidobolus preissianus* subsp. *preissianus* | |
| Rubiaceae | **Galium murale* | |
| Rutaceae | *Boronia ramosa* subsp. *anethifolia* | |
| Rutaceae | *Philotheca spicata* | |
| Scrophulariaceae | **Dischisma capitatum* | |
| Solanaceae | **Solanum nigrum* | |
| Stylidiaceae | *Stylidium araeophyllum ms* | |
| Stylidiaceae | *Stylidium calcaratum* | |
| Stylidiaceae | *Stylidium ciliatum* | |
| Stylidiaceae | *Stylidium diuroides* | |
| Stylidiaceae | *Stylidium piliferum* | |
| Stylidiaceae | *Stylidium repens* | |
| Stylidiaceae | *Stylidium schoenoides* | |
| Stylidiaceae | *Stylidium* sp. | |
| Thymelaeaceae | *Pimelea leucantha* | |
| Violaceae | *Hybanthus calycinus* | |

| Family | Name | Status |
|---|---|---|
| Xanthorrhoeaceae | *Xanthorrhoea brunonis* | |
| Xanthorrhoeaceae | *Xanthorrhoea gracilis* | |
| Xanthorrhoeaceae | *Xanthorrhoea preissii* | |
| Xanthorrhoeaceae | *Xanthorrhoea* sp. | |
| Zamiaceae | *Macrozamia fraseri* | |

* denotes weed/introduced species

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH01 | | | |
| **Observers** | ML, EL, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 400594 mE | 6484375 mN |
| **Date** | 24/09/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Exotic weeds | | | |
| **Percentage of disturbance** | <1 % | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Dry, plants not stressed | | | |
| **Grazing** | Light | | | |
| **Grazing type** | Native herbivore | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | No damage | | | |
| **Soil colour** | Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | Plain | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | <1 | | | |
| **% logs** | 2-10 | | | |
| **% twigs** | 10-30 | | | |
| **% leaves** | 30-70 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 2-10 | | | |
| **Vegetation description** | Banksia Woodland | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Adenanthos cygnorum* | M1 2-10 | 4 |
| *Astroloma xerophyllum* | M2 <2 | 0.7 |
| *Banksia ilicifolia* | U2 2-10 | 5 |
| *Banksia menziesii* | U1 10-30 | 5 |
| *Dasypogon bromeliifolius* | G1 <2 | 0.3 |
| **Gladiolus caryophyllaceus* | G1 <2 | 0.8 |
| *Hensmania turbinata* | G1 <2 | 0.2 |
| *Hibbertia subvaginata* | G1 <2 | 0.3 |
| *Hypocalymma angustifolium* | M2 <2 | 0.7 |
| *Laxmannia ramosa* | G2 <2 | 0.05 |
| *Lyginia imberbis* | G1 <2 | 0.3 |
| *Lysinema ciliatum* | G1 <2 | 1.1 |
| *Melaleuca preissiana* | M1 2-10 | 4 |
| *Patersonia occidentalis* | G1 <2 | 0.5 |
| Poaceae sp. | G2 <2 | 0.1 |
| *Regelia inops* | M2 10-30 | 1.5 |
| *Stylidium ciliatum* | G2 <2 | 0.2 |
| *Trachymene pilosa* | G1 <2 | 0.1 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH02 | | | |
| **Observers** | ML, EL, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 400562 mE | 6484521 mN |
| **Date** | 24/09/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Exotic weeds, Animal | | | |
| **Percentage of disturbance** | 2-10%, <2% | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Dry, plants not stressed | | | |
| **Grazing** | - | | | |
| **Grazing type** | - | | | |
| **Fire frequency** | Old >5yr | | | |
| **Fire intensity** | No damage | | | |
| **Soil colour** | Grey/White | | | |
| **Soil** | Sand | | | |
| **Landform** | Slope – middle | | | |
| **Vegetation condition** | Excellent (2) – Very Good (3) | | | |
| **% bare ground** | 10-30 | | | |
| **% logs** | <2 | | | |
| **% twigs** | <2 | | | |
| **% leaves** | <2 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 30-70 | | | |
| **Vegetation description** | Banksia Woodland | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Banksia ilicifolia* | U2 <2 | 3 |
| **Briza maxima* | n/a | 0.3 |
| *Burchardia congesta* | n/a | 0.3 |
| *Caladenia flava* | n/a | 0.2 |
| *Conostylis aculeata* | G2 <2 | 0.05 |
| *Dasypogon bromeliifolius* | G1 30-70 | 0.4 |
| *Drosera erythrorhiza* | G2 <2 | - |
| **Ehrharta calycina* | G1 <2 | 0.2 |
| **Gladiolus caryophyllaceus* | G1 <2 | 0.7 |
| *Gompholobium scabrum* | M2 <2 | 0.5 |
| **Hypochaeris radicata* | G2 2-10 | - |
| *Hypolaena exsulca* | G1 <2 | 0.5 |
| *Lyginia imberbis* | n/a | 0.5 |
| *Lysinema ciliatum* | n/a | 0.3 |
| *Melaleuca preissiana* | U1 2-10 | 5 |
| *Patersonia occidentalis* | G1 10-30 | 0.5 |
| *Philotheca spicata* | G1 <2 | 0.3 |
| *Podotheca gnaphalioides* | n/a | 0.2 |
| *Regelia inops* | M2 2-10 | |
| **Waitzia* sp. | G2 <2 | 0.02 |
| *Xanthorrhoea preissii* | M1 10-30 | 1.6 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH03 | | | |
| **Observers** | ML, EL, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 400045 mE | 6484728 mN |
| **Date** | 24/09/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Exotic weeds, Animal | | | |
| **Percentage of disturbance** | <2%, <2% | | | |
| **Climate** | Dry, plants not stressed | | | |
| **Grazing** | - | | | |
| **Grazing type** | - | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on some trees | | | |
| **Soil colour** | Dark Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | Slope - middle | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | <2 | | | |
| **% logs** | 10-30 | | | |
| **% twigs** | 2-10 | | | |
| **% leaves** | 10-30 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 30-70 | | | |
| **Vegetation description** | Banksia Woodland | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Anigozanthos humilis* | - | - |
| **Arctotheca calendula* | G2 <2 | 0.1 |
| *Astroloma pallidum* | M2 <2 | 0.2 |
| *Banksia attenuata* | U1 10-30, M1 2-10 | 6 |
| *Banksia menziesii* | M1 <2 | 2 |
| *Boronia ramosa* subsp. *anethifolia* | G1 <2 | 0.3 |
| **Briza maxima* | G1 <2 | 0.5 |
| *Burchardia congesta* | G1 <2 | 0.5 |
| *Caladenia flava* | G2 <2 | 0.15 |
| **Carpobrotus edulis* | G2 <2 | 0.1 |
| *Conostylis aculeata* | G1 <2 | 0.3 |
| *Dasypogon bromeliifolius* | G1 <2 | 0.3 |
| *Desmocladus flexuosus* | G2 <2 | 0.1 |
| *Drosera erythrorhiza* | G2 <2 | - |
| *Drosera pallida* | G2 <2 | - |
| *Eremaea pauciflora* | M2 <2 | 0.6 |
| **Gladiolus caryophyllaceus* | M2 <2 | 0.8 |
| *Haemodorum* sp. | G1 <2 | 0.5 |
| *Hibbertia hypericoides* | G1 2-10 | 0.5 |
| *Hibbertia subvaginata* | G1 2-10 | 0.4 |
| *Lechenaultia biloba* | M3 <2 | 0.2 |
| *Leucopogon propinquus* | M2 <2 | 0.5 |
| *Lyginia imberbis* | G1 2-10 | 0.5 |

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Melaleuca seriata* | M3 2-10 | 0.5 |
| *Nuytsia floribunda* | U1 2-10 | 5 |
| *Patersonia occidentalis* | G1 <2 | 0.5 |
| *Petrophile linearis* | M2 <2 | 0.4 |
| Poaceae sp. | G2 <2 | 0.05 |
| *Podotheca gnaphalioides* | G1 <2 | 0.05 |
| *Regelia ciliata* | M2 <2 | 1.7 |
| *Scholtzia involucrata* | M2 2-10, G2 <2 | 0.4 |
| *Stirlingia latifolia* | G1 <2 | 0.5 |
| *Stylidium calcaratum* | G2 <2 | 0.03 |
| *Stylidium ciliatum* | G2 <2 | 0.15 |
| *Trachymene pilosa* | G2 <2 | 0.05 |
| **Ursinia anthemoides* | G2 <2 | 0.2 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH04 | | | |
| **Observers** | ML, EL, LZ | | | |
| **Location** | - | | | |
| **Coordinates** | **MGA Zone** | 50 | 400030 mE | 6484885 mN |
| **Date** | 24/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Other – Plants dead, fallen over | | | |
| **Percentage of disturbance** | 10-30% | | | |
| **Frequency of disturbance** | Single recent 1-10 yr | | | |
| **Site drainage** | Poor drain | | | |
| **Climate** | Recent rain, impact on veg | | | |
| **Grazing** | - | | | |
| **Grazing type** | - | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on some trees | | | |
| **Soil colour** | Grey | | | |
| **Soil** | Peaty sand | | | |
| **Landform** | Drainage depression | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | 10-30 | | | |
| **% logs** | - | | | |
| **% twigs** | >70 | | | |
| **% leaves** | 30-70 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | - | | | |
| **Vegetation description** | Closed Tall Scrub | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Adenanthos cygnorum* | U2 2-10 | 2.2 |
| *Banksia attenuata* | U1 2-10 | 5 |
| *Banksia menziesii* | M1 <2 | 0.5 |
| *Lepidosperma* sp. | G1 <2 | 0.3 |
| *Melaleuca preissiana* | U1 2-10 | 6 |
| *Regelia ciliata* | U3 >70 | |
| *Trachymene pilosa* | G1 <2 | 0.05 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH05 | | | |
| **Observers** | ML, EL, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 400137 mE | 6484927 mN |
| **Date** | 24/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Other: dead plants | | | |
| **Percentage of disturbance** | <2% | | | |
| **Frequency of disturbance** | Current disturbance | | | |
| **Nearest water** | ?Swamp | | | |
| **Climate** | Recent rain, no impact on veg | | | |
| **Grazing** | - | | | |
| **Grazing type** | - | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impacts, scars on some trees | | | |
| **Soil colour** | Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | Drainage depression | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | 2-10 | | | |
| **% logs** | <2 | | | |
| **% twigs** | 30-70 | | | |
| **% leaves** | 10-30 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | - | | | |
| **Vegetation description** | Closed Tall Scrub | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Adenanthos cygnorum* | U2 10-30 | 3 |
| *Banksia attenuata* | U2 <2 | 2.5 |
| Cyperaceae sp. | G1 <2 | 0.1 |
| *Melaleuca preissiana* | U1 <2 | 6 |
| *Regelia ciliata* | U2 >70 | 2.5 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH06 | | | |
| **Observers** | EL, ML, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 400445 mE | 6484826 mN |
| **Date** | 24/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Exotic weeds | | | |
| **Percentage of disturbance** | <2% | | | |
| **Site drainage** | Poor | | | |
| **Climate** | Dry, plants not stressed / Recent rain, no impact on veg | | | |
| **Grazing** | - | | | |
| **Grazing type** | - | | | |
| **Fire frequency** | >5 yr | | | |
| **Fire intensity** | - | | | |
| **Soil colour** | Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | Plain (lower dune) | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | <2 | | | |
| **% logs** | 2-10 | | | |
| **% twigs** | <2 | | | |
| **% leaves** | >70 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 2-10 | | | |
| **Vegetation description** | Banksia Woodland | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Asteraceae* sp. | G1 <2 | 0.05 |
| *Asteraceae* sp. | G1 <2 | 0.2 |
| *Banksia attenuata* | U1 10-30 | 5 |
| *Burchardia congesta* | G1 <2 | 0.2 |
| *Conostephium pendulum* | G1 <2 | 0.2 |
| *Conostylis juncea* | G1 <2 | 0.15 |
| *Dasypogon bromeliifolius* | G1 <2 | 0.2 |
| *Drosera* sp. | G1 <2 | - |
| *Hibbertia racemosa* | G1 <2 | 0.2 |
| **Hypochaeris radicata* | G2 <2 | - |
| *Leucopogon sprengelioides* | G1 <2 | 0.3 |
| *Lyginia imberbis* | G1 <2 | 0.2 |
| *Macrozamia fraseri* | M1 <2 | 1.2 |
| *Patersonia occidentalis* | G1 <2 | 0.5 |
| *Petrophile linearis* | G1 <2 | 0.2 |
| *Philotheca spicata* | G1 <2 | 0.4 |
| *Stylidium* sp. | G1 <2 | - |
| *Trachymene pilosa* | G1 <2 | 0.05 |
| **Ursinia anthemoides* | G1 <2 | 0.15 |
| *Xanthorrhoea preissii* | M1 30-70 | 1 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH07 | | | |
| **Observers** | EL, ML, LZ | | | |
| **Location** | Wetland (mu) | | | |
| **Coordinates** | **MGA Zone** | 50 | 397525 mE | 6480699 mN |
| **Date** | 25/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Clearing, Exotic weeds, Other: Farming | | | |
| **Percentage of disturbance** | >70% | | | |
| **Frequency of disturbance** | Current disturbance | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Recent rain, +ve veg response | | | |
| **Grazing** | Light | | | |
| **Grazing type** | Native herbivore, Other: Rabbits | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on most trees | | | |
| **Soil colour** | Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | Low lying drainage depression | | | |
| **Vegetation condition** | Degraded (5) | | | |
| **% bare ground** | <2 | | | |
| **% logs** | <2 | | | |
| **% twigs** | 10-30 | | | |
| **% leaves** | 10-30 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 10-30 | | | |
| **Vegetation description** | Melaleuca Low Woodland | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| **Avena barbata* | G1 <2 | 0.2 |
| *Caladenia flava* | G1 <2 | 0.15 |
| *Corymbia calophylla* | U1 2-10 | 8 |
| **Ehrharta longiflora* | G1 2-10 | 0.2 |
| *Eucalyptus marginata* | U1 10-30 | 8 |
| **Geranium dissectum* | G1 <2 | 0.15 |
| *Hypocalymma robustum* | M2 <2 | 0.3 |
| **Hypochaeris glabra* | G1 <2 | - |
| *Melaleuca preissiana* | U2 10-30 | 5 |
| *Ornithopus compressus* | G1 <2 | 0.05 |
| *Patersonia occidentalis* | G1 <2 | 0.4 |
| **Pelargonium* sp. | G1 <2 | 0.05 |
| *Podotheca gnaphalioides* | G1 <2 | 0.2 |
| **Romulea rosea* | G1 <2 | 0.2 |
| *Trachyandra divaricata* | G1 <2 | 0.2 |
| **Ursinia anthemoides* | G1 <2 | 0.2 |
| *Xanthorrhoea preissii* | M1 2-10 | 1.6 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH08 | | | |
| **Observers** | EL, ML, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 397534 mE | 6480015 mN |
| **Date** | 25/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Clearing, Exotic weeds, Animal | | | |
| **Percentage of disturbance** | 70% | | | |
| **Frequency of disturbance** | Current disturbance | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Recent rain, +ve veg response | | | |
| **Grazing** | Light | | | |
| **Grazing type** | Native herbivore, Other: Rabbits | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on most trees | | | |
| **Soil colour** | Black / Dark Grey | | | |
| **Soil** | Loamy Sand | | | |
| **Landform** | Flat low lying drainage depression | | | |
| **Vegetation condition** | Degraded (5) | | | |
| **% bare ground** | <2 | | | |
| **% logs** | 2-10 | | | |
| **% twigs** | 10-30 | | | |
| **% leaves** | 10-30 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | >70 | | | |
| **Vegetation description** | Melaleuca Low Woodland | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| **Arctotheca calendula* | G1 >70 | 0.2 |
| **Brassica tournefortii* | - | 0.5 |
| **Bromus diandrus* | G1 <2 | 0.15 |
| **Ehrharta longiflora* | G1 <2 | 0.3 |
| *Eucalyptus marginata* | U1 2-10 | 5 |
| **Hypochaeris glabra* | G2 2-10 | - |
| **Lolium rigidum* | G1 <2 | 0.1 |
| *Melaleuca preissiana* | U1 10-30 | 6 |
| **Moraea flaccida* | G1 <2 | 0.4 |
| **Ornithopus compressus* | G2 <2 | 0.05 |
| **Orobanche minor* | G1 <2 | 0.1 |
| **Phytolacca octandra* | M1 <2 | 0.7 |
| *Podotheca gnaphalioides* | - | 0.2 |
| **Solanum nigrum* | - | 0.3 |
| **Sonchus oleraceus* | G1 <2 | 0.2 |
| **Ursinia anthemoides* | G1 2-10 | 0.2 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH09 | | | |
| **Observers** | EL ML LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 396377 mE | 6480592 mN |
| **Date** | 25/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Clearing, Exotic weeds, Animal | | | |
| **Percentage of disturbance** | >70% | | | |
| **Site drainage** | Poor drain | | | |
| **Climate** | Recent rain, +ve veg response | | | |
| **Grazing** | - | | | |
| **Grazing type** | Native herbivore, Other: Rabbit | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on most trees | | | |
| **Soil colour** | Dark grey | | | |
| **Soil** | Peaty sand | | | |
| **Landform** | Seasonally waterlogged | | | |
| **Vegetation condition** | Degraded (5) | | | |
| **% bare ground** | 2-10 | | | |
| **% logs** | <2 | | | |
| **% twigs** | 2-10 | | | |
| **% leaves** | >70 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 30-70 | | | |
| **Vegetation description** | Melaleuca Low Woodland | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| **Arctotheca calendula* | G1 2-10 | - |
| **Brassica tournefortii* | G1 2-10 | 0.4 |
| **Disa bracteata* | G1 <2 | 0.05 |
| **Geranium dissectum* | G1 <2 | 0.05 |
| **Hypochaeris glabra* | G2 2-10 | - |
| *Melaleuca preissiana* | U1 >70 | 5 |
| **Ornithopus compressus* | G1 <2 | 0.05 |
| **Ornithopus pinnatus* | G1 <2 | 0.05 |
| **Pentaschistis* sp. | G1 30-70 | 0.05 |
| *Podotheca gnaphalioides* | G1 2-10 | 0.2 |
| **Ursinia anthemoides* | G1 <2 | 0.2 |
| *Xanthorrhoea preissii* | M1 2-10 | 1.5 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH10 | | | |
| **Observers** | ML, EL, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 396649 mE | 6481316 mN |
| **Date** | 25/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Clearing, Exotic weeds, Animal | | | |
| **Percentage of disturbance** | 30-70% | | | |
| **Frequency of disturbance** | Current disturbance | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Recent rain, +ve veg response | | | |
| **Grazing** | Light | | | |
| **Grazing type** | Native herbivore, Other: Rabbit | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on most trees | | | |
| **Soil colour** | Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | Flat | | | |
| **Vegetation condition** | Good (4) | | | |
| **% bare ground** | 2-10 | | | |
| **% logs** | 2-10 | | | |
| **% twigs** | 10-30 | | | |
| **% leaves** | 30-70 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 30-70 | | | |
| **Vegetation description** | Open Paddock | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| **Arctotheca calendula* | - | 0.2 |
| *Caladenia flava* | G1 <2 | 0.15 |
| *Corymbia calophylla* | U1 10-30 | 8 |
| **Ehrharta calycina* | G1 <2 | 0.4 |
| **Geranium dissectum* | G1 <2 | 0.05 |
| **Hypochaeris glabra* | G2 2-10 | - |
| **Ornithopus compressus* | G1 <2 | 0.05 |
| **Petrorhagia dubia* | G1 <2 | 0.2 |
| *Podotheca gnaphalioides* | G1 2-10 | 0.2 |
| **Romulea rosea* | G1 2-10 | 0.1 |
| **Ursinia anthemoides* | G1 <2 | 0.2 |
| *Xanthorrhoea preissii* | M1 10-30 | 1.5 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH11 | | | |
| **Observers** | EL, ML, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | XXXXXX mE | XXXX mN |
| **Date** | 25/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Clearing, Exotic weeds, Animal | | | |
| **Percentage of disturbance** | 30-70% | | | |
| **Frequency of disturbance** | Current | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Recent rain, +ve veg response | | | |
| **Grazing** | - | | | |
| **Grazing type** | Native herbivore, Other: Rabbit | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on most trees | | | |
| **Soil colour** | Grey White | | | |
| **Soil** | Loamy Sand | | | |
| **Landform** | Flat | | | |
| **Vegetation condition** | Good (4) to Degraded (5) | | | |
| **% bare ground** | 10-30 | | | |
| **% logs** | - | | | |
| **% twigs** | 2-10 | | | |
| **% leaves** | 2-10 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | - | | | |
| **Vegetation description** | Open Paddock | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| **Arctotheca calendula* | G1 <2 | 0.1 |
| **Carpobrotus edulis* | G1 2-10 | - |
| **Crassula* sp. | G2 <2 | 0.02 |
| **Ehrharta longiflora* | G2 <2 | 0.2 |
| **Geranium dissectum* | G2 <2 | 0.05 |
| **Gladiolus caryophyllaceus* | G1 <2 | - |
| **Hypochaeris glabra* | G2 <2 | - |
| *Isolepis* sp. | G2 <2 | 0.02 |
| *Nuytsia floribunda* | U1 2-10 | 5 |
| **Pentaschistis airoides* | G2 <2 | - |
| *Podotheca gnaphalioides* | G1 10-30 | 0.2 |
| *Trachymene pilosa* | G2 2-10 | 0.05 |
| **Ursinia anthemoides* | G1 <2 | - |
| *Xanthorrhoea preissii* | M1 10-30 | 1.7 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH 12 | | | |
| **Observers** | EL, ML, LZ | | | |
| **Location** | - | | | |
| **Coordinates** | **MGA Zone** | 50 | 397889 mE | 6476585 mN |
| **Date** | 25/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Exotic weeds | | | |
| **Percentage of disturbance** | 30-70% | | | |
| **Site drainage** | Seasonally wet | | | |
| **Climate** | Recent rain, +ve veg response | | | |
| **Grazing** | - | | | |
| **Grazing type** | - | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on most trees | | | |
| **Soil colour** | Dark Grey | | | |
| **Soil** | Peaty Sand | | | |
| **Landform** | Drainage depression | | | |
| **Vegetation condition** | Degraded (5) | | | |
| **% bare ground** | 30-70% | | | |
| **% logs** | 0 | | | |
| **% twigs** | 2-10% | | | |
| **% leaves** | <2% | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | - | | | |
| **Vegetation description** | Melaleuca Low Woodland | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Acacia pulchella* | M2 <2 | 0.8 |
| **Arctotheca calendula* | G2 2-10 | - |
| *Astartea scoparia* | M1 10-30 | 1.4 |
| **Brassica tournefortii* | G1 <2 | 0.3 |
| **Briza maxima* | G1 <2 | 0.15 |
| **Briza minor* | G1 <2 | 0.05 |
| **Carpobrotus edulis* | G1 10-30 | 0.2 |
| **Disa bracteata* | G1 <2 | - |
| **Galium murale* | G2 2-10 | - |
| *Hypocalymma angustifolium* | M2 2-10 | 0.3 |
| **Hypochaeris glabra* | G2 2-10 | - |
| *Lepidosperma pubisquameum* | G1 <2 | 0.5 |
| *Lepidosperma longitudinale* | G1 10-30 | 0.8 |
| *Melaleuca preissiana* | U1 >70 | 6 |
| **Moraea flaccida* | G1 <2 | - |
| **Ornithopus pinnatus* | G2 <2 | 0.05 |
| Poaceae sp. | G1 <2 | - |
| **Solanum nigrum* | M2 <2 | 0.3 |
| *Trachyandra divaricata* | G1 <2 | - |
| **Ursinia anthemoides* | G1 <2 | 0.1 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH13 | | | |
| **Observers** | ML EL LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 397911 mE | 6478276 mN |
| **Date** | 26/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Exotic weeds, Animal | | | |
| **Percentage of disturbance** | <2% | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Recent rain +ve veg response | | | |
| **Grazing** | Light | | | |
| **Grazing type** | Native herbivore, Other: Rabbit | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | No damage | | | |
| **Soil colour** | Dark Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | Drainage depression (slight) | | | |
| **Vegetation condition** | Very Good (3) | | | |
| **% bare ground** | 10-30 | | | |
| **% logs** | - | | | |
| **% twigs** | 10-30 | | | |
| **% leaves** | 2-10 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 30-70 | | | |
| **Vegetation description** | Mixed Open Heath | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *IAira cupaniana* | G1 <2 | 0.05 |
| *Allocasuarina fraseriana* | U1 <2 | 7 |
| *Calytrix fraseri* | M1 30-70 | 1.6 |
| **Crassula* sp. | G1 <2 | 0.02 |
| *Dasypogon bromeliifolius* | G1 <2 | - |
| *Hibbertia subvaginata* | - | 0.2 |
| **Hypochaeris glabra* | G1 <2 | - |
| **Hypochaeris* sp. | G1 <2 | 0.05 |
| *Millotia* sp. | G1 <2 | 0.1 |
| *Nuytsia floribunda* | U2 <2 | 3 |
| *Patersonia occidentalis* | G1 <2 | |
| *Podotheca gnaphalioides* | G1 <2 | 0.05 |
| *Scholtzia involucrata* | G1 2-10 | 0.2 |
| *Stylidium calcaratum* | G1 <2 | 0.05 |
| *Trachymene pilosa* | G1 <2 | 0.05 |
| **Ursinia anthemoides* | M1 2-10 | 0.1 |
| *Verticordia densiflora* | M1 <2 | 1.5 |
| *Waitzia nitida* | G1 <2 | 0.25 |
| *Waitzia suaveolens* | G1 <2 | 0.2 |
| *Xanthorrhoea preissii* | M1 2-10 | - |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH14 | | | |
| **Observers** | EL, ML, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 397836 mE | 6478502 mN |
| **Date** | 26/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | - | | | |
| **Percentage of disturbance** | - | | | |
| **Frequency of disturbance** | Current disturbance | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Recent rain, +ve veg response | | | |
| **Grazing** | - | | | |
| **Grazing type** | - | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on some trees | | | |
| **Soil colour** | Dark Grey / Brown | | | |
| **Soil** | Sand | | | |
| **Landform** | Flat | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | <2 | | | |
| **% logs** | - | | | |
| **% twigs** | 2-10 | | | |
| **% leaves** | 100 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 10-30 | | | |
| **Vegetation description** | Banksia Low Open Forest | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Aira* sp. | G2 <2 | - |
| *Allocasuarina fraseriana* | U2 10-30 | 4 |
| *Banksia attenuata* | U1 >70 | 6 |
| *Banksia menziesii* | U1 10-30 | 6 |
| *Bossiaea eriocarpa* | M3 <2 | 0.1 |
| *Calytrix fraseri* | M1 10-30 | 1.8 |
| *Dasypogon bromeliifolius* | - | - |
| *Gompholobium confertum* | G1 <2 | 0.3 |
| *Hibbertia hypericoides* | M3 2-10 | 0.4 |
| *Hibbertia racemosa* | M3 <2 | 0.1 |
| *Hibbertia subvaginata* | M3 2-10 | 0.4 |
| *Hypocalymma robustum* | M3 <2 | 0.4 |
| *Leporella fimbriata* | G2 <2 | - |
| *Patersonia occidentalis* | G1 <2 | 0.3 |
| **Pyrorchis nigricans* | G2 <2 | - |
| *Stylidium calcaratum* | G2 <2 | - |
| *Stylidium* sp. | G2 <2 | |
| *Trachymene pilosa* | G2 <2 | 0.05 |
| *Xanthorrhoea preissii* | M2 30-70 | 0.5 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH15 | | | |
| **Observers** | ML EL LZ | | | |
| **Location** | Within CC wetland | | | |
| **Coordinates** | **MGA Zone** | 50 | 397746 mE | 6478733 mN |
| **Date** | 26/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Exotic weeds | | | |
| **Percentage of disturbance** | 10-30% | | | |
| **Site drainage** | - | | | |
| **Climate** | - | | | |
| **Grazing** | - | | | |
| **Grazing type** | Native herbivore, Other | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | No damage | | | |
| **Soil colour** | Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | Flat, high water table | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | 2-10 | | | |
| **% logs** | - | | | |
| **% twigs** | 30-70 | | | |
| **% leaves** | 2-10 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 10-30 | | | |
| **Vegetation description** | Mixed Open Heath | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Adenanthos cygnorum* | | |
| *Aira* sp. | G1 <2 | 0.05 |
| **Arctotheca calendula* | G1 <2 | - |
| *Caladenia flava* | G1 <2 | 0.1 |
| *Cassytha* sp. | - | - |
| *Dasypogon bromeliifolius* | U1 <2 | 2.5 |
| *Drosera erythrorhiza* | G1 <2 | - |
| *Elythranthera brunonis* | G1 <2 | 0.1 |
| *Hibbertia subvaginata* | G1 <2 | 0.2 |
| *Hypocalymma* sp. | M2 <2 | 0.3 |
| *Melaleuca seriata* | M1 30-70 | 1.6 |
| *Pericalymma ellipticum* | M1 30-70 | - |
| *Podotheca gnaphalioides* | G1 <2 | 0.1 |
| *Scholtzia involucrata* | M2 <2 | 0.6 |
| **Sonchus oleraceus* | G1 <2 | 0.1 |
| *Stylidium calcaratum* | G1 <2 | 0.05 |
| *Trachymene pilosa* | G1 <2 | 0.05 |
| **Ursinia anthemoides* | G1 <2 | 0.2 |
| *Verticordia densiflora* | M2 2-10 | 0.4 |
| *Verticordia lindleyi* subsp. *lindleyi* | M2 2-10 | 0.4 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH16 | | | |
| **Observers** | ML, EL, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 397748 mE | 6479204 mN |
| **Date** | 26/9/12 | | | |
| **Site type** | Qudrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Exotic weeds, Animal | | | |
| **Percentage of disturbance** | 2-10% | | | |
| **Frequency of disturbance** | Current disturbance | | | |
| **Site drainage** | Good drain, Seasonal wet | | | |
| **Climate** | - | | | |
| **Grazing** | - | | | |
| **Grazing type** | Native herbivore, Other: Rabbit | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on some trees | | | |
| **Soil colour** | Dark Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | Riparian bank (slight) | | | |
| **Vegetation condition** | Very Good (3) | | | |
| **% bare ground** | <2 | | | |
| **% logs** | - | | | |
| **% twigs** | 30-70 | | | |
| **% leaves** | 2-10 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | >70 | | | |
| **Vegetation description** | Mixed Open Heath | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Aira* sp. | G1 <2 | 0.05 |
| *Banksia menziesii* | M1 <2 | 1.7 |
| *Caladenia flava* | G1 <2 | 0.1 |
| *Chamaescilla corymbosa* | G1 <2 | 0.15 |
| *Conostylis juncea* | G1 <2 | 0.1 |
| *Conostylis* sp. | G1 <2 | 0.2 |
| *Dasypogon bromeliifolius* | M3 <2 | 0.3 |
| *Daviesia divaricata* | M2 <2 | 0.7 |
| *Drosera erythrorhiza* | G1 <2 | - |
| *Elythranthera brunonis* | G1 <2 | 0.1 |
| **Gladiolus caryophyllaceus* | G1 <2 | 0.5 |
| *Hibbertia stellaris* | G1 <2 | 0.4 |
| *Hypocalymma angustifolium* | M2 2-10 | 0.4 |
| *Leporella fimbriata* | G1 <2 | 0.2 |
| *Melaleuca preissiana* | U1 2-10 | 5 |
| *Nuytsia floribunda* | U1 2-10 | 6 |
| *Patersonia occidentalis* | M3 2-10 | 0.4 |
| *Pericalymma ellipticum* | M1 30-70 | 1.4 |
| *Stylidium calcaratum* | G1 2-10 | 0.05 |
| *Trachymene pilosa* | G1 <2 | 0.05 |
| **Ursinia anthemoides* | G1 2-10 | 0.2 |
| *Waitzia suaveolens* | G1 2-10 | 0.05 |
| *Xanthorrhoea preissii* | M2 2-10 | 1 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH 17 | | | |
| **Observers** | EL, ML, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 397771 mE | 6480108 mN |
| **Date** | 26/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Exotic weeds | | | |
| **Percentage of disturbance** | <2% | | | |
| **Frequency of disturbance** | Current disturbance | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Recent rain, +ve veg response | | | |
| **Grazing** | - | | | |
| **Grazing type** | Native herbivore, Other | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on some trees | | | |
| **Soil colour** | Dark Grey / Brown | | | |
| **Soil** | Sand | | | |
| **Landform** | Flat | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | 10-30 | | | |
| **% logs** | - | | | |
| **% twigs** | 2-10 | | | |
| **% leaves** | 10-30 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 30-70 | | | |
| **Vegetation description** | Jarrah-Marri-Banksia Woodland | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Acacia huegelii* | M2 <2 | 0.3 |
| *Acacia pulchella* | M2 <2 | 0.3 |
| *Banksia ilicifolia* | M1 <2 | 3 |
| *Banksia menziesii* | U1 2-10 | 4 |
| **Briza maxima* | G1 <2 | 0.1 |
| *Caladenia flava* | G2 <2 | 0.05 |
| *Calytrix* sp. | M2 <2 | 0.3 |
| *Conostephium pedulum* | M2 2-10 | 0.4 |
| *Dasypogon bromeliifolius* | M3 2-10 | 0.4 |
| *Drosera erythrorhiza* | G2 <2 | - |
| **Ehrharta calycina* | G2 <2 | 0.6 |
| *Elythranthera brunonis* | G2 <2 | 0.05 |
| *Eremaea pauciflora* | M2 2-10 | 0.4 |
| *Eucalyptus marginata* | U1 2-10 | 6 |
| *Gompholobium scabrum* | M1 2-10 | 1.1 |
| *Hibbertia huegelii* | G1 <2 | 0.2 |
| *Hibbertia subvaginata* | M2 2-10 | 0.3 |
| *Hovea chorizemifolia* | M2 <2 | 0.7 |
| *Hypocalymma robustum* | M3 <2 | 0.7 |
| *Leucopogon sprengelioides* | M3 <2 | 0.3 |
| *Patersonia occidentalis* | M2 2-10 | 0.5 |
| *Philotheca spicata* | M2 <2 | 0.4 |
| *Schoenus curvifolius* | G2 <2 | 0.1 |

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Trachymene pilosa* | G2 <2 | 0.05 |
| **Ursinia anthemoides* | G1 <2 | 0.1 |
| *Waitzia suaveolens* | G2 <2 | 0.05 |
| *Xanthorrhoea preissii* | M2 10-30 | 0.9 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH18 | | | |
| **Observers** | ML, EL, LZ | | | |
| **Location** | Archery range | | | |
| **Coordinates** | **MGA Zone** | 50 | XXXXXX mE | XXXX mN |
| **Date** | 27/9/12 | | | |
| **Site type** | | | | |
| **Dimensions** | | | | |
| **Disturbance** | Exotic weeds | | | |
| **Percentage of disturbance** | <2% | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Wet | | | |
| **Grazing** | - | | | |
| **Grazing type** | Native herbivore, Other | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on some trees | | | |
| **Soil colour** | Grey / Brown | | | |
| **Soil** | Organic matter Sand | | | |
| **Landform** | Flat | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | - | | | |
| **% logs** | <2 | | | |
| **% twigs** | 10-30 | | | |
| **% leaves** | 100 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 30-70 | | | |
| **Vegetation description** | Jarrah-Marri-Banksia Woodland | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Acacia huegelii* | M3 <2 | 0.2 |
| *Banksia attenuata* | M1 2-10 | 3 |
| *Banksia menziesii* | U2 <2 | <2 |
| **Briza maxima* | G1 <2 | 0.1 |
| *Burchardia congesta* | G1 <2 | 0.4 |
| *Caladenia flava* | G2 <2 | 0.1 |
| *Conostephium pendulum* | M3 <2 | 0.3 |
| *Conostylis aculeata* | G1 <2 | 0.2 |
| *Corymbia calophylla* | U1 10-30 | 10 |
| *Crassula* sp. | G2 <2 | 0.02 |
| *Dasypogon bromeliifolius* | M3 2-10 | 0.3 |
| *Drosera erythrorhiza* | G2 <2 | - |
| *Eucalyptus marginata* | U2 2-10 | 5 |
| *Hibbertia hypericoides* | G1 <2 | 0.3 |
| *Hibbertia subvaginata* | G1 10-30 | 0.3 |
| *Hypocalymma angustifolium* | M3 <2 | 0.3 |
| *Hypocalymma robustum* | M3 2-10 | 0.4 |
| *Hypochaeris* sp. | G1 <2 | - |
| *Jacksonia sternbergiana* | M2 <2 | 0.6 |
| *Kennedia prostrata* | G2 <2 | - |
| *Patersonia occidentalis* | G1 10-30 | 0.6 |
| *Petrophile linearis* | M3 <2 | 0.2 |
| *Scholtzia involucrata* | M3 <2 | 0.4 |

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Trachymene pilosa* | G2 <2 | 0.05 |
| *Waitzia suaveolens* | G2 <2 | 0.05 |
| *Xanthorrhoea preissii* | M2 30-70 | 0.7 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH19 | | | |
| **Observers** | ML, LZ, EL | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 397852 mE | 6480401 mN |
| **Date** | 27/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Other: Archery (recreational activities) | | | |
| **Percentage of disturbance** | - | | | |
| **Frequency of disturbance** | Current disturbance | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Wet | | | |
| **Grazing** | Light | | | |
| **Grazing type** | Native herbivore | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on some trees | | | |
| **Soil colour** | Grey / Brown | | | |
| **Soil** | Sand | | | |
| **Landform** | Flat | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | 2-10 | | | |
| **% logs** | <12 | | | |
| **% twigs** | 10-30 | | | |
| **% leaves** | 30-70 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 30-70 | | | |
| **Vegetation description** | Jarrah-Marri-Banksia Woodland | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Banksia attenuata* | U2 10-30 | 4.5 |
| *Banksia menziesii* | U2 10-30 | 4.5 |
| **Briza maxima* | G2 <2 | 0.1 |
| *Caladenia flava* | G2 <2 | 0.05 |
| *Corymbia calophylla* | U1 2-10 | 12 |
| *Dasypogon bromeliifolius* | G1 2-10 | 0.4 |
| *Drosera erythrorhiza* | G2 2-10 | - |
| *Elythranthera brunonis* | G2 <2 | 0.1 |
| **Gladiolus caryophyllaceus* | G1 <2 | 1.0 |
| *Hibbertia hypericoides* | M3 <2 | 0.3 |
| *Hibbertia subvaginata* | M2 | |
| *Hypocalymma robustum* | M2 <2 | 0.3 |
| **Hypochaeris glabra* | G2 2-10 | - |
| *Jacksonia furcellata* | M1 <2 | 1.7 |
| *Macrozamia fraseri* | M2 <2 | 1 |
| *Patersonia occidentalis* | G1 10-30 | 0.4 |
| *Petrophile linearis* | M2 <2 | 0.3 |
| *Scholtzia involucrata* | - | 0.2 |
| *Trachymene pilosa* | G2 <2 | 0.05 |
| **Ursinia anthemoides* | G1 <2 | 0.1 |
| *Verticordia lindleyi* subsp. *lindleyi* | M2 <2 | 0.7 |
| *Waitzia suaveolens* | | 0.05 |
| *Xanthorrhoea preissii* | M1 30-70 | 1.5 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH20 | | | |
| **Observers** | ML, EL, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 400680 mE | 6483568 mN |
| **Date** | 27/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Exotic weeds, Animal | | | |
| **Percentage of disturbance** | 2-10% | | | |
| **Frequency of disturbance** | Current | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Wet | | | |
| **Grazing** | Light | | | |
| **Grazing type** | Native herbivore, pigs, Other: Rabbit | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on some trees | | | |
| **Soil colour** | Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | Slope – middle, Slope – upper | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | 15 | | | |
| **% logs** | <2 | | | |
| **% twigs** | 10-30 | | | |
| **% leaves** | 10-30 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 30-70 | | | |
| **Vegetation description** | Banksia Woodland | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Adenanthos cygnorum* | M2 <2 | 0.2 |
| *Anigozanthos manglesii* | M3 <2 | 0.3 |
| *Austrostipa compressa* | G1 <2 | 0.4 |
| *Banksia attenuata* | U1 10-30 | 15 |
| *Banksia menziesii* | U1 10-30 | 5 |
| **Briza maxima* | G1 <2 | 0.1 |
| *Conostephium pendulum* | M2 2-10 | 0.5 |
| *Dampiera linearis* | G1 <2 | 0.05 |
| *Daviesia triflora* | M2 <2 | 0.3 |
| *Drosera pallida* | G1 <2 | - |
| *Gastrolobium capitatum* | M3 <2 | 0.3 |
| *Gladiolus caryophyllaceus* | G1 <2 | 0.7 |
| *Haemodorum* sp. | M3 <2 | 0.5 |
| *Hensmania turbinata* | M3 <2 | 0.3 |
| *Hibbertia hypericoides* | M3 <2 | - |
| *Hibbertia subvaginata* | G1 2-10 | 0.4 |
| *Hovea chorizemifolia* | M2 <2 | 1.2 |
| **Hypochaeris glabra* | G2 <2 | - |
| *Lyginia barbata* | G1 2-10 | 0.4 |
| *Patersonia occidentalis* | G1 10-30 | 0.6 |
| *Persoonia saccata* | G1 <2 | 0.7 |
| *Petrophile linearis* | M3 <2 | 0.3 |
| *Podotheca chrysantha* | G1 <2 | 0.05 |
| *Regelia ciliata* | M2 2-10 | 0.7 |

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Scholtzia involucrata* | M3 30-70 | 0.2 |
| *Stirlingia latifolia* | M2 2-10 | 0.5 |
| *Stylidium piliferum* | G1 <2 | 0.2 |
| *Thysanotus* sp. | G1 <2 | twining |
| *Trachymene pilosa* | G2 <2 | 0.05 |
| **Ursinia anthemoides* | G1 2-10 | 0.05 |
| *Verticordia* sp. | M1 30-70 | 1.5 |
| *Xanthosia huegelii* | - | - |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH21 | | | |
| **Observers** | EL, ML, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 396718 mE | 6479336 mN |
| **Date** | 27/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Animal | | | |
| **Percentage of disturbance** | - | | | |
| **Frequency of disturbance** | Current disturbance | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Wet | | | |
| **Grazing** | Light | | | |
| **Grazing type** | Native herbivore | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on some trees | | | |
| **Soil colour** | Grey / Brown | | | |
| **Soil** | Sand | | | |
| **Landform** | Flat | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | <2 | | | |
| **% logs** | <2 | | | |
| **% twigs** | 10-30 | | | |
| **% leaves** | >70 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 30-70 | | | |
| **Vegetation description** | Banksia Low Open Forest | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| **Aira caryophyllea* | G2 <2 | 0.1 |
| *Allocasuarina fraseriana* | U3 2-10 | 2 |
| *Banksia attenuata* | U2 2-10 | 5 |
| *Banksia menziesii* | U2 2-10 | 5 |
| *Bossiaea eriocarpa* | G1 <2 | 0.1 |
| *Burchardia congesta* | G1 <2 | 0.4 |
| *Caladenia flava* | G2 <2 | 0.1 |
| *Conostephium pendulum* | - | 0.2 |
| *Conostylis juncea* | G2 <2 | 0.1 |
| *Corymbia calophylla* | U1 10-30 | - |
| *Dampiera linearis* | G1 <2 | 0.1 |
| *Dasypogon bromeliifolius* | G1 2-10 | 0.3 |
| *Drosera erythrorhiza* | G2 2-10 | - |
| *Drosera pallida* | G2 <2 | - |
| Fabaceae sp. | M2 <2 | 0.2 |
| *Gompholobium confertum* | - | 0.3 |
| *Hibbertia huegelii* | M3 <2 | 0.2 |
| *Hibbertia hypericoides* | M2 10-30 | 0.6 |
| *Hibbertia subvaginata* | M3 10-30 | - |
| *Hovea trisperma* | G1 <2 | 0.1 |
| *Hypocalymma robustum* | M3 2-10 | 0.5 |
| **Hypochaeris* sp. | G2 <2 | - |
| *Kennedia prostrata* | G2 <2 | - |

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Lomandra sericea* | M3 <2 | 0.4 |
| *Patersonia occidentalis* | M3 10-30 | 0.6 |
| *Petrophile linearis* | M2 <2 | 0.3 |
| *Philotheca spicata* | M3 <2 | 0.3 |
| *Podotheca gnaphalioides* | G2 <2 | 0.1 |
| *Pyrorchis nigricans* | G2 <2 | - |
| *Stylidium calcaratum* | G1 <2 | 0.2 |
| *Stylidium ciliatum* | G1 <2 | 0.3 |
| *Stylidium repens* | - | 0.2 |
| *Stylidium* sp. | G1 <2 | 17 |
| *Trachymene pilosa* | G2 <2 | 0.05 |
| **Ursinia anthemoides* | G1 <2 | 0.1 |
| *Waitzia suaveolens* | G1 <2 | 0.05 |
| *Xanthorrhoea preissii* | M1 10-30 | 1.2 |
| *Xanthosia huegelii* | G2 <2 | 0.05 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH22 | | | |
| **Observers** | EL, ML, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 396614 mE | 6478871 mN |
| **Date** | 27/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | - | | | |
| **Percentage of disturbance** | - | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Wet | | | |
| **Grazing** | - | | | |
| **Grazing type** | Native herbivore, Other | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | Minor impact, scars on most trees | | | |
| **Soil colour** | Dark Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | Flat | | | |
| **Vegetation condition** | Excellent (2) to Very Good (3) | | | |
| **% bare ground** | <2 | | | |
| **% logs** | <2 | | | |
| **% twigs** | 2-10 | | | |
| **% leaves** | >70 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 10-30 | | | |
| **Vegetation description** | Banksia Low Open Forest | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Allocasuarina fraseriana* | U1 2-10 | 10 |
| *Banksia attenuata* | U1 2-10 | 8 |
| *Banksia ilicifolia* | U1 2-10 | 8 |
| *Caladenia flava* | G2 <2 | 0.1 |
| *Conostephium pendulum* | M3 <2 | 0.2 |
| *Dasypogon bromeliifolius* | M3 2-10 | 0.3 |
| *Desmocladus flexuosus* | - | 0.05 |
| *Drosera erythrorhiza* | G2 <2 | - |
| *Eucalyptus marginata* | U1 2-10 | 8 |
| **Gladiolus caryophyllaceus* | M3 <2 | 0.5 |
| *Hibbertia hypericoides* | M3 <2 | 0.3 |
| *Hibbertia subvaginata* | G1 2-10 | 0.2 |
| *Hypocalymma robustum* | M3 <2 | 0.3 |
| *Lomandra preissii* | G1 <2 | 0.1 |
| *Lomandra sericea* | G1 <2 | 0.3 |
| *Patersonia occidentalis* | - | 0.5 |
| *Petrophile linearis* | G1 <2 | 0.4 |
| *Podotheca gnaphalioides* | G2 <2 | 0.1 |
| *Pyrorchis nigricans* | G2 <2 | - |
| *Stylidium repens* | G1 <2 | 0.2 |
| *Stylidium* sp. | G2 <2 | 0.2 |
| *Trachymene pilosa* | G2 <2 | 0.05 |
| *Waitzia suaveolens* | G2 <2 | 0.05 |
| *Xanthorrhoea preissii* | M1 10-30 | 0.8 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH23 | | | |
| **Observers** | ML, EL, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 396703 mE | 6478554 mN |
| **Date** | 27/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Exotic weeds, Animal | | | |
| **Percentage of disturbance** | 2-10%, <2% | | | |
| **Frequency of disturbance** | Old >5 yr | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Wet (hail) | | | |
| **Grazing** | - | | | |
| **Grazing type** | Native herbivore, Other | | | |
| **Fire frequency** | Old >5 yr | | | |
| **Fire intensity** | No damage | | | |
| **Soil colour** | Pale Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | Flat | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | 10-30 | | | |
| **% logs** | - | | | |
| **% twigs** | <2 | | | |
| **% leaves** | 2-10 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 10-30 | | | |
| **Vegetation description** | Verticordia Low Open Heath | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Allocasuarina fraseriana* | M2 <2 | 0.9 |
| *Banksia dallanneyi* | G1 <2 | 0.2 |
| *Cassytha* sp. | G2 2-10 | - |
| *Conostephium pendulum* | M3 <2 | 0.5 |
| *Gladiolus caryophyllaceus* | M3 <2 | 0.6 |
| **Hypochaeris glabra* | G2 <2 | - |
| *Lyginia imberbis* | M3 2-10 | 0.5 |
| *Melaleuca seriata* | M1 10-30 | 0.7 |
| *Pentaschistis* sp. | - | 0.1 |
| *Podotheca gnaphalioides* | G2 <2 | 0.05 |
| *Stirlingia latifolia* | M3 <2 | 0.7 |
| *Stylidium calcaratum* | G1 <2 | 0.1 |
| **Ursinia anthemoides* | G1 <2 | 0.3 |
| *Verticordia* sp. | M1 30-70 | 0.6 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNH24 | | | |
| **Observers** | ML, EL, LZ | | | |
| **Location** | | | | |
| **Coordinates** | **MGA Zone** | 50 | 397380 mE | 6428620 mN |
| **Date** | 27/9/12 | | | |
| **Site type** | Quadrat | | | |
| **Dimensions** | 10 x 10 m | | | |
| **Disturbance** | Exotic weeds, Animal | | | |
| **Percentage of disturbance** | 10-30%, <2% | | | |
| **Frequency of disturbance** | Current disturbance | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Wet | | | |
| **Grazing** | | | | |
| **Grazing type** | Native herbivore, Other | | | |
| **Fire frequency** | - | | | |
| **Fire intensity** | - | | | |
| **Soil colour** | Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | Flat | | | |
| **Vegetation condition** | Excellent (2) | | | |
| **% bare ground** | 10-30 | | | |
| **% logs** | - | | | |
| **% twigs** | <2 | | | |
| **% leaves** | <2 | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | 30-70 | | | |
| **Vegetation description** | Mosaic Banksia Low Open Forest and Mixed Open heath | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Banksia dallanneyi* | G1 10-30 | 0.2 |
| *Calytrix fraseri* | M2 <2 | 0.8 |
| *Conostephium pendulum* | - | - |
| *Dasypogon bromeliifolius* | M1 30-70 | 0.4 |
| *Daviesia divaricata* subsp. *divaricata* | M1 <2 | - |
| *Hibbertia subvaginata* | - | 0.2 |
| **Hypochaeris* sp. | G2 <2 | - |
| *Lepidosperma* sp. | M2 2-10 | 0.6 |
| *Lyginia imberbis* | M1 2-10 | 0.3 |
| *Petrophile linearis* | M2 <2 | 0.5 |
| *Philotheca spicata* | M3 <2 | 0.3 |
| *Podotheca gnaphalioides* | G1 <2 | 0.1 |
| *Stylidium repens* | G1 <2 | 0.2 |
| **Ursinia anthemoides* | G1 10-30 | 0.15 |
| *Waitzia suaveolens* | G2 <2 | 0.05 |
| *Xanthorrhoea preissii* | M2 2-10 | 0.5 |

**PERTH–DARWIN NATIONAL HIGHWAY TONKIN LINK**

| | | | | |
|---|---|---|---|---|
| **Site** | PDNHT1 | | | |
| **Observers** | EL, ML, LZ | | | |
| **Location** | SE Strip | | | |
| **Coordinates** | **MGA Zone** | 50 | 397851 mE | 6477106 mN |
| **Date** | 26/09/12 | | | |
| **Site type** | Transect | | | |
| **Dimensions** | 150 m | | | |
| **Disturbance** | Clearing, Exotic weeds | | | |
| **Percentage of disturbance** | 10-30%, 10-30% | | | |
| **Frequency of disturbance** | Current disturbance | | | |
| **Site drainage** | Good drain | | | |
| **Climate** | Recent rain +ve veg response | | | |
| **Grazing** | - | | | |
| **Grazing type** | - | | | |
| **Fire frequency** | - | | | |
| **Fire intensity** | - | | | |
| **Soil colour** | Dark Grey | | | |
| **Soil** | Sand | | | |
| **Landform** | - | | | |
| **Vegetation condition** | Good(4) to Degraded (5) | | | |
| **% bare ground** | - | | | |
| **% logs** | - | | | |
| **% twigs** | - | | | |
| **% leaves** | - | | | |
| **% rocks <2 cm** | - | | | |
| **% rocks 2-30 cm** | - | | | |
| **% rocks >30 cm** | - | | | |
| **% vegetation (ground layer)** | - | | | |
| **Vegetation description** | Open Paddock | | | |

**Species list**

| Species | Cover (Class, %) | Average height (m) |
|---|---|---|
| *Acacia longifolia* | - | - |
| *Adenanthos cygnorum* | M1 2-10 | - |
| *Allocasuarina fraseriana* | U2 <2 | 5 |
| *Astroloma xerophyllum* | M3 <2 | - |
| *Banksia menziesii* | - | - |
| *Bossiaea eriocarpa* | M3 2-10 | - |
| **Briza maxima* | - | - |
| *Burchardia congesta* | - | - |
| *Caladenia flava* | - | - |
| *Carpobrotus edulis* | G1 2-10 | - |
| *Conostephium pendulum* | - | - |
| *Corymbia calophylla* | - | - |
| *Crassula* sp. | - | - |
| *Dampiera linearis* | - | - |
| *Dasypogon bromeliifolius* | - | - |
| *Daviesia divaricata* subsp. *divaricata* | M2 <2 | - |
| *Desmocladus flexuosus* | - | - |
| **Ehrharta calycina* | G1 <2 | - |
| *Eucalyptus marginata* | - | - |
| *Eucalyptus rudis* | U2 2-10 | 6 |
| **Gladiolus caryophyllaceus* | G1 <2 | - |
| *Hibbertia hypericoides* | - | - |
| **Hypochaeris glabra* | - | - |
| *Hypolaena exsulca* | - | - |
| *Lechenaultia biloba* | M3 2-10 | - |
| *Macrozamia fraseri* | - | - |
| **Ornithopus compressus* | - | - |
| *Patersonia occidentalis* | - | - |
| *Persoonia saccata* | - | - |
| *Petrophile brevifolia* | - | - |
| *Philotheca spicata* | - | - |
| *Phlebocarya ciliata* | G1 2-10 | - |
| *Podotheca gnaphalioides* | G1 2-10 | - |
| *Scholtzia involucrata* | - | - |
| **Tagetes minuta* | G1 <2 | - |
| **Trachyandra divaricata* | - | - |
| **Ursinia anthemoides* | G1 2-10 | - |
| *Xanthorrhoea gracilis* | - | - |
| *Xanthorrhoea preissii* | M2 10-30 | - |

## Fauna species recorded within the Study Area during the Spring 2012 survey

| Family | Taxon | Common Name | EPBC Act | WC Act | DEC | Introduced |
|---|---|---|---|---|---|---|
| **Birds** | | | | | | |
| Acanthizidae | *Smicrornis brevirostris occidentalis* | Weebill | | | | |
| Acanthizidae | *Acanthiza chrysorrhoa* | Yellow-rumped Thornbill | | | | |
| Acanthizidae | *Gerygone fusca* | Western Gerygone | | | | |
| Accipitridae | *Haliastur sphenurus* | Whistling Kite | | | | |
| Accipitridae | *Accipiter fasciatus* | Brown Goshawk | | | | |
| Accipitridae | *Hieraaetus morphnoides* | Little Eagle | | | | |
| Cacatuidae | *Eolophus roseicapilla* | Galah | | | | |
| Cacatuidae | *Calyptorhynchus latirostris* | Carnaby's Black Cockatoo | Endangered | Threatened | | |
| Campephagidae | *Lalage sueurii* | White-winged Triller | | | | |
| Campephagidae | *Coracina novaehollandiae* | Black-faced Cuckoo-shrike | | | | |
| Columbidae | *Ocyphaps lophotes* | Crested Pigeon | | | | |
| Columbidae | *Phaps chalcoptera* | Common Bronzewing | | | | |
| Corvidae | *Corvus coronoides perplexus* | Australian Raven | | | | |
| Cracticidae | *Cracticus tiibicen dorsalis* | Australian Magpie | | | | |
| Cracticidae | *Cracticus nigrogularis* | Pied Butcherbird | | | | |
| Dicruridae | *Grallina cyanoleuca* | Magpie-lark | | | | |
| Dicruridae | *Rhipidura fuliginosa* | Grey Fantail | | | | |
| Dicruridae | *Rhipidura leucophrys leucophrys* | Willie Wagtail | | | | |
| Falconidae | *Falco cenchroides cenchroides* | Nankeen Kestrel | | | | |
| Halcyonidae | *Todiramphus sanctus* | Sacred Kingfisher | | | | |
| Halcyonidae | *Dacelo novaequineae* | Laughing Kookaburra | | | | X |
| Hirundinidae | *Petrochelidon nigricans* | Tree Martin | | | | |
| Maluridae | *Malurus splendens* | Splendid Fairy-wren | | | | |
| Meliphagidae | *Phylidonyris novaehollandiae* | New Holland Honeyeater | | | | |

| Family | Taxon | Common Name | EPBC Act | WC Act | DEC | Introduced |
|---|---|---|---|---|---|---|
| Meliphagidae | *Phylidonyris niger* | White-cheeked Honeyeater | | | | |
| Meliphagidae | *Anthochaera carunculata* | Red Wattlebird | | | | |
| Meliphagidae | *Lichenostomus virescens virescens* | Singing Honeyeater | | | | |
| Meliphagidae | *Lichmera indistincta* | Brown Honeyeater | | | | |
| Meropidae | *Merops ornatus* | Rainbow Bee-eater | Migratory | | | |
| Neosittidae | *Daphoenositta chrysoptera* | Varied Sitella | | | | |
| Pachycephalidae | *Colluricincla harmonica* | Grey Shrike-thrush | | | | |
| Pachycephalidae | *Pachycephala rufiventris* | Rufous Whistler | | | | |
| Pardalotidae | *Pardalotus striatus* | Striated Pardelote | | | | |
| Petroicidae | *Petroica boodang* | Scarlet Robin | | | | |
| Petroicidae | *Microeca fascinans* | Jacky Winter | | | | |
| Psittacidae | *Platycercus zonarius semitorquatus* | Twenty-eight Parrot | | | | |
| Threskiornithidae | *Threskiornis spinicollis* | Straw-necked Ibis | | | | |
| **Reptiles** | | | | | | |
| Agamidae | *Pogona minor minor* | Western Bearded Dragon | | | | |
| Elapidae | *Pseudonaja affinis* | Dugite | | | | |
| Scincidae | *Cryptoblephorus plagiocephalus* | Fence Skink | | | | |
| Scincidae | *Lerista praepedita* | | | | | |
| Scincidae | *Ctenotus fallens* | West Coast Ctenotus | | | | |
| Scincidae | *Tiliqua rugosa rugosa* | Western Bobtail | | | | |
| Varanidae | *Varanus gouldii* | Gould's Monitor | | | | |
| **Mammals** | | | | | | |
| Canidae | *Vulpes vulpes* | Red Fox | | | | x |
| Leporidae | *Oryctolagus cuniculus* | European Rabbit | | | | x |
| Macropodidae | *Macropus fuliginosus* | Western Grey Kangaroo | | | | |
| Macropodidae | *Macropus irma* | Western Brush Wallaby | | | Priority 4 | |
| Permelidae | *Isoodon obesulus fusciventer* | Quenda, Southern Brown Bandicoot | | | Priority 5 | |

| Family | Taxon | Common Name | EPBC Act | WC Act | DEC | Introduced |
|---|---|---|---|---|---|---|
| Suidae | *Sus scrofa* | Feral Pig | | | | x |
| Tachyglossidae | *Tachyglossus aculeatus* | Echidna | | | | |

# Appendix E – Likelihood of Occurrence Assessment

## Likelihood of occurrence assessment of conservation significant flora species identified as potentially occurring within 10 km of the Study Area

| Taxon | WC Act | EPBC Act | DEC | Habitat description (Source: Florabase, DSEWPaC SPRAT database) | Likelihood of occurrence |
|---|---|---|---|---|---|
| *Acacia benthamii* | | | P2 | Shrub, ca 1 m high. Flowers yellow, August to September. Recorded from sand, typically on limestone breakaways. | Potential to occur. Suitable habitat occurs in the Study Area. |
| *Acacia oncinophylla* subsp. *oncinophylla* | | | P3 | Shrub, 0.9-2.5 m high with 'mini-ritchi' bark. Phyllodes are mostly 8-13 cm long and 1-2 mm wide. Flowers are yellow, August to October. Generally occurs on granitic soils. | Unlikely to occur. Optimum habitat for this species does not occur within the Study Area. |
| *Acacia ridleyana* | | | P3 | Spreading, sprawling shrub, 0.2-0.9 m high and 0.5-2 m wide. Flowers yellow, August to December. Known to occur in grey or yellow/brown sand, gravelly clay and granitic loam. | Unlikely to occur, given its known distribution. Additionally, optimum habitat for this species does not occur within the Study Area |
| *Adenanthos cygnorum* subsp. *chamaephyton* | | | P3 | Prostrate, mat-forming, non-lignotuberous shrub, to 0.3 m high. Flowers white-cream-pink-green, July or September to December or January. Occurs on grey sand and lateritic gravel. | Unlikely to occur, given its known distribution. Additionally, optimum habitat for this species does not occur within the Study Area |
| *Amperea protensa* | | | P3 | Decumbent perennial, herb, (0.03-) 0.1-0.4 m high. Flowers brown/cream-green, November to December or January. Occurs on sandy soils, seasonally wet flats, depressions and swampy areas. | Potential to occur as suitable habitat is present in the Study Area. |
| *Andersonia gracilis* | T | En | | Slender shrub to 50 cm tall with few spreading branches. Pink to mauve flowers. Currently known from Badgingarra, Dandaragan and Kenwick areas. The species occurs in damp black, sandy clay flats near swamps in open low heath with C*alothamnus hirsutus, Verticordia densiflora, Kunzea recurva* and *Banksia telmatiaea* over sedges. Flowers white-pink-purple, September to November. | Unlikely to occur, optimum habitat for this species does not occur within the Study Area. |
| *Bolboschoenus medianus* | | | P1 | Rhizomatous, perennial, grass-like herb (sedge). Flowers red-brown. Occurs in mud, in water and on river banks. | Unlikely to occur. Optimum habitat for this species does not occur within the Study Area. |

| Taxon | WC Act | EPBC Act | DEC | Habitat description (Source: Florabase, DSEWPaC SPRAT database) | Likelihood of occurrence |
|---|---|---|---|---|---|
| *Byblis gigantea* | | | P3 | Small, branched perennial, herb (or sub-shrub), to 0.45 m high. Flowers pink-purple/white, September to December or January. Occurs on sandy-peat swamps on seasonally wet areas. | Unlikely to occur based on its known distribution. However suitable habitat is present within the Study Area. |
| *Caladenia huegelii* | T | Cr | | *Caladenia huegelii* is a spider orchid which grows up 60 cm tall with a single erect, pale green, hairy leaf and one or two (rarely three) predominantly pale greenish-cream flowers 7-10 cm across, with variable suffusions, lines and spots of red-maroon. It occurs in areas of mixed woodland of jarrah (*Eucalyptus marginata*), *Banksia attenuata, B. ilicifolia, B. menziesii* with scattered *Allocasuarina fraseriana* and *Corymbia calophylla* over dense shrubs of *Stirlingia latifolia, Hypocalymma robustum, Hibbertia hypericoides, H. subvaginata, Xanthorrhoea preissii, Adenanthos cuneatus* and *Conostylis species*, from just north of Perth to the Busselton area, usually within 20 km of the coast. Species tends to favour areas of dense undergrowth. Soil is usually deep grey-white sand usually associated with the Bassendean sand-dune system. However rare plants have been known to extend into the Spearwood system in some areas. Flowers green, cream and red, September to October. | Known to occur. There is one record in the Study Area recorded in 2005. No plants were recorded during the recent survey by GHD. There is habitat for this species present within the Study Area. |
| *Calectasia cyanea* | T | Cr | | *Calectasia cyanea* is an undershrub to 40 cm, with a few short lateral branches, usually with stilt roots. It occurs on yellow sand or gravel over laterite in low heathland on a low ridge to gentle slope. This species is not known to occur on the Swan Coastal Plain. | Unlikely to occur, optimum habitat for this species does not occur within the study area and the study area is not within this species known range |
| *Calectasia* sp. Pinjar (C. Tauss 557) | | | P1 | Perennial, herb. To 0.4 m high, with multiple stems and roots. Deep grey quartz soils. Occurs on gentle slopes, above damplands. | Unlikely to occur. Optimum habitat for this species does not occur within the Study Area. |
| *Calothamnus rupestris* | | | P4 | Erect, compact or spreading shrub or tree (occasionally), 0.9-4 m high. Flowers pink-red in July to December. Occurs on gravelly skeletal soils on granite outcrops and rocks, hillsides. | Unlikely to occur. Optimum habitat for this species does not occur within the Study Area however it is a commonly used plant in road reserve rehabilitation. |
| *Calytrix breviseta* subsp. *breviseta* | T | En | | *Calytrix breviseta* subsp. *breviseta* is an erect or spreading shrub that can grow up to 40 cm high. It grows on low lying, sandy clay | Unlikely to occur, given its known distribution. Additionally |

| Taxon | WC Act | EPBC Act | DEC | Habitat description (Source: Florabase, DSEWPaC SPRAT database) | Likelihood of occurrence |
|---|---|---|---|---|---|
| | | | | flats among low heath of *Verticordia acerosa, Verticordia plumosa*, *Calothamnus hirsutus* and *Melaleuca uncinata*, over very open sedges. Although originally recorded from Gosnells and Bellevue the taxon is now apparently confined to the Kenwick area. Flowers purple- blue, October to November. | habitat for this species does not occur in the Study Area. |
| *Carex tereticaulis* | | | P1 | Monoecious, rhizomatous, tufted perennial, grass-like or herb (sedge), 0.7 m high. Flowers brown in September to October. Occurs on black peaty sand. | Unlikely to occur. Optimum habitat for this species does not occur in the Study Area. |
| *Centrolepis caespitosa* | | En | P4 | *Centrolepis caespitosa* is a diminutive, densely tufted, glabrous annual herb. The leaves are red or green, slender and 5-10 mm long. These form a dense clump or cushion up to 2 cm in diameter. This species occurs in winter-wet clay pans dominated by low shrubs and sedges. It was recorded in the Floristic Survey of the southern Swan Coastal Plain in 1994 from two community types; herb rich shrubland in clay pans (Type 8) and shrubland on southern ironstone (Type 10b) (Gibson *et al*1994). Flowers October to December. | Unlikely to occur, optimum habitat for this species does not occur in the study area. |
| *Chamelaucium* sp. Gingin (N.G. Marchant 6) | T | En | | *Chamelaucium* sp. Gingin is endemic to Western Australia and is apparently confined to the Gingin area, where it is known from a range of only 3 km. It is an open straggly shrub 1 to 2 m tall with many slender stiff branches that bear numerous 5 to 20 mm long axillary shoots. The species occurs on white/yellow sand supporting open low woodland with *Eucalyptus todtiana, Banksia attenuata* and *Hibbertia* sp. | Highly unlikely to occur, the Study Area is outside the known distribution of this species. |
| *Cyanicula ixioides* subsp. *ixioides* | | | P4 | Tuberous, perennial, herb, 0.05-0.15 m high. Flowers are yellow, August-October. Occurs on laterite, gravel. | Unlikely to occur. Optimum habitat for this species does not occur in the Study Area. |
| *Cyathochaeta teretifolia* | | | P3 | Rhizomatous, clumped, robust perennial, grass-like or herb (sedge), to 2 m high, to 1.0 m wide. Flowers brown. Occurs on grey sand, sandy clay on swamps and creek edges. | Unlikely to occur. Optimum habitat for this species does not occur in the Study Area. |
| *Dampiera triloba* | | | P1 | Erect perennial, herb or shrub, 0.5 m high. Flowers blue, August to December. | Potential to occur. There is no information available on the preferred habitat for this species. |

| Taxon | WC Act | EPBC Act | DEC | Habitat description (Source: Florabase, DSEWPaC SPRAT database) | Likelihood of occurrence |
|---|---|---|---|---|---|
| *Darwinia foetida* | T | Cr | | Muchea Bell is an erect, or spreading shrub to 0.7 m high, often using other shrubs for support. Young branches are slender, green-brown with prominent, decurrent leaf bases, becoming grey and woody. This species has green flowers and flowers between October to November. It occurs in grey-white sand on swampy, seasonally wet flats and on winter-damp to wet clay under *Regelia inops* and *Kunzea recurva* tall shrubland, over *Hypocalymma angustifolium* low shrubland or low *Melaleuca* spp. shrubland. It has been recorded at three locations near the town of Muchea. | Unlikely, the Study Area contains suitable habitat for this species however it is outside the known distribution of this species. |
| *Darwinia pimelioides* | | | P4 | Erect shrub, 0.25-0.5(-1) m high. Flowers red/pink and green, September to October. Occurs on loam, sandy loam on granite outcrops. | Unlikely to occur. Optimum habitat for this species does not occur within the Study Area. |
| *Dasymalla axillaris* | T | | | No information available. | Potential to occur as there is one record of this species less than 5 km north west of the Study Area. |
| *Drosera occidentalis* subsp. *occidentalis* | | | P4 | Fibrous-rooted, rosetted perennial, herb, to 0.01 m high. Flowers pink/white from November to December. Occurs on sandy and clayey soils in swamps and wet depressions. | Potential to occur, there is suitable habitat for this species within the Study Area. There are records of this species within 5 km of the Study Area. |
| *Drosera x sidjamesii* | | | P1 | Fibrous-rooted, rosetted perennial, herb, to 0.06 m high. Flowers green-pink from November to December or January to March. Occurs on peaty sand along lake margins, close to winter high-water line. | Potential to occur. Suitable habitat for this species is present within the Study Area. |
| *Eleocharis keigheryi* | T | Vu | | Eleocharis keigheryi is a rhizomatous, tufted/clumped perennial herb, reaching a maximum diameter of 40 cm. it is known from 15 populations between north of Eneabba and south-east to Qualeup. It grows in small clumps in a substrate of clay or sandy loam. This species is emergent in freshwater creeks and claypans. Associated species include *Melaleuca glateritia* and herbs such as *Wurmbea, Tribonanthes* and *Leptocarpus* spp. | Unlikely, optimum habitat for this species does not occur within the Study Area. |

| Taxon | WC Act | EPBC Act | DEC | Habitat description (Source: Florabase, DSEWPaC SPRAT database) | Likelihood of occurrence |
|---|---|---|---|---|---|
| *Epiblema grandiflorum* var. *cyaneum* | | En | | *Epiblema grandiflorum* var. *cyaneum* was a manuscription name applied to a small population of sky-blue flowered plants of the widespread *E. grandiflorum*. However, subsequent studies have determined that *E. grandiflorum* var. *cyaneum* is not likely to warrant taxonomic recognition and has been removed from the Census of Western Australia Plants (Thiele, K.R. (2011) Nuytsia: 21 (1): 33-34. Removal of the informal name *Epiblema grandiflorum* var. *cyaneum*.) | It has been recently determined that this species is not likely to warrant taxonomic recognition and it has been named in error. |
| *Eryngium pinnatifidum* subsp. *palustre* | | | P3 | No information available. | Unknown. |
| *Eucalyptus balanites* | T | En | | Mallee, to 5 m high, bark rough, flaky. This species is found on light coloured sandy soils over laterite. Eucalyptus balanites was previously only known from Badgingarra National Park. In 1997 a single plant was discovered in bushland in the City of Armadale; however it is not certain whether the plant at Armadale is a naturally occurring population or has been planted. Flowers white October to December or January to February. | Unlikely to occur, given its known distribution. |
| *Grevillea curviloba* subsp. *curviloba* | T | Cr | | Prostrate to erect shrub. Flowers white-cream - October. In grey sand, winter-wet heath. This species was originally collected from the Muchea-Bullsbrook area and is still only known from a range of less than 20 km. This subspecies is associated with the Muchea Limestone community and with a suite of shrubs including *Melaleuca huegelii, M. systena* and *Acacia saligna*. | Unlikely to occur, given its known distribution. Additionally, optimum habitat for this species does not occur within the Study Area |
| *Grevillea curviloba* subsp. *incurva* | T | En | | Flowers white-cream, August to September. Sand, sandy loam. Winter-wet heath. This species is thought to be confined to an area between Muchea and Badgingarra and grows in open heath in winter-wet sites on sand over limestone, or over ironstone at sites with a high water table | Unlikely to occur, given its known distribution. Additionally, optimum habitat for this species does not occur within the Study Area |
| *Haemodorum loratum* | | | P3 | Bulbaceous, perennial, herb, 0.45-1.2(-2) m high. Flowers black/brown-black/green in November. Occurs on grey or yellow sand, gravel. | Unlikely to occur given its currently known distribution and preferred habitat type. |
| *Hibbertia helianthemoides* | | | P3 | Spreading to erect, low or prostrate shrub, 0.3 m high. Flowers are yellow from July or September to October. Occurs on clayey sand over sandstone or loam over quartzite. Occurs on hills and scree slopes. | Unlikely to occur. Optimum habitat for this species does not occur in the Study Area. |

| Taxon | WC Act | EPBC Act | DEC | Habitat description (Source: Florabase, DSEWPaC SPRAT database) | Likelihood of occurrence |
|---|---|---|---|---|---|
| *Hydrocotyle lemnoides* | | | P4 | Aquatic, floating annual, herb. Flowers purple, August to October. Occurs in swamps. | Unlikely to occur. There are no permanent water sources in the Study Area. |
| *Hydrocotyle striata* | | | P1 | Herb, occurs on clay in springs. | Unlikely to occur, given its known distribution. Additionally, optimum habitat for this species does not occur within the Study Area |
| *Hypolaena robusta* | | | P4 | Dioecious rhizomatous, perennial, herb, ca 0.5 m high. Flowers September to October. Occurs on white sand and sandplains. | Potential to occur. Suitable habitat for this species is present in the Study Area. |
| *Isopogon drummondii* | | | P3 | Erect, lignotuberous shrub, 0.4-1 m high. Flowers yellow/cream-yellow, February to June. Occurs on white, grey or yellow sand, often over laterite. | Potential to occur due to suitable habitat present however considered unlikely given its currently known distribution. |
| *Jacksonia sericea* | | | P4 | Low spreading shrub, to 0.6 m high. Flowers orange, usually December or January to February. Occurs on calcareous and sandy soils. | Potential to occur. Suitable habitat for this species is present within the Study Area. |
| *Lepidosperma rostratum* | T | En | | This species is known from four populations in the east of the metropolitan area of Perth. It grows in sandy soil among low heath in winter-wet swamp and is associated with *Banksia telmatiaea* and *Calothamnus hirsutus* | Unlikely to occur, given its known distribution. Additionally, optimum habitat for this species does not occur within the Study Area |
| *Meionectes tenuifolia* | | | P3 | No information available. | Unknown. |
| *Myriophyllum echinatum* | | | P3 | Erect, herb, 0.02-0.03 m high. Flowers red in November. Occur on clay and winter-wet flats. | Unlikely to occur. Suitable habitat for this species is present within the Study Area however based on its currently known distribution it is unlikely to occur in the Study Area. |

| Taxon | WC Act | EPBC Act | DEC | Habitat description (Source: Florabase, DSEWPaC SPRAT database) | Likelihood of occurrence |
|---|---|---|---|---|---|
| *Ornduffia calthifolia* (was *Villarsia calthifolia*) | T | En | | *Ornduffia calthifolia* is an erect, semi-succulent perennial herb growing to 40 cm. This species is restricted to the Porongorup Range where it occurs in moist sheltered positions on the upper slopes of granite outcrops. | Highly unlikely to occur, the Study Area is outside the known distribution of this species and the study area does not contain habitat for this species. |
| *Persoonia sulcata* | | | P4 | Erect, spreading to decumbent shrub, 0.2-1 m high. Flowers yellow from September to November. Occurs on lateritic or granitic soils. | Unlikely to occur given its currently known distribution. |
| *Phlebocarya pilosissima* subsp. *pilosissima* | | | P3 | Shortly rhizomatous, compactly tufted perennial, grass-like or herb, 0.15-0.4 m high. Flowers cream-white from August to October. Occurs on white or grey sand on lateritic gravel. | Unlikely to occur. Optimum habitat for this species does not occur in the Study Area. |
| *Pimelea calcicola* | | | P3 | Erect to spreading shrub, 0.2-1 m high. Flowers pink from September to November. Occurs on sand on coastal limestone ridges. | Potential to occur. Suitable habitat for this species is present within the Study Area. |
| *Schoenus capillifolius* | | | P3 | Semi-aquatic tufted annual, grass-like or herb (sedge), 0.05 m high. Flowers green, October to November. Occurs on brown mud and claypans. | Unlikely to occur. No suitable habitat for this species is present within the Study Area. |
| *Schoenus griffinianus* | | | P3 | Small, tufted perennial, grass-like or herb (sedge), to 0.1 m high. Flowers from September to October and occurs in white sand. | Potential to occur, there is suitable habitat for this species within the Study Area. |
| *Schoenus natans* | | | P4 | Aquatic annual, grass-like or herb (sedge), 0.3 m high. Flowers brown in October. Occurs in winter-wet depressions. | Potential to occur, there is suitable habitat for this species within the Study Area. |
| *Schoenus* sp. Bullsbrook | | | P2 | Grass-like or herb (sedge), ca 0.15 m high. Flowers green-brown. Occurs on grey peaty sand on low-lying flats. | Potential to occur. Suitable habitat is present within the Study Area. |
| *Schoenus* sp. Waroona (G.J. Keighery 12235) | | | P3 | Tufted annual, grass-like or herb (sedge), 0.02-0.06 m high. Flowers are brown-red-green, October to November. Occurs on clay or sandy clay on winter-wet flats. | Potential to occur. Suitable habitat is present within the Study Area. |
| *Stachystemon* sp. Keysbrook (R. Archer 17/11/99) | | | P1 | No information available. | Unknown. |

| Taxon | WC Act | EPBC Act | DEC | Habitat description (Source: Florabase, DSEWPaC SPRAT database) | Likelihood of occurrence |
|---|---|---|---|---|---|
| *Stylidium longitubum* | | | P3 | Erect annual (ephemeral), herb, 0.05-0.12 m high. Flowers pink from October to December. Occurs on sandy clay, clay on seasonal wetlands. | Unlikely to occur, optimum habitat for this species is not present in the Study Aerea, however there is one record within 5 km of the Study Area. |
| *Stylidium trudgenii* | | | P3 | Caespitose perennial, herb, 0.05-0.5 m high. Occurs on grey sand, dark grey to black sandy peat. Occurs on margins of winter-wet swamps and depressions. | Potential to occur. Suitable habitat for this species is present within the Study Area. |
| *Templetonia drummondii* | | | P4 | Prostrate or ascending shrub, 0.1-0.4(-0.6) m high. Flowers yellow and brown/purple from August to September. Occurs on lateritic soils. | Unlikely to occur given its preferred habitat and currently known distribution. |
| *Thelymitra dedmaniarum* (was *Thelymitra manginiorum*) | T | En | | Tuberous, perennial, herb to 0.8 m high. Flowers yellow November to December of January. *Thelymitra dedmaniarum* has been recorded in the Gidgegannup area. This species occurs on open wandoo woodland on red/brown sandy loam associated with dolerite and granite outcropping. | Unlikely to occur, given its known distribution. Additionally, optimum habitat for this species does not occur within the Study Area |
| *Thelymitra stellata* | T | En | | Tuberous, perennial, herb, Flowers yellow and brown, October to November. This widespread species is known from nine small populations between Eneabba and Mt Lesueur in the north, and scattered populations along the Darling Range, with one population known in the Narrogin District and one in the Katanning District. This species grows among low heath and scrub in Jarrah and Wandoo woodland, both on ridges and slopes, flats, also on riverbanks and breakaways. | Unlikely to occur, given its known distribution. Additionally, optimum habitat for this species does not occur within the Study Area |
| *Trithuria occidentalis* (was *Hydatella dioica*) | T | En | | Minute, semi-aquatic annual with male and female flowers borne on separate plants. This species is known from one population in Ellenbrook area in the Swan Coastal Plain. This species grows partly submerged on the edge of shallow, winter-wet claypans in very open shrubland of *Melaleuca lateritica*. | Unlikely to occur as only marginal habitat for this species occurs in the Study Area. |
| *Verticordia lindleyi* subsp. *lindleyi* | | | P4 | Erect shrub, 0.2-0.75 m high. Flowers pink in May or November to December or January. Occurs in sand, sandy clay on winter-wet depressions. | Present. This species was recorded in the Study Area. |

## Likelihood of occurrence assessment of conservation significant fauna species identified as potentially occurring within 10 km of the Study Area

| Species name | Status | | | Source | | Habitat requirements | Likelihood of occurrence |
|---|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | EPBC Act PMST | NatureMap search | | |
| **Birds** | | | | | | | |
| *Anous tenuirostris melanops* Australian Lesser Noddy | Vu | T | | | X | The Australian Lesser Noddy usually occupies coral-limestone islands that are densely fringed with White Mangrove *Avicennia marina*. It occasionally occurs on shingle or sandy beaches. The Australian Lesser Noddy roosts mainly in mangroves, especially at night but may sometimes rest on beaches (DSEWPaC 2013b). | Unlikely<br>There is no suitable habitat for this species within the Study Area. |
| *Botaurus poiciloptilus* Australasian Bittern | En | T | | | X | Densely vegetated freshwater wetlands and, rarely, in estuaries or tidal wetlands. In the southwest of Western Australia, the Bittern is found in beds of tall rush mixed with or near short fine sedge or open pools. It also occurs around swamps, lakes, pools, rivers and channels fringed with lignum Muehlenbeckia, canegrass Eragrostis or other dense vegetation. It occasionally ventures into areas of open water or onto banks (DSEWPaC 2013b). | Unlikely<br>There is no suitable habitat for this species within the Study Area. |
| *Burhinus grallarius* Bush Stone-curlew | | | P4 | | X | The Bush Stone-curlew prefers dry open woodland areas, lightly timbered country, mallee and mulga – anywhere with groundcover of small sparse shrubs, grass or litter of twigs. This species avoids dense forest, closed canopy habitats (Morcombe 2003). | Unlikely<br>There is some suitable habitat for this species within the Study Area. However this species is considered highly unlikely to occur in Swan Coastal Plain region (Davis 2009). |
| *Cacatua leadbeateri* Major Mitchell's | | S4 | | | X | The Major Mitchell's Cockatoo is found in two areas: along the Murchison River where it is not common, and in the northern and eastern Wheatbelt, through the | Unlikely<br>The Study Area is outside the currently known distribution for this species. |

| Species name | Status | | | Source | | Habitat requirements | Likelihood of occurrence |
|---|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | EPBC Act PMST | NatureMap search | | |
| Cockatoo | | | | | | Transitional Woodland to Lake Barlee. This species inhabits open, sparsely timbered grassland, farmland with well-treed paddocks, mulga and similar open scrub, open mallee country, Callitris and casuarina country, watercourse trees. It is never far from water (Morcombe 2003). | |
| *Cacatua pastinator pastinator* Muir's Corella (Western Corella SW WA) | Vu, Mi | T | | | X | Muir's Corella occurs in eucalypt woodlands dominated by wandoo, marri, or jarrah. This subspecies is confined to the extreme south-west of Western Australia. Its current distribution extends from McAlinden and Qualeup, south to the lower Perup River and Lake Muir, and east to Rocky Gully and Frankland. This species disappeared from the Swan River and Vasse River in colonial times (DSEWPaC 2013b). | Unlikely<br>The Study Area is outside the currently known distribution for this species. This species is considered to be locally extinct on the Swan Coastal Plain portion of the Perth Metropolitan region (Government of Western Australia 2000) |
| *Calyptorhynchus banksii naso* Forest Red-tailed Black Cockatoo | Vu | T | | X | | Typically dense Jarrah (*Eucalyptus marginata*), Karri (*E. diversicolor*) and Marri (*Corymbia calophylla*) forests, however the species also occurs in a range of other forest and woodland types, including Blackbutt (*E. patens*), Wandoo (*E. wandoo*), Tuart (*E. gomphocephala*), Albany Blackbutt, Yate (*E. cornuta*), and Flooded Gum (*E. rudis*) (DSEWPaC 2012b). | Unlikely<br>The Study Area contains suitable habitat for this species, including Marri-Jarrah forests and woodlands and scattered Tuart and Flooded Gum trees. These habitats provide suitable feeding habitat and potential breeding trees. However the Forest Red-tailed Black Cockatoo is almost entirely restricted to the forested Darling Range to the east of Perth and are not generally a concern within the Gnangara area (Davis 2009). |
| *Calyptorhynchus baudinii* Baudin's Black Cockatoo | Vu | T | | X | X | This species occurs in high-rainfall areas, usually at sites that are heavily forested and dominated by Marri and *Eucalyptus* species, especially Karri and Jarrah. The species also occurs in woodlands of | Unlikely<br>According to the EPBC Act Referral Guidelines (DSEWPaC 2012b) the Study Area is outside the currently known |

| Species name | Status | | | Source | | Habitat requirements | Likelihood of occurrence |
|---|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | EPBC Act PMST | NatureMap search | | |
| | | | | | | Wandoo, Blackbutt, Flooded Gum, and Yate (DSEWPaC 2012b). | foraging and breeding range for this species. |
| *Calyptorhynchus latirostris* Carnaby's Black Cockatoo | E | T | | X | X | This species mainly occurs in uncleared or remnant native eucalypt woodlands and in shrubland or kwongan heathland dominated by *Hakea*, *Dryandra*, *Banksia* and *Grevillea* species. The species also occurs in forests containing Marri, Jarrah or Karri (DSEWPaC 2012b). | Present<br>This species was recorded in the Study Area during the spring field survey. There is suitable foraging habitat and potential breeding and roosting habitat in the Study Area for this species, including the *Banksia* woodlands, Jarrah-Marrri forest and woodlands and scattered trees of Flooded Gum and Tuart. |
| *Falco peregrinus macropus* Australian Peregrine Falcon | | S4 | | | X | The Peregrine Falcon is seen occasionally anywhere in the south-west of Western Australia. It is found everywhere from woodlands to open grasslands and coastal cliffs - though less frequently in desert regions. It is widespread and uncommon but is known to nest and hunt in the Perth CBD and is not considered at risk from urbanisation (Davis 2009). | Likely<br>There is suitable habitat for this species in the Study Area, and it has previously been recorded in the Whiteman Park area. |
| *Ixobrychus flavicollis australis* Australian Black Bittern | | | P3 | | X | The Black Bittern inhabits both terrestrial and estuarine wetlands, generally in areas of permanent water and dense vegetation. Where permanent water is present, this species may occur in flooded grassland, forest, woodland, rainforest and mangroves (Marchant & Higgins 1990). | Unlikely<br>There is no suitable habitat for the species within the Study Area. |
| *Ixobrychus minutus dubius* Australian Little Bittern | | | P4 | | X | The species is most common in freshwater marshes with beds of bulrushes *Typha* spp., reeds *Phragmites* spp. (Hockey *et al.* 2005) or other dense aquatic vegetation, preferably also with deciduous bushes and trees. It may also occupy the margins of | Unlikely<br>There is no suitable habitat for the species within the Study Area. |

| Species name | Status | | | Source | | Habitat requirements | Likelihood of occurrence |
|---|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | EPBC Act PMST | NatureMap search | | |
| | | | | | | lakes, pools and reservoirs, wooded and marshy banks of streams and rivers (del Hoyo *et al*. 1992). | |
| *Leipoa ocellata* Malleefowl | Vu, Mi | T | | X | | Shrublands and low woodlands that are dominated by mallee vegetation, as well as native pine Callitris woodlands, *Acacia* shrublands, Broombush *Melaleuca uncinata* vegetation or coastal heathlands (Nevill 2008). | Unlikely<br>The Study Area is outside the currently known distribution for this species. |
| *Rostratula australis* Australian Painted Snipe | Vu, Mi | T | | X | | The Australian Painted Snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. Australian Painted Snipe breeding habitat requirements may be quite specific: shallow wetlands with areas of bare wet mud and both upper and canopy cover nearby (DSEWPaC 2013b). | Unlikely<br>There is no suitable habitat for the species within the Study Area. |
| *Sternula nereis nereis* Fairy Tern (Australian) | Vu | T | | X | X | The Fairy Tern (Australian) nests on sheltered sandy beaches, spits and banks above the high tide line and below vegetation. The subspecies has been found in embayments of a variety of habitats including offshore, estuarine or lacustrine (lake) islands, wetlands and mainland coastline (DSEWPaC 2013b). | Unlikely<br>There is no suitable habitat for this species within the Study Area. |
| *Tyto novaehollandiae novaehollandiae* Masked Owl (southern ssp.) | | | P3 | | X | This subspecies is restricted to the thicker humid forests of the south-west region, particularly in the Pemberton and Manjimup area and along the Murray River in the Lane Poole area. They roost mostly in large hollowed trees of marri, jarrah and karri (Nevill 2008). | Unlikely<br>The Study Area is considered to be outside the currently known distribution of this species, however there is suitable habitat for this species in the Study Area. |

| Species name | Status | | | Source | | Habitat requirements | Likelihood of occurrence |
|---|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | EPBC Act PMST | NatureMap search | | |
| **Migratory Terrestrial Birds** | | | | | | | |
| *Apus pacificus* Fork-tailed Swift | Mi | S3 | | X | X | In south-west WA there are sparsely scattered records along the south coast, ranging from the Eyre Bird Observatory and west to Denmark. They are widespread in coastal and sub-coastal areas between Augusta and Carnarvon, including some on nearshore and offshore islands. This species is almost exclusively aerial, flying less than 1 m to at least 300 m above ground. This species is considered rare in the south-west region (DSEWPaC 2013b). | Possible<br>There is potential this species may occur as an occasional vagrant however considering it is an almost exclusively aerial species, the Study Area is not considered to contain optimum habitat for this species. |
| *Ardea alba modesta* Eastern Great Egret | Mi | S3 | | X | X | The eastern Great Egret is widespread in Australia. They have been reported in a wide range of wetland habitats, include swamps and marshes; margins of rivers and lakes; damp or flooded grasslands, pasture or agricultural lands; reservoirs; sewerage treatment ponds; drainage channels; salt pans; salt marshes; mangrove, and a range of coastal/marine habitats (DSEWPaC 2013b). | Possible<br>This species is likely to occur as a opportunistic visitor to the Study Area, particularly after heavy rainfall when the seasonal damplands and drainage lines in the study Area are inundated with water. |
| *Ardea ibis* Cattle Egret | Mi | S3 | | X | X | The Cattle Egret is a common and widespread species. Typical habitat includes tropical and temperate grasslands, wooded lands and terrestrial wetlands. It often forages away from water on low lying grasslands, improved pastures and croplands and roosts in trees, or amongst ground vegetation in or near lakes and swamps. | Possible<br>This species is likely to occur as a opportunistic visitor to the Study Area, particularly after heavy rainfall when the seasonal damplands and drainage lines in the Study Area are inundated with water. |
| *Actitis hypoleucos* Common | Mi | S3 | | | X | This species is widespread and in small numbers and is found along all coastlines of Australia and in many areas inland. It | Unlikely<br>The Study Area does not contain suitable |

| Species name | Status | | | Source | | Habitat requirements | Likelihood of occurrence |
|---|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | EPBC Act PMST | NatureMap search | | |
| sandpiper | | | | | | utilises a wide range of coastal wetlands and some inland wetlands, with varying levels of salinity, and is mostly found around muddy margins or rocky shores and rarely on mudflats (DSEWPaC 2013b). | habitat for this species. |
| *Calidris acuminata* Sharp-tailed Sandpiper | Mi | S3 | | X | | This species is found from Carnarvon to Hamelin Bay occasionally on the coast but mostly in flooded samphire or the many bores with overfklow pools that create wet grassy areas. Found throughout many wetlands along the Swan Coastal Plain (Nevill 2008). | Unlikely<br>The Study Area does not contain suitable habitat for this species. |
| *Calidris ruficollis* Red-necked stint | Mi | S3 | | X | X | The Red-necked Stint is distributed along most of the Australian coastline with large densities on the Victorian and Tasmanian coasts. It is mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, near spits, islets and banks (DSEWPaC 2013b). | Unlikely<br>The Study Area does not contain suitable habitat for this species. |
| *Tringa glareola* Wood Sandpiper | Mi | S3 | | X | X | The Wood Sandpiper has its largest numbers recorded in north-west Australia. Typical habitat includes well-vegetated, shallow, freshwater wetlands, such as swamps, billabongs, lakes, pools and waterholes. This species does not breed in Australia (DSEWPaC 2013b). | Unlikely<br>The Study Area does not contain suitable habitat for this species. |
| *Tringa nebularia* Common Greenshank | Mi | S3 | | | X | The Common Greenshank does not breed in Australia; however, the species occurs in all types of wetland and has the widest distribution of any shorebird in Australia (DSEWPaC 2013b). | Unlikely<br>The Study Area does not contain suitable habitat for this species. |
| *Tringa stagnatilis* Marsh Sandpiper | Mi | S3 | | | X | The Marsh Sandpiper is found on coastal and inland wetlands throughout Australia. It | Unlikely<br>The Study Area does not contain suitable |

| Species name | Status | | | Source | | Habitat requirements | Likelihood of occurrence |
|---|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | EPBC Act PMST | NatureMap search | | |
| | | | | | | lives in permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, saltpans, saltmarshes, estuaries, pools on inundated floodplains, and intertidal mudflats and also regularly at sewage farms and saltworks (DSEWPaC 2013b). | habitat for this species. |
| *Plegadis falcinellus* Glossy Ibis | Mi | S3 | | | X | Within Australia, the Glossy Ibis is generally located east of the Kimberley. The species is also known to be patchily distributed in the rest of Western Australia. Its preferred habitat for foraging and breeding are freshwater marshes at the edges of lakes and rivers, lagoons, floodplains, wet meadows, swamps, reservoirs, sewerage ponds, rice-fields and cultivated areas under irrigation (DSEWPaC 2013b). | Unlikely<br>The Study Area contains limited suitable habitat for this species. The Glossy Ibis is considered scarce to uncommon on the Swan Coastal Plain (Neville 2008). |
| *Haliaeetus leucogaster* White-bellied Sea-Eagle | Mi | S3 | | X | | Coastal habitats (especially those close to the sea-shore as well as any habitat characterized by the presence of large areas of open water (larger rivers, swamps, lakes, the sea) (Morcombe 2003). | Unlikely<br>The Study Area does not contain suitable habitat for this species. |
| *Merops ornatus* Rainbow Bee-eater | Mi | S3 | | | X | Open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation. It also inhabits sand dune systems in coastal areas and at inland sites that are in close proximity to water (DSEWPaC 2013b). | Present<br>The Rainbow Bee-eater was recorded in the Study Area during the spring field survey. The Study Area contains suitable habitat for this species. |
| **Mammals** | | | | | | | |
| *Bettongia penicillata ogilbyi* Woylie | En | T | | | X | Preferred habitat included dense undergrowth, logs and rock-cavities and occasionally in burrows (Burbidge 2004). | Unlikely<br>This species has experienced considerable population decline in the wild, and only |

| Species name | Status | | | Source | | Habitat requirements | Likelihood of occurrence |
|---|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | EPBC Act PMST | NatureMap search | | |
| | | | | | | Scattered Woylie populations may be found throughout the Jarrah forest in the south-west corner of Western Australia. Extant naturally occurring populations are restricted to three small wheatbelt reserves in WA – Dryandra Woodland, Tutanning Nature Reserve and Perup Forest. All are characterised by the presence of thickets of the plant *Gastrolobium* (Van Dyck and Strahan 2008). | naturally occurs in three wheatbelt reserves in WA. The presence of feral cats and foxes would reduce the likelihood of the species. |
| *Dasyurus geoffroii* Chuditch | Vu | T | | X | X | Eucalypt forest (especially Jarrah), dry woodland and mallee shrublands. In Jarrah forest, Chuditch populations occur in both moist, densely vegetated, steeply sloping forest and drier, open, gently sloping forest (DSEWPaC 2013b). | Unlikely<br>The Chuditch had disappeared from the Swan Coastal Plain by the 1930s, according to Orell and Morris (1994). |
| *Hydromys chrysogaster* Water-rat | | | P4 | | X | The Water Rat lives in the vicinity of permanent bodies of fresh and brackish water-from subalpine streams to lakes and farm dams-and on sheltered coastal beaches, mangroves and offshore islands (Van Dyck and Strahan 2008). | Unlikely<br>The Study Area does not contain suitable habitat for this species. |
| *Isoodon obesulus fusciventer* Southern Brown Bandicoot / Quenda | | | P5 | | X | This species is found in forest, woodland, shrub and heath communities at localities in southern and eastern Australia, and these sites generally display a combination of sandy soils with dense healthy vegetation in the lower stratum (Van Dyck and Strahan 2008). | Present<br>Bandicoot diggings were recorded in the Study Area during the spring field survey. The Study Area provides some suitable habitat for this species, restricted mainly to vegetation associated with a dense understorey, particularly near low-lying damplands. This species is known to occur in Whiteman Park. |

| Species name | Status | | | Source | | Habitat requirements | Likelihood of occurrence |
|---|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | EPBC Act PMST | NatureMap search | | |
| *Macropus irma* Western Brush Wallaby | | | P4 | | X | Habitat includes open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets. It is also found in some areas of mallee and heathland, and is uncommon in karri forest (Van Dyck and Strahan 2008). | Present<br>The Western Brush Wallaby was recorded in the Study Area during the spring field survey. One individual was observed in the Jarrah-Marri-*Banksia* Woodland east of Beechboro Road. Suitable habitat for this species occurs throughout the Study Area, particularly in vegetation east of Beechboro Road. This species is known to occur in Whiteman Park. |
| *Macrotis lagotis* Greater Bilby | Vu | T | | | X | The Greater Bilby occupies three major vegetation types; open tussock grassland on uplands and hills, mulga woodland/shrubland growing on ridges and rises, and hummock grassland in plains and alluvial areas. In the south of its range, the Greater Bilby lives on rises and ridges among sparse grasses, especially mitchell grass Astrebla and short shrubs. In Western Australia there are disjunct populations in the Gibson Desert, south-western Kimberley, inland areas of the Pilbara and northern Great Sandy Desert (Van Dyck and Strahan 2008). | Unlikely<br>This species has experienced a substantial decline in its distribution. This species was formerly found in south-western Australia but is now locally extinct. |
| *Myrmecobius fasciatus* Numbat | Vu | T | | | X | The numbat's distribution once encompassed a number of habitat types, including eucalypt forest, eucalypt woodland, Acacia woodland and *Triodia* grasslands. Current populations occupy several different habitat types: upland Jarrah forest, open eucalypt woodland, banksia woodland and tall closed shrubland. There are currently two remnant native populations at Dryandra and Perup, | Unlikely<br>Given the numbat's current restricted distribution, it is unlikely to occur within the Study Area. |

| Species name | Status | | | Source | | Habitat requirements | Likelihood of occurrence |
|---|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | EPBC Act PMST | NatureMap search | | |
| | | | | | | WA and several reintroduced populations including Boyagin Nature Reserve, Tutanning Nature Reserve, Batalling block and Karroun Hill Nature Reserve. At Dryandra, numbats inhabit brown mallet (*Eucalyptus astringens*) plantations. Habitats usually have an abundance of termites in the soil, hollow logs and branches for shelter (Van Dyck and Strahan 2008). | |
| *Phascogale tapoatafa tapoatafa* Southern Brush-tailed Phascogale | | T | | | X | Brush-tailed Phascogales are one of the most arboreal dasyurids and seldom feed on the ground. They occur in dry sclerophyll forests and open woodlands with a generally sparse ground-storey, which contain suitable nesting resources such as tree hollows, rotted stumps and tree cavities (Van Dyck and Strahan 2008). | Unlikely<br>The Study Area contains suitable habitat (including suitable nesting resources) for the Southern Brush-tailed Phascogale. However this species is considered to be extinct from the northern Swan Coastal Plain (Wilson *et al*. 2010). |
| **Reptiles** | | | | | | | |
| *Pseudemydura umbrina* Western Swamp Turtle | Cr | T | | X | X | This species currently occurs in a single viable population in the wild, with a further two populations maintained by supplementation with translocated individuals. The Ellen Brook Nature Reserve population is the only viable, naturally occurring population in the wild. The Twin Swamps Nature Reserves and Mogumber Nature Reserve populations are maintained with translocated individuals (DSEWPaC 2013b). | Unlikely<br>The Study Area does not contain suitable habitat for this species. |
| *Neelaps calonotos* Black-striped | | | P3 | | X | This Black-striped Snake is restricted to the sandy coastal strip near Perth, between Mandurah and Lancelin. It occurs on dunes | Likely<br>Suitable habitat for the Black-striped Snake is present within the Study Area and there |

| Species name | Status | | | Source | | Habitat requirements | Likelihood of occurrence |
|---|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | EPBC Act PMST | NatureMap search | | |
| Snake | | | | | | and sand-plains vegetated with heaths and eucalypt/banksia woodlands. This species is seriously threatened by increasing development within its restricted distribution (Wilson and Swan 2008). | are a number of records of this species within 10 km of the Study Area (DEC and WAM 2013). |
| *Ctenotus gemmula* (Swan Coastal Plain Population) | | | P3 | | X | This species occurs in two isolated populations in Western Australia; one along the lower west coastal plain from Cataby south to Perth, the second along the south coast and adjacent interior, from Rocky Gully east to the beginning of the Great Australian Bight, and inland to Lake Magenta (Maryan and Shea 2010). Preferred habitat includes pale sand-plains supporting heaths in association with banksia or mallee woodland (Wilson and Swan 2008). | Likely<br>There is suitable habitat present for this species within the Study Area. This species has previously been recorded within 5 km of the Study Area. |
| *Morelia spilota imbricata*<br>Carpet Python | | S4 | P4 | | X | Semi-arid coastal and inland habitats, Banksia woodland, eucalypt woodlands, and grasslands. The carpet python generally occurs in large, undisturbed bush; and areas, preferring coastal limestone and woodlands on the Swan Coastal Plain (Bush *et al.* 1995; 2010). | Likely<br>There is suitable habitat present for this species within the Study Area, and it has been recorded within 10 km of the Study Area. It is likely that the Carpet Python would only occur in larger areas of contiguous native vegetation within the Study Area. |
| **Fish** | | | | | | | |
| *Galaxiella nigrostriata*<br>Black-stripe Minnow | | | P3 | | X | This freshwater fish generally lives in acidic black water (tannin stained) in seasonal wetlands between Muchea and Albany, but mostly within the Swan Coastal Plain. These wetlands only hold water for about half of the year. Also found in a range of conditions from slow-flowing rivers, swamps, | Unlikely<br>The Study Area does not contain suitable habitat for this species. |

| Species name | Status | | | Source | | Habitat requirements | Likelihood of occurrence |
|---|---|---|---|---|---|---|---|
| | EPBC Act | WC Act | DEC | EPBC Act PMST | NatureMap search | | |
| | | | | | | freshwater lakes and pools, and road side ditches. It can often be found in and around submerged vegetation in lakes and swamps (Morgan *et al*. 1996; Allen *et al*. 2002). | |
| *Geotria australis* Pouched lamprey | | | P1 | | X | Sporadic records exist throughout the South West Coast Drainage Division between Perth and Albany including the Swan, Canning, Serpentine, Margaret, Donnelly, Warren and Goodga rivers. | Unlikely<br>The Study Area does not contain suitable habitat for this species. |
| **Invertebrates** | | | | | | | |
| *Synemon gratiosa* Graceful Sun Moth | | | P4 | X | X | The Graceful Sun-moth is closely associated with Banksia woodland. The species is also dependent upon *Lomandra maritima* and *L. hermaphrodita* being present for breeding. | Possible<br>The Study Area contains some suitable habitat for this species, particularly in vegetation associated with the *Banksia* woodlands. However no *Lomandra maritima* or *L. hermaphrodita* was recorded in the Study Area. This species has been recorded within 10 km of the Study Area (DEC and WAM 2013). |
| *Hylaeus globuliferus* Bee | | | P3 | | X | This native bee is thought to favour flowers of *Adenanthos cygnorum* for feeding, but has also been recorded on *Banksia attenuata*. | Possible<br>The only known record of this species within 10 km of the Study Area was recorded in 1957. Suitable habitat is present within the Study Area. |

# Appendix F – Preliminary Site Investigation Report

# Appendix G – Ethnographic and Archaeological Survey Report

# Appendix H – Non-Indigenous Heritage Survey-

GHD

GHD House, 239 Adelaide Tce. Perth, WA 6004
P.O. Box 3106, Perth WA 6832
T: 61 8 6222 8222  F: 61 8 6222 8555  E: permail@ghd.com.au



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