Fauna Assessment for VRX Silica
Muchea Silica Sand Project

Little Dunnart *Sminthopsis 'dolichura'* captured in the Project Area (Photo:Tim Gamblin)

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Executive Summary

Overview

Bamford Consulting Ecologists (BCE) were commissioned by VRX Silica (VRX) to conduct a Detailed (level 2) fauna assessment for the Muchea Silica Sands project (Project). A level 2 assessment involves a site inspection, desktop review and field investigations. The purposes of this report are: to provide information on the fauna values of the Project Area, particularly for significant species, and to provide an overview of the ecological function of the site within the local and regional context. This information is required by the proponent (VRX) and government agencies to decide upon the significance of impacts of the proposed development.

Project Area Description

For the purposes of this report, the Project Area refers to the area in which the fauna assessment was conducted. The development footprint of the Project (expected to be a smaller area within the Project Area) has not yet defined.

The Project Area is located approximately 44 kilometres (km) north-east of Perth and 15 km south of Gingin within the Shire of Chittering. It occupies exploration lease E70/4886, covering an area of approximately 3395 hectares (ha). The Project Area is largely a greenfields site comprising native vegetation with a few abandoned farming buildings. It supports a mixture of intact native vegetation comprising Banksia woodland on elevated sand dunes, pockets of Marri and Jarrah woodland and Melaleuca shrublands, across a landscape of undulating low rises on Bassendean sands.

Field Investigations

The field survey incorporated a range of survey techniques to maximise sampling results. The following techniques were used:

- Identification of VSAs;
- Systematic sampling transects;
    - Pit trapping
    - Funnel trapping
    - Bird census
- Black-Cockatoo foraging value assessment;
- Motion-sensitive cameras;
- Bat echolocation devices;
- Opportunistic observations; and
- Opportunistic invertebrate collection.

Vegetation and Substrate Associations (VSAs)

Three broad VSAs were identified within the Project Area from aerial images, during the field investigations and cross-referencing with botanical surveys: VSA 1 - Low-lying Melaleuca shrubland; VSA 2 - Eucalypt woodland; and VSA 3 - Banksia woodland (also an Endangered ecological community listed by the federal Department of the Environment and Energy (DEE) and a Priority 3

ecological community listed by the state Department of Biodiversity, Conservation and Attractions (DBCA)).

Fauna assemblage and significant species

The desktop study identified 215 vertebrate fauna species as potentially occurring in the Project Area, comprising ten frogs, 49 reptiles, 128 birds and 28 mammals. The field investigations confirmed the presence of 79 vertebrate fauna species, comprising three frogs, 21 reptiles, 41 birds and 14 mammals. The assemblage includes 56 conservation significant vertebrate species, comprising four reptile, 42 bird and ten mammal species. Field investigations confirmed the presence of 20 species of conservation significance including both Carnaby's and Forest Red-tailed Black-Cockatoos. The capture of the Little Dunnart and Noodji in the Project Area is significant given these species are considered to be rare in the general area. They are at the southern edge of their range in the Project Area and are extinct closer to Perth. Six conservation significant invertebrate species are expected to occur in the Project Area.

The key features of the fauna assemblage expected in the Project Area are:

- Uniqueness: The expected assemblage is typical of Banksia woodlands of the Swan Coastal Plain with this assemblage expected in similar habitats across the coastal plain nearby. However, the large extent, high degree of connectivity and intact condition of the bushland within the Project Area means that it is likely to support a number of woodland birds, reptiles and several small mammal species that are less prevalent in remnant bushland areas in the region, particularly closer to Perth. This area represents the southern extent of the range of some reptiles and mammals.
- Completeness: The assemblage is likely to be intact in terms of frogs, reptiles and birds due to the extent and intact condition of the environment, but incomplete in terms of mammals due to the loss of some mammal species from habitat loss and feral predation.
- Richness: The assemblage is moderately rich in the local context given the intact condition of the woodland and connectivity to nearby bushland areas.

Based on a detailed foraging assessment system developed by BCE which incorporates presence and quality of food plants, context and species density, the majority of the Project Area was found to be of moderate and high foraging quality for Carnaby's Black-Cockatoo, representing about 10% of foraging habitat for the species within 12km of the Project Area respectively. A smaller part of the Project Area, outside the development footprint, was of moderate foraging value for the Forest Red-tailed Black-Cockatoo. No roosting or breeding of either black-cockatoo species was recorded, with known roost and breeding sites mostly outside the 12km radius, but the eucalypt woodlands that lie outside the development footprint have potential for both roosting and breeding.

Patterns of biodiversity

The patterns of biodiversity within the Project Area are likely to be largely homogenous given the similar environment which occurs across the majority of the Project Area. There is expected to be a high level of vertebrate fauna diversity, particularly reptiles, in the banksia and eucalypt woodlands which occurs across the Project Area. The patches of Marri and Jarrah woodland may support higher diversity of birds, as recorded during field investigations. The high diversity across the Project Area is expected because the woodlands are of excellent condition, with high quality understorey vegetation containing few weeds, and are well-connected to wider bushland to the west and south. The Melaleuca shrubland has experienced historical clearing which may reflect reduced fauna richness; this was not evident in field investigations with bird diversity being highest at this site. The northern sampling sites (mostly Banksia woodland) recorded markedly higher abundance and richness of reptiles which may reflect the more complex vegetation structure present in the north due to the longer length of time following wildfire.

Key ecological processes

Key ecological processes that may be important for ecosystem function in the Project Area include:

Fire. The Project Area has been subjected to at least three fires of varying intensity and coverage over the last ten years, and a fire break extending from east to west was installed in 2011 around the time of one extensive fire that that burned the approximate northern half. The most recent fire appears to have burnt the southern half in 2015.

Feral species and interactions with over-abundant native species. Feral species occur throughout Western Australia, particularly in areas close to urban areas. The Rabbit, Fox, Cat, House Mouse, Dog and Pig were recorded during field investigations and are likely to be resident in the Project Area. Feral predation has caused historical mammal species loss across the coastal plain and increased feral species may cause further mammal and bird species loss in the vicinity of the Project Area. Honey bees are almost certainly present in tree hollows in the Project Area.

Hydrology. While there are no surface drainage systems, much of the vegetation, particularly in low-lying areas, interacts with the unconfined aquifer and impacts to the groundwater could lead to habitat degradation.

Connectivity and landscape permeability. The Project Area is part of a larger and extensive area of native vegetation and has continuous connectivity with Yeal Nature Reserve to the northwest, Gnangara/Moore River State Forest to the southwest, and Melaleuca Park bushland to the south. Historical land clearing for semi-rural use and major roads have led to considerable habitat fragmentation to the east. Connectivity is thus very good to the west but poor to the east, affecting movement of fauna from the coastal plain to the escarpment.

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1 Introduction

Bamford Consulting Ecologists (BCE) was commissioned by Ventnor Resources to conduct a detailed (Level 2) fauna assessment for the Muchea Silica Sand Project (Project), a proposed greenfields mining operation to extract silica sand to be used in the manufacture of glass and for a range of industrial process applications.

A detailed assessment involves a desktop review and field investigations. The purposes of this report are: to provide information on the fauna values of the Project Area, particularly for significant species; to provide an overview of the ecological function of the site within the local and regional context. This report presents the results of a database review and field investigations in the Project Area.

1.1 General Approach to Fauna Impact Assessment

The purpose of impact assessment is to provide government agencies and proponents with the information they need to decide upon the significance of impacts of a proposed development. BCE uses an impact assessment process with the following components:

- The identification of fauna values:
    - Assemblage characteristics: uniqueness, completeness and richness;
    - Species of conservation significance;
    - Recognition of ecotypes or vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
    - Patterns of biodiversity across the landscape; and
    - Ecological processes upon which the fauna depend.
- The review of impacting processes such as:
    - Habitat loss leading to population decline;
    - Habitat loss leading to population fragmentation;
    - Degradation of habitat due to weed invasion leading to population decline;
    - Ongoing mortality from operations;
    - Species interactions including feral and overabundant native species;
    - Hydrological change;
    - Altered fire regimes; and
    - Disturbance (dust, light, noise).
- The recommendation of actions to mitigate impacts.

In this report, only the identification of fauna values is presented. Assessment of the Project's impacts on fauna and other environmental values will be conducted independent of this report.

Descriptions and background information on these values and processes can be found in Appendices 1 to 4. In particular, Appendix 1 explains and defines the fauna values, including the recognition of three classes of species of conservation significance (CS): those listed under legislation (CS1), those listed as priority by the Department of Biodiversity, Conservation and Attractions (CS2), and those that can be considered of local or other significance, but which have no formal listing (CS3). Appendix 2 describes threatening processes, while Appendix 3 outlines

the legal definitions and classes of conservation significance, and Appendix 4 presents the threatening processes recognised under legislation.

1.2 Description of Project Area

For the purposes of this report, the term 'Project Area' refers to the area in which the fauna assessment was conducted. The development footprint of the Project (a smaller area within the Project Area) has not yet defined.

The regional location of the Project Area is approximately 44 kilometres (km) north-east of Perth and 15 km south of Gingin within the Shire of Chittering (Figure 1-1). The Project Area is located in exploration lease E70/4886 and covers an area of approximately 3,395 hectares (ha; Figure 1-2).

The Project Area is situated on unallocated crown land adjacent to freehold farmland and is bounded by the Gingin Airfield to the north, Yeal Nature Reserve and Gnangara/Moore River State Forest to the west. Muchea townsite lies to the south and the Brand Highway to the east. For the purpose of this report, the Project Area is synonymous with the exploration lease. The development footprint has not been defined but is probably restricted to the north of the lease.

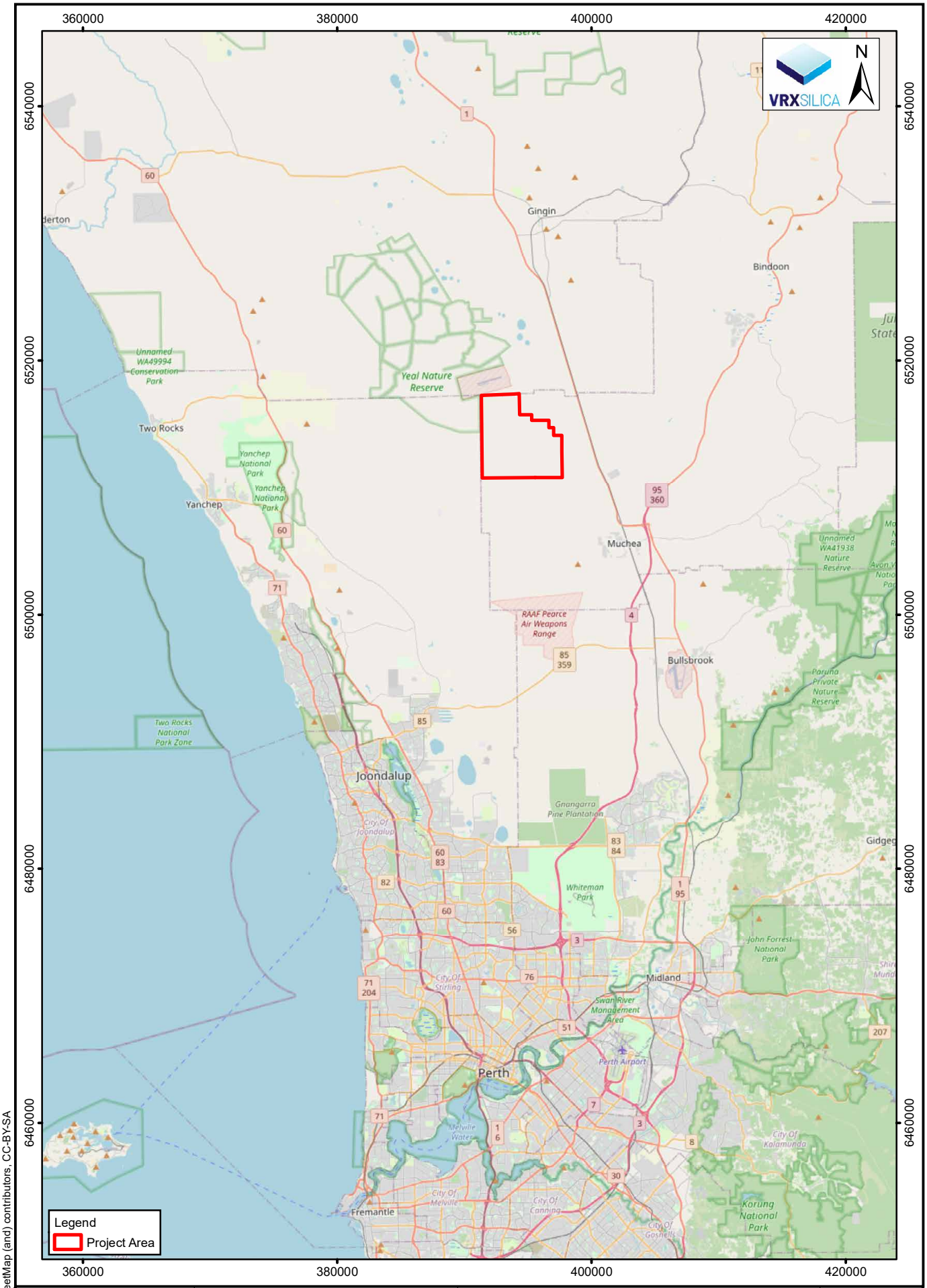
The Project Area is largely a greenfields site comprising native vegetation with a few abandoned farming buildings. It supports a mixture of intact native vegetation comprising Banksia woodland on elevated sand dunes, pockets of Marri and Jarrah woodland and Melaleuca shrublands, across a landscape of undulating low rises on Bassendean sands.

There are no permanent watercourses within the Project Area although lower-lying areas east of the Project Area are subject to seasonal inundation where shallow surface water may be present temporarily after significant rainfall. Aerial imagery indicates that the Project Area has been subjected to several fires of varying intensity over the last ten years and a fire break extending from east to west was installed in 2011 around the time of one extensive fire. There are also tracks through the Project Area, some accessing Department of Water and Environmental Regulation monitoring bores.

The Project Area and extensive adjacent southern bushland to the west of Muchea and the Project Area is included within the Strategic Assessment of Perth and Peel Regions (2015) as a proposed expansion of conservation reserves. This reserve expansion is highlighted within the Strategic Assessment as being key to meeting conservation outcomes.

The Interim Biogeographic Regionalisation of Australia (IBRA) has identified 26 bioregions in Western Australia which are further divided into subregions (Environment Australia 2000). Bioregions are classified on the basis of climate, geology, landforms, vegetation and fauna (Thackway and Cresswell, 1995). IBRA Bioregions are affected by a range of different threatening processes and have varying levels of sensitivity to impact (EPA, 2004). The Project Area lies in the Swan Coastal Plain Perth Subregion (Figure 1-3).

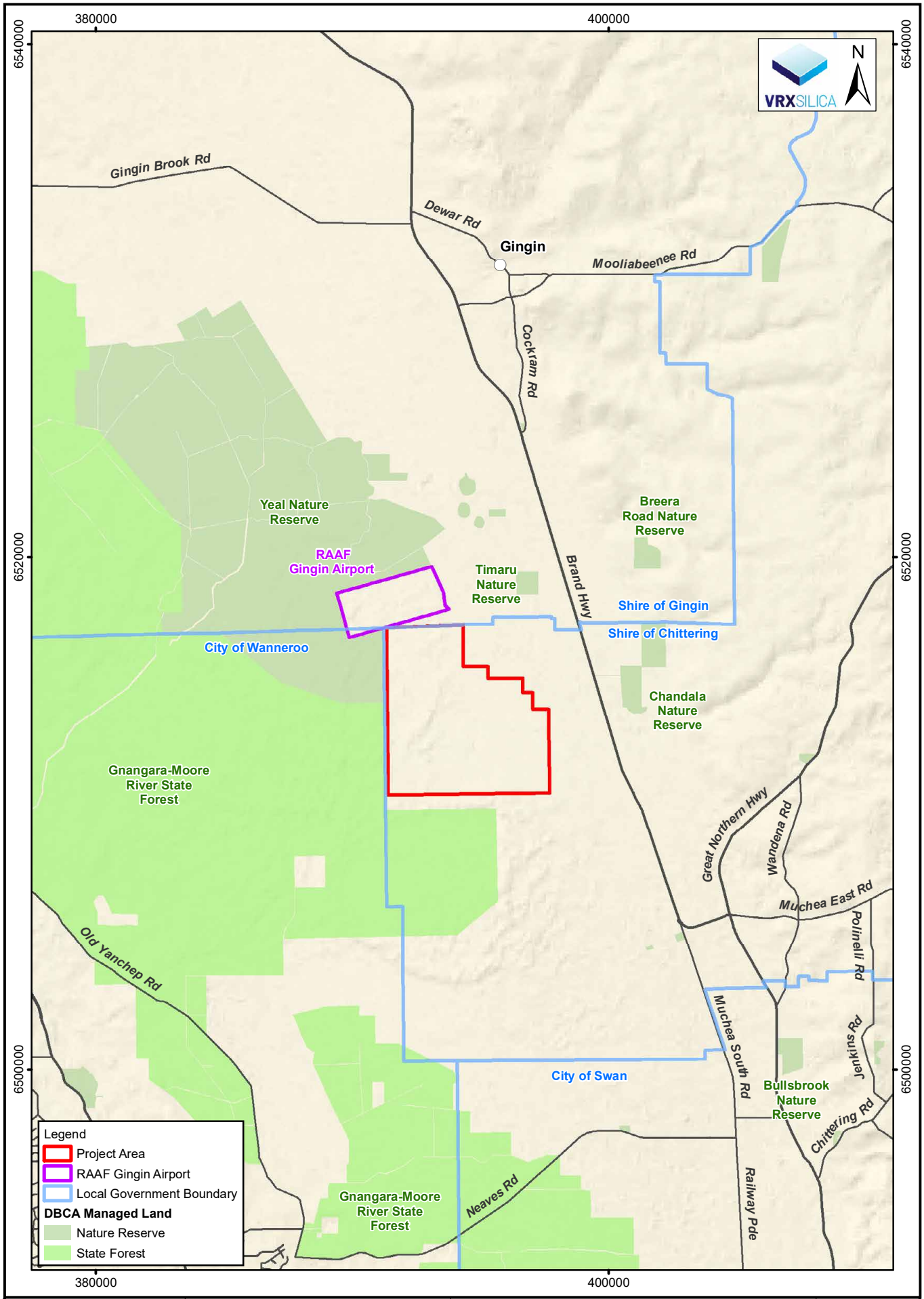
The subregion is characterised by 'low lying coastal plain covered with woodland dominated by *Banksia* or Tuart on sandy soils, *Casuarina obesa* on outwash plains, and paperbark in swampy areas. The subregion is composed of colluvial and aeolian sands, alluvial river flats, and coastal limestone' (Mitchell *et al.* 2003). The dominant land uses in this subregion are mainly cultivation, conservation, UCL and Crown reserves, urban, rural residential, plantations, forestry-plantations, roads and other easements and infrastructure, and grazing.



Source: © OpenStreetMap (and) contributors, CC-BY-SA

0 6 km Scale: 1:400,000 MGA94 (Zone 50)	BCE	**Project Location**	Figure: **1-1**
CAD Ref: a2576_MCE_f01_01	Author: M. Bamford		
Date: August 2022 | Rev: A | A4	Drawn: CAD Resources ~ www.cadresources.com.au Tel: (08) 9246 3242 ~ Fax (08) 9246 3202		

Figure 1-1. Location of the Project Area (indicated on map as "Site").



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Scale: 1:200,000
MGA94 (Zone 50)

BCE

Author: M. Bamford
Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

CAD Ref: a2576_MCE_f01_04
Date: August 2022 | Rev: A | A4

Source:

Project Area

Figure: **1-2**

Figure 1-2: Project Area boundary

Figure 1-3. IBRA Subregions in Western Australia. Note the Project Area lies in the SWA2 Perth IBRA subregion (location of Project Area indicated on figure by a star).

2 Methods

2.1 Overview

This approach to fauna impact assessment has been developed with reference to guidelines and recommendations set out by the Western Australian Environmental Protection Authority (EPA) on fauna surveys and environmental protection (EPA 2002, 2016a, b, 2020), and Commonwealth biodiversity legislation (DotE 2013; DSEWPaC 2013). The EPA (2020) recommends three levels of investigation that differ in their approach for field investigations:

- Basic – a low-intensity survey, conducted at the local scale to gather broad fauna and habitat information (formerly referred to as a level 1). The primary objectives are to verify the overall adequacy of the desktop study, and to map and describe habitats. A basic survey can also be used to identify future survey site locations and determine site logistics and access. The results from the basic survey are used to determine whether a detailed and/or targeted survey is required. During a basic survey, opportunistic fauna observations should be made and low-intensity sampling can be used to gather data on the general faunal assemblages present. While referred to as 'basic', this level of survey is involved and powerful, and should be considered the primary level of assessment. Other levels of assessment (where deemed necessary) add information to inform this primary level.
- Detailed – a detailed survey to gather quantitative data on species, assemblages and habitats in an area (formerly referred to as level 2). A detailed survey requires comprehensive survey design and should include at least two survey phases appropriate to the biogeographic region (bioregion). Surveys should be undertaken during the seasons of maximum activity of the relevant fauna and techniques should be selected to maximise the likelihood that the survey will detect most of the species that occur, and to provide data to enable some community analyses to be carried out.
- Targeted – to gather information on significant fauna and/or habitats, or to collect data where a desktop study or field survey has identified knowledge gaps. Because impacts must be placed into context, targeted surveys are not necessarily confined to potential impact areas. A targeted survey usually requires one or more site visits to detect and record significant fauna and habitats. For areas with multiple significant species there may not be a single time of year suitable to detect all species. In these cases, multiple visits, each targeting different species or groups, should be conducted.

The level of assessment recommended by the EPA (2020) is determined partly by geographic position, with a generic statement that detailed surveys are expected across all of the state except the south-west, but also recommending that site and project characteristics be considered. These include: survey objectives, existing available data, information required, presence of significant species, the scale and nature of the potential impacts of the proposal, and the sensitivity of the surrounding environment in which the disturbance is planned (including extent of existing regional impact). These aspects should be considered in the context of the information acquired by the desktop study. The EPA (2016c) also indicates that the scale and nature of the proposal can be used to determine the appropriate level of investigations, with, for example, large scale projects requiring higher levels of investigations. This sort of advice from the EPA (2016c, 2020) provides a framework for determining the appropriate level

of field investigations. The Project Area lies on the Swan Coastal Plain and thus in a region where the EPA (2020) suggests a detailed survey may not be required, but the detailed approach was taken due to the location close to reserves and in a partly fragmented landscape.

The following approach and methods are divided into two groupings that relate to the stages and the objectives of impact assessment:

- **Desktop assessment**. The purpose of the desktop assessment is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the Project Area based on unpublished and published data using a precautionary approach.

- **Field investigations**. The purpose of the field investigations is to gather information on this assemblage: confirm the presence of as many species as possible (with an emphasis on species of conservation significance), place the list generated by the desktop review into the context of the environment of the Project Area, collect information on the distribution and abundance of this assemblage, and develop an understanding of the Project Area's ecological processes that maintain the fauna. Note that field investigations can neither confirm the presence of an entire assemblage nor confirm the absence of a species. This requires far more work than is possible in the EIA process. For example, in an intensive trapping survey, How and Dell (1990) recorded in any one year only about 70% of the vertebrate species found over three years. In a study spanning over two decades, Bamford *et al.* (2010) has found that the vertebrate assemblage varies over time and space, meaning that even complete sampling at a set of sites only defines the assemblage of those sites at the time of sampling.

2.2 Desktop Assessment

2.2.1 Sources of information

Information on the fauna assemblage of the survey area was drawn from a wide range of sources. These included state and federal government databases and results of regional studies. Databases accessed were the Atlas of Living Australia (ALA), Department of Biodiversity, Conservation and Attractions (DBCA) NatureMap (incorporating the Western Australian Museum's FaunaBase and the DBCA Threatened and Priority Fauna Database), BirdLife Australia's Atlas Database (BA) and the EPBC Protected Matters Search Tool of the Department of Energy and the Environment (DEE) (

Table **2-1**). Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were:

- Frogs: Tyler *et al.* (2009) and Anstis (2013);
- Reptiles: Storr *et al.* (1983, 1990, 1999 and 2002) and Wilson and Swan (2017);
- Birds: Johnstone and Storr (1998, 2005) and Barrett *et al.* (2003); and
- Mammals: Menkhorst & Knight (2004); Churchill (2008); and Van Dyck and Strahan (2008).

Table 2-1. Sources of information used for the desktop assessment.

Database	Type of records held on database	Area searched
Atlas of Living Australia	Records of biodiversity data from multiple sources across Australia.	Point search: 31° 29' 55"S, 115° 53' 15"E plus 20 km buffer. Searched: May 2018.
NatureMap (DBCA)	Records in the WAM and DBCA databases. Includes historical data and records on Threatened and Priority species in WA.	Point search: 31° 29' 55"S, 115° 53' 15"E plus 20 km buffer. Searched: May 2018
BirdLife Australia Atlas Database (Birdlife Australia)	Records of bird observations in Australia, 1998-2014.	Point search: 31° 29' 55"S, 115° 53' 15"E plus 10 km buffer. Searched: May 2018.
EPBC Protected Matters (DEE)	Records on matters of national environmental significance protected under the EPBC Act.	Point search: 31° 29' 55"S, 115° 53' 15"E plus 10 km buffer. Searched: May 2018

2.2.2 Previous fauna surveys and studies

The northern Swan Coastal Plain is known for its high biodiversity. A number of state government studies have been carried out to better understand the regional and biodiversity values in the area, especially terrestrial fauna at a landscape scale, such as Valentine *et al*. (2009) and Reaveley & Bettink (2009). Extensive fauna surveys have been conducted on the Plain by BCE and other organisations (for example, How *et al.* (2009b); Bancroft *et al.* (2018); and Bamford *et al.* (2015)), such that the fauna in the area are well-known.

2.2.3 Nomenclature and taxonomy

As per the recommendations of EPA (2020), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's (WAM) Checklist of the Fauna of Western Australia 2016. The authorities used for each vertebrate group were: Doughty *et al.* 2016a (amphibians); Doughty *et al*. 2016b (reptiles); Johnstone and Darnell 2016 (birds); and Travouillon 2016 (mammals). In some cases, more widely-recognised names and naming conventions have been followed, particularly for birds where there are national and international naming conventions in place (e.g. the BirdLife Australia working list of names for Australian Birds). English names of species where available are used throughout the text; Latin species names are presented with corresponding English names in tables in the appendices.

2.2.4 Interpretation of species lists

Species lists generated from the review of sources of information are generous as they include records drawn from a large region and possibly from environments not represented in the survey area. Therefore, some species that were returned by one or more of the data searches have been excluded because their ecology, or the environment within the survey area, meant that it is highly unlikely that these species will be present. Such species can include, for example, seabirds that might occur as extremely rare vagrants at a terrestrial, inland site, but for which the Project Area is of no importance. Similarly, waterbirds were generally excluded even though

they could over-fly the site, since the site provides little habitat for them. The only exceptions were species that might nest on the site, such as some duck species that nest in tree hollows, and species that might use seasonally inundated paddocks. Species returned from databases but excluded from species lists due to lack of suitable habitat are presented in Appendix 7. Locally extinct species are included in Appendix 7.

Species returned from the databases and not excluded on the basis of ecology or environment are therefore considered potentially present or expected to be present in the survey area at least occasionally, whether or not they were recorded during field surveys, and whether or not the survey area is likely to be important for them. This list of expected species is therefore subject to interpretation by assigning each a predicted status in the survey area.

The status categories used are:

- **Resident:** species with a population permanently present in the survey area;
- **Migrant or Regular Visitor**: species that occur within the Project Area regularly in at least moderate numbers, such as part of an annual cycle;
- **Irregular Visitor**: species that occur within the Project Area irregularly such as nomadic and irruptive species. The length of time between visitations could be decades but when the species is present, it uses the Project Area in at least moderate numbers and for some time;
- **Vagrant**: species that occur within the Project Area unpredictably, in small numbers and/or for very brief periods. Therefore, the Project Area is unlikely to be of importance for the species; and
- **Locally Extinct**: species that would have been present but have not been recently recorded in the local area and therefore is almost certainly no longer present in the Project Area.

These status categories make it possible to distinguish between vagrant species, which may be recorded at any time but for which the site is not important in a conservation context, and species which use the site in other ways but for which the site is important at least occasionally. This is particularly useful for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile or irruptive, and further recognises that even the most detailed field survey can fail to record species which will be present at times, or may have been previously confirmed as present. The status categories are assigned conservatively. For example, a lizard known from the general area is assumed to be a resident unless there is very good evidence that the site will not support it, and even then it may be classed as a vagrant rather than assumed to be absent if the site might support dispersing individuals. It must be stressed that these status categories are predictions only and that often very intensive sampling would be required to confirm a species' status.

2.3 Field Investigation

2.3.1 Survey overview

The field survey incorporated a range of survey techniques to maximise sampling results. The following techniques were used:

- Identification of VSAs;
- Systematic sampling transects;
    - Pit trapping
    - Funnel trapping
    - Bird census
- Black-Cockatoo foraging value assessment;
- Motion-sensitive cameras;
- Bat echolocation devices;
- Opportunistic observations; and
- Opportunistic invertebrate collection.

2.3.1 Dates and personnel

The Project Area was initially visited on 11th July 2018 by Dr Mike Bamford (B.Sc. Hons. Ph.D. Biol.) and Mr Robert Browne-Cooper (B.Sc. Biol.). The site visit involved looking around as much of the Project Area as possible in daylight. This enabled environmental descriptions to be prepared and some opportunistic observations on fauna to be made. Targeted searching was undertaken for several significant species known from the general area - in particular foraging evidence of Quenda and Black-Cockatoos and a preliminary assessment of the potential for large trees to be nest trees for Black-Cockatoos. Opportunistic hand-searching was conducted by Dr Mike Bamford, and herpetologists Mr Robert Browne-Cooper and Mr Brad Maryan (Perth herpetologist) on 23rd August 2018. Comprehensive field investigations were undertaken over two periods from 23rd to 28th November 2018 and 11th to 14th December 2018. Personnel on these field investigations were:

- Dr Mike Bamford (B.Sc. Hons. Ph.D.);
- Mr Tim Gamblin (B.Sc. Cert. Env. Man.);
- Dr Wes Bancroft (B.Sc. Hons. Ph.D.);
- Dr Barry Sheppard (B.Sc. Hons. Ph.D.);
- Ms Katherine Chuk (B.Sc.); and
- Ms Eliza-Joyce Mellersh (B.Sc.).

The field investigations were carried out under Regulation 17 permit No 08-002545-1. This fauna assessment report was prepared by Mike Bamford, Tim Gamblin, Andy McCreery, and Natalia Huang (B.Sc. Hons.).

2.3.2 Vegetation and Substrate Associations

Vegetation and Substrate Associations (VSAs) in the Project Area were assessed during the desktop review and as part of the field investigations. An explanation of VSAs is given in Appendix 1. Within the Project Area, all major VSAs were visited to develop an understanding of major fauna habitat types present and to assess the likelihood of conservation significant species being present in the area.

In the assessment for Black-Cockatoos, systems for describing the potential value of the environment for Black-Cockatoos that have been developed by BCE were used. This is outlined in the following section.

2.3.3 Assessment for Black-Cockatoo foraging, nesting and roosting values

There are at least two species of Black-Cockatoo expected to occur in the Project Area, and an additional species which may be a vagrant in the area; all three species are of high conservation significance (CS1). As these species move across the landscape between food sources, the value of a site for Black-Cockatoos is highly dependent on the foraging opportunities it provides. Therefore, the vegetation in an area may be assessed to determine the foraging values it provides for Black-Cockatoos, which indicates its importance for the species.

In the Project Area, each VSA was examined and awarded a foraging value as per the Black-Cockatoo foraging assessment system developed by BCE (outlined in Appendix 8). The foraging score provides a numerical value that reflects the significance of vegetation as foraging habitat for Black-Cockatoos, and this numerical value is designed to provide the sort of information needed by the federal Department of the Environment and Energy (DEE) to assess impact significance and offset requirements. The foraging value of vegetation depends upon the type, density and condition of trees and shrubs in an area, and can be influenced by the context such as the availability of foraging habitat nearby. The BCE scoring system for value of foraging habitat has three components as detailed in Appendix 8. These three components are drawn from the DEE offset calculator with the scoring approach being developed by BCE:

- A score out of six for vegetation composition, condition and structure.
- A score out of three for the context of the site.
- A score out of one for species density.

Foraging value can thus be assigned a score out of six, based upon site vegetation characteristics, or a score out of 10 if context and species density are also considered. The score out of 10 is calculated only for vegetation of at least Low to Moderate foraging value (that is, with a vegetation characteristics score of ≥3). Under most circumstances, vegetation with No, Negligible or Low foraging value is effectively assigned context and species density scores of '0' because the context and species density are of little relevance if the vegetation supports little or no foraging by Black-Cockatoos. The decision to assign a context and species density score to vegetation with No, Negligible or Low foraging value is also subject to some judgement based upon activity of birds in the area. Foraging value scores are calculated differently for the three Black-Cockatoo species depending upon the vegetation present due to their variation in diet (Appendix 8).

Nesting values for Black-Cockatoos were not specifically addressed as the vast majority of the Project Area, and all the area within the proposed development footprint, does not contain nesting habitat. Limited areas of eucalypt forest and woodland lie outside the development area and were visited to check for signs of breeding, but individual trees were not assessed. The database of the Great Cocky Count and records held by the WA Museum were checked for known roosts in the general area. The lack of large trees in the development area made it extremely unlikely that roosting would occur in that area.

2.3.4 Systematic fauna sampling

Eight fauna sampling sites were established across the Project Area to sample representative VSAs (Sites 1 to 8, Table 2-2 and Figure 2-1). In each sampling site, fifteen pitfall traps were installed approximately 20 m apart along a transect. The GPS coordinates for each pitfall trap are given in Appendix 5. In addition, five funnel traps were installed at Sites 1, 2 and 4 at approximately 5 m intervals and connected by drift fences. Pitfall traps were operated for nine nights or 135 trapnights at each site. Funnel traps were kept open only for the first half of the trapping survey (five nights, 50 trapnights) due to heat and animal welfare concerns during the latter survey (animals trapped in funnel traps are particularly prone to desiccation from overheating due to trap design). All traps were checked in the morning within three to four hours of sunrise. Site locations, site descriptions and trapping effort are given in Systematic sampling transect locations, description and trapping effort.

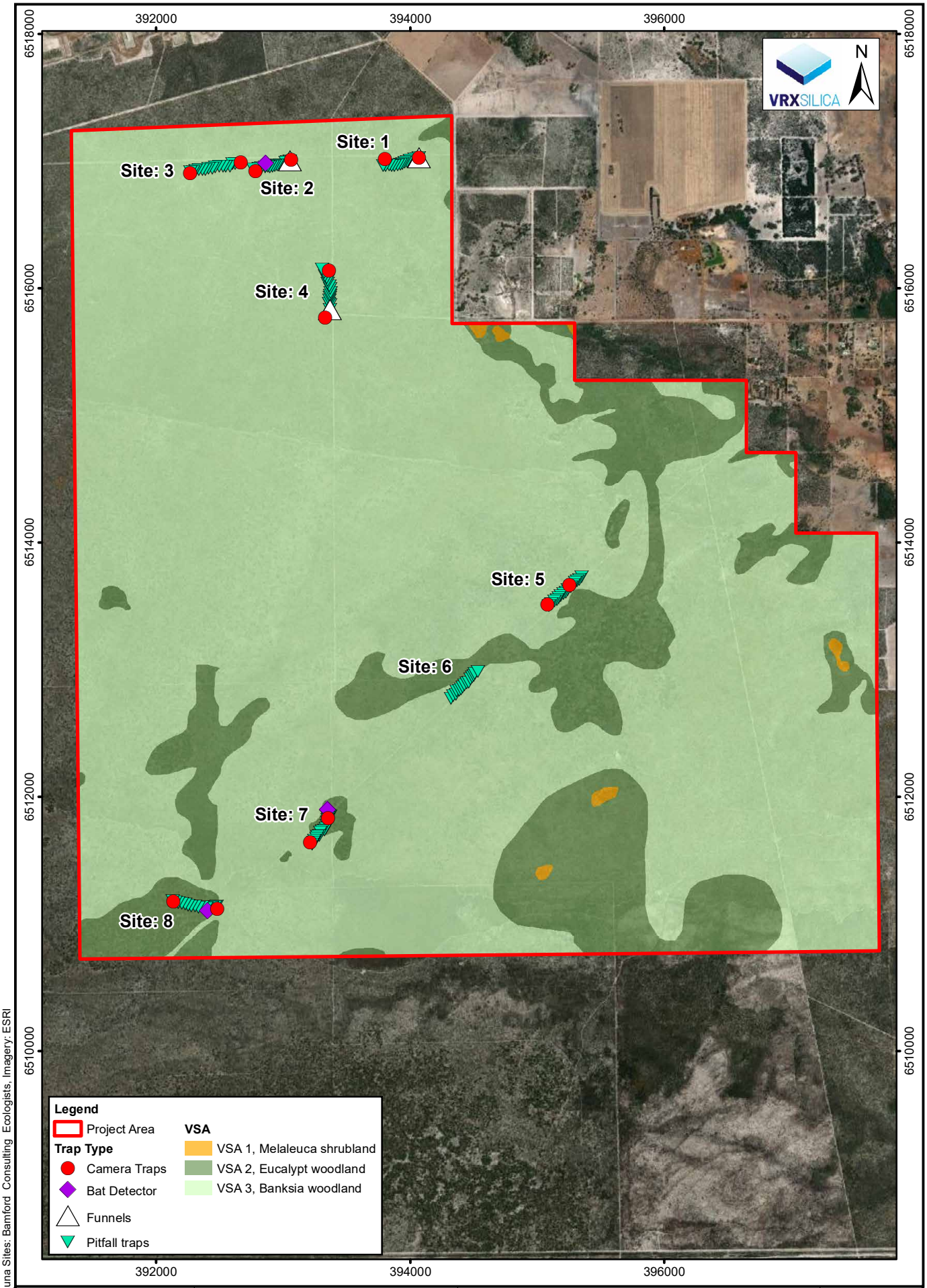
Table 2-2. In addition to pitfall and funnel traps, bird surveys were conducted along the length of the pitfall transect. This involved personnel pausing at every second pitfall trap (i.e. at 40 m spacing) for one to two minutes to record birds seen and heard within an approximate 25 m radius of the trap.

Table 2-2. Systematic sampling transect locations, description and trapping effort.

Site	GPS coordinates of transect start and end points (zone 50J)		VSA description	Trap effort
Site 1	Pit 1	394070.4E 6517025N	VSA 1; Melaleuca shrubland with scattered *Eucalyptus rudis* on dark grey clay/peaty sands. VSA 3; Banksia woodland with scattered *Eucalyptus todtiana* over *Adenanthos* and mixed Myrtaceous shrubs on pale grey sandy soil.	135 pitfall trap nights, 50 funnel trap nights
	Pit 15	393786.8E 6516964N		
Site 2	Pit 1	393053.7E 6516999N	VSA 3; Banksia woodland with scattered *Eucalyptus todtiana* over *Adenanthos* and mixed Myrtaceous shrubs on pale grey sandy soil.	135 pitfall trap nights 50 funnel trap nights
	Pit 15	392767.6E 6516938N		
Site 3	Pit 1	392624.8E 6516981N	VSA 3; Banksia woodland with scattered *Eucalyptus todtiana* over *Adenanthos* and mixed Myrtaceous shrubs on pale grey sandy soil.	135 pitfall trap nights
	Pit 15	392273.9E 6516916N		
Site 4	Pit 1	393367.7E 6515830N	VSA 3; Banksia woodland with scattered *Eucalyptus todtiana* over *Adenanthos* and mixed Myrtaceous shrubs on pale grey sandy soil.	135 pitfall trap nights 50 funnel trap nights
	Pit 15	393307.1E 6516148N		
Site 5	Pit 1	395348E 6513727N	VSA 3; Banksia woodland with scattered *Eucalyptus todtiana* over *Adenanthos* and mixed Myrtaceous shrubs on pale grey sandy soil.	135 pitfall trap nights
	Pit 15	395092.9E 6513500N		
Site 6	Pit 1	394323.4E 6512770N	VSA 3; Banksia woodland with scattered *Eucalyptus todtiana* over *Adenanthos* and mixed Myrtaceous shrubs on pale grey sandy soil.	135 pitfall trap nights
	Pit 15	394533.1E 6512984N		

Site	GPS coordinates of transect start and end points (zone 50J)		VSA description	Trap effort
Site 7	Pit 1	393372.7E 6511851N	VSA 2; Jarrah-dominated Eucalypt woodland over *Xanthorrhoea* and Myrtaceous shrubs on pale grey sand. VSA 3; Banksia woodland with scattered *Eucalyptus todtiana* over *Adenanthos* and mixed Myrtaceous shrubs on pale grey sandy soil.	135 pitfall trap nights
	Pit 15	393229.9E 6511623N		
Site 8	Pit 1	392478.8E 6511140N	VSA 2; Eucalypt woodland over *Xanthorrhoea* and occasional *Banksia attenuata, B. menziesii* and *Allocasuarina* on pale grey sandy soil.	135 pitfall trap nights
	Pit 15	392134.3E 6511181N		

Note bird surveys were conducted at every site.



Source: VSA and Fauna Sites: Bamford Consulting Ecologists, Imagery: ESRI

0 600 m
Scale: 1:40,000
MGA94 (Zone 50)

CAD Ref: a2576_MCE_f01_02
Date: August 2022 | Rev: A | A4

BCE

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VSA's

Figure:
2-1

Figure 2-1. Locations of sample sites (pitfall traps, funnel trap lines; bird surveys were conducted along pitfall trap lines), motion-sensitive cameras, and bat echolocation devices; and boundaries of VSAs across Project Area.

2.3.5 Motion-sensitive cameras

Motion-sensitive cameras are commonly used to detect mammals which may be otherwise difficult to detect. Two cameras were installed at each of Sites 1, 2, 3, 4, 5, 7, and 8 and left operational for a period of 14 nights (from 27th November to 11th December 2018), or 28 camera-nights at each site. A non-reward lure was used to attract fauna to the camera in the form of bait tubes filled with universal bait (peanut butter, oats and sardines). Bait tubes were placed into the camera frame and attached to a solid object to immobilise the tubes. Cameras were positioned in areas selected to maximise fauna detection such as along a trail. Details of camera traps, including GPS coordinates, are given in Table 2-3 (see also Figure 2-1).

Table 2-3. Description and location of motion-sensitive cameras.

Location	Camera type	Camera ID	Set	Retrieved	Coordinates (UTM; Zone 50J)
Site 1	Reconyx	BCE18	27/11/2018	11/12/2018	6517014E 393801N
Site 1	Reconyx	BCE22	27/11/2018	11/12/2018	6517025E 394070N
Site 2	Reconyx	BCE11	27/11/2018	11/12/2018	6517006E 393065N
Site 2	Reconyx	BCE23	27/11/2018	11/12/2018	6516920E 392782N
Site 3	Reconyx	BCE13	27/11/2018	11/12/2018	6516905E 392269N
Site 3	Reconyx	BCE08	27/11/2018	11/12/2018	6516986E 392669N
Site 4	Reconyx	UWA24	27/11/2018	11/12/2018	6516137E 393363N
Site 4	Reconyx	BCE17	27/11/2018	11/12/2018	6515768E 393333N
Site 5	Reconyx	BCE02	27/11/2018	11/12/2018	6513667E 395255N
Site 5	Reconyx	BCE16	27/11/2018	11/12/2018	6513512E 395082N
Site 7	Reconyx	UWA27	27/11/2018	11/12/2018	6511640E 393213N
Site 7	Reconyx	C2	27/11/2018	11/12/2018	6511832E 393354N
Site 8	Reconyx	UWA325	27/11/2018	11/12/2018	6511117E 392483N
Site 8	Reconyx	BCE05	27/11/2018	11/12/2018	6511175E 392136N

2.3.6 Bat echolocation devices

During the November/December 2018 surveys, bat echolocation devices were installed at three sites (Sites 2, 7 and 8) within the Project Area to record nocturnal bat activity (Figure 2-1). The devices used were an Anabat Swift (Titley) and an SM4 FS bat detector. Devices were operated for a total of 23 nights. Dates of operation and GPS coordinates of device locations are given in Table 2-4.

Calls were assessed using Anabat Insight software and compared against previously collected calls using the following characteristics:

Fmax (kHz): Average maximum frequency of call pulses within each call sequence;
Fpeak (kHz): Average frequency of peak energy within call pulses, within each call sequence;
Fmin (kHz): Average minimum frequency of call pulses within each call sequence; and
Dur (ms): Average duration of call pulses.

Table 2-4. Dates of operation and GPS coordinates of bat echolocation devices.

Date set	Retrieved	Coordinates (UTM; Zone 50J)	Site
Anabat Swift			
25/11/2018	27/11/2018	393353E 6511897N	7
27/11/2018	28/11/2018	393353E 6511897N	7
SM4 FS			
24/11/2018	4/12/2018	392407E 6511103N	8
4/12/2018	14/12/2018	392865E 6516979N	2

2.3.7 Active hand-searching

Opportunistic hand-searching of reptiles and frogs was conducted in August 2018 when conditions were cool and such fauna would be inactive. During the winter months many small reptiles lie dormant under leaf litter, tree bark and the top layers of soil where they can be uncovered through active hand-searching. This searching method involves turning over ground debris including logs and rocks, and raking through leaf-litter and soil.

2.3.8 Opportunistic observations

At all times, observations of fauna were noted when they contributed to the accumulation of information on the fauna of the site. These included such casual observations as birds or reptiles seen while walking through the survey area.

2.3.9 Invertebrate fauna

Opportunistic observations and collections of invertebrate fauna were made in November 2018 near Sites 1, 2, 3 and 5. These were limited to those taxonomic groups that potentially include short range endemic (SRE) species such as isopods, scorpions, pseudoscorpions, mygalomorph spiders and millipedes. In addition, potential SRE specimens were collected as by-catch in the vertebrate fauna pitfall traps and sent to specialists for identification.

2.4 Survey Limitations

The EPA Guidance Statement 56 (EPA 2004) outlines a number of limitations that may arise during surveying. These survey limitations are discussed in the context of the BCE investigation of the Project Area in Table 2-5.

Table 2-5. Survey limitations as outlined by the EPA.

EPA Limitation	BCE Comment
Level of survey.	Level 2 (desktop study and field investigation). Survey intensity was deemed adequate due to the scale of the project and the amount of data records available in the region.
Competency/experience of the consultant(s) carrying out the survey.	The ecologists have had extensive experience in conducting fauna surveys and have conducted multiple fauna studies within the immediate region.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	The survey focused on vertebrate fauna and fauna values, although some potential short range endemic species were collected when encountered.
Proportion of fauna identified, recorded and/or collected.	All vertebrate fauna observed and caught were identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Abundant information from databases and previous studies is available.
The proportion of the task achieved and further work which might be needed.	The survey was completed and the report provides fauna values for the Project Area.
Timing/weather/season/cycle.	The major field investigations were completed in November and December 2018 which is the ideal time for Level 2 surveys in the south-west as majority of vertebrate fauna are active and detectable.
Disturbances (e.g. fire, flood, accidental human intervention etc.) that affected results of survey.	None
Intensity. (In retrospect, was the intensity adequate?)	Intensity was considered adequate as sampling using various methods was undertaken to sample across the fauna assemblage.
Completeness (e.g. was relevant area fully surveyed).	Site was fully surveyed to the level appropriate for a Level 2 assessment. Fauna database searches covered a 10 to 20 km radius beyond the survey area boundary.
Resources (e.g. degree of expertise available in animal identification to taxon level).	Field personnel have extensive experience with fauna and habitats in the region.
Remoteness and/or access problems.	None
Availability of contextual (e.g. bio-geographic) information on the region.	Extensive regional information was available and was consulted.

3 Results

3.1 Vegetation and Substrate Associations

The vegetation is comprised largely of Banksia woodland with some patches of Eucalypt woodland, while the substrate across majority of the Project Area comprises grey sandy soils. Three broad VSAs were identified within the Project Area from aerial images, during field investigations and through cross-referencing with the botanical surveys already completed for the area. The boundaries of each VSA are shown in Figure 2-1. These boundaries were based upon vegetation mapping provided by Mattiske (2017). The descriptions of each VSA are:

- VSA 1: Melaleuca tall shrubland to low woodland in low-lying areas (Plate 1). Poorly drained low-lying dampland supporting *Kunzea*, *Melaleuca preissiana* shrubland with occasional *Eucalyptus rudis* on dark grey clay/peaty sands. This includes small patches of ephemeral swamp subject to shallow and temporary seasonal inundation. This VSA occurs near the eastern and north-eastern boundaries of the Project Area. This VSA aligns with vegetation types K1 and K1d recognised by Mattiske (2017).
- VSA 2: Eucalypt woodland (Plates 2 and 3). Patches of *Corymbia calophylla* and/or *Eucalyptus marginata* woodland over *Xanthorrhoea* and mixed shrubs on pale grey sandy soils. Areas of *Corymbia calophylla* over occasional *Banksia attenuata, B. menziesii* and *Allocasuarina* occur in low elevation areas and swales, while areas of *Corymbia calophylla* and *Eucalyptus marginata* over mixed low Myrtaceous shrubs occur in the low to moderate elevation areas in central and south-western parts of the Project Area. This VSA aligns with vegetation types J1, J1d and J2 recognised by Mattiske (2017).
- VSA 3: Banksia woodland (Plate 4). Intact mixed woodland of *Banksia attenuata, B. menziesii* and *B. illicifolia* with scattered *Eucalyptus todtiana* over *Adenanthos* and complex mixed Myrtaceous and Proteaceous low shrubland over *Hibbertia* and other low shrubs and herbs, on pale grey deep sands. This VSA includes low dunes, low gentle mid-slopes and swales on Spearwood sands in the west of the Project Area and plains on Bassendean sands in the east of the Project Area. This is the most extensive VSA, accounting for at least 80 percent of the Project Area. This VSA corresponds with Banksia Woodlands of the Swan Coastal Plain Threatened Ecological Community, a Threatened Ecological Community (TEC) formally recognised by the Western Australian DBCA as Priority 3 and listed as an Endangered ecological community by the federal DEE. This VSA aligns with vegetation types G1, H1 and I1 recognised by Mattiske (2017).

Plate 1. VSA 1: Melaleuca tall shrubland to low woodland

Plate 2. VSA 2: Marri-dominated eucalypt woodland in the east

Plate 3. VSA 2: Jarrah-dominated eucalypt woodland in the south-west

Plate 4. VSA 3: Banksia woodland

3.2 Fauna

3.2.1 Overview of fauna assemblage

A total of 215 vertebrate species is expected to occur in the Project Area, comprising ten frog, 49 reptile, 128 bird, 19 native mammal and 9 introduced mammal species (Table 3-1). A total of 79 species was recorded during surveys, comprising three frog, 21 reptile, 41 bird, 8 native mammal and 6 introduced mammal species (Table 3-1). A total of 120 species is expected to be resident in the Project Area, with 46 regular visitors or migrants, 33 irregular visitors and 14 vagrants to the Project Area (Table 3-1). The expected fauna assemblage is considered rich and typical of Banksia and eucalypt woodlands on the Swan Coastal Plain, with some elements of adjacent assemblages due to the location on the north-eastern edge of the Plain. Given the high degree of connectivity to nearby vegetation, species which may be declining further south (around Perth) due to vegetation clearance and fragmentation are expected to have healthy populations within the Project Area and/or nearby.

Of the ten frog species expected to occur in the Project Area, three were recorded during field investigations. All expected species are moderately widespread in the Southwest and none is of conservation significance. The assemblage includes one species, the Turtle Frog, which breeds in woodland areas in the absence of surface water. All other species are terrestrial as adults but are expected to breed in seasonal wetlands either within the Project Area or nearby, such as in Chandala Swamp. All species are considered resident or at least regular visitors to the Project Area. It is noted that conditions for detecting most frog species were not ideal during field investigations (i.e., low rainfall).

There are 49 reptile species expected to occur in the Project Area, with 21 of these recorded during field investigations. All species but one (the Long-necked Tortoise) are considered resident in the Project Area and four are of conservation significance. The reptile assemblage is expected to be rich in fossorial and burrowing species due to the presence of woodland over sandy soils which is ideal for such species. Most of the reptile assemblage is widespread in the region.

There are 128 bird species expected to occur in the Project Area, with 41 of these recorded during field investigations. The bird assemblage includes 45 species considered to be residents, 42 regular visitors, 29 irregular visitors and 12 vagrants. The bird assemblage comprises species typical of Banksia woodland on the Swan Coastal Plain, with a diverse assemblage of nectivores and insectivores expected during flowering and fruiting. Some waterbirds are expected as regular visitors to low-lying areas which may experience seasonal flooding. There is also a suite of birds which are restricted to forested areas such as canopy-specialists.

There are 28 mammal species expected to occur in the Project Area, comprising 19 native and 9 introduced species. Of these, eight native species and six introduced species were recorded during field investigations. As is typical of the Swan Coastal Plain, the mammal assemblage is depauperate as a result of habitat loss in the region and predation by feral species. Several locally extinct species are likely, and a number of species expected to be residents (including the South-West Pygmy-possum and Quenda) have been recorded infrequently in the area and may

also be locally extinct. Notably, field investigations confirmed the presence of the Noodji (Ashy-grey Mouse) and one of the dunnarts, which are discussed further below as locally significant (CS3) species.

The key features of the fauna assemblage expected in the Project Area are:

- Uniqueness: The expected assemblage is typical of Banksia woodlands of the Swan Coastal Plain with this assemblage expected in similar habitats across the coastal plain nearby. However, the large extent, high degree of connectivity and intact condition of the bushland within the Project Area means that it is likely to support a number of woodland birds, reptiles and several small mammal species that are less prevalent in remnant bushland areas in the region, particularly closer to Perth. This area represents both the southern and northern extent of the range of some reptiles and mammals.
- Completeness: The assemblage is likely to be intact in terms of frogs, reptiles and birds due to the extent and intact condition of the environment, but incomplete in terms of mammals due to the loss of some mammal species from habitat loss and feral predation. The presence of at least two small mammal species (Noodji and one of the dunnarts) is notable as these are extinct even in large tracts of native vegetation closer to Perth.
- Richness: The assemblage is moderately rich in the local context given the intact condition of the woodland and connectivity to nearby bushland areas.

Table 3-1. Composition of vertebrate fauna assemblage of the Project Area; recorded species indicated in parentheses.

Taxon	Number of species	Number of species in each status category				
		Resident	Migrant or regular visitor	Irregular visitor	Vagrant	Locally extinct
Frogs	10 (3)	8 (3)	2	-	-	-
Reptiles	49 (21)	48 (21)	-	1	-	1
Birds	128 (41) (8 introduced)	45 (30)	42 (10)	29 (1)	12	-
Native Mammals	19 (8)	14 (7)	1 (1)	2	2	4
Introduced Mammals	9 (6)	5 (4)	1 (1)	1 (1)	2 (1)	-
Total	215 (79)	120 (65)	46 (12)	33 (2)	14 (1)	5

Documenting the invertebrate assemblage is beyond the scope of a Level 2 investigation, but nine invertebrate species were collected as by-catch or recorded opportunistically, two of which are potential short-range endemic (SRE) species and therefore of local conservation significance. It should be noted that vertebrate fauna represents a small proportion of the total fauna assemblage; in an invertebrate fauna survey conducted at Mooliabeenee Nature Reserve (about 20 km to the north-east of the Project Area), Knowles *et al.* (2018) documented over 500 invertebrate species.

3.2.2 Results of fauna investigations

3.2.2.1 Black-Cockatoo foraging assessment

The Banksia (VSA 3) and Marri/Jarrah (VSA 2) woodlands are the main VSAs which will provide foraging value for the Black-Cockatoo species and are assessed here. The extent of these two VSAs is illustrated on figure 2-1. VSA 1 (Melaleuca tall shrubland to low woodland) is limited in extent and of limited value as foraging habitat. The extensive banksia woodland (VSA 3) over most of the Project Area is in excellent condition with little obvious dieback or weeds. A summary of the total foraging score for each VSA and Black-Cockatoo species is given in Table 3-2.

Carnaby's Black-Cockatoo

The foraging value of the Banksia woodland (VSA 3) for the Carnaby's Black-Cockatoo was calculated as:

- Vegetation score: 5 out of a possible 6 because the key food plants are abundant and the vegetation is in good to excellent condition throughout the woodland.
- Context score: 2 out of a possible 3 because the Project Area has extensive high quality mixed Banksia woodlands but this is regionally extensive. Furthermore, actual foraging activity in the woodland appeared to be low. Banksia woodland within the Project Area (2,833ha) represents ca. 10.2% of remaining black-cockatoo foraging habitat (27,752ha most of which is Banksia Woodland) within a 12km radius (DBCA 2011; see Figure 3.5)). The actual area of banksia woodland to be impacted will be much less than this but the long-term footprint has yet to be defined. Rehabilitation will also take place and the value of rehabilitation as foraging habitat cannot be assessed at this stage.
- Species density score: 1 out of a possible 1 as the species was recorded as present.
- Total score: This gives the Banksia woodland (VSA 3) a foraging score of 8 out of 10 for Carnaby's Black-Cockatoo.

The foraging value of the Marri/Jarrah woodland (VSA 2) for the Carnaby's Black-Cockatoo was calculated as:

- Vegetation score: 3 out of a possible 6 because there are some key food plants present.
- Context score: 1 out of a possible 3 because the extent of the VSA is limited in the Project Area.
- Species density score: 1 out of a possible 1 as the species was recorded as present.
- Total score: This gives the Marri/Jarrah woodland (VSA 2) a foraging score of 5 out of 10 for Carnaby's Black-Cockatoo.

Forest Red-tailed Black-Cockatoo

The foraging value of the Banksia woodland (VSA 3) for the Forest Red-tailed Black-Cockatoo was calculated as:

- Vegetation score: 2 out of a possible 6 because there are few key food plants present although they will feed on scattered *Eucalyptus todtiana* and *Allocasuarina sp.*.
- Context score: 0 out of a possible 3 because the vegetation score is low.
- Species density score: 1 out of a possible 1 as, while the vegetation score was low, the species was recorded as present.
- Total score: This gives the Banksia woodland a foraging score of 3 out of 10 for the Forest Red-tailed Black-Cockatoo.

The foraging value of the Marri/Jarrah woodland (VSA 2) for the Forest Red-tailed Black-Cockatoo was calculated as:

- Vegetation score: 5 out of a possible 6 because the key food plants are abundant.
- Context score: 2 out of a possible 3 because the Project Area has some good foraging habitat for the species but this is regionally extensive. Furthermore, actual foraging activity in the eucalypt woodland appeared to be low. Eucalypt woodland (554ha) within the Project Area represents ca. 0.2% of remaining black-cockatoo foraging habitat (27,752ha) within a 12km radius (DBCA 2011; see Figure 3.5).
- Species density score: 1 out of a possible 1 as the species was recorded as present.
- Total score: This gives the Marri/Jarrah woodland a foraging score of 8 out of 10 for the Forest Red-tailed Black-Cockatoo.

Table 3-2. Summary of foraging score for each VSA for Black-Cockatoos; area of each VSA in the Project Area given in parentheses.

VSA	Vegetation	Context	Species Density	Total
Carnaby's Black-Cockatoo				
Banksia woodland	5	2	1	8 (2833 ha)
Marri/Jarrah woodland	3	1	1	5 (554 ha)
Forest Red-tailed Black-Cockatoo				
Banksia woodland	2	0	1	3 (2833 ha)
Marri/Jarrah woodland	5	2	1	8 (554 ha)

The Banksia woodland (VSA 3; incorporating Mattiske (2017) vegetation types G1, H1 and I1), is extensive across the Project Area (2833 ha), provides high quality foraging value for the Carnaby's Black-Cockatoo (8/10) but low to moderate quality foraging value for the Forest Red-tailed Black-Cockatoo (3/10). Conversely, the pockets of Marri/Jarrah woodland (VSA 2, incorporating Mattiske (2017) vegetation types J1, J1d and J2) is scattered throughout the Project Area (554 ha) and provides high quality foraging value for the Forest Red-tailed Black-Cockatoo (8/10) but moderate quality foraging value for the Carnaby's Black-Cockatoo (5/10). Both types of foraging habitat are declining across the Swan Coastal Plain, particularly those which contain continuous connectivity between adjacent habitat such as is the case in the Project Area. The Project Area is therefore expected to be an important foraging source for these species. Further considerations on these species are given in Section 3.2.3.

3.2.2.2 Systematic fauna sampling

Overview

Trapping and census data at the eight sampling sites provide measures of abundance which make it possible to compare species richness and abundance between sites. As may be expected, species richness and abundance were similar across all sites. This is likely to be due to all sites (except one) being located in the same VSA (i.e., Banksia woodland) as this VSA occurs

across the majority of the Project Area. The suite of species recorded were also those considered typical of Banksia and Eucalypt woodlands on sandy plains of the Swan Coastal Plain.

Trapping

A total of 23 frog, reptile and mammal species were recorded from pitfall and funnel trapping surveys comprising 257 individuals. Raw data from trapping surveys are presented in Table 3-3.

Three frog species were recorded despite unsuitable survey timing, which is likely due to some light rain falling during field surveys. A total of 16 reptile species was recorded and most species are considered typical of Banksia and Eucalypt woodland on sandy plains of the Plain. Majority of captures were comprised of *Lerista elegans* (n=63) and *Ctenophorus adelaidensis* (n=75) which are species commonly associated with this environment. Species which are less commonly expected in this area were recorded; for example, *Ctenotus impar*, which is known to occur in areas south of the Swan River and is considered scarce further north (Bush *et al.*, 2010). Four mammal species were recorded, one of which was an introduced species. The Honey Possum is widespread in this habitat across the northern Swan Coastal Plain, however the Little Dunnart and Noodji are at the southern edge of their current range, apparently being extinct even in extensive native vegetation closer to Perth. These species are considered further in Section 3.2.3.

Trapping surveys found markedly higher numbers of captures and slightly higher number of species recorded in Sites 1 to 4 (located in the north) compared with Sites 5 to 8 (located in the southern half of the Project Area) (Figure 3-1; Figure 3-2; Table 3-3). This may be due to the altered vegetation structure in the southern sites which was burnt in 2015. Recently burnt sites were found to be more open in vegetation structure. Majority of pitfall captures are reptiles, and reptiles are known to require complex vegetation structure. As vegetation in the south recovers over time, it is expected the reptile assemblage will become richer and more abundant across the Project Area as long as connectivity remains. Site 1 recorded the highest richness and abundance of captures (Figure 3-1) – this is likely due to the site being lower in the landscape where it is more mesic and therefore more productive. This site traverses both Melaleuca shrubland (which is damp in winter and therefore will support a different suite of species) and Banksia woodland which is high in fauna richness.

Table 3-3. Raw data of frog, reptile and mammal captures from pitfall trapping surveys at each site; funnel trap captures in parentheses and VSA indicated.

VSA	**1, 3**	**3**	**3**	**3**	**3**	**3**	**2, 3**	**2**	
Species	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 8**	**Total captures**
Heleioporus eyrei					6				6
Limnodynastes dorsalis	1			5		2	3	1	12
Myobatrachus gouldii				1		1	1	1	4
Ctenophorus adelaidensis	10	15	13	22	6	5	3	1	75
Pogona minor minor	2	2		5					9
Strophurus spinigerus spinigerus	2			1 (1)					3
Aprasia repens	1								1

VSA	1, 3	3	3	3	3	3	2, 3	2	
Species	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 8**	**Total captures**
Pletholax gracilis gracilis							1		1
Cryptoblepharus buchananii	6	3	1	3	1				14
Ctenotus fallens	3 (3)			1					4
Ctenotus impar					1		1		2
Egernia napoleonis	1 (1)						1		2
Lerista elegans	18	9	10	8 (1)	1	7	4	7	63
Lerista praepedita			1	3					4
Menetia greyii					1			3	4
Morethia lineoocellata	4	7	5				1	1	18
Morethia obscura	6	5 (1)	2	6 (5)	3		1	1	24
Simoselaps bertholdi			1						1
Little Dunnart		1							1
Honey Possum	3							1	4
House Mouse			1	1		1			3
Noodji, Ash-grey Mouse							1		1
Total number of species	**13**	**7**	**8**	**11**	**7**	**6**	**10**	**8**	**23**
Total number of captures	**53**	**37**	**34**	**41**	**19**	**16**	**17**	**16**	**257**

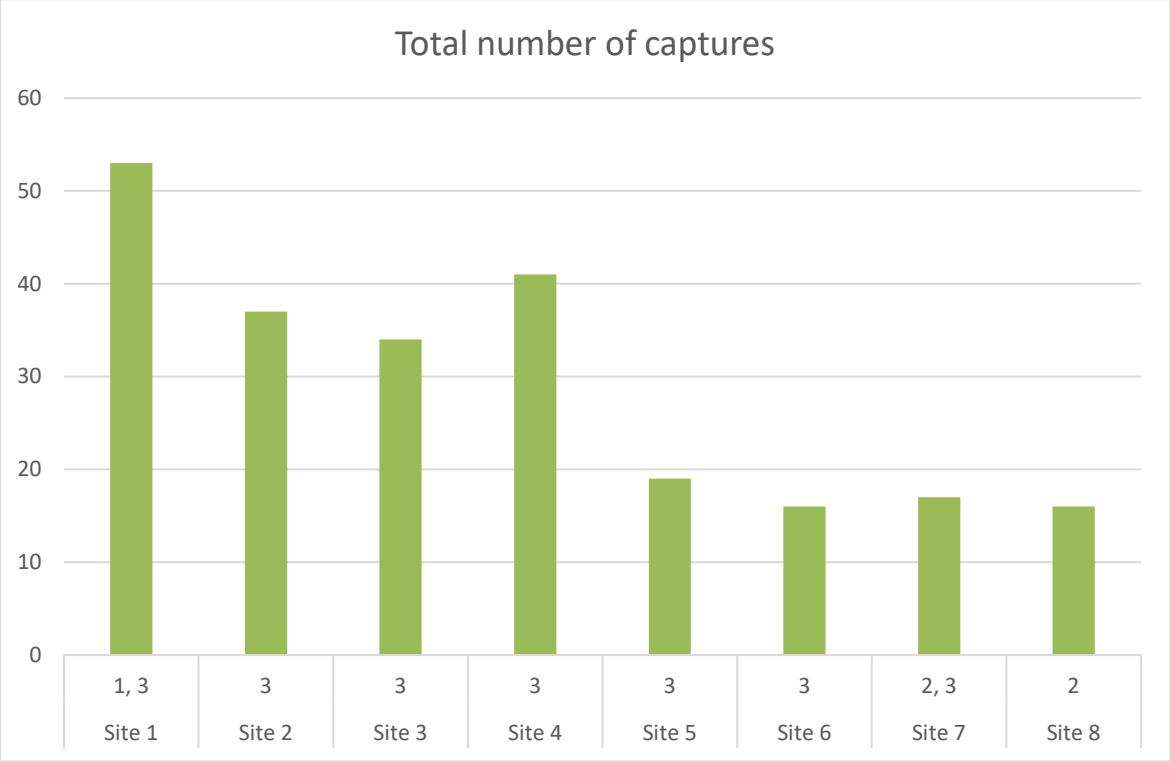

Figure 3-1. Total number (abundance) of pitfall captures by site, numbers above site indicate VSA.

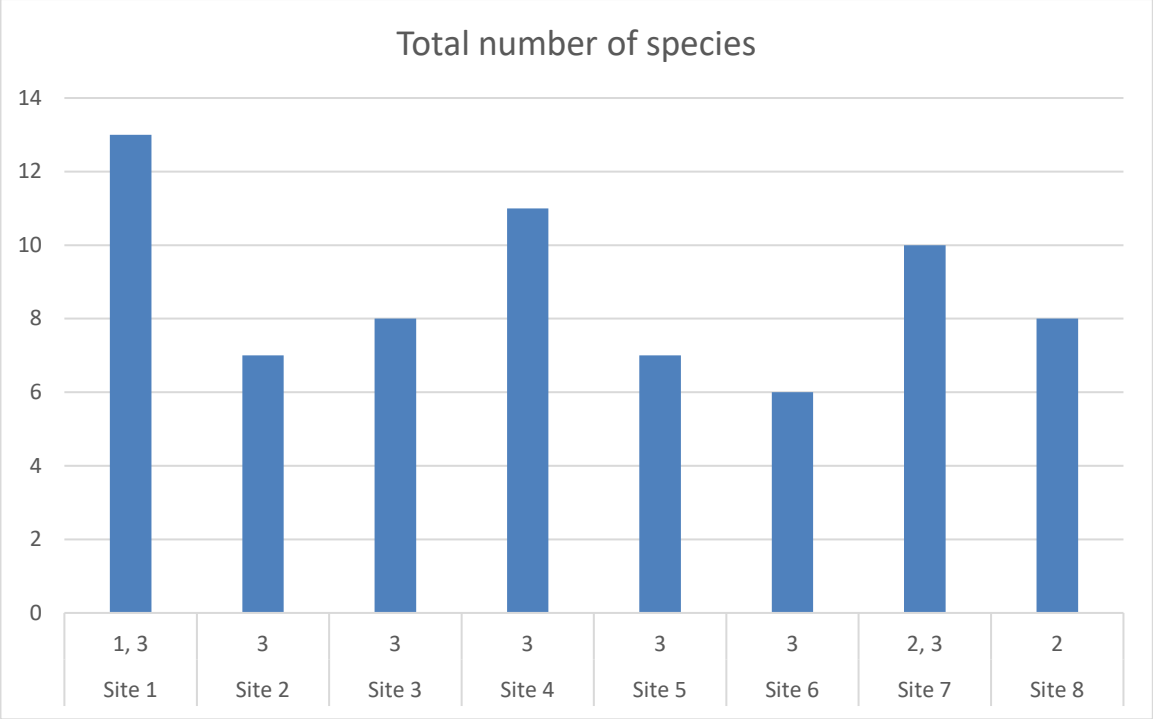

Figure 3-2. Total number of species (richness) of pitfall captures by site, numbers above site indicate VSA.

Bird surveys

A total of 31 bird species was recorded from bird surveys, comprising 605 records. Raw data from bird surveys are presented in Table 3-4. Species recorded are those commonly-associated with Banksia and Eucalypt woodland on the Swan Coastal Plain.

The highest abundance and richness of birds was recorded at Site 8, the only sampling site which contains only Marri and Jarrah woodland (Figure 3-3 and Figure 3-4). The other forested site (Site 7) recorded the second highest abundance and richness of birds, although this was similar to adjacent Banksia woodland sites. Forested areas are expected to support a higher richness of birds due to the range of structural levels available (i.e., understorey, midstorey, canopy) where different suites of species can reside. Some bird species were restricted to forest patches in the Project Area, being higher in abundance in Site 8 (Marri and Jarrah woodland) than at other sites. These included species which are canopy specialists such as the Western Gerygone, Weebill and Striated Pardalote, nectivorous birds such as the Brown Honeyeater, and the insectivorous Rufous Whistler. The lowest abundance and richness of birds was recorded at Site 2 which is likely due to the site being located higher in the landscape with a drier environment and structurally simple vegetation.

Table 3-4. Raw data from bird surveys

VSA	**1, 3**	**3**	**3**	**3**	**3**	**3**	**2, 3**	**2**	
Species	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 8**	**Total # records**
Emu	1				1	1		1	4
Forest Red-tailed Black-Cockatoo					2				2
Galah								5	5

VSA	1, 3	3	3	3	3	3	2, 3	2	
Species	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 8**	**Total # records**
Australian Ringneck				2	3		1	3	9
Red-capped Parrot				1					1
Laughing Kookaburra					1	6	3	12	22
Rainbow Bee-eater	1			2			1	1	5
Splendid Fairy-wren	8	5	10	4	7	7	3	15	59
Weebill								6	6
Western Gerygone	1	2			1	8	19	17	48
Yellow-rumped Thornbill	4		5	1		1			11
Western Thornbill	8	1	8	2	6	11	2	4	42
Inland Thornbill			1						1
Striated Pardalote							2	9	11
Western Spinebill	4	4	6	6	3	7	3	5	38
Singing Honeyeater	11	4	15	15	5	3	5	2	60
Red Wattlebird	3		2		2	2	1		10
Tawny-crowned Honeyeater	1	1	3						5
Brown Honeyeater	19	14	17	14	10	13	15	33	135
Black-faced Cuckoo-shrike	1	2				1	1	3	8
Rufous Whistler	4	8	3		8	8	14	26	71
Grey Shrike-thrush							4	2	6
Black-faced Woodswallow			1						1
Dusky Woodswallow								1	1
Grey Butcherbird			2	1		3	2	3	11
Grey Fantail					1		5	5	11
Willy Wagtail				1		1			2
Scarlet Robin				3		1		1	5
Red-capped Robin		1							1
Silver Eye	3		1		2	1	3		10
Tree Martin	4								4
Total number of species	**15**	**10**	**13**	**12**	**14**	**16**	**17**	**20**	**31**
Total number of records	**73**	**42**	**74**	**52**	**52**	**74**	**84**	**154**	**605**

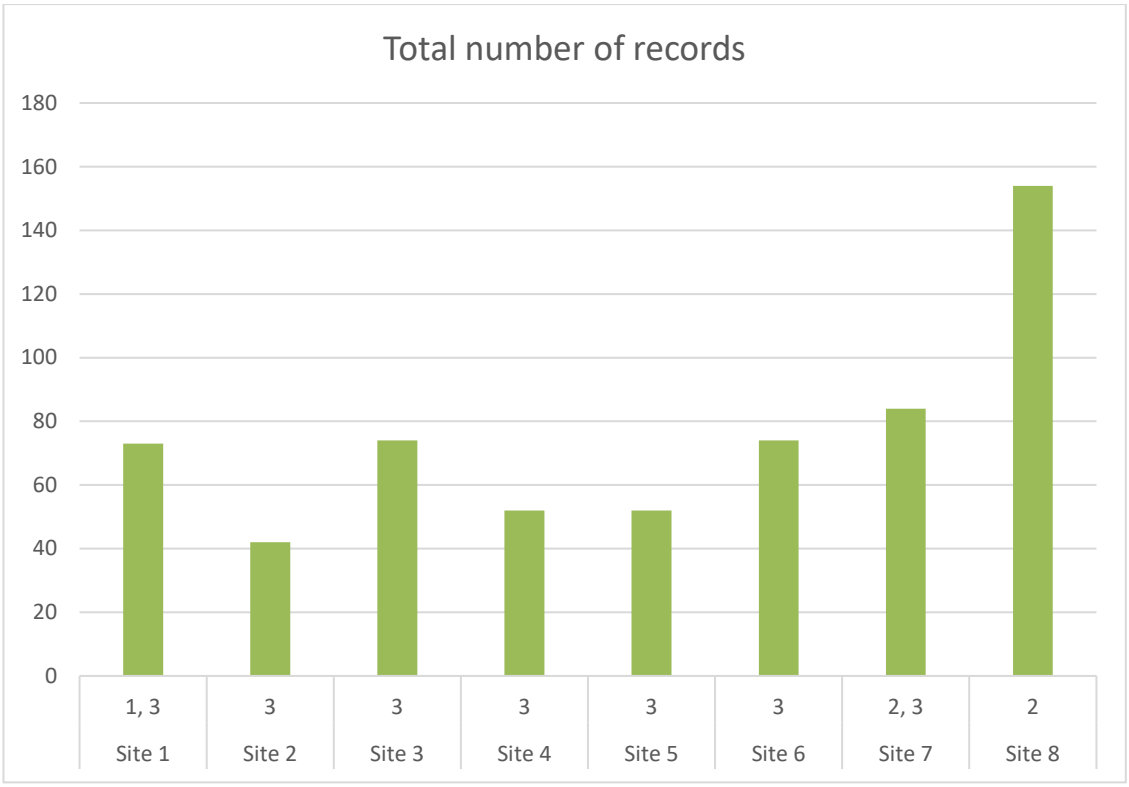

Figure 3-3. Total number of records (abundance) of birds recorded during bird surveys

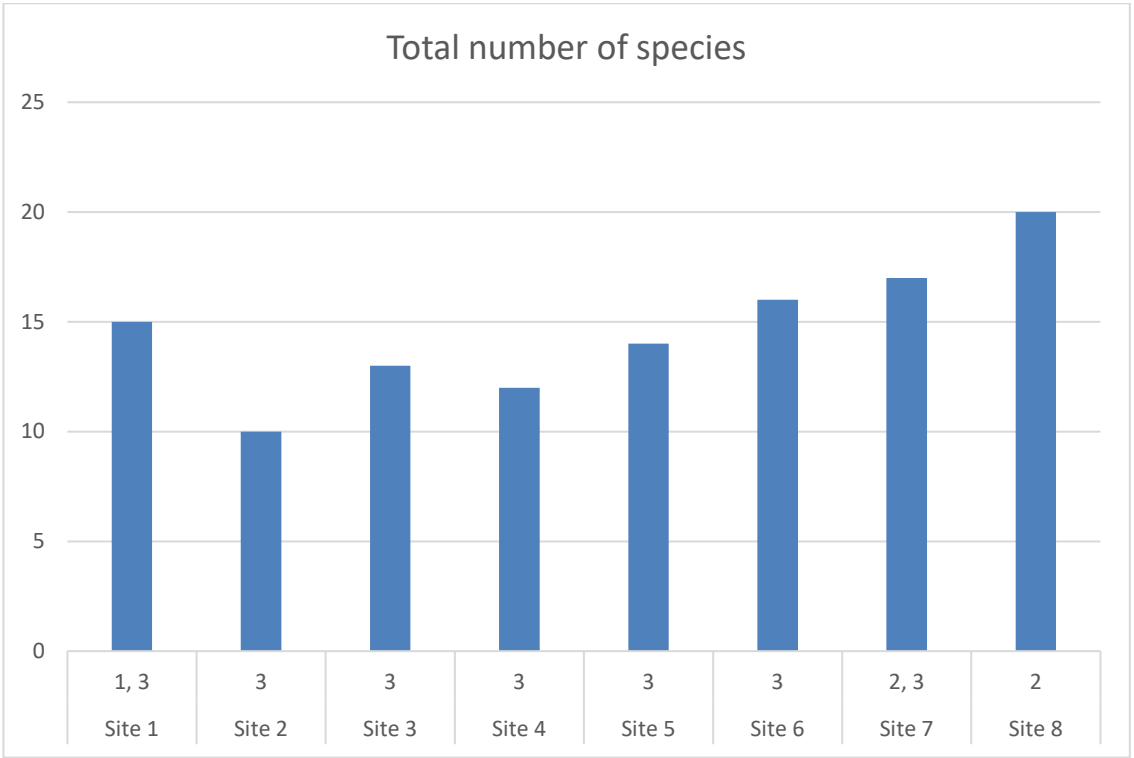

Figure 3-4. Total number of species (richness) of bird recorded during bird surveys

3.2.2.3 Motion-sensitive cameras

Motion-sensitive cameras detected two species – the Western Grey Kangaroo and the feral Fox. The Western Grey Kangaroo was recorded at five cameras and sites (Sites 1, 2, 3, 7 and 8), while the Fox was recorded at one site (Site 3, Table 3-5). Both species are expected to occur throughout the Project Area.

Table 3-5. Species recorded on motion-sensitive cameras

Camera ID	Site	Species
BCE18	1	Nil
BCE22	1	Western Grey Kangaroo *Macropus fuliginosus*
BCE11	2	Nil
BCE23	2	Western Grey Kangaroo *Macropus fuliginosus*
BCE13	3	Fox *Vulpes vulpes* (two, one young), Western Grey Kangaroo (male) *Macropus fuliginosus*
BCE08	3	Nil
UWA24	4	Nil
BCE17	4	Nil
BCE02	5	Nil
BCE16	5	Nil
UWA27	7	Nil
C2	7	Western Grey Kangaroo *Macropus fuliginosus*
UWA325	8	Western Grey Kangaroo *Macropus fuliginosus*
BCE05	8	Nil

3.2.2.4 Bat surveys

Bat echolocation devices detected the presence of at least five bat species, with all five bat species recorded at all three sampling locations. In declining order of abundance of call activity, these species were *Vespadelus regulus*, *Chalinobus gouldii*, *Austronomus australis*, *Nyctophilus sp.* and *Nyctophilus major*. There was a potential record of a conservation significant (CS3) species at Site 2, *Ozimops kitcheneri*, and this species is expected to be resident in the area. However, their calls look similar to calls of *C. gouldii*, so the record could not be confirmed. All species recorded are expected to be residents or regular visitors to the Project Area. The call charts for each species from the bat echolocation devices are given in Appendix 9.

All bat species expected in the Project Area are tree dwellers, roosting in tree-hollows or crevices. *C. gouldii* and *A. australis* are widespread across most of Australia, occurring in a variety of habitat including urban areas. In contrast, *V. regulus* occurs in woodlands and forests of southern Australia and is sensitive to fragmentation, avoiding vegetation remnants. *N. major* is restricted to Banksia woodlands, Melaleuca forests and eucalypt forests within the southwest of Western Australia. Similarly, *O. kitcheneri* is restricted to the southwest of Western Australia, although it occurs in a variety of habitats including urban areas.

3.2.2.5 Hand-searching and opportunistic observations

Hand-searching recorded a suite of burrowing reptile species which were not recorded through pitfall-trapping or other means. Species recorded were: *Delma fraseri*, *Cyclodomorphus celatus*, *Hemiergis quadrilineata*, *Neelaps bimaculatus*, *Neelaps calonotos* (a CS2 [Priority 3] snake) and *Parasuta gouldii*. Opportunistic records included nine bird, one native mammal and six introduced mammal species (Table 3-6).

Table 3-6. Opportunistic records

Birds	Mammals
Common Bronzewing	Western Grey Kangaroo
Brown Goshawk	Red Fox
Wedge-tailed Eagle	Feral Cat
Carnaby's Black-Cockatoo	Dog
Horsfield's Bronze-Cuckoo	Rabbit
Pallid Cuckoo	Pig
Fan-tailed Cuckoo	
New Holland Honeyeater	
Australian Magpie	

3.2.2.6 Invertebrate Fauna

While there are expected to be a vast suite of invertebrate species in the Project Area, nine potentially significant invertebrate species were recorded in the Project Area, comprising one sun-moth, one bee, six spiders and one scorpion. Opportunistic observations included the Spring Flying Sun-Moth *Synemon sp.* which was recorded near Sites 1, 2 and 3, and the Blue-banded Bee *Amegilla sp.,* recorded near Site 1. In addition, six spider species and one scorpion species were recorded as by-catch in pitfall traps at Site 5. These species and their distribution are given in Table 3-7.

Table 3-7. Invertebrates collected as by-catch in pitfall traps

Family	Species	Sex and Distribution
Spiders		
Nemesiidae	*Aname mainae* group (short embolus)	1 Male, likely widespread in SW WA
Nemesiidae	*Proshermacha tepperi*	1 Male, previously *Aname tepperi*, currently reported as widespread
Nemesiidae	*Aname mainae*	1 Male, widespread in SW WA
Nemesiidae	*Aname mellosa group*	1 Male, potential SRE
Idiopidae	Possible *Gaius sp.*	1 Juvenile, not SRE if *Gaius* (indeterminable)
Nemesiidae	*Kwonkan sp.*	1 Male, previously *Yilgarnia sp*, species indeterminable, possible SRE
Scorpions		
Urodacidae	*Urodacus novaehollandiae*	1 Female, widespread

3.2.3 Fauna of conservation significance

Based primarily upon databases, 56 vertebrate species of conservation significance may occur in the Project Area, comprising four reptiles, 42 birds, and ten mammals (Table 3-8). The majority of these species are CS3 birds (n=35). Field investigations confirmed the presence of 20 species of conservation significance including both Carnaby's and Forest Red-tailed Black-Cockatoos. A summary of the conservation significant species, their predicted occurrence and confirmed presence in the Project Area is provided in Table 3-8. Species or groups of species which are at least irregular visitors are discussed below.

Table 3-8. Composition of extant conservation significant fauna of the Project Area with confirmed species in brackets.

Taxon	Conservation Significant fauna		
	CS1	CS2	CS3
Frogs	-	-	-
Reptiles	-	2 (1)	2
Birds	5 (2)	2	35 (15)
Native Mammals	2	3	5 (2)
Invertebrates	1	2	3 (2)

(CS – Conservation Significant: CS1 = listed under WA State and/or Commonwealth legislation; CS2 = listed as Priority by DBCA; CS3 = considered locally significant (including species listed by DEP 2000).

Conservation Significance Level 1

Fork-tailed Swift

This is a non-breeding migrant from Asia but is a largely aerial species of unpredictable occurrence in southern Western Australia. It does not rely closely on small areas of native vegetation.

Peregrine Falcon

This species is found in a wide variety of habitats, with its distribution often linked to the abundance of prey. Blakers *et al*. (1984) consider that Australia is one of the strongholds of the species, since it has declined in many other parts of the world. A pair is known to reside at nearby Lake Chandala so the Project Area will be part of their home range (and therefore they are considered residents in the area). They may forage in the Project Area, with a possibility of nesting in very large trees in the area.

Black-Cockatoo species

Carnaby's and Forest Red-tailed Black-Cockatoos were confirmed present during the field investigations and are expected to be regular visitors to the Project Area, although the only records were of a flock of 15 Carnaby's Black-Cockatoos over the site on 11th July 2018, and a single Forest Red-tailed Black-Cockatoo along Timaru Road on 23rd November 2018. Baudin's Black-Cockatoo is considered to be a vagrant to the Project Area and was not recorded.

Both the Carnaby's and Forest Red-tailed Black-Cockatoo species are known to roost communally and often at sites that are used regularly (Peck *et al.* 2017). No roosting sites have been recorded previously within the Project Area based on the Great Cocky Count database (Peck *et al.* 2017), however, the database available from the DBCA (2011) that incorporates Great Cocky Count records shows many confirmed roost sites, notable to the west and south-west. Some of these are just within the 12km radius from the Project Area (Figure 3-5). A very large roost (5,000+ birds) is known from the Gnangara pine plantation (Peck *et al.* 2017), but this lies nearly 20km to the west. Potential roost sites may occur in the Jarrah and Marri woodlands (VSA 2) in the Project Area, but were not detected during evening work in winter 2018. However, roost sites are not used consistently so the likelihood of roosting in VSA 2 remains. Banksia woodland (VSA 3) lacks large trees used by roosting black-cockatoos so roosting in this VSA is very unlikely.

The foraging habitat assessment (see Section 3.2.2.1) concluded that extensive banksia woodlands (VSA 3; 2833ha within Project Area boundary, representing about 10% of foraging habitat within 12km of the Project Area) are of High foraging value for Carnaby's Black-Cockatoo, but only Low to Moderate value for the Forest Red-tailed Black-Cockatoo. The less extensive eucalypt woodlands (VSA 2; 554ha within Project Area boundary), is of Moderate foraging value for Carnaby's Black-Cockatoo, but High value for the Forest Red-tailed Black-Cockatoo.

No foraging residue (chewed Jarrah, Marri or Banksia fruit) was recorded during field investigations, although both species almost certainly forage within the Project Area given the abundance and extent of foraging plant species across the VSAs, particularly in the Banksia woodland, which occupies the majority of the Project Area. The lack of foraging residue suggests that neither species had foraged in the Project Area recently (the previous 12 months) in anything but small numbers. It also reinforces the conclusion that the birds are not currently roosting or breeding within or very close to the Project Area. This may vary from year to year, and it is possible that foraging activity will increase as pine plantations to the west are harvested.

The Eucalypt woodland areas (VSA 2) may provide suitable nesting locations (very large, usually vertical hollows in large trees) for Black-Cockatoos, but there was no nesting behaviour observed despite multiple field trips during the late winter to late spring breeding season. There was also no foraging residue in the vicinity of eucalypt woodlands, as would be expected if birds were breeding in these areas. The only possible breeding behaviour was seen along Timaru Road, just north of the Project Area, where in November 2018 a single male Forest Red-tailed Black-Cockatoo was seen flying around and alighting in a large paddock tree, suggesting there was a female on a nest nearby. The Eucalypt woodland areas were not searched thoroughly for possible nest trees as they lie outside any impact footprint. The Carnaby's Black-Cockatoo is known to breed in small numbers on the northern Swan Coastal Plain and immediately to the east (Figure 3-5), but these locations are outside the 12km radius from the Project Area. Banksia woodland (VSA 3) lacks large trees with the potential to provide nesting hollows.

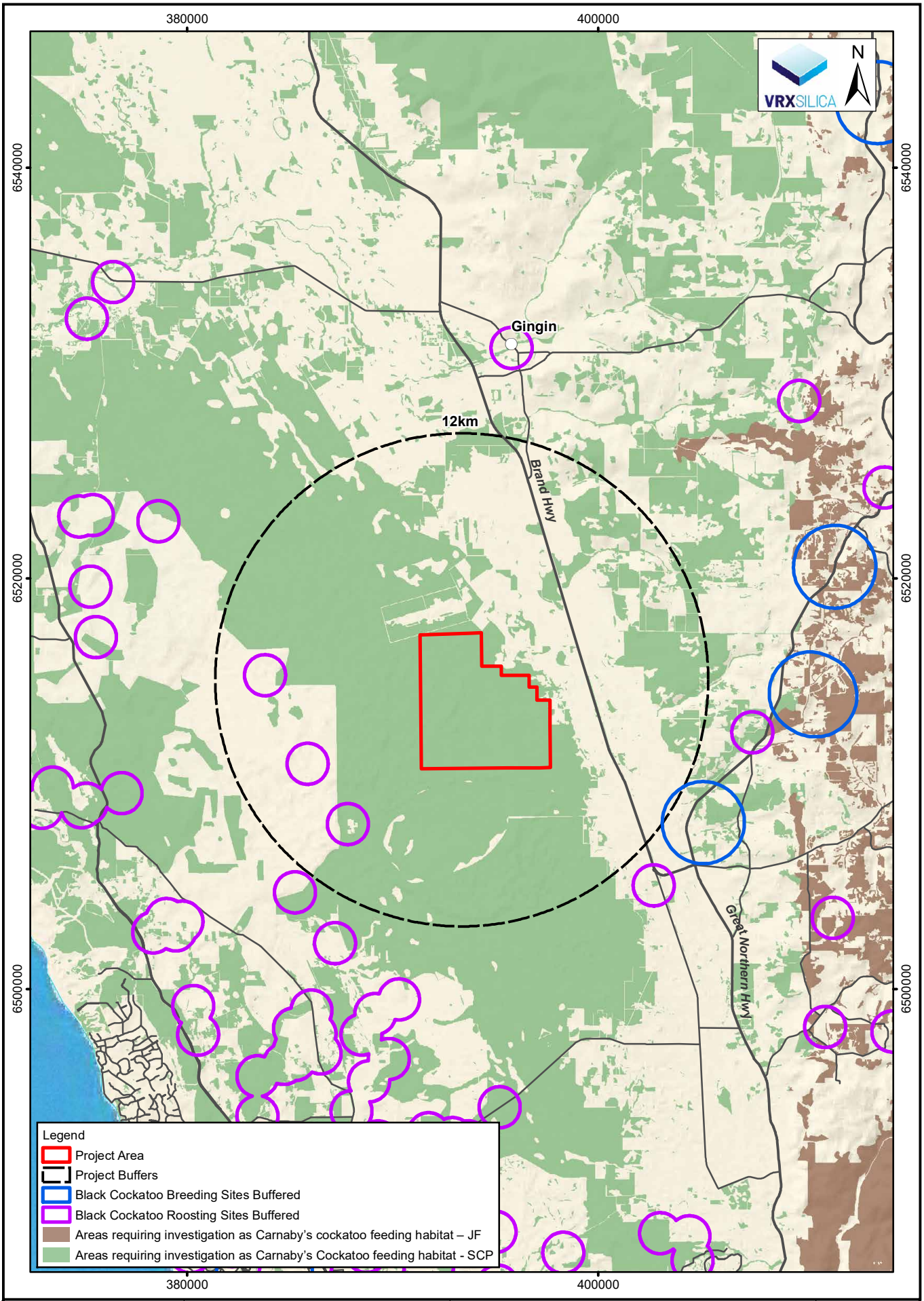

Figure 3-5. Significant locations for Carnaby' Black-Cockatoo in the region, from DBCA (2011) records. Note that precise locations for roost and nest sites are not available, but are buffered by 1km and 2km respectively.

Chuditch and Brush-tailed Phascogale

Both these species may occur in the general region and are considered to be at least irregular visitors to the Project Area. Both species are highly mobile, particularly the Chuditch, and the Project Area has continuous bushland connectivity to the west and south through which the species can move. The taller woodlands may provide suitable shelter or den habitat. Detailed surveys could confirm the presence of these species.

Conservation Significance Level 2

Jewelled Sand-plain Skink and Black-striped Snake

Both these species have limited distributions on the coastal plain and both have been recorded on the northern Swan Coastal Plain within Banksia woodlands on sandy soil in a VSA comparable to VSA 3 (M. Bamford, pers.obs.). The Black-striped Snake was confirmed present during field investigations while the Jewelled Sand-plain Skink is also expected to be resident in the Project Area.

Barking Owl

This species occupies dry forest or woodland, often along watercourses, and nests in tree hollows. It is considered common in northern Australia but rare and declining in the south-west. The decline is mainly due to habitat loss and degradation and competition from Honey Bees for tree hollows (Johnstone and Storr, 1998). This species may occur as a vagrant in the Project Area.

Masked Owl

This species inhabits a variety of forests and woodlands but is more common through the deep south-west where it nests in hollows of large old trees. The Project Area is at the edge of its range and it may occur as a vagrant in the Project Area.

Quenda

This species is usually easily detected as it leaves distinctive foraging holes. No signs of foraging were found during the field investigations, however it is known to occur on the northern Swan Coastal Plain in a range of habitats where low and dense vegetation provides cover from predators. There are recent records of the Quenda from around Muchea <10 km to the south of the Project Area (M. Bamford pers. obs.). VSA 1 is potential habitat for the species, therefore it may be expected to visit and even colonise the Project Area.

Brush Wallaby

This species is known to occur within the northern Swan Coastal in damp low-lying areas; it is expected to be resident in the Project Area and likely to utilise the Melaleuca shrublands (VSA 1).

Rakali

The Rakali is known to occur in drainage systems across the south-west. It is expected to be an irregular visitor to the Project Area when it may visit seasonally-inundated low-lying areas from the drainage system to the east (Chandala Brook). While there are no known records of the Rakali in Chandala Brook, it is almost certainly there as the Rakali is known from the drainage system which connects Chandala Brook to Ellen Brook and the Swan River further downstream.

Conservation Significance Level 3

There are 43 vertebrate species of CS3 expected to occur in the Project Area and they are discussed in species groups below.

CS3 reptiles (Bold-striped Slider and Carpet Python)
The Bold-striped Slider is found on sandplains with or without Banksia and as such may occur throughout the Project Area. The Project Area lies close to the southern end of their range (the most southerly mainland record is Ellenbrook approximately 25 km to the south). It is considered locally significant due to its small and poorly-documented distribution within the bioregion. The Carpet Python is absent from bushland within and close to urban areas but persists on the northern Swan Coastal Plain. Both species are expected to be residents in the Project Area.

CS3 birds
There are 35 bird species considered to be CS3, with the majority of these being small species of woodlands that are listed in Bush Forever (DEP 2000) as being sensitive to fragmentation and declining in urban landscapes. They are therefore at risk within the northern Swan Coastal Plain and are likely to be residents within the Project Area due to the extent and high degree of connectivity of remnant vegetation in the area. Fifteen species were recorded during field investigations.

CS3 mammals
There are five mammal species considered to be CS3 and they have all declined on the Swan Coastal Plain. All CS3 mammals are expected to be residents in the Project Area but they may be declining even in large reserves such as Melaleuca Park and Yeal Nature Reserve. The Project Area represents the edge of the current range for many species, including the Noodji (Ash-grey Mouse) and the Little Dunnart, which were both recorded during the field investigations and are discussed in separate sections below. The Little and Grey-bellied Dunnarts are likely to be extinct in Perth, with the Muchea area representing the southern end of their range.

Little Dunnart and Noodji (Ash-grey Mouse)
The records of the Little Dunnart and Noodji in the Project Area are significant because these species are not common on the Swan Coastal Plain in the Perth area. The DBCA is conducting an ongoing study on ground-dwelling vertebrate fauna assemblages in Banksia woodland on the Swan Coastal Plain north of Perth (A. Reaveley, pers.comm.), and over the past 12 years has opened pitfall traps biannually (or annually in some years) across the region (mainly northern Swan Coastal Plain) to a total of approximately 1680 trap-nights since 2007. In that time, just two individuals of dunnarts were captured. One individual was an unidentified dunnart species which was caught in 2008 just north of Gingin Airfield, less than 5 km from the Project Area. The other was identified as a Little Long-tailed Dunnart *Sminthopsis doclichura* and was caught further west in Yanchep in 2014. Similarly, the Noodji was only captured twice in the 12 years of study – they were captured at two separate sites near the Gingin Airfield in 2016, less than 5 km north of the Project Area. One individual was captured in a long-unburnt site while the other was captured in a recently-burnt site. This indicates how rare these species are in the general area and how the Project Area may be significant for populations of the species; the Project Area records are also

the most southerly records for both. Furthermore, following discussion and DNA analysis with experts in the Western Australian Museum, the dunnart on the Coastal Plain may be a distinct taxon, as it identifies as the Little long-tailed Dunnart *Sminthopsis dolichura* on the basis of mitochondrial DNA, but it has a tail length the same as the head and body length, compared with much longer in true *S. dolichura*.

Conservation significant invertebrates

Information on the invertebrate assemblage of the Project Area is limited, but six invertebrate species of conservation significance were returned from databases and may be present (

Table 3-9). There is too little information available on their biology to predict their status on the site, but all could be resident. They include a native bee that was presumed extinct under the WA Wildlife Conservation Act (CS1) but which was recently rediscovered nearby in Pinjar in March 2019, two native bees listed as Priority (CS2), and a millipede and two spiders considered to be short range endemics (SRE; therefore CS3). The two spider species were recorded during the field investigations as opportunistic by-catch.

Table 3-9. Conservation significant species expected to occur in the Project Area.

Species		Conservation significance	Status in Project Area	Recorded
REPTILES				
Ctenotus gemmula	Jewelled Sand-plain Skink	CS2 (P3)	resident	
Lerista christinae	Bold-striped Slider	CS3	resident	
Morelia spilota imbricata	Carpet Python (south-west pop'n)	CS3	resident	
Neelaps calonotos	Black-striped Snake	CS2 (P3)	resident	X
BIRDS				
Phaps chalcoptera	Common Bronzewing	CS3 (HS)	resident	X
Apus pacificus	Fork-tailed Swift	CS1 (M, S5)	vagrant	
Lophoictinia isura	Square-tailed Kite	CS3 (WR)	regular visitor	
Haliastur sphenurus	Whistling Kite	CS3 (WR)	regular visitor	
Accipiter fasciatus	Brown Goshawk	CS3 (WR)	regular visitor	X
Accipiter cirrocephalus	Collared Sparrowhawk	CS3 (WR)	regular visitor	
Aquila audax	Wedge-tailed Eagle	CS3 (WR)	regular visitor	X
Hieraaetus morphnoides	Little Eagle	CS3 (WR)	regular visitor	
Falco berigora	Brown Falcon	CS3 (WR)	regular visitor	
Falco peregrinus	Peregrine Falcon	CS1 (S7)	regular visitor	
Turnix varius	Painted Button-quail	CS3 (WR)	resident	
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	CS1 (V, S3[v])	regular visitor	X
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	CS1 (E, S2[e])	regular visitor	X
Calyptorhynchus baudinii	Baudin's Black-Cockatoo	CS1 (V, S2[e])	vagrant	
Platycercus icterotis	Western Rosella	CS3 (WR)	irregular visitor	

Species		Conservation significance	Status in Project Area	Recorded
Ninox connivens	Barking Owl	CS2 (P2, WR)	vagrant	
Tyto novaehollandiae	Masked Owl	CS2 (P2, WR)	vagrant	
Malurus splendens	Splendid Fairy-wren	CS3 (HS)	resident	X
Malurus leucopterus	White-winged Fairy-wren	CS3 (HS)	Regular visitor	
Malurus lamberti	Variegated Fairy-wren	CS3 (HS)	resident	
Sericornis frontalis	White-browed Scrubwren	CS3 (HS)	regular visitor	
Smicrornis brevirostris	Weebill	CS3 (HS)	resident	X
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	CS3 (HS)	resident	X
Acanthiza inornata	Western Thornbill	CS3 (HS)	resident	X
Acanthiza apicalis	Inland Thornbill	CS3 (HS)	irregular visitor	X
Anthochaera lunulata	Western Wattlebird	CS3 (WR)	resident	
Glyciphila melanops	Tawny-crowned Honeyeater	CS3 (WR)	regular visitor	X
Phylidonyris novaehollandiae	New Holland Honeyeater	CS3 (WR)	resident	X
Phylidonyris niger	White-cheeked Honeyeater	CS3 (WR)	resident	
Ptilotula ornata	Yellow-plumed Honeyeater	CS3 (WR)	regular visitor	
Daphoenositta chrysoptera	Varied Sittella	CS3 (HS)	regular visitor	
Pachycephala fuliginosa	Western Whistler	CS3 (HS)	resident	
Colluricincla harmonica	Grey Shrike-thrush	CS3 (HS)	resident	X
Artamus cinereus	Black-faced Woodswallow	CS3 (WR)	resident	X
Artamus cyanopterus	Dusky Woodswallow	CS3 (WR)	resident	X
Cracticus nigrogularis	Pied Butcherbird	CS3 (WR)	irregular visitor	
Strepera versicolor	Grey Currawong	CS3 (WR)	irregular visitor	
Myiagra inquieta	Restless Flycatcher	CS3 (HS)	Irregular visitor	
Petroica boodang	Scarlet Robin	CS3 (HS)	regular visitor	X
Petroica goodenovii	Red-capped Robin	CS3 (HS)	regular visitor	X
Eopsaltria georgiana	White-breasted Robin	CS3 (HS)	irregular visitor	
Melanodryas cucullata	Hooded Robin	CS3 (HS)	regular visitor	
MAMMALS				
Dasyurus geoffroii	Chuditch	CS1 (V, S3[v])	irregular visitor	
Phascogale tapoatafa wambenger	Brush-tailed Phascogale	CS1 (V,S3[v])	irregular visitor	
Sminthopsis 'dolichura'	Little Dunnart	CS3 (LS)	resident	X
Sminthopsis fuliginosus	Grey-bellied Dunnart	CS3 (LS)	resident	
Isoodon fusciventer	Quenda	CS2 (P5)	resident	
Macropus irma	Brush Wallaby	CS2 (P4)	resident	
Cercartetus concinnus	Western Pygmy-possum	CS3 (LS)	resident	
Mormopterus kitcheneri	Western Freetail-Bat	CS3 (LS)	resident	
Pseudomys albocinereus	Noodji, Ash-grey Mouse	CS3 (LS)	resident	X
Hydromys chrysogaster	Rakali, Water-Rat	CS2 (P4)	irregular visitor	
INVERTEBRATES				

Species		Conservation significance	Status in Project Area	Recorded
Hesperocolletes douglasi	Short-tongued bee	CS1 (S3[Ex])	resident	
Leioproctus contrarius	Short-tongued bee	CS2 (P3)	resident	
Glossurocolletes bilobatus	Short-tongued bee	CS2 (P2)	resident	
Antichiropus UBS2	millipede	CS3 (SRE)	resident	
Aname mellosa group	Spider	CS3 (SRE)	resident	X
Kwonkan sp.	Spider	CS3 (SRE)	resident	X

3.2.4 Patterns of biodiversity

The patterns of biodiversity within the Project Area are likely to be largely homogenous given the similar environment across the majority of the Project Area. Very extensive sampling would be required to define fauna assemblages in the three key VSAs, and even then there would be considerable overlap and probably only differences in relative abundance between common species, rather than actual differences in species composition.

There is expected to be a high level of vertebrate fauna diversity, particularly reptiles, in the banksia and eucalypt woodlands which occurs across the Project Area. The patches of Marri and Jarrah woodland may support higher diversity of birds, as recorded during field investigations, with just a few species largely restricted to eucalypt areas. The high diversity across the Project Area is expected because the woodlands are in excellent condition, with high quality understorey vegetation containing few weeds, and are well-connected to wider areas of bushland to the west and south. The Melaleuca shrubland has high bird richness, which may be due to the higher productivity (related to soil moisture) and diversity of vegetation in the site. The northern sampling sites (mostly Banksia woodland) recorded markedly higher abundance and richness of reptiles which may reflect the more complex vegetation structure present in the north due to the longer length of time following wildfire. Bushland of the northern Swan Coastal Plain is well-recognised as having high biodiversity values (e.g. Bleby *et al*. 2009). At the micro-landscape scale, individual large Jarrah and Marri trees may be important for hollow-nesting, roosting and canopy species, while a higher proportion of small insectivorous birds may occur in areas with thicker understorey and midstorey layers.

3.2.5 Ecological processes

The nature of the landscape and the fauna assemblage indicate some of the ecological processes that may be important for ecosystem function (see Appendices 2 and 4 for descriptions and other ecological processes). These include:

Fire. As is the case throughout most of Western Australia, the vegetation of the region is fire-adapted to some degree, but the flora and fauna assemblages can be altered by too-frequent fires, fire intensity and even by fire exclusion. Some species are particularly sensitive to wildfires and altered fire regimes. Fire season may also be important in seed germination. Fauna in small and isolated reserves can be vulnerable to local extinction due to an inappropriate fire regime, and this may be a concern for the Project Area. The Project Area has been subjected to at least three fires

of varying intensity and extent over the last ten years. A fire break extending from east to west was installed in 2011 around the time of one extensive fire that burnt the northern half of the Project Area, while the most recent fire appears to have burnt the southern half of the Project Area in 2015.

Hydrology. There do not appear to be drainage systems in the Project Area and, as such, there should not be any changes to surface hydrology and consequent direct impacts to fauna. However, much of the area is low-lying so there is likely to be an interaction between vegetation and near-surface groundwater.

Feral species and interactions with over-abundant native species. Feral species occur throughout Western Australia and are particularly prevalent in areas of unmanaged vegetation, such as the Project Area. The Rabbit, Fox, Cat, House Mouse, Dog and Pig were recorded during field investigations, and additional feral species are expected to be resident. Honey Bees are almost certainly present in tree hollows in the Project Area. In a recent study in a small bushland reserve in Bullsbrook, BCE found several domestic Cats were regularly visiting the reserve from nearby private property (unpub. data). The same is likely to be happening within the Project Area with several rural properties on the eastern side of the Project Area close to the Brand highway. This can lead to further loss of mammals and to the local extinction of sedentary birds such as fairy-wrens (Bamford 2008).

Connectivity and landscape permeability. The Project Area is part of a larger and extensive area of native vegetation and has continuous connectivity with Yeal Nature Reserve to the northwest, Gnangara/Moore River State Forest to the southwest, and Melaleuca Park bushland to the south. Historical land clearing for semi-rural use and major roads have led to considerable habitat fragmentation to the east. Connectivity is thus very good to the west but poor to the east, affecting movement of fauna from the coastal plain to the escarpment. This may affect species such as the Chuditch and Brush-tailed Phascogale that are still present in forests of the escarpment but occur irregularly on the coastal plain.

3.2.6 Summary of fauna values

The desktop study identified 215 vertebrate fauna species as potentially occurring in the survey area (see Table 3-1 and Appendix 6): 10 frogs, 49 reptiles, 128 birds, 19 native mammals and nine feral mammals. This does not include several locally extinct mammal species. The assemblage includes 56 species of conservation significance. Fauna values within the survey area can be summarised as follows:

Fauna assemblage. The fauna assemblage is largely intact, but some species loss has occurred in mammals and possibly birds, although the persistence of a suite of small mammals is uncertain. The lowland Melaleuca (VSA 1) in the eastern part has undergone some historical clearing and is likely to have undergone some reduction in fauna richness. A notable feature of the assemblage is the large proportion of fossorial (burrowing and sand-swimming) reptiles due to the VSAs present, some species with limited distributions. Overall, the fauna assemblage is likely to be well-represented in the region encompassing the northern Swan Coastal Plain but may be the best representation of this assemblage close to Perth. The assemblage is considered rich due to the

assemblage expected to occur and the high quality, extent and degree of connectivity of the bushland.

Species of conservation significance. The Project Area potentially has a rich assemblage of conservation significant species, a large proportion of these being locally significant and not having any formal listing (i.e. CS3). Species of most interest are:

- The two Black-Cockatoo species (Carnaby's and Forest Red-tailed Black-Cockatoos) for which extensive and high quality foraging habitat occurs across the Project Area (VSAs 2, 3 and 4), and some limited but potential hollow nesting habitat (VSAs 2 and 3). Both Black-Cockatoo species were confirmed as present within the Project Area.
- Four reptile species with limited or reduced distributions on the northern Swan Coastal Plain that are almost certainly present.
- A suite of CS3 bird species which are sensitive to fragmentation.
- Several species of mammals located at the edge of their range in the Project Area; Noodji and at least one dunnart species.
- A previously-believed extinct bee which is likely to be resident in the Project Area.

Patterns of biodiversity. Similar patterns of biodiversity are expected across the majority of the Project Area as it is mostly banksia and eucalypt woodland on sandy soils, which is expected to support similar suites of species. Higher richness of birds was recorded in the eucalypt woodlands, while higher diversity of reptiles was recorded in the northern sampling sites due to more complex vegetation structure. Higher richness of fauna can be expected in the seasonally-damp Melaleuca shrublands in the north.

Key ecological processes. The most important ecological processes affecting the fauna assemblage are fire, hydrology, impacts of feral predators (including domestic Cats), habitat fragmentation and landscape connectivity.

Overall, the fauna assemblage is likely to be well-represented in the region encompassing the northern Swan Coastal Plain, but is notable for being close to Perth where such fauna assemblages have declined. The assemblage is considered rich due to the assemblage expected to occur and the high quality and extent of the bushland, particularly Banksia woodland.

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5 Appendices.

5.1 Appendix 1. Explanation of fauna values.

Fauna values are the features of a site and its fauna that contribute to biodiversity, and it is these values that are potentially at threat from a development proposal. Fauna values can be examined under the five headings outlined below. It must be stressed that these values are interdependent and should not be considered equal, but rather contribute to an understanding of the biodiversity of a site. Understanding fauna values provides opportunities to predict and therefore mitigate impacts.

Assemblage characteristics

Uniqueness. This refers to the combination of species present at a site. For example, a site may support an unusual assemblage that has elements from adjacent biogeographic zones, it may have species present or absent that might be otherwise expected, or it may have an assemblage that is typical of a very large region. For the purposes of impact assessment, an unusual assemblage has greater value for biodiversity than a typical assemblage.

Completeness. An assemblage may be complete (i.e., has all the species that would have been present at the time of European settlement) or it may have lost species due to a variety of factors. Note that a complete assemblage, such as on an island, may have fewer species than an incomplete assemblage (such as in a species-rich but degraded site on the mainland).

Richness. This is a measure of the number of species at a site. At a simple level, a species-rich site is more valuable than a species-poor site, but value is also determined by other factors, for example, by the sorts of species present.

Vegetation and Substrate Associations

Vegetation and Substrate Associations (VSAs) combine broad vegetation types, the soils or other substrate with which they are associated, and the landform. In the context of fauna assessment, VSAs are the environments that provide habitats for fauna. The term habitat is widely used in this context, but by definition an animal's habitat is the environment that it utilises (Calver *et al.* 2009), not the environment as a whole. Habitat is a function of the animal and its ecology, rather than being a function of the environment. For example, a species may occur in eucalypt canopy or in leaf-litter on sand, and that habitat may be found in only one or in several VSAs. VSAs are not the same as vegetation types since these may not incorporate soil and landform, and recognise floristics to a degree that VSAs do not. Vegetation types may also not recognise minor but often significant (for fauna) structural differences in the environment, which VSAs will recognise. VSAs also do not necessarily correspond with soil types, but may reflect some of these elements.

Because VSAs provide the habitat for fauna, they are important in determining assemblage characteristics. For the purposes of impact assessment, VSAs can also provide a surrogate for detailed information on the fauna assemblage. For example, rare, relictual or restricted VSAs should automatically be considered a significant fauna value. Impacts may be significant if the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna. The

disturbance of even small amounts of habitat in a localised area can have significant impacts to fauna if rare or unusual habitats are disturbed.

Patterns of biodiversity across the landscape

This fauna value relates to how the assemblage is organised across the landscape. Generally, the fauna assemblage is not distributed evenly across the landscape or even within one VSA. There may be zones of high biodiversity, such as particular environments or ecotones (transitions between VSAs). There may also be zones of low biodiversity. Impacts may be significant if a wide range of species is affected even if most of those species are not significant per se.

Species of conservation significance

Species of conservation significance are of special importance in impact assessment. The conservation status of fauna species in Australia is assessed under Commonwealth and State Acts such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Western Australian *Biodiversity Conservation Act 2016* (Biodiversity Conservation Act). In addition, the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) recognises priority levels, while local populations of some species may be significant even if the species as a whole has no formal recognition. Therefore, three broad levels of conservation significance can be recognised and are used for the purposes of this report and are outlined below. A full description of the conservation significance levels, schedules and priority levels mentioned below is provided in Appendix 3.

Conservation Significance (CS) level 1: Species listed under State or Commonwealth Acts.

Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the Convention on the Conservation of Migratory Species of Wild Animals (CMS; also referred to as the Bonn Convention). The Biodiversity Conservation Act uses a series of Schedules to classify status, but also recognizes the IUCN categories and ranks species within the Schedules using the categories of Mace and Stuart (1994).

Conservation Significance (CS) level 2: Species listed as Priority by the DBCA but not listed under State or Commonwealth Acts.

In Western Australia, the DBCA has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the Biodiversity Conservation Act but for which the DBCA believes there is cause for concern. Some Priority species are also assigned to the Conservation Dependent category of the IUCN.

Conservation Significance (CS) level 3: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution.

This level of significance has no legislative or published recognition and is based on interpretation of distribution information and expert judgment, but is used here as it may have links to preserving biodiversity at the genetic level (EPA 2002). If a population is isolated but a subset of a widespread

(common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Conservation significance is applied to allow for the preservation of genetic richness at a population level, and not just at a species level. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3, as may colonies of waterbirds. The Western Australian Department of Environmental Protection, now DBCA, used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan (DEP 2000).

Invertebrate species considered to be short range endemics (SREs) also fall within the CS3 category, as they have no legislative or published recognition and their significance is based on interpretation of distribution information. Harvey (2002) notes that the majority of species that have been classified as short-range endemics have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. Several groups, therefore, have particularly high instances of short-range endemic species: Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Pseudoscorpionida (pseudoscorpions), Schizomida (schizomids), Diplopoda (millipedes), Phreatoicidea (phreatoicidean crustaceans), and Decapoda (freshwater crayfish). The poor understanding of the taxonomy of many of the short-range endemic species hinders their conservation (Harvey 2002).

Introduced species

In addition to these conservation levels, species that have been introduced (INT) are indicated throughout the report. Introduced species may be important to the native fauna assemblage through effects by predation and/or competition.

Ecological processes upon which the fauna depend

These are the processes that affect and maintain fauna populations in an area and as such are very complex; for example, populations are maintained through the dynamic of mortality, survival and recruitment being more or less in balance, and these are affected by a myriad of factors. The dynamics of fauna populations in a project may be affected by processes such as fire regime, landscape patterns (such as fragmentation and/or linkage), the presence of feral species and hydrology. Impacts may be significant if processes are altered such that fauna populations are adversely affected, resulting in declines and even localised loss of species. Threatening processes as outlined below are effectively the ecological processes that can be altered to result in impacts upon fauna.

5.2 Appendix 2. Explanation of threatening processes.

Potential impacts of proposed developments upon fauna values can be related to threatening processes. This is recognised in the literature (e.g. Gleeson and Gleeson 2012) and under the EPBC Act, in which threatening processes are listed. Processes that may impact fauna values are discussed below. Rather than being independent of one another, processes are complex and often interrelated. They are the mechanisms by which fauna can be affected by development. Impacts may be significant if large numbers of species or large proportions of populations are affected.

Loss of habitat affecting population survival

Clearing for a development can lead to habitat loss for a species with a consequent decline in population size. This may be significant if the smaller population has reduced viability. Conservation significant species or species that already occur at low densities may be particularly sensitive to habitat loss affecting population survival.

Loss of habitat leading to population fragmentation

Loss of habitat can affect population movements by limiting movement of individuals throughout the landscape as a result of fragmentation (Gleeson and Gleeson 2012, Soule *et al.* 2004). Obstructions associated with the development, such as roads, pipes and drainage channels, may also affect movement of small, terrestrial species. Fragmented populations may not be sustainable and may be sensitive to effects such as reduced gene flow.

Degradation of habitat due to weed invasion leading to population decline

Weed invasion, such as through introduction by human boots or vehicle tyres, can occur as a result of development and if this alters habitat quality, can lead to effects similar to habitat loss.

Increased mortality

Increased mortality can occur during project operations; for example, roadkill, animals striking infrastructure, and entrapment in trenches. Roadkill as a cause of population decline has been documented for several medium-sized mammals in eastern Australia (Dufty 1989, Jones 2000). Increased mortality due to roadkill is often more prevalent in habitats that have been fragmented (Scheick and Jones 1999, Clevenger and Waltho 2000, Jackson and Griffin 2000). Increased mortality of common species during development is unavoidable and may not be significant for a population. However, the cumulative impacts of increased mortality of conservation significant species or species that already occur at low densities may have a significant impact on the population.

Species interactions, including predation and competition

Changes in species interactions often occur with development. Introduced species, including the feral Cat, Red Fox and Rabbit, may have adverse impacts upon native species and development can alter their abundance. In particular, some mammal species are very sensitive to introduced predators and the decline of many mammals in Australia has been linked to predation by the Red Fox, and to a lesser extent, the feral Cat (Burbidge and McKenzie 1989). Introduced grazing species, such as the Rabbit, Goat, Camel and domestic livestock, can also degrade habitats and deplete vegetation that may be a food source for other species.

Changes in the abundance of some native species at the expense of others, due to the provision of fresh watering points, can also be a concern. Harrington (2002) found the presence of artificial fresh waterpoints in the semi-arid mallee rangelands to influence the abundance and distribution of certain bird species. Common, water-dependent birds were found to out-compete some less common, water-independent species. Over-abundant native herbivores, such as kangaroos, can also adversely affect less abundant native species through competition and displacement.

Hydroecology

Interruptions of hydroecological processes can have major effects because they underpin primary production in ecosystems and there are specific, generally rare habitats that are hydrology-dependent. Fauna may be impacted by potential changes to groundwater level and chemistry and altered flow regime. These changes may alter vegetation across large areas and may lead to habitat degradation or loss. Impacts upon fauna can be widespread and major. Changes to flow regime across the landscape may alter vegetation and may lead to habitat degradation or loss, affecting fauna. For example, Mulga has a shallow root system and relies on surface sheet flow during flood events. If surface sheet flow is impeded, Mulga can die (Kofoed 1998), which may impact on a range of fauna associated with this vegetation type.

Fire

The role of fire in the Australian environment and its importance to vertebrate fauna has been widely acknowledged (Gill et al. 1981, Fox 1982, Bamford and Roberts 2003). It is also one of the factors that has contributed to the decline and local extinction of some mammal and bird species (Burbidge and McKenzie 1989). Fire is a natural feature of the environment but frequent, extensive fires may adversely impact some fauna, particularly mammals and short-range endemic species. Changes in fire regime, whether to more frequent or less frequent fires, may be significant to some fauna. Impacts of severe fire may be devastating to species already occurring at low densities or to species requiring long unburnt habitats to survive. In terms of conservation management, it is not fire *per se* but the fire regime that is important, with evidence that infrequent, extensive and intense fires adversely affect biodiversity, whereas frequent fires that cover small areas and are variable in both season and intensity can enhance biodiversity. Fire management may be considered the responsibility of managers of large tracts of land, including managers of mining tenements.

Dust, light, noise and vibration

Impacts of dust, light, noise and vibration upon fauna are difficult to predict. Some studies have demonstrated the impact of artificial night lighting on fauna, with lighting affecting fauna behaviour more than noise (Rich and Longcore 2006). Effects can include impacts on predator-prey interactions, changes to mating and nesting behaviour, and increased competition and predation within and between invertebrates, frogs, birds and mammals.

The death of very large numbers of insects has been observed around some remote mine sites and attracts other fauna, notably native and introduced predators (M. Bamford, pers. obs). The abundance of some insects can decline due to mortality around lights, although this has previously been recorded in fragmented landscapes where populations are already under stress (Rich and

Longcore 2006). Artificial night lighting may also lead to disorientation of migratory birds. Aquatic habitats and open habitats such as grasslands and dunes may be vulnerable to light spill.

5.3 Appendix 3. Categories used in the assessment of conservation status.

IUCN categories (based on review by Mace and Stuart 1994) as used for the *Environment Protection and Biodiversity Conservation Act 1999* and the Western Australian *Biodiversity Conservation Act 2016*.

Extinct	Taxa not definitely located in the wild during the past 50 years.
Extinct in the Wild (Ex)	Taxa known to survive only in captivity.
Critically Endangered (CR)	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
Endangered (E)	Taxa facing a very high risk of extinction in the wild in the near future.
Vulnerable (V)	Taxa facing a high risk of extinction in the wild in the medium-term future.
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 classed 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 Threatened.

Schedules used in the WA *Biodiversity Conservation Act 2016.*

Schedule 1 (S1)	Critically Endangered fauna
Schedule 2 (S2)	Endangered fauna
Schedule 3 (S3)	Vulnerable Migratory species listed under international treaties
Schedule 4 (S4)	Presumed extinct fauna
Schedule 5 (S5)	Migratory birds under international agreement
Schedule 6 (S6)	Conservation dependent fauna
Schedule 7 (S7)	Other specially protected fauna

WA Department of Biodiversity, Conservation and Attractions Priority species (species not listed under the *Biodiversity Conservation Act 2016*, but for which there is some concern).

Priority 1 (P1)	Taxa with few, poorly known populations on threatened lands.
Priority 2 (P2)	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3 (P3)	Taxa with several, poorly known populations, some on conservation lands.
Priority 4. (P4)	Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.
Priority 5 (P5)	Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

5.4 Appendix 4. Ecological and threatening processes identified under legislation and in the literature.

Ecological processes are processes that maintain ecosystems and biodiversity. They are important for the assessment of impacts of development proposals because ecological processes make ecosystems sensitive to change. The interaction of ecological processes with impacts and conservation of biodiversity has an extensive literature. Following are examples of the sorts of ecological processes that need to be considered.

Ecological processes relevant to the conservation of biodiversity in Australia (Soule *et al.* 2004):

- Critical species interactions (highly interactive species);
- Long distance biological movement;
- Disturbance at local and regional scales;
- Global climate change;
- Hydroecology;
- Coastal zone fluxes;
- Spatially-dependent evolutionary processes (range expansion and gene flow); and
- Geographic and temporal variation of plant productivity across Australia.

Threatening processes (EPBC Act)

Under the EPBC Act, a key threatening process is an ecological interaction that threatens or may threaten the survival, abundance or evolutionary development of a threatened species or ecological community. There are currently 20 key threatening processes listed by the federal Department of the Environment and Energy (DoEE 2018c):

- Competition and land degradation by rabbits.
- Competition and land degradation by unmanaged goats.
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*).
- Incidental catch (bycatch) of Sea Turtle during coastal otter-trawling operations within Australian waters north of 28 degrees South.
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations.
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis.
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris.
- Invasion of northern Australia by Gamba Grass and other introduced grasses.
- Land clearance.
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.
- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean.
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases.
- Novel biota and their impact on biodiversity.
- Predation by European red fox.
- Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha).

- Predation by feral cats.
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs.
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species.
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Bufo marinus*).
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta* (fire ant).

General processes that threaten biodiversity across Australia (Department of Environment, Water, Heritage and the Arts 2009):

- Vegetation clearing;
- Increasing fragmentation, loss of remnants and lack of recruitment;
- Firewood collection;
- Grazing pressure;
- Feral animals;
- Exotic weeds;
- Changed fire regimes;
- Pathogens;
- Changed hydrology—dryland salinity and salt water intrusion;
- Changed hydrology— such as altered flow regimes affecting riparian vegetation; and
- Pollution.

In addition to the above processes, DSEWPaC (2013) (now DoEE) has produced Significant Impact Guidelines that provide criteria for the assessment of the significance of impacts. These criteria provide a framework for the assessment of significant impacts. The criteria are:

- Will the proposed action lead to a long-term decrease in the size of a population?
- Will the proposed action reduce the area of occupancy of the species?
- Will the proposed action fragment an existing population?
- Will the proposed action adversely affect habitat critical to the survival of a species?
- Will the proposed action disrupt the breeding cycle of a population?
- Will the proposed action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?
- Will the proposed action result in introducing invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat?
- Will the proposed action introduce disease that may cause the species to decline?
- Will the proposed action interfere with the recovery of the species?

5.5 Appendix 5. GPS coordinates of pitfall traps and funnel lines

Site	Trap type	Pitfall number	Easting	Northing
1	Pitfall traps	1	394070.4	6517025
1	Pitfall traps	2	394055.5	6517018
1	Pitfall traps	3	394035.9	6517013
1	Pitfall traps	4	394016.7	6517008
1	Pitfall traps	5	393997.1	6517008
1	Pitfall traps	6	393977.8	6516994
1	Pitfall traps	7	393957.3	6516985
1	Pitfall traps	8	393942.1	6516978
1	Pitfall traps	9	393922.6	6516974
1	Pitfall traps	10	393903.1	6516967
1	Pitfall traps	11	393876.1	6516963
1	Pitfall traps	12	393857.8	6516965
1	Pitfall traps	13	393834.5	6516966
1	Pitfall traps	14	393810.4	6516964
1	Pitfall traps	15	393786.8	6516964
2	Pitfall traps	1	393053.7	6516999
2	Pitfall traps	2	393035	6516994
2	Pitfall traps	3	393019.4	6516988
2	Pitfall traps	4	392999.7	6516972
2	Pitfall traps	5	392975.1	6516969
2	Pitfall traps	6	392956.2	6516968
2	Pitfall traps	7	392934.1	6516964
2	Pitfall traps	8	392918.9	6516957
2	Pitfall traps	9	392899.9	6516954
2	Pitfall traps	10	392880.3	6516956
2	Pitfall traps	11	392859.8	6516949
2	Pitfall traps	12	392832.3	6516945
2	Pitfall traps	13	392809.1	6516944
2	Pitfall traps	14	392782.3	6516934
2	Pitfall traps	15	392767.6	6516938
3	Pitfall traps	1	392624.8	6516981
3	Pitfall traps	2	392603.9	6516976
3	Pitfall traps	3	392582.2	6516960
3	Pitfall traps	4	392550	6516956
3	Pitfall traps	5	392528.1	6516961
3	Pitfall traps	6	392497.7	6516960
3	Pitfall traps	7	392469.2	6516955
3	Pitfall traps	8	392444.6	6516942
3	Pitfall traps	9	392415.2	6516941
3	Pitfall traps	10	392390.6	6516933
3	Pitfall traps	11	392365.9	6516932
3	Pitfall traps	12	392341.2	6516933
3	Pitfall traps	13	392313.7	6516927

Site	Trap type	Pitfall number	Easting	Northing
3	Pitfall traps	14	392293.9	6516916
3	Pitfall traps	15	392273.9	6516916
4	Pitfall traps	1	393367.7	6515830
4	Pitfall traps	2	393370.6	6515871
4	Pitfall traps	3	393361.7	6515880
4	Pitfall traps	4	393366.7	6515903
4	Pitfall traps	5	393369.2	6515928
4	Pitfall traps	6	393371.3	6515941
4	Pitfall traps	7	393377	6515965
4	Pitfall traps	8	393372.4	6515997
4	Pitfall traps	9	393366.2	6516015
4	Pitfall traps	10	393353.5	6516037
4	Pitfall traps	11	393351.8	6516060
4	Pitfall traps	12	393344	6516081
4	Pitfall traps	13	393332.7	6516096
4	Pitfall traps	14	393323.4	6516123
4	Pitfall traps	15	393307.1	6516148
5	Pitfall traps	1	395348	6513727
5	Pitfall traps	2	395333	6513707
5	Pitfall traps	3	395316	6513699
5	Pitfall traps	4	395299.1	6513682
5	Pitfall traps	5	395283.1	6513663
5	Pitfall traps	6	395264.3	6513649
5	Pitfall traps	7	395239.8	6513627
5	Pitfall traps	8	395226.7	6513610
5	Pitfall traps	9	395205.9	6513595
5	Pitfall traps	10	395185.2	6513578
5	Pitfall traps	11	395170.2	6513562
5	Pitfall traps	12	395155.1	6513548
5	Pitfall traps	13	395136.2	6513537
5	Pitfall traps	14	395111.7	6513519
5	Pitfall traps	15	395092.9	6513500
6	Pitfall traps	1	394323.4	6512770
6	Pitfall traps	2	394341.3	6512792
6	Pitfall traps	3	394361.1	6512804
6	Pitfall traps	4	394365.6	6512828
6	Pitfall traps	5	394389.2	6512838
6	Pitfall traps	6	394400.5	6512846
6	Pitfall traps	7	394414.6	6512862
6	Pitfall traps	8	394428.7	6512878
6	Pitfall traps	9	394443.8	6512891
6	Pitfall traps	10	394461.7	6512900
6	Pitfall traps	11	394474.8	6512926
6	Pitfall traps	12	394490.8	6512939

Site	Trap type	Pitfall number	Easting	Northing
6	Pitfall traps	13	394501.1	6512953
6	Pitfall traps	14	394509.4	6512971
6	Pitfall traps	15	394533.1	6512984
7	Pitfall traps	1	393372.7	6511851
7	Pitfall traps	2	393360.4	6511837
7	Pitfall traps	3	393353.1	6511820
7	Pitfall traps	4	393347.9	6511798
7	Pitfall traps	5	393344.9	6511775
7	Pitfall traps	6	393337.8	6511753
7	Pitfall traps	7	393326.9	6511739
7	Pitfall traps	8	393306.7	6511731
7	Pitfall traps	9	393295	6511716
7	Pitfall traps	10	393286.3	6511695
7	Pitfall traps	11	393269.8	6511686
7	Pitfall traps	12	393262.3	6511674
7	Pitfall traps	13	393246.3	6511656
7	Pitfall traps	14	393238.7	6511643
7	Pitfall traps	15	393229.9	6511623
8	Pitfall traps	1	392478.8	6511140
8	Pitfall traps	2	392463.8	6511137
8	Pitfall traps	3	392441.4	6511129
8	Pitfall traps	4	392423.5	6511120
8	Pitfall traps	5	392399	6511121
8	Pitfall traps	6	392367.5	6511130
8	Pitfall traps	7	392334.9	6511130
8	Pitfall traps	8	392308.6	6511140
8	Pitfall traps	9	392278.1	6511140
8	Pitfall traps	10	392255.9	6511147
8	Pitfall traps	11	392232.2	6511151
8	Pitfall traps	12	392203.5	6511159
8	Pitfall traps	13	392178.4	6511167
8	Pitfall traps	14	392154.2	6511172
8	Pitfall traps	15	392134.3	6511181
1	Funnel line		394070.4	6517025
2	Funnel line		393053.7	6516999
4	Funnel line		393367.7	6515830

5.6 Appendix 6. Fauna expected to occur in the Project Area.

Conservation significance codes:

- CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 3 for full explanation.
- EPBC Act listings (CS1): Ex = Presumed Extinct, C = Critically Endangered; E = Endangered, V = Vulnerable, M = Migratory.
- Western Australia Wildlife Conservation Act listings (CS1): S1 to 7 = Schedules 1 to 7.
- DBCA Priority species (CS2): P1 to P5 = Priority 1 to 5.
- Bush Forever (DEP 2000) status (CS3): HS = habitat specialists with a reduced distribution on the Swan Coastal Plain; LE = locally extinct; WR = wide ranging species with reduced populations on the Swan Coastal Plain.
- LS (CS3) = considered to be of local significance by Bamford Consulting Ecologists.
- Int = introduced species.
- X = recorded by BCE during site visits and field investigations

Status in Project Area is based on the categories described in Section 2.2.4. Species marked with a superscript 'w' are generally dependent on wetlands. Sources of information (see Section 2.2.1 for more details):

- 1 = Atlas of Living Australia database search.
- 2 = NatureMap database search.
- 3 = BirdLife Australia Atlas II database search.
- 4 = EPBC Protected Matters Search Tool.

Species		Conservation significance	Status in Project Area	Source	Recorded
FROGS					
Hylidae (Tree frogs)					
Litoria adelaidensis	Slender Tree Frog		regular visitor	1	
Litoria moorei	Motorbike Frog		regular visitor	1,2	
Limnodynastidae (Burrowing frogs)					
Heleioporus eyrei	Moaning Frog		resident	1,2	X
Heleioporus psammophilus	Sand Frog		resident	2	
Limnodynastes dorsalis	Pobblebonk		resident	1,2	X
Myobatrachidae (Australian frogs)					
Crinia glauerti	Clicking Froglet		resident	1,2	
Crinia insignifera	Squelching Froglet		resident	1,2	
Myobatrachus gouldii	Turtle Frog		resident	1,2	X
Neobatrahus pelobatoides	Humming Frog		resident	1,2	
Pseudophryne guentheri	Crawling Toadlet		resident	1,2	
REPTILES					
Chelidae (side-necked tortoises)					
Chelodina colliei	South-west Long-necked Tortoise		irregular visitor	1,2	
Agamidae (Dragons)					
Ctenophorus adelaidensis	Western Heath Dragon		resident	1,2	X
Pogona minor minor	Western Bearded Dragon		resident	1,2	X

Species		Conservation significance	Status in Project Area	Source	Recorded
Diplodactylidae (Diplodactylids)					
Crenadactylus occelatus	Clawless Gecko		resident	1,2	
Strophurus spinigerus spinigerus	Soft Spiny-tailed Gecko		resident	1,2	X
Lucasium alboguttatum	White Spotted Gecko		resident	1,2	
Gekkonidae (Gekkonids)					
Christinus marmoratus	Marbled Gecko		resident	1,2	
Pygopodidae (Legless lizards)					
Aprasia repens	Sand-plain Worm-lizard		resident	1,2	X
Delma concinna	Javelin Legless Lizard		resident	1,2	
Delma fraseri	Fraser's Legless Lizard		resident	1,2	X
Delma grayii	Gray's Legless Lizard		resident	1,2	
Lialis burtonis	Burton's Legless Lizard		resident	1,2	
Pletholax gracilis	Keeled Legless Lizard		resident	1,2	X
Pygopus lepidopodus	Common Scaly-foot		resident	1,2	
Scincidae (Skinks)					
Acritoscincus trilineatum	Cool Skink		resident	1,2	
Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink		resident	1,2	X
Ctenotus australis	Western Limestone Ctenotus		resident	1,2	
Ctenotus fallens	West Coast Ctenotus		resident	1,2	X
Ctenotus impar	Odd-striped Ctenotus		resident		X
Ctenotus schomburgkii	Barred Wedge-snout Ctenotus		resident	2	
Ctenotus gemmula	Jewelled Sand-plain Skink	CS2 (P3)	resident		
Cyclodomorphus celatus	Western Slender Blue-tongue		resident		X
Egernia kingii	King's Skink		resident	1,2	
Egernia napoleonis	Salmon-bellied Skink		resident	1,2	X
Hemiergis quadrilineata	Two-toed Earless Skink		resident	1,2	X
Lerista christinae	Bold-striped Slider	CS3	resident	1,2	
Lerista elegans	West Coast Four-toed Slider		resident	1,2	X
Lerista lineopunctulata	West Coast Line-spotted Slider		resident	1,2	
Lerista praepedita	West Coast Worm-slider		resident	1,2	X
Menetia greyii	Common Dwarf Skink		resident		X
Morethia lineoocellata	Western Pale-flecked Morethia		resident	1,2	X
Morethia obscura	Dusky Morethia		resident	1,2	X
Tiliqua occipitalis	Western Blue-tongue		resident	1,2	
Tiliqua rugosa	Bobtail		resident	1,2	
Varanidae (Monitor lizards)					
Varanus gouldii	Gould's Monitor		resident	1,2	

Species		Conservation significance	Status in Project Area	Source	Recorded
Varanus tristis	Black-headed Monitor		resident	1,2	
Typhlopidae (Blind snakes)					
Anilios australis	Southern Blind Snake		resident	1,2	
Boidae (Pythons)					
Morelia spilota imbricata	Carpet Python (south-west pop'n)	CS3	resident	1,2	
Elapidae (Venomous land snakes)					
Brachyurophis fasciolatus	Narrow-banded Burrowing Snake		resident	1,2	
Brachyurophis semifasciatus	Southern Shovel-nosed Snake		resident	1,2	
Demansia reticulata	Yellow-faced Whip Snake		resident	1,2	
Echiopsis curta	Bardick		resident	1,2	
Neelaps bimaculatus	Black-naped Snake		resident	1,2	X
Neelaps calonotos	Black-striped Snake	CS2 (P3)	resident	2	X
Notechis scutatus	Tiger Snake		resident	1,2	
Parasuta gouldii	Gould's Snake		resident	1,2	X
Parasuta nigreceps	Black-backed Snake		resident	1,2	
Pseudonaja affinis	Dugite		resident	1,2	
Simoselaps bertholdi	Jan's Banded Snake		resident	1,2	X
BIRDS					
Casuariidae (Cassowaries, emus)					
Dromaius novaehollandiae	Emu		resident	1,2,3	X
Phasianidae (Pheasants and allies)					
Coturnix pectoralis	Stubble Quail		regular visitor		
Anatidae (Ducks and allies)					
Cygnus atratus	Black Swan		regular visitor	1,2	
Tadorna tadornoides	Australian Shelduck [w]		regular visitor	1,2,3	
Chenonetta jubata	Australian Wood Duck [w]		regular visitor	1,2,3	
Anas gracilis	Grey Teal [w]		regular visitor	1,2,3	
Anas castanea	Chestnut Teal [w]		regular visitor	1,2	
Anas rhynchotis	Australasian Shoveler [w]		regular visitor	1,2,3	
Anas superciliosa	Pacific Black Duck [w]		regular visitor	1,2,3	
Aythya australis	Hardhead [w]		regular visitor	1,2	
Columbidae (Pigeons and doves)					
Columba livia	Rock Dove/Feral Pigeon	Int	vagrant	1	
Streptopelia chinesensis	Spotted Dove	Int	irregular visitor	2	
Streptopelia senegalensis	Laughing Dove	Int	irregular visitor	1,2,3	
Phaps chalcoptera	Common Bronzewing	CS3 (HS)	resident	1,2,3	X

Species		Conservation significance	Status in Project Area	Source	Recorded
Ocyphaps lophotes	Crested Pigeon		regular visitor	1,2,3	
Podargidae (Australian frogmouth)					
Podargus strigoides	Tawny Frogmouth		resident	1,2,3	
Aegothelidae (Owlet-nightjars)					
Aegotheles cristatus	Australian Owlet-nightjar		regular visitor	1,2	
Apodidae (Typical swifts)					
Apus pacificus	Fork-tailed Swift	CS1 (M, S5)	irregular visitor	1,2	
Phalacrocoracididae (cormorants)					
Phalacrocorax melanoleucos	Little Pied Cormorant		irregular visitor	1,2,3	
Ardeidae (Heron, bittern, egret)					
Egretta novaehollandiae	White-faced Heron		irregular visitor	1,2,3	
Ardea modesta	Eastern Great Egret		irregular visitor	4	
Ardea ibis	Cattle Egret		vagrant	4	
Ardea pacifica	White-necked Heron		irregular visitor	1,2	
Threskiornithidae (Ibis, Spoonbill)					
Threskiornis moluccus	Australian White Ibis		regular visitor	1,3	
Threskiornis spinicollis	Straw-necked Ibis		irregular visitor	1,2,3	
Platalea flavipes	Yellow-billed Spoonbill		irregular visitor	1,3	
Accipitridae (Osprey, hawk, eagle)					
Elanus caeruleus (axillaris)	Black-shouldered Kite		regular visitor	1,2,3	
Lophoictinia isura	Square-tailed Kite	CS3 (WR)	regular visitor	1,2	
Haliastur sphenurus	Whistling Kite	CS3 (WR)	regular visitor	1,2,3	
Accipiter fasciatus	Brown Goshawk	CS3 (WR)	resident	1,2,3	X
Accipiter cirrocephalus	Collared Sparrowhawk	CS3 (WR)	resident	1,2,3	
Circus assimilis	Spotted Harrier		irregular visitor	1	
Circus approximans	Swamp Harrier		vagrant	1,2,3	
Aquila audax	Wedge-tailed Eagle	CS3 (WR)	regular visitor	1,2,3	X
Hieraaetus morphnoides	Little Eagle	CS3 (WR)	regular visitor	1,2,3	
Falconidae (Falcons)					
Falco cenchroides	Nankeen Kestrel		regular visitor	1,2,3	
Falco berigora	Brown Falcon	CS3 (WR)	regular visitor	2	
Falco longipennis	Australian Hobby		resident	1,2,3	
Falco peregrinus	Peregrine Falcon	CS1 (S7)	resident	1,2	

Species		Conservation significance	Status in Project Area	Source	Recorded
Rallidae (crakes and rails)					
Grallinula tenebrosa	Dusky Moorhen		irregular visitor	2,3	
Fulica atra	Eurasian Coot		irregular visitor	1,2,3	
Tribonyx ventralis	Black-tailed Native-hen		irregular visitor	1,2,3	
Charadriidae (Plovers and Lapwings)					
Charadrius ruficapillus	Red-capped Plover		irregular visitor	1	
Vanellus tricolor	Banded Lapwing		irregular visitor	1,3	
Elseyornis melanops	Black-fronted Dotterel		Irregular visitor		X
Turnicidae (Button-quails)					
Turnix varius	Painted Button-quail	CS3 (WR)	resident	1,2,3	
Recurvirostridae (stilts and avocets)					
Himantopus himantopus	Pied (Black-winged) Stilt		irregular visitor	1,2	
Cacatuidae (Cockatoos)					
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	CS1 (V, S3)	regular visitor	1,2,3,4	X
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	CS1 (E, S2)	regular visitor	1,2,3,4	X
Calyptorhynchus baudinii	Baudin's Black-Cockatoo	CS1 (V, S2)	vagrant	1	
Eolophus roseicapillus	Galah		resident	1,2,3	X
Cacatua galerita	Sulphur-crested Corella	Int	vagrant	1,2,3	
Cacatua pastinator	Western Long-billed Corella		regular visitor	1,2,3	
Cacatua tenuirostris	Eastern Long-billed Corella	Int	irregular visitor	1,2	
Cacatua sanguinea	Little Corella	Int	irregular visitor	1,2,3	
Psittacidae (Parrots)					
Trichoglossus haematodus	Rainbow Lorikeet	Int	irregular visitor	1,2	
Glossopsitta porphyrocephala	Purple-crowned Lorikeet		irregular visitor	2	
Polytelis anthopeplus	Regent Parrot		irregular visitor	1	
Platycercus icterotis	Western Rosella	CS3 (WR)	irregular visitor	1,2,3	
Platycercus zonarius	Australian Ringneck		resident	1,2,3	X
Purpureicephalus spurius	Red-capped Parrot		resident	1,2,3	X
Neophema elegans	Elegant Parrot		irregular visitor	1,2	

Species		Conservation significance	Status in Project Area	Source	Recorded
Cuculidae (Old world cuckoos)					
Chalcites basalis	Horsfield's Bronze-Cuckoo		regular visitor	1,3	X
Chalcites lucidus	Shining Bronze-Cuckoo		regular visitor	1,2,3	
Cacomantis pallidus	Pallid Cuckoo		regular visitor	1,2.3	X
Cacomantis flabelliformis	Fan-tailed Cuckoo		regular visitor	1,2,3	X
Strigidae (Hawk owls)					
Ninox connivens	Barking Owl (South-west pop'n)	CS2 (P2, WR)	vagrant		
Ninox boobook	Southern Boobook		resident	1	
Tytonidae (Barn owls)					
Tyto novaehollandeae	Masked Owl	CS2 (P3, WR)	vagrant	1	
Tyto javanica	Eastern Barn Owl		regular visitor	1,2,3	
Halcyonidae (Tree kingfishers)					
Dacelo novaeguineae	Laughing Kookaburra	Int	resident	1,2,3	X
Todiramphus sanctus	Sacred Kingfisher		regular visitor	1,2,3	
Meropidae (Bee-eaters)					
Merops ornatus	Rainbow Bee-eater		regular visitor	1,2,3	X
Maluridae (Fairy-wrens and allies)					
Malurus splendens	Splendid Fairy-wren	CS3 (HS)	resident	1,2,3	X
Malurus leucopterus	White-winged Fairy-wren	CS3 (HS)	regular visitor	1,2,3	
Malurus lamberti	Variegated Fairy-wren	CS3 (HS)	resident	1,2	
Acanthizidae (Thornbills and allies)					
Sericornis frontalis	White-browed Scrubwren	CS3 (HS)	regular visitor	1,2,3	
Smicrornis brevirostris	Weebill	CS3 (HS)	resident	1,2,3	X
Gerygone fusca	Western Gerygone		resident	1,2,3	X
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	CS3 (HS)	resident	1,2,3	X
Acanthiza inornata	Western Thornbill	CS3 (HS)	resident	1,2,3	X
Acanthiza apicalis	Inland Thornbill	CS3 (HS)	resident	1,2,3	X
Pardalotidae (Pardalotes)					
Pardalotus punctatus	Spotted Pardalote		regular visitor	1,2,3	
Pardalotus striatus	Striated Pardalote		resident	1,2	X
Meliphagidae (Honeyeaters)					
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		vagrant	1,2	
Acanthorhynchus superciliosus	Western Spinebill		resident	1,2,3	X
Gavicalis virescens	Singing Honeyeater		resident	1,2,3	X
Anthochaera lunulata	Western Wattlebird	CS3 (WR)	resident	1,2,3	
Anthochaera carunculata	Red Wattlebird		resident	1,2,3	X
Manorina flavigula	Yellow-throated Miner		regular visitor		

Species		Conservation significance	Status in Project Area	Source	Recorded
Epthianura albifrons	White-fronted Chat		regular visitor	1,2,3	
Glyciphila melanops	Tawny-crowned Honeyeater	CS3 (WR)	regular visitor	1,2	X
Lichmera indistincta	Brown Honeyeater		resident	1,2,3	X
Phylidonyris novaehollandiae	New Holland Honeyeater	CS3 (WR)	resident	1,2,3	X
Phylidonyris niger	White-cheeked Honeyeater	CS3 (WR)	resident	1,2,3	
Ptilotula ornata	Yellow-plumed Honeyeater	CS3 (WR)	vagrant	1,3	
Melithreptus brevirostris	Brown-headed Honeyeater		regular visitor	1,2	
Neosittidae (Sitellas)					
Daphoenositta chrysoptera	Varied Sittella	CS3 (HS)	resident	1,2,3	
Campephagidae (Cuckoo-shrikes and trillers)					
Coracina novaehollandiae	Black-faced Cuckoo-shrike		resident	1,2,3	X
Lalage sueurii	White-winged Triller		regular visitor	1,3	
Pachycephalidae (Whistlers, shrike-thrushes)				**1**	
Pachycephala pectoralis fuliginosa	Western Whistler	CS3 (HS)	resident	1	
Pachycephala rufiventris	Rufous Whistler		resident	1,2,3	X
Colluricincla harmonica	Grey Shrike-thrush	CS3 (HS)	resident	1,2,3	X
Artamidae (Woodswallows, butcherbirds, currawong)					
Artamus cinereus	Black-faced Woodswallow	CS3 (WR)	resident	2,3	X
Artamus cyanopterus	Dusky Woodswallow	CS3 (WR)	regular visitor	1,2,3	X
Cracticus nigrogularis	Pied Butcherbird	CS3 (WR)	vagrant	1,2	
Cracticus torquatus	Grey Butcherbird		resident	1,2,3	X
Cracticus tibicen	Australian Magpie		resident	1,2,3	X
Corvus coronoides	Australian Raven		resident	1,2,3	
Strepera versicolor	Grey Currawong	CS3 (WR)	vagrant	1,2,3	
Rhipiduridae (Fantails)					
Rhipidura albiscapa	Grey Fantail		resident	1,2,3	X
Rhipidura leucophrys	Willie Wagtail		resident	1,2,3	X
Monarchidae (Flycatchers and magpie-lark)					
Myiagra inquieta	Restless Flycatcher	CS3 (HS)	irregular visitor	1	
Grallina cyanoleuca	Magpie-lark		resident	1,2,3	
Petroicidae (Robins)					
Petroica boodang	Scarlet Robin	CS3 (HS)	resident	1,2,3	X
Petroica goodenovii	Red-capped Robin	CS3 (HS)	resident	1,2,3	X
Eopsaltria georgiana	White-breasted Robin	CS3 (HS)	irregular visitor	1,2	
Melanodryas cucullata	Hooded Robin	CS3 (HS)	regular visitor	1,2	
Microeca fascinans	Jacky Winter		vagrant	1,2	

Species		Conservation significance	Status in Project Area	Source	Recorded
Megaluridae (Grassbirds)					
Cincloramphus mathewsi	Rufous Songlark		regular visitor	1,3	
Cincloramphus cruralis	Brown Songlark		irregular visitor	1,3	
Timaliidae (White-eyes)					
Zosterops lateralis	Silvereye		resident	1,2,3	X
Hirundinidae (Swallows and martins)					
Cheramoeca leucosterna	White-backed Swallow		irregular visitor	1	
Hirundo neoxena	Welcome Swallow		resident	1,2,3	
Petrochelidon nigricans	Tree Martin		regular visitor	1,2,3	X
Petrochelidon ariel	Fairy Martin		irregular visitor	1,2	
Nectariniidae (Sunbirds and allies)					
Dicaeum hirundinaceum	Mistletoebird		resident	1,2	
Motacillidae (Old world wagtail, pipit)					
Anthus novaeseelandiae	Australasian Pipit		regular visitor	1,3	
MAMMALS					
Tachyglossidae (Echidnas)					
Tachyglossus aculeatus	Echidna		resident	1,2	
Dasyuridae (Dasyurids)					
Dasyurus geoffroii	Chuditch	CS1 (V, S3)	vagrant	2	
Phascogale tapoatafa wambenger	Brush-tailed Phascogale	CS1 (V, S3)	vagrant	1	
Sminthopsis dolichura	Little Long-tailed Dunnart (coastal plain form)	CS3 (LS)	resident		X
Sminthopsis fuliginosus	Grey-bellied Dunnart	CS3 (LS)	resident	1,2	
Peremelidae (Bandicoots)					
Isoodon fusciventer	Quenda	CS2 (P5)	resident	1,2	
Macropodidae (Kangaroos, wallabies)					
Macropus fuliginosus	Western Grey Kangaroo		resident	1,2	X
Notamacropus irma	Brush Wallaby	CS2 (P4)	resident	1,2	
Phalangeridae (Brushtail possums)					
Trichosurus vulpecula	Brushtail Possum		irregular visitor	1	
Burramyidae (Pygmy possums)					
Cercartetus concinnus	Western Pygmy-possum	CS3 (LS)	resident	1	
Tarsipedidae (Honey Possum)					
Tarsipes rostratus	Honey Possum		resident	1,2	X

Species		Conservation significance	Status in Project Area	Source	Recorded
Vespertilionidae (Vespertillionid bats)					
Chalinolobus gouldii	Gould's Wattled Bat		resident	1,2	X
Nyctophilus geoffroyi	Lesser Long-eared Bat		resident	1,2	
Nyctophilus major major	Western long-eared Bat		resident	1,2	X
Vespadelus regulus	Southern Forest Bat		resident	1,2	X
Molossidae (Freetail bats)					
Austronomus (Tadarida) australis	White-striped Freetail-Bat		regular visitor	1,2	X
Ozimops kitcheneri	Western Freetail-Bat	CS3 (LS)	resident		
Muridae (Rats and mice)					
Hydromys chrysogaster	Rakali (water-rat)	CS2 (P4)	irregular visitor	2	
Mus musculus	House Mouse	Int	resident	1,2	X
Pseudomys albocinereus	Noodji, Ash-grey Mouse	CS3 (LS)	resident	2	X
Rattus rattus	Black Rat	Int	resident	1,2	
Leporidae (Rabbits and hares)					
Oryctolagus cuniculus	Rabbit	Int	resident	4	X
Canidae (Dogs and foxes)					
Canis lupus familiaris	Dog	Int	irregular visitor		X
Vulpes vulpes	Red Fox	Int	resident	1,2,4	X
Felidae (Cats)					
Felis catus	Cat	Int	resident	4	X
Equidae (Horses and donkeys)					
Equus caballus	Horse	Int	vagrant		
Bovidae (Cattle)					
Bos taurus	European Cattle	Int	vagrant	1,2	
Suidae (Pigs)					
Sus scrofa	Pig	Int	regular visitor	BCE	X
SIGNIFICANT INVERTEBRATES					
Hesperocolletes douglasi	Short-tongued bee	CS1 (Ex, S1)	resident	1,2	
Leioproctus contrarius	Short-tongued bee	CS2 (P3)	resident	1,2	
Glossurocolletes bilobatus	Short-tongued bee	CS2 (P2)	resident	1,2	
Antichiropus UBS2	Millipede	CS3 (SRE)	resident	BCE	
Aname mellosa group	Spider	CS3 (SRE)	resident	BCE	X
Kwonkan sp.	Spider	CS3 (SRE)	resident	BCE	X

5.7 Appendix 7. Species returned from database search but for which there is no suitable habitat or that are locally extinct

Note that some waterbirds in this table could still occur as very rare vagrants. Wholly marine species returned from databases have been excluded. Species considered to be locally extinct are indicated with "LE".

Species		Conservation significance	Source
Austroconops mcmillani	McMillan's Biting Midge	CS2 (P4)	2
Pseudemydura umbrina	Western Swamp Tortoise	CS1 (C, S1), LE	
Ardeotis australis	Australian Bustard	CS3 (WR)	1
Chroicocephalus novaehollandiae	Silver Gull		1
Platalea regia	Royal Spoonbill		1
Gallirallus philippensis	Buff-banded Rail		1,2
Malurus pulcherrimus	Blue-Breasted Fairy-wren	CS3 (HS)	1,2,3,
Malurus elegans	Red-winged Fairy wren	CS3 (HS)	1,2
Acrocephalus australis	Australian Reed-Warbler		1,2
Biziura lobata	Musk Duck		1,2,3
Botaurus poiciloptilus	Australasian Bittern	CS1 (E, S2)	1,2
Anhinga novaehollandiae	Australasian Darter		1,2,3
Actitis hypoleucos	Common Sandpiper	CS1 (M, S5)	1,4
Calidris acuminata	Sharp-tailed Sandpiper	CS1 (M, S5)	4
Calidris ferruginea	Curlew Sandpiper	CS1 (M, S5)	1,4
Calidris melanotos	Pectoral Sandpiper	CS1 (M, S5)	4
Calidris ruficollis	Red-necked Stint		1,3
Cladorhynchus leucocephalus	Banded Stilt		1
Erythrogonys cinctus	Red-Kneed Dotterel		1
Haematopus longirostris	Pied Oystercatcher		1
Haliaeetus leucogaster	White-bellied Sea Eagle	CS1 (M, S5)	1,4
Limosa lapponica	Bar-tailed Godwit	CS1 (M, S5)	1
Numenius madagascariensis	Eastern Curlew	CS1 (M, S5)	4
Pandion haliaetus	Osprey	CS1 (M, S5)	4
Plegadis falcinellus	Glossy Ibis	CS1 (M, S5)	2
Recurvirostra novaehollandiae	Australian Red-necked Avocet	CS1 (M, S5)	1,3
Rostratula australis	Australian Painted-snipe		4
Thinornis rubricollis	Hooded Plover		2,4
Tringa nebularia	Common Greenshank	CS1 (M, S5)	1,3
Tringa glareola	Wood Sandpiper	CS1 (M, S5)	1
Megalurus gramineus	Little Grassbird		1
Macrotis lagotis	Bilby, Dalgyte	CS1 (V, S3), LE	1,2
Bettongia penicillata ogilbyi	Woylie, Brush-tailed Bettong	CS1 (E, S1), LE	2
Petrogale lateralis lateralis	Black-footed Rock-Wallaby	CS1 (V, S3), LE	2
Setonix brachyurus	Quokka	CS1 (V, S3), LE	4,7

5.8 Appendix 8. Scoring system for the assessment of foraging value of vegetation for Black-Cockatoos.

System developed by BCE, with components drawn from the DEE offset calculator.
Total score (out of 10) comprises:

- A score out of six for the vegetation composition, condition and structure; plus
- A score out of three for the context of the site; plus
- A score out of one for species density.

These are described in detail below.

A. Vegetation composition, condition and structure scoring

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
0	No foraging value. No Proteaceae, eucalypts or other potential sources of food. Examples would be salt lakes and bare ground.	No foraging value. No eucalypts or other potential sources of food.	No foraging value. No eucalypts (i.e. Marri, Jarrah, Wandoo, Blackbutt or Karri) or other potential sources of food.
1	Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these <2%. Could include urban areas with scattered foraging trees. Blue Gum plantations are considered to have a score of 1 as foraging by Black-Cockatoos has been reported but appears to be unusual.	Negligible to low foraging value. Scattered specimens of known food plants (e.g. Marri and Jarrah) but projected foliage cover of these <1%. Could include urban areas with scattered foraging trees.	Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these <1%. Could include urban areas with scattered foraging trees.

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
2	Low foraging value. Examples: • Shrubland in which species of foraging value, such as shrubby banksias, with <10% projected foliage cover • Open eucalypt woodland/mallee of small-fruited species • Paddocks with melons or other weeds (a short-term, seasonal food source).	Low foraging value. Example: • Woodland or forest with scattered specimens of known food plants (e.g. Marri and Jarrah) but projected foliage cover of these 1-<5%. Could include urban areas with scattered foraging trees.	Low foraging value. Examples: • Open eucalypt woodland (i.e. Marri, Jarrah, Wandoo, Blackbutt or Karri). Projected foliage cover of these 1-<5% • Urban areas with scattered food plants such as Cape Lilac, *Eucalyptus caesia* and *Eucalyptus erythrocorys*.
3	Low to Moderate foraging value. Examples: • Shrubland in which species of foraging value, such as shrubby banksias, with 10-20% projected foliage cover • Woodland with tree banksias 2-10% projected foliage cover • Eucalypt woodland/mallee of small-fruited species; Marri, if present, <10% project foliage cover.	Low to Moderate foraging value. Examples: • Eucalypt woodland with known food plants (and in particular Marri) with a projected foliage cover of 5-<10%. • Parkland-cleared eucalypt woodland with projected foliage cover of known food plants of 10-<20% can be considered low-to-moderate because of poor long-term viability without management.	Low to Moderate foraging value. Examples: • Eucalypt woodland (i.e. Marri, Jarrah, Wandoo, and Blackbutt), if present, <10% project foliage cover.

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
4	Moderate foraging value. Examples: • Woodland with tree banksias 20-40% projected foliage cover. • Eucalypt woodland/forest with Marri 20-40% projected foliage cover.	Moderate foraging value. Examples: • Eucalypt woodland with known food plants (and in particular Marri) with a projected foliage cover of 10-<20% • Parkland-cleared eucalypt woodland with projected foliage cover of known food plants of 20-<40% can be considered moderate because of poor long-term viability without management • Areas of orchards and especially those with apples can be considered of moderate value.	Moderate foraging value. Examples: • Eucalypt woodland/forest (i.e. Marri, Jarrah, Wandoo, and Blackbutt) with 20-40% projected foliage cover.
5	Moderate to High foraging value. Examples: • Banksia Woodlands with tree banksias >40%. Vegetation condition moderate due to weed invasion and some tree deaths. • Pine plantations with trees more than 10 years old.	Moderate to High foraging value. Examples: • Eucalypt woodland with known food plants (and in particular Marri) with a projected foliage cover of 20-<40% • Parkland-cleared eucalypt woodland with projected foliage cover of known food plants of >40% can be considered moderate because of poor long-term viability without management.	Moderate to High foraging value. Examples: • Eucalypt woodland/forest (i.e. Marri, Jarrah, Wandoo, and Blackbutt) with >40% projected foliage cover. Vegetation condition moderate due to weed invasion and some tree deaths.

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
6	High foraging value. Example: • Banksia Woodlands of key species (e.g. *B. attenuata, B. menziesii*) with projected foliage cover >60%. Vegetation condition good with low weed invasion and low tree death to indicate it is robust and unlikely to decline in the medium term.	High foraging value. Example: • Eucalypt woodland/forest with a high proportion of Marri (>40% projected foliage cover). Vegetation condition good with low weed invasion and low tree death to indicate it is robust and unlikely to decline in the medium term.	High foraging value. Example: • Eucalypt woodland/forest (i.e. Marri, Jarrah, Wandoo, and Blackbutt) with >60% projected foliage cover. Vegetation condition good with low weed invasion and low tree death to indicate it is robust and unlikely to decline in the medium term.

B. Site context

The maximum score is given in situations where foraging habitat is supporting breeding birds. It can also be given in fragmented landscapes where there is little foraging habitat remaining and thus what is left has a high contextual value. The site context score is species-specific as it depends upon factors such as the vegetation type and extent, and the presence of breeding birds. Criteria for the assignment of the context score are discussed below. 'Local area' is defined as within a 15 km radius of the centre point of the site.

A score of 3 applies to sites that support:

- 5% or more of that local area's total remaining foraging habitat, if it also supports breeding birds (breeding habitat within the site or within 10km of the site), or
- 10% or more of the local area's total remaining foraging habitat.

A score of 2 applies to sites that support:

- 1-5% of that local area's total remaining foraging habitat, if it also supports breeding birds (breeding habitat within the site or within 10km of the site), or
- foraging habitat (but not breeding habitat) which is less than 10% of that local area's total remaining foraging habitat.

A score of 1 applies to sites that support:

- 0.1-1% of that local area's total remaining foraging habitat, whether or not it also supports breeding birds (breeding habitat within the site or within 10km of the site).

A score of 0 applies to sites that support:

- less than 0.1% of that local area's total remaining foraging habitat, whether or not it also supports breeding birds (breeding habitat within the site or within 10km of the site).

C. Species density

Assignation of the species density score (0 or 1) is based upon the Black-Cockatoo species being either abundant or not abundant, and is species specific. A score of 1 is used where the species is seen or reported regularly and/or there is abundant foraging evidence. Regularly is when the species is seen at intervals of every few days or weeks for at least several months of the year. A score of 0 is used when the species is recorded or reported very infrequently and there is little or no foraging evidence.

5.9 Appendix 9. Bat call charts from bat echolocation devices in the Project Area

All bat species were recorded in all 3 sampling locations; charts are presented in order of abundance of calls.

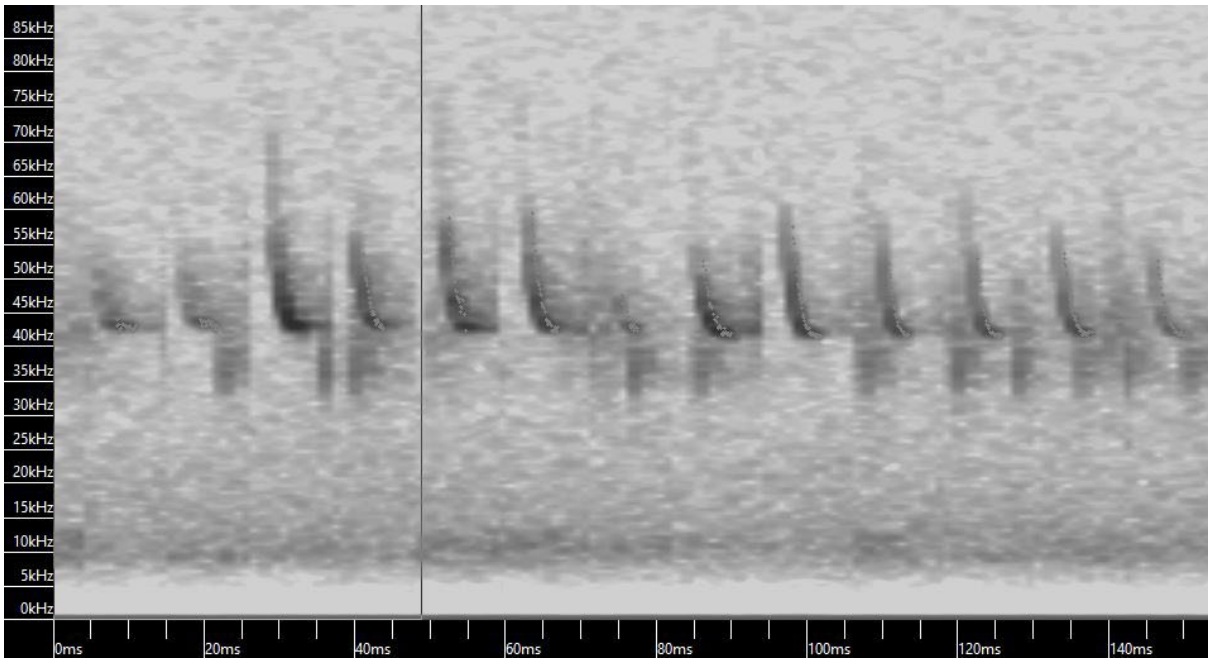

Figure 5-1. Call chart for *Vespedellus regulus*

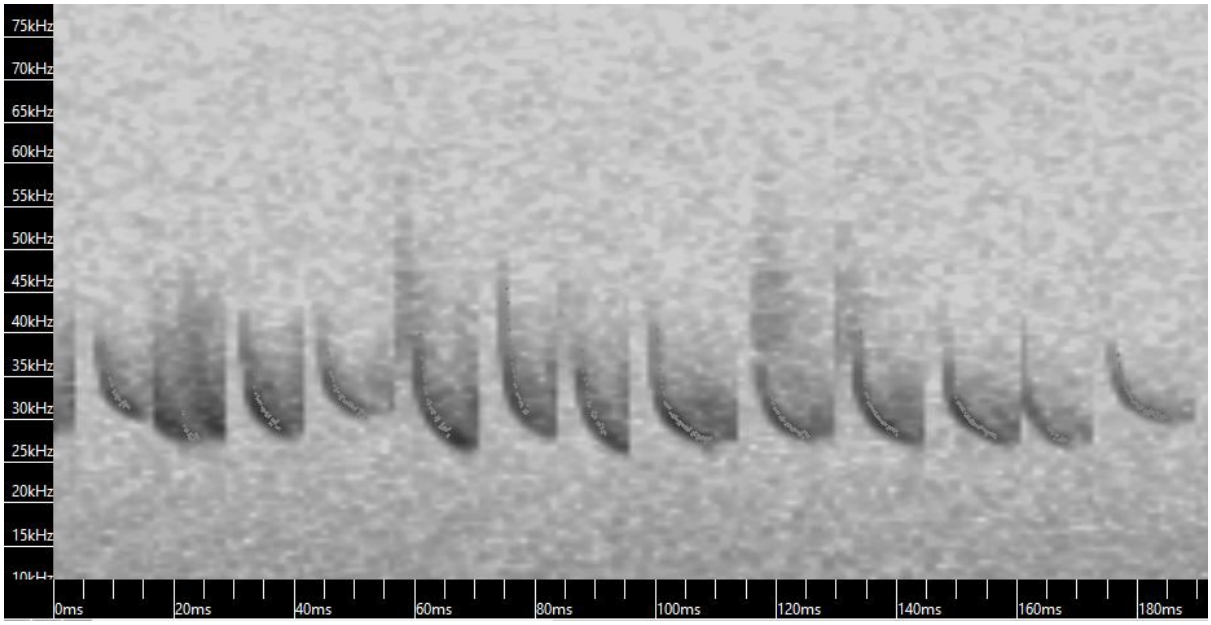

Figure 5-2. Call chart for *Chalinolobus gouldii*

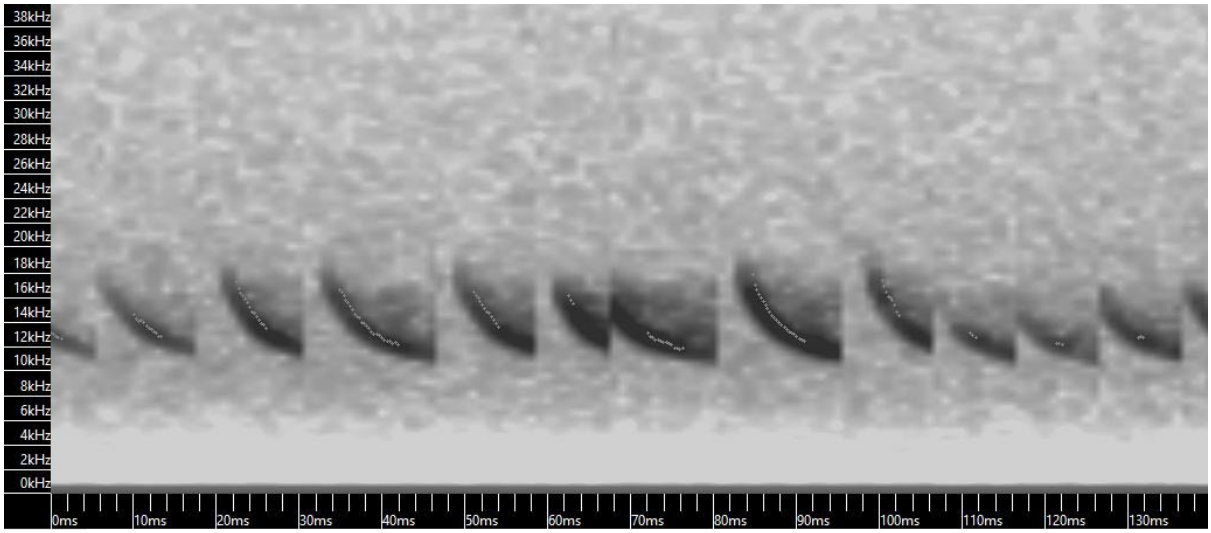

Figure 5-3. Call chart for *Austronomous australis*

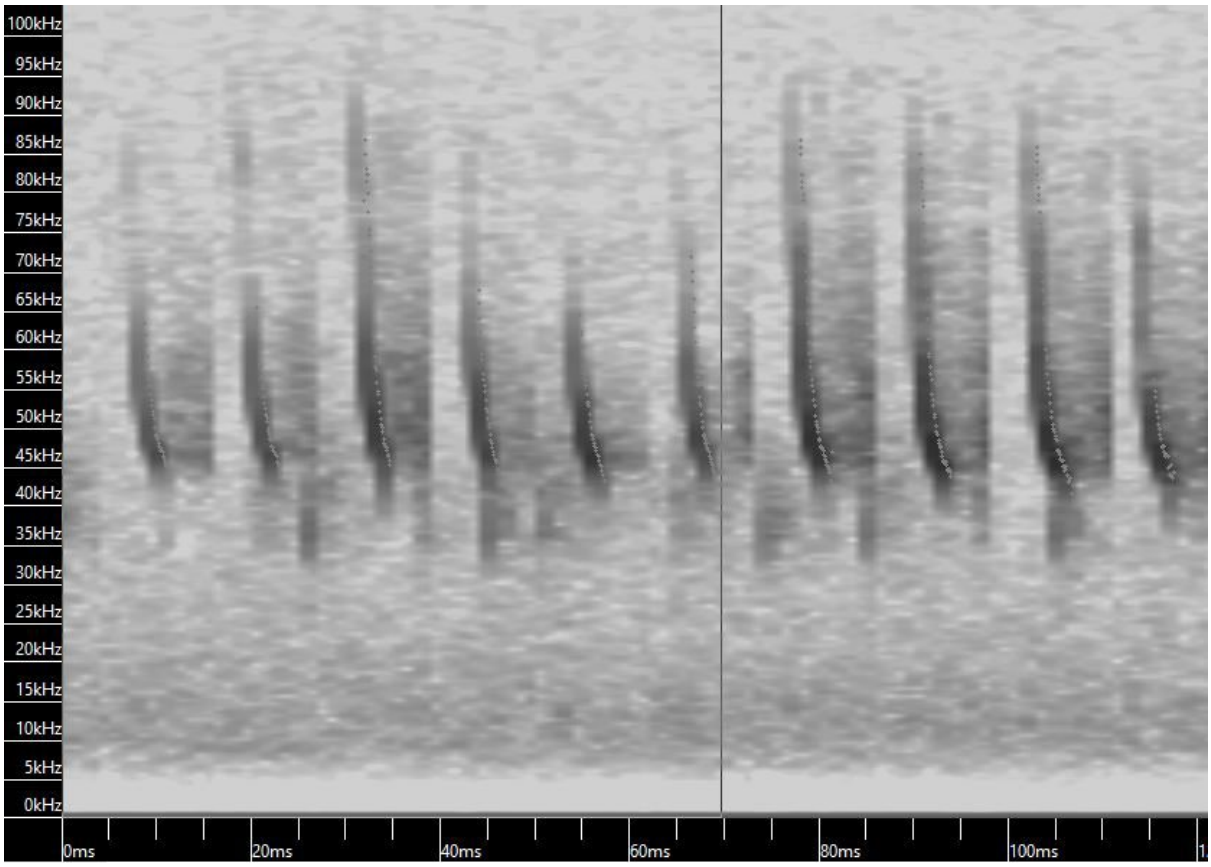

Figure 5-4. Call chart for *Nyctophilus major*

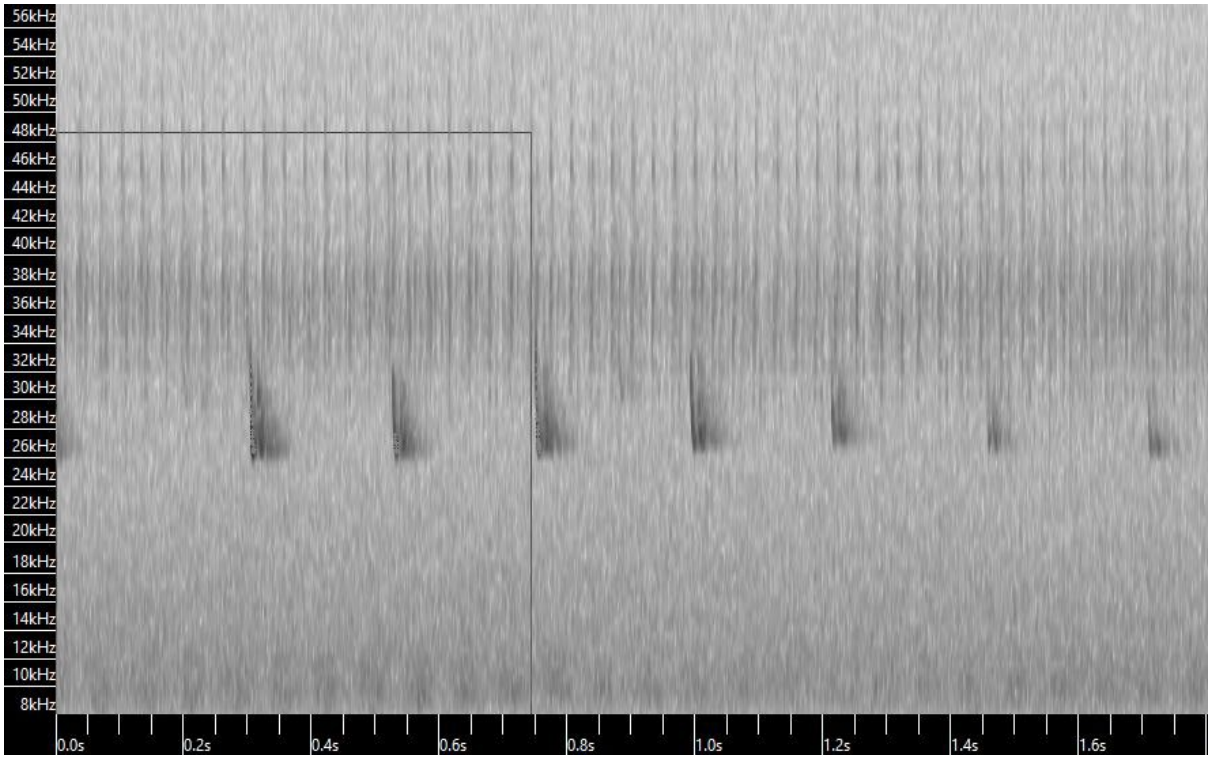

Figure 5-5. Call chart for possible *Ozimops kitcheneri* (but this can be similar to *C. gouldii*), recorded only at Site 2.