Fauna Survey of the Proposed Forrestfield - Airport Link Swan River Crossing

Rakali (Water Rat) footprints found at Claughton Reserve, Bayswater (S. Cherriman)

Prepared for: Public Transport Authority

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EXECUTIVE SUMMARY

As part of a new transport strategy, the WA State government has proposed to develop a rail link between Perth City and the Perth Airport. The plan is for the railway to cross the Swan River at the same point as Tonkin Highway, at Bayswater.

As part of the Environmental Impact Assessment for the Project, Bamford Consulting Ecologists (BCE) was commissioned by RPS Australia Asia Pacific on behalf of the Public Transport Authority to conduct a Level 1 fauna investigation (desktop review and fauna assessment) of approximately 20ha (the "project area") of terrestrial and riparian habitat (Figure 1). The remaining 17ha of riverine habitat indicated in Figure 1 was assessed as part of a different assessment.

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 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;
  - 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.

The desktop study identified 176 vertebrate fauna species (not including aquatic species) as potentially occurring in the project area: six frogs, 20 reptiles, 136 birds and 14 mammals. Included in this are eight introduced birds and seven introduced mammals. Due to loss of habitat through urbanisation and other key threats like disturbed remnant vegetation and introduced cats and foxes, 17 mammals, 18 birds and one reptile are considered to be locally extinct and were not included in the above total. The presence of just under a fifth (37) of the expected species, one frog, one reptile, 31 birds and four mammals, was confirmed during a site visit in March 2014.

The database search identified 15 species listed in State or Federal legislation as threatened or priority fauna. Of these, four (Carnaby's Black-Cockatoo, Caspian Tern, Common Sandpiper and Rakali or Water-rat) were recorded, and the remaining 11 species are considered potentially present as habitat was recorded in the project area. Nine (including Carpet Python, Western Ringtail Possum, Woylie, Chuditch and Quenda) are locally extinct and not included in these calculations. Another 20 species were considered to have conservation significance despite not being formally listed. These include species listed as significant in the Perth region by Dell and

Banyard (2000). One of these species (Weebill) was recorded, and the remainder are considered potentially present.

Key **fauna values** are:

Fauna assemblage. Moderately rich but with some obvious gaps due to loss and fragmentation of habitat associated with nearby urban development (See Section 3.1.3 for more detail). For example, the bird assemblage lacked most of the more sensitive species, the only burrowing snake recorded in the database search was *Ramphotyphlops australis*, and there were very few native mammals. While likely to be typical of the fauna assemblages in the Perth region, it may be slightly unusual because of the variety of environments present and the proximity of the project area to the river. As a result, the assemblage could have a combination of species not always seen across a small area.

Species of conservation significance. These include at least 33 bird species and two mammal species. Species of note are the Rakali or Water-rat, Carnaby's Black-Cockatoo, migratory waders and waterbirds, and a suite of declining woodland birds.

Vegetation and Substrate Associations. Nine VSAs were identified across the project area. Clearing of native vegetation on the Swan Coastal Plain makes remnant patches of bush important. Vegetation along the Swan River is also of importance for its habitat value as well as its function in reducing pollution and waste entering the river.

Patterns of biodiversity. Biodiversity is likely to be spread across the VSAs and the landscape, but areas of particular significance are the uncleared vegetation around wetlands and along the river.

Key ecological processes. Main processes currently affecting the fauna assemblage in the project area include connectivity, local hydrology and fauna interactions (feral predators, over-abundant introduced and native species). Local hydrology may be particularly significant because of reliance of some of the vegetation on wetter areas and the proximity of the project area to the river. The project area lies between two Bush Forever sites and is part of fauna connectivity along the Swan River.

Recommendations

Should the FAL project impact the survey area, the following recommendations should be considered.

- Minimise vegetation clearing, particularly the quality habitat in the Wetland and Riparian VSAs.
- Minimise the disturbance footprint.
- Clearly delineate areas to be cleared.
- Avoid disturbance to the river, develop and implement a runoff and rubbish management plan.
- Where possible, retain riparian vegetation to maintain linkages between remnant patches along the river.
- Discourage the presence of feral species, particularly the feral Cat and Fox, by the use of appropriate waste management procedures;

- Develop an understanding of the surface and sub-surface drainage in order to identify the potential for hydrological changes that could potentially impact fauna habitats;
- Where practicable, implement management actions where it is expected that changes to hydrology may affect significant fauna habitats.
- Develop a weed management/hygiene plan, including runoff into the river;
- Develop a fire management plan.
- Minimise the production of dust, noise and light spill.

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1 INTRODUCTION

1.1 Project Background

As part of a new transport strategy the government has proposed to develop a rail between Perth City and the Airports. The plan is for the railway to cross the Swan River at the same point the Tonkin Highway does, at Bayswater.

As part of the Environmental Impact Assessment for the Project, Bamford Consulting Ecologists (BCE) was commissioned by RPS Australia Asia Pacific on behalf of the Public Transport Authority to conduct a Level 1 fauna investigation (desktop review and fauna assessment) of the 20 ha of terrestrial and riparian habitat termed the "project area" (Figure 1). The remaining 17ha of riverine habitat has been assessed as part of a Benthic Habitat Assessment by RPS (2014).

1.2 Project Area

The proposed airport railway is planned to cross the Swan River where Tonkin Highway crosses the river at Bayswater, approximately 8 km north-east of the Perth CBD (project area, Figure 1). The project area consists of cleared parkland, wetlands, riparian vegetation and the Swan River. Residential development lies to the north and south of the project area, with further parkland and wetland reserves to the east and west (Figure 2). Although largely surrounded by urban development, the 20 ha project area is connected to the river and its associated riparian and wetland habitats (Figure 2).

The project area contains riparian and wetland habitat and is one of the few remnant bushland areas remaining in the City of Bayswater. The site is not listed as a Bush Forever Site, but there are Bush Forever Sites 200 m to the north (No. 214) and 1.2 km to the west (No. 313) (Figure 3). The project area is managed by the City of Bayswater but also comes under the Swan River Trust Development Control Area which provides guidelines and policies on the management of development on and adjacent to the Swan River (EMRC 2008).

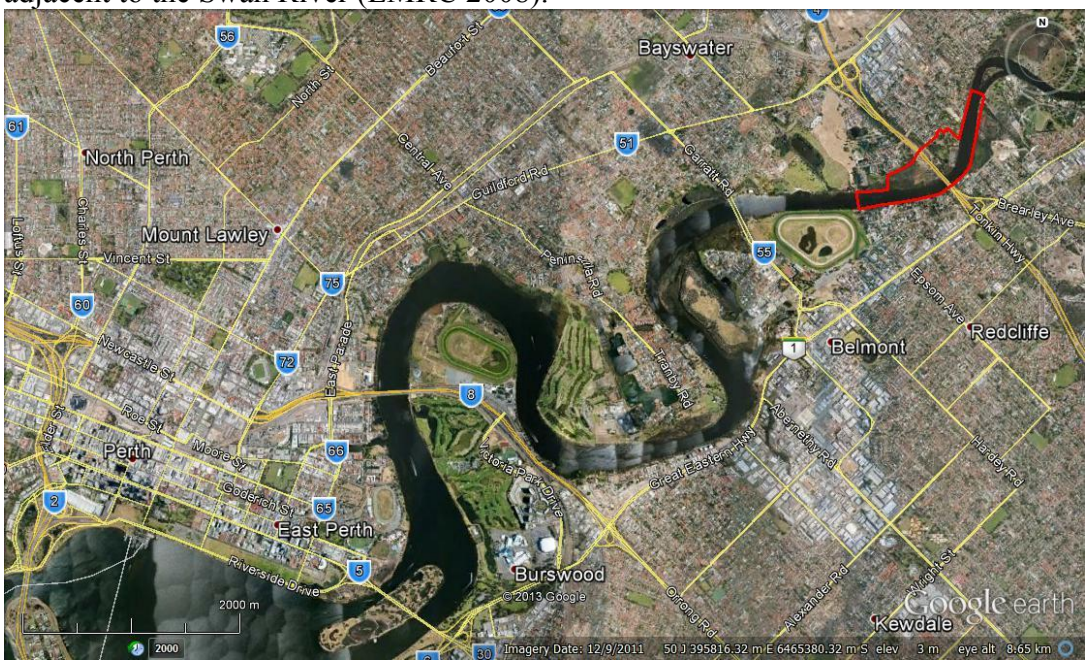

Figure 1. Location of Project Area (red outline shows both terrestrial and riverine habitat).

Figure 2. Outline of Project Area (red outline shows both terrestrial and riverine habitat).

Figure 3. Bush Forever sites adjacent to the project area (red). Site 313 in blue to the west and 214 in green to the north.

1.3 Scope of Works

The purpose of impact assessment is to provide government agencies 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;
  - 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.

Descriptions and background information on these values and processes can be found in Appendices 1 to 4. Based on this impact assessment process, the objectives of investigations are to: identify fauna values; review impacting processes with respect to these values and the proposed development; and provide recommendations to mitigate these impacts.

2 METHODS

2.1 Nomenclature

As per the recommendations of EPA (2004), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's (WAM) *Checklist of the Vertebrates of Western Australia 2010*. The authorities used for each vertebrate group were: amphibians (Doughty and Maryan 2010a), reptiles (Doughty and Maryan 2010b), birds (Christidis and Boles 2008), and mammals (How *et al*. 2009). 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 Desktop Survey

Information on the fauna assemblage of the project 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 Department of Parks and Wildlife (DPaW) NatureMap (incorporating the Western Australian Museum's Fauna database and the DPaW Threatened and Priority Fauna Database), Birds Australia's Atlas Database (BA), the EPBC Protected Matters Search Tool and the BCE database (Table 1). All databases were interrogated in March 2014 (See Table 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 & Doughty (2009);
- Reptiles: Storr *et al.* (1983); Storr *et al.* (1990); Storr *et al.* (1999); Storr *et al.* (2002) and Wilson & Swan (2010);
- Birds: Blakers *et al.* (1984); Johnstone and Storr (1998, 2004) and Barrett *et al.* (2003); and
- Mammals: Menkhorst & Knight (2004); Strahan (1995) and Churchill (2009).

Table 1. Database searches conducted for the desktop survey.

Title	Comments	Area searched / Date
NatureMap	Records of specimens held in the WA Museum. DPaW records, Information and records on Threatened and Priority species in Western Australia. Includes historical data.	31° 55' 44"S, 115° 56' 11"E, plus 10km buffer – March 2014.
Birds Australia Atlas Database	Records of bird observations in Australia, 1998-2011.	Species list for the 1 degree grid cell containing -31.92765, 115.93486 – March 2014.
EPBC Protected Matters Search Tool	Records on matters protected under the EPBC Act, including threatened species and conservation estate.	31° 55' 44"S, 115° 56' 11"E, plus 10km buffer – March 2014.
BCE Database	Records from sightings during BCE staff visits and surveys within the area.	

Species lists generated from the review of sources of information are generous in that they include local fauna species found in environments not represented in the project area. Therefore some species returned by the database search which are obviously pelagic (for example Wandering Albatross) have been removed, other species which are out of their range, or for which habitat is not suitable, have been put into another table (Appendix 6). The overall species lists for the project area are presented in Appendix 5.

2.3 Field Surveys

2.3.1 Overview

The field survey included several components:

- targeted searching for conservation significant fauna;
- habitat assessment; and
- opportunistic observations.

2.3.2 Personnel

The personnel involved with the collection and handling of data and in report compilation and editing are listed below.

- Ms Gillian Basnett *B.Sc.* (*R.E.M.*)*, M.Sc., M.Sc res*.
- Mr Simon Cherriman *BSc.* (*Env Biol., Hons.), MSciComm. (Nat. Hist. Film.)*
- Dr Michael Bamford *BSc.* (*Biol., Hons.*)*, Ph.D.* (*Biol.*)

2.3.3 Survey Dates

The survey was carried out on Friday 14th March 2014. The weather was warm and clear with a maximum temperature of 26.3°C and a minimum of 14.3°C.

2.3.4 Vegetation and Substrate Associations

Vegetation and Substrate Associations (VSAs) throughout the survey area were assessed during the desktop review and as part of the field investigations. Within the project area each major VSA was 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.

2.3.5 Targeted searching for conservation significant species

Significant species recorded during the desktop assessment include several that can be found by searching for evidence of their activities (e.g. scats, tracks, diggings, burrows). These included the Red-tailed, Carnaby's and Baudin's Black-Cockatoos, Quenda or Southern Brown Bandicoot and Rakali or Water-rat. Searching for evidence of significant fauna was therefore undertaken by walking through habitat considered suitable for such species.

2.3.6 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 traveling through the site.

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 fauna survey at the project area in Table 2.

Table 2. Survey limitations as outlined by EPA (2004).

EPA Limitation	BCE Comment
Level of survey.	Level 1 (desktop study and reconnaissance survey). Survey intensity was deemed adequate due to the small size of the area, level of survey and the number of fauna surveys previously conducted in the region.
Competency/experience of the consultant(s) carrying out the survey.	The authors have had extensive experience in conducting desktop reviews and site inspections.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	Due to the nature of the survey and time constraints, low level sampling was conducted for birds, reptiles, amphibians and mammals.
Proportion of fauna identified, recorded and/or collected.	No species collected, all fauna observed identified.
Sources of information e.g. previously available information	Sources include previous reports on the fauna of the local area (BCE database); databases (BA,

(whether historic or recent) as distinct from new data.	DEC, WAM, EPBC); BCE (and other) surveys in nearby areas.
The proportion of the task achieved and further work which might be needed.	Site inspection completed.
Timing/weather/season/cycle.	Site inspection conducted during March 2014. Conditions were mild.
Disturbances (e.g. fire, flood, accidental human intervention etc.) which affected results of survey.	No disturbances affected the survey.
Intensity. (In retrospect, was the intensity adequate?)	Survey intensity was low (desktop study and site inspection) however was adequate to satisfy EPA guidelines.
Completeness (e.g. was relevant area fully surveyed).	Desktop study covered survey area and adjacent habitats. Site inspection covered all areas of the project.
Resources (e.g. degree of expertise available in animal identification to taxon level).	All species identified to taxon level.
Remoteness and/or access problems.	No access problems.
Availability of contextual (e.g. biogeographic) information on the region.	Extensive regional information was available and was consulted.

2.5 Presentation of Results for Impact Assessment

While some impacts are unavoidable during a development, of concern are long-term, deleterious impacts upon biodiversity. This is reflected in documents such as the Significant Impact Guidelines provided by DSEWPaC (see Appendix 4). Significant impacts may occur if:

- There is direct impact upon a VSA and the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna.
- There is direct impact upon conservation significant fauna.
- Ecological processes are altered and this affects large numbers of species or large proportions of populations, including significant species.

The impact assessment process therefore involves reviewing the fauna values identified through the desktop assessment and field investigations with respect to the project and impacting processes. The severity of impacts on the fauna assemblage and conservation significant fauna can then be quantified on the basis of predicted population change.

The presentation of this assessment follows the general approach to impact assessment as given in Section 1.3, but modified to suit the characteristics of the site and the field investigations for the possible development of the Perth/Airport railway

line. Key components to the general approach to impact assessment are addressed as follows:

Fauna values

This section presents the results of the desktop and field investigations in terms of key fauna values (described in detail in Appendix 1):

- Assemblage characteristics (uniqueness, completeness and richness) - based upon desktop assessment and information from the intensive study;
- Species of conservation significance – based upon desktop assessment and intensive study;
- Recognition of ecotypes or vegetation/substrate associations (VSAs) - based upon desktop assessment and intensive study;
- Patterns of biodiversity across the landscape - based upon desktop assessment and reconnaissance for general patterns, and presenting the results of the intensive study at Polaris;
- Ecological processes upon which the fauna depend - based upon desktop assessment and intensive study.

Impact assessment

At the time of writing this report no details were provided as to the actual proposed scope of works, therefore this section reviews impacting processes (as described in detail in Appendix 2) with respect to the project area as a whole and examines the potential effect of these impacts upon biodiversity of the whole project area. It thus expands upon the Project Description (Section 1.2) and discusses the contribution of the project to impacting processes, and the consequences of this with respect to biodiversity. A major component of impact assessment is consideration of threats to species of conservation significance as these are a major and sensitive element of biodiversity. Therefore, the impact assessment includes the following:

- Review of impacting processes; will the proposal result in:
  - Habitat loss leading to population decline, especially for significant species;
  - Habitat loss leading to population fragmentation, especially for significant species;
  - Weed invasion that leads to habitat degradation;
  - Ongoing mortality;
  - Species interactions that adversely affect native fauna, particularly significant species;
  - Hydrological change;
  - Altered fire regimes; and
  - Disturbance (dust, light, noise).
- Summary of impacts upon significant species, and other fauna values.

3 RESULTS

3.1 Fauna Assemblage

3.1.1 Overview of fauna assemblage

The desktop study identified 176 vertebrate fauna species (not including aquatic species) as potentially occurring in the project area (see Table 3 and Appendix 5): six frogs, 20 reptiles, 136 birds and 14 mammals. Included in this are eight introduced birds and seven introduced mammals. Due to loss of habitat through urbanisation and other key threats like disturbed remnant vegetation and introduced cats and foxes, 17 mammals, 18 birds and one reptile that would once have been in the area are considered to be locally extinct (Appendix 6) and were therefore not included in the above total. Appendix 6 also presents species returned from databases but for which no suitable habitat is present in the project area.

The presence of just under a fifth (37) of the expected species was confirmed during field investigations: one frog, one reptile, 31 birds and four mammals (indicated in Table 3 and Appendix 5, and discussed below).

Table 3. Composition of vertebrate fauna assemblage expected to occur in the survey area and recorded during the field investigations.

Taxon	Number of species expected	Number Recorded	Significant fauna expected			Significant fauna Recorded		
			CS1	CS2	CS3	CS1	CS2	CS3
Frogs	6	1	-	-	-	-	-	-
Reptiles	20	1	-	-	-	-	-	-
Birds	136 (9*)	31 (4*)	14	-	19	3	-	1
Mammals	14 (7*)	4 (3*)	-	1	1	-	1	
Total	**176 (16*)**	**37 (7*)**	**14**	**1**	**20**	**3**	**1**	**1**

* Introduced Species included in total

3.1.2 Conservation Significant Species

Species of conservation significance are of special importance in management planning. 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 Wildlife Conservation Act 1950* (Wildlife Conservation Act). In addition, the Western Australian Department of Parks and Wildlife 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 and in more detail in Appendix 1.

1. **Conservation Significance (CS) 1**: Species listed under State and/or Commonwealth Acts.
2. **Conservation Significance (CS) 2**: Species not listed under State or Commonwealth Acts, but listed in publications on threatened fauna or as Priority species by the DEC.

3. **Conservation Significance (CS) 3**: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution. This level may have links to preserving biodiversity at the genetic level (EPA 2002). For example, 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. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3. Short Range Endemic species also fit into this category.

In addition, species that have been introduced (INT) are indicated.

The database search identified 15 species listed in State or Federal legislation as threatened or priority fauna (CS1 and CS2, Table 4). Of these, four (Carnaby's Black-Cockatoo, Caspian Tern, Common Sandpiper and Rakali or Water-rat) were recorded; the remaining 11 CS1 or CS2 species are considered potentially present as habitat was recorded in the project area. Nine (including Carpet Python, Western Ringtail Possum, Woylie, Chuditch and Quenda) are locally extinct and not included in these calculations. Another 20 species were considered to have conservation significance despite not being listed (CS3, Table 5). These include species listed as significant in the Perth region by Dell and Banyard (2000). One of these CS3 species was recorded while the remainder are considered potentially present. Seven CS3 species returned in the database search are locally extinct and not included in these calculations. Further information on the significant species recorded during sampling is presented in Sections 3.1.1.1 to 3.1.1.2.

Table 4. Threatened and Priority Fauna (CS1 and CS2) identified in a Database Search for the Project Area.
Species not found but not considered locally extinct may be present, perhaps only intermittently.
Mig – Schedule 3, migratory birds protected by an international agreement.
En – Endangered.
Vu – Vulnerable.
S4 – Schedule 4, other specially protected fauna.
P4 – Priority Four, taxa in need of monitoring.

Common Name	Scientific Name	WA Code	Conservation Significance	Recorded
Great Egret	*Ardea alba*	Mig	CS1	
Cattle Egret	*Ardea ibis*	Mig	CS1	
Common Sandpiper	*Acticus hypoleucos*	Mig	CS1	√
Red-necked Stint	*Calidris ruficollis*	Mig	CS1	
Sharp-tailed Sandpiper	*Calidris acuminata*	Mig	CS1	
Curlew Sandpiper	*Calidris ferruginea*	Mig	CS1	
Common Greenshank	*Tringa nebularia*	Mig	CS1	
Caspian Tern	*Hydroprogne caspia*	Mig	CS1	√
Baudin's Black-Cockatoo	*Calyptorhynchus baudinii*	En	CS1	
Carnaby's Black-Cockatoo	*Calyptorhynchus latirostris*	En	CS1	√
Forest Red-tailed Black-Cockatoo	*Calyptorhynchus banksii naso*	Vu	CS1	
Fork-tailed Swift	*Apus pacificus*	Mig	CS1	
Peregrine Falcon	*Falco peregrinus*	S4	CS1	
Rainbow Bee-eater	*Merops ornatus*	Mig	CS1	
Rakali or Water-rat	*Hydromys chrysogaster*	P4	CS2	√

Table 5. Conservation Significant 3 species identified in a Database Search for the Project Area. Species not found but not considered locally extinct may be present, perhaps only intermittently.

Common Name	Scientific Name	Conservation Significance	Recorded
Dusky Moorhen	*Gallinula tenebrosa*	CS3	
Musk Duck	*Biziura lobata*	CS3	
Pink-eared Duck	*Malacorhynchus membranaceus*	CS3	
Common Bronzewing	*Phaps chalcoptera*	CS3	
Brown Goshawk	*Accipiter fasciatus*	CS3	
Collared Sparrowhawk	*Accipiter cirrhocephalus*	CS3	
Little Eagle	*Hieraaetus morphnoides*	CS3	
Splendid Fairy-wren	*Malurus splendens*	CS3	
White-winged Fairy-wren	*Malurus leucopterus*	CS3	
White-browed Scrubwren	*Sericornis frontalis*	CS3	
Weebill	*Smicrornis brevirostris*	CS3	√
Inland Thornbill	*Acanthiza apicalis*	CS3	
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	CS3	
Western Wattlebird	*Anthochaera lunulate*	CS3	
White-cheeked Honeyeater	*Phylidonyris nigra*	CS3	
New Holland Honeyeater	*Phylidonyris novaehollandiae*	CS3	
Rufous Whistler	*Pachycephala rufiventris*	CS3	
Varied Sittella	*Daphoenositta chrysoptera*	CS3	
Black-faced Woodswallow	*Artamus cinereus*	CS3	
Brush-tailed Possum	*Trichosurus vulpecula*	CS3	

3.1.2.1 Conservation Significance Level 1 (CS1)

Fork-tailed Swift

The Fork-tailed Swift is listed as migratory under the EPBC Act and the project area is within its range. This species was not recorded during the survey but may occur occasionally on site, although it is a largely aerial species mostly independent of terrestrial ecosystems.

Rainbow Bee-eater

The Rainbow Bee-eater is listed as migratory under the EPBC Act and is a widespread and common breeding visitor in late spring and summer in the Perth area. It nests in burrows in open ground and some suitable nesting habitat was present, so the species is likely to make seasonal use of the site.

Eastern Great Egret, Cattle Egret, Common Sandpiper, Sharp-tailed Sandpiper, Curlew Sandpiper, Red-necked Stint and Common Greenshank

These species are listed as migratory under the EPBC Act and are included under international conservation treaties. The species are threatened by loss and/or

degradation of foraging, migratory staging sites and breeding habitat through alteration of water flows, drainage and/or clearing of wetlands for development, frequent burning of wetland vegetation used as nest sites, salinisation and invasion by exotic plants (Kushlan and Hancock 2005). The project area does not provide particularly suitable habitat for these species although they may forage in small numbers in the wetlands areas when inundated.

The Common Sandpiper was recorded in the area during the survey.

Forest Red-tailed, Baudin's and Carnaby's Black-Cockatoos

All three species of Black-Cockatoo found in the south west are listed as either Endangered or Vulnerable under EBPC and WA *Wildlife Conservation Act* 1950. They are in decline due to loss of foraging and breeding habitat throughout their range. Carnaby's and Forest Red-tailed Black-Cockatoos are common in the Perth Airport region and Baudin's Black-Cockatoo may occur as a vagrant. The project area contains very few large trees with suitable hollows for nesting; the two that were recorded were *Eucalyptus rudis* which are unlikely nesting species (WGSM 84 - 399549E, 6467105N, Figure 4). The only foraging species for these Black-Cockatoos were some isolated Jarrah and Marri trees present in the Parkland Cleared VSA.

The Carnaby's Black-Cockatoo was recorded during the site survey.

Figure 4. Potential Black-Cockatoo Nest Tree. Outline of project area in red.

Peregrine Falcon

The Peregrine Falcon is classified as "Specially Protected Fauna" under Schedule 4 of the Wildlife Conservation Act. This species is found in a variety of habitats, including rocky ledges, cliffs, watercourses, open woodland and acacia shrublands.

The distribution of the Peregrine Falcon is often tied to the abundance of prey as this species preys heavily on other birds. They are known to nest in buildings around Perth where there is an abundance of Rock Doves (feral pigeons). This species has not been recorded in project area but is likely to occur as an occasional visitor.

Caspian Tern

The Caspian Tern is widespread in coastal regions in Western Australia, usually preferring sheltered coastal embayments such as harbours, inlets and river deltas. It often feeds in open wetlands (including lakes and rivers) and coastal inlets. There is the potential for this species to forage in the Swan River adjacent to the Project Area, however is unlikely to roost or breed in the area. This species was identified during the site surveys.

3.1.2.2 Conservation Significance Level 2 (CS2)

Rakali or Water-rat

The Rakali is listed as a P4 species, taxa in need of monitoring, by the DPaW. They occupy habitats around permanent water, be this fresh, brackish or marine. In the south-west of WA they have been shown to prefer areas with riparian vegetation, better water quality and a degree of habitat complexity. Significant declines in populations have occurred in the south-west of WA due to habitat loss and degradation, particularly through salinization, acidification and eutrophication of wetlands and waterways (DEC 2008). It is not considered threatened but drying or wetlands and rivers, loss of habitat adjacent to permanent water and predation by foxes and cats have led to reduced sightings of Rakali, hence to P4 listing. The thick reed and wetland habitat along the river is likely to provide a stronghold for the species amongst the developed areas of the Swan River. During the site survey, tracks of the Rakali were observed at the northern end of the Project Area.

3.1.2.3 Conservation Significance Level 3 (CS3)

Musk Duck, Pink-eared Duck, Common Bronzewing, Dusky Moorhen, Splendid Fairy-wren, White-browed Scrubwren, Weebill, Inland Thornbill, Varied Sittella, Rufous Whistler

These species are considered to be CS3 as they are listed by Dell and Banyard (2000) as habitat specialists with a reduced distribution on the Swan Coastal Plain. All are likely to be in the project area either permanently or as intermittent visitors when conditions are right. Only the Weebill was recorded during the March 2014 survey.

Brown Goshawk, Collared Sparrowhawk, Little Eagle, Western Wattlebird, New Holland Honeyeater, White-cheeked Honeyeater, Black-faced Woodswallow

These species are considered to be CS3 species as they are listed by Dell and Banyard (2000). They are wide ranging species but have reduced populations on the Swan Coastal Plain. Habitat for all these species is present in the Project Area despite none being recorded in the March 2014 survey.

Common Brushtail Possum

This species is not listed either under legislation or as priority, however this formerly widespread species has declined across much of the South-West. Its population is now fragmented and clearing of habitat and predation by foxes, cats and dogs are having a significant impact. The Brushtail Possum has not been identified in the Project Area but there is suitable habitat including tree hollows and it is within its range.

3.1.3 Summary of fauna assemblage

Field investigations confirmed the presence of 37 vertebrate species, but interpretation of desktop data with respect to the site's location, size and types of environments present suggest that the assemblage could include 176 species, 35 of these were considered to have conservation significance (Appendix 5). Also important in this interpretation is information on the sorts of species that persist in urban bushland remnants in Perth. While uncertainty exists, some published observations (How and Shine 1999, How and Dell 2000, Dell and Banyard 2000, Bamford 2008, Bamford and Calver 2012) make it possible to identify some well-defined trends in this regard. For example:

- Frogs persist well where wetlands are retained, even if wetlands are greatly modified, and several species disperse widely.
- Small and especially fossorial (semi-burrowing) skinks and legless-lizards persist very well even in urban areas.
- Fossorial snakes persist only in large remnants, with the exception of *Simoselaps bertholdi* which persists in small and even degraded reserves.
- Most large reptiles (dragon lizards, monitor lizards, large snakes) persist poorly in urban remnants, with the exception of Tiger Snakes (around wetlands) and Dugites.
- Sedentary, insectivorous birds (fairy-wrens, thornbill, scrubwrens, robins, whistlers and shrike-thrush) do poorly in urban remnants. Robins, the Grey-Shrike-thrush and Western Thornbill appear especially sensitive to habitat loss, degradation, fragmentation and probably predation by domestic cats, while species such as the Splendid Fairy-wren, White-browed Scrubwren and Yellow-rumped Thornbill are able to survive under some circumstances.
- Birds that are naturally mobile to exploit seasonal food sources (honeyeaters, parrots and cockatoos) or that are migratory (Rainbow Bee-eater, cuckoos) are able to visit urban remnants, and these remnants can be important for maintaining their presence within the urban landscape.
- Birds such as the Magpie-lark, Willie Wagtail, Australian Magpie, Australian Raven and Australasian Pipit can benefit from urban development, especially where open parkland is created adjacent to remnant vegetation.
- Some wide-ranging birds (large bird of prey, Fork-tailed Swift) may forage over urban areas independent of remnant vegetation; thus the presence of remnant vegetation may be unimportant for them.
- Few mammals persist in urban remnants. Large mammals (Woylies, wallabies and kangaroos) cannot generally maintain viable populations in small reserves with high levels of disturbance and mortality (roads, dogs, Foxes), while small mammals (Honey Possum, Noodji or Ashy-grey Mouse, dunnarts) do not persist for reasons unknown. Some bat species do remain, as does the Brush-

tailed Possum (with sufficient large trees) and in this case the Rakali (as there are areas of dense vegetation around wetlands and the river).

The sort of fauna recorded are consistent with these trends. For example, the bird assemblage lacked most of the more sensitive species, the only burrowing snake recorded in the database search was *Ramphotyphlops australis*, and there were very few native mammals. As discussed previously, the riverine habitat has been assessed as part of a separate report and therefore estuarine species have not been included in this report. Each vertebrate group is discussed below.

Frogs

The only frog recorded during the site visit was the Motorbike Frog (Figure 5), but at least five other species may be present (Slender Tree-frog, Clicking Frog, Squelching Frog, Moaning Frog and Banjo Frog). The presence of the river and wetlands make it likely that all these species are present.

Figure 5. Motorbike Frog *Litoria moorei*, recorded in the project area (photo G. Basnett).

Reptiles

Although none of the 20 reptile species expected to be present were recorded, this assemblage is expected because many reptiles do persist in small remnants of native vegetation, and they are also hard to sample completely. None of the reptiles expected in the area is of listed conservation significance. However, probably all of the species expected but not recorded would represent locally significant populations if they were found to be present.

Birds

The 31 bird species recorded represent 23% of the bird assemblage of 136 species expected (Appendix 5). Interestingly, in a long-term study of two annual field trips at a coastal plain site north of Perth, 132 bird species have been recorded over a period of 22 years, with typically 45-55 bird species per trip, representing 34%-42% of the total assemblage (M. Bamford unpubl. data).

The bird assemblage consists largely of species that are mobile and able to move through the suburbs, thus making it possible for them to exploit resources in isolated bushland remnants. Over 18% of the birds recorded are of conservation significance, including Carnaby's Black-Cockatoo, the Rainbow Bee-eater, several migratory waders and a number of CS3 birds. Since European settlement, one in four temperate

woodland-dependent bird species has been listed as threatened or declining, due largely to habitat loss and fragmentation. Species that seem to be most affected are those that are resident, small-bodied, ground-foraging and insectivorous (Watson 2011), and it is many in this suite of species missing from the project area: robins, some fairy-wrens, emu-wrens and the Grey Shrike-thrush. However, the presence of the Weebill indicates that at least this species in this group are able to survive. Others such as of Yellow-rumped and Inland Thornbills, Splendid and White-winged Fairy-wrens, Western Wattlebirds, White-cheeked and New Holland Honeyeaters, Rufous Whistler and Varied Sittellas are also likely to occur.

Mammals

The mammal assemblage is very depauperate with more species considered locally extinct (17; Appendix 6) than expected to be present (14; Appendix 5). Like the birds, loss and fragmentation of habitat and the degradation of what is left, through introduced weeds and changed fire regimes and water flows, along with introduced predators such as cats and foxes, has seen the extinction and decline of many mammal species. What remains is fairly typical for small remnants in the Swan Coastal Plain: Brushtail Possum, bats and introduced mice, rats, foxes and cats but also includes the Water-rat.

One of the mammal species recorded is of conservation significance, the Rakali or Water-rat (CS2). The Brush-tailed Possum (CS3) and several bat species are expected to be present, although there was no evidence of the possum and individuals may just be occasional visitors to the area.

Invertebrates and Aquatic Species

Invertebrates and wholly aquatic species were not recorded for this survey.

3.2 Vegetation and Substrate Associations

Nine major VSAs were identified during the site inspection in March 2014 (Figure 5).

1. Parkland Cleared
2. Riparian Vegetation
3. Ephemeral Wetlands
4. Sandy Beach and Tidal Mudflats
5. Dense *Melaleuca* Wetland
6. Road Regeneration
7. Degraded Swamp and Cleared Grassland
8. Samphire Wetland
9. River

Figure 6. Vegetation and Substrate Associations in the project area (outlined in red)

3.2.1 Parkland Cleared VSA

This vegetation was within Claughton Reserve. It consisted of large Flooded Gum (*Eucalyptus rudis*) and the occasional Tuart (*Eucalyptus gomphocephala*), Marri (*Corymbia calophylla*) and Jarrah (*Eucalyptus marginata*) with a cleared introduced grassy understorey on sandy soil (Figure 6).

a) Representation. Occurred along the eastern side of the project area and covered about a third of the terrestrial part of the site.

b) Conservation Significance for Fauna. The trees within this VSA were large enough to contain small to large hollows. This could be important to species such as Brushtail Possums (CS3), bats and small native parrots. However, the majority of the hollows were being utilised by introduced Rainbow Lorikeets, Galahs (overabundant self-introduced species) and feral honeybees. There were two trees with suitable sized hollows for Black-Cockatoos but there are no records of them breeding in Flooded Gums. This VSA is locally important for the presence of large trees and associated hollows, and for supporting canopy-dependent birds such as the Weebill.

Figure 7. Example of the Parkland Cleared VSA.

3.2.2 Riparian Vegetation

This VSA consisted of the fringing vegetation along the Swan River, including: *Casuarina obesa* Woodlands with Flooded Gum and Melaleuca, and sedge and samphire understorey close to river and thick grassy understorey further away (Figure 7 and 8); Sedgeland to Closed Sedgeland with *Juncus* sp. and *Bolboschoenus* sp. (Figure 9 and 10); and Regeneration (planted) Vegetation of *Acacia pulchella, Kennedia prostrata*, *Casuarina obesa, Eucalyptus rudis* and sedges. The condition of this VSA in the project area varies from highly degraded and young to dense remnant patches.

a) Representation. Occurred along both sides of the river and covered about a third of the terrestrial part of the project area.

b) Conservation Significance for Fauna. Riparian vegetation has high conservation significance to fauna. It is usually thick and provides good cover for many small species of birds, reptiles and mammals (such as the CS2 Rakali or Water-rat). It may also be important in providing refuge for aquatic species, such as larval fish and prawns. It provides a protective barrier for the river and helps maintain riverbanks, as well as reducing rubbish and runoff flows. This VSA has been highly cleared and degraded within the region making remaining remnants important.

Figure 8. Example of the Riparian Vegetation – Casuarina Woodland

Figure 9. Example of the Riparian Vegetation – Casuarina Woodland

Figure 10. Example of the Riparian Vegetation – Open Sedgeland

Figure 11. Example of the Riparian Vegetation –Closed Sedgeland

3.2.3 Ephemeral Wetlands

A small low point in the project area that gets runoff from the Parkland Cleared area. This VSA was surrounded by sedges and young replanted Flooded Gums.

a) Representation. Only a small portion of Claughton Reserve.

b) Conservation Significance for Fauna. Only a small wetland likely to be used by a number of frog species when full but of low conservation significance due to the size of the wetland and the amount of other similar habitat within the area.

3.2.4 Sandy Beaches and Tidal Mudflats

This VSA is in small sections along the riverbank. Both beaches (Figure 11) and mudflats (Figure 12) have debris from the river and the mudflats are likely to provide important habitat for invertebrates and therefore possible foraging areas for waders.

a) Representation. Small portions along the river.

b) Conservation Significance for Fauna. Water-rat (CS2) tracks (Figure 13 and 14) were identified along this VSA. May provide foraging habitat for waders and waterbirds, some of which are of conservation significance.

Figure 12. Example of the Beach VSA.

Figure 13. Example of the Mudflats VSA.

Figure 14. Location of Water-rat (CS2) tracks.

Figure 15. Water-rat tracks located on a beach adjacent to Caughton Reserve.

3.2.5 Dense Melaleuca Wetland

A small section within Claughton Reserve contains dense *Melaleuca rhaphiophylla* on sand (Figure 15). Within the centre of the thicket grows *Typha* sp. and African Feather Grass (*Pennisetum macrourum*).

a) Representation. Small portion within Claughton Reserve.

b) Conservation Significance for Fauna. May provide nesting habitat for small woodland birds many of which are considered to have conservation significance due to loss of vegetation throughout the region.

Figure 16. Example of the Dense *Melaleuca rhaphiophylla* Thicket.

3.2.6 Road Regeneration

Revegetated road verges beside the Tonkin Highway. Includes Peppermint (*Agonis flexuosa*), Flooded Gum, Prickly Acacia (*Acacia pulchella*), Melaleuca and other mixed shrubs.

a) Representation. Small portion along Tonkin Highway about a tenth of the project area.

b) Conservation Significance for Fauna. May provide nesting and foraging habitat for small woodland birds many of which are considered to have conservation significance due to loss of vegetation throughout the region. However as it is young regeneration vegetation which can be replaced it is not considered of high conservation significance.

3.2.7 Degraded Swamp and Cleared Grassland

Melaleuca rhaphiophylla and *Casuarina obesa* swamp with sedge, grass, weedy understorey. Trees dead or dying, recently burnt, full of weeds alongside open grassland of introduced species (Figure 16).

a) Representation. Small portion of project area to the west of the Tonkin Highway.

b) Conservation Significance for Fauna. Highly degraded habitat unlikely to be of high conservation significance to fauna.

Figure 17. Example of the Degraded Swamp VSA.

3.2.8 Samphire Wetland

The samphire wetland is to the west of the Tonkin Highway and covers about a sixth of the project area. Consists of thick low samphire vegetation including *Sarcocornia* sp. and *Suaeda* sp. on flooded clay soils (Figure 17 and 18).

a) Representation. A large proportion of the project area to the west of the Tonkin Highway. Much of the samphire vegetation has been degraded and cleared along the Perth rivers.
b) Conservation Significance for Fauna. Samphire wetland has high conservation significance to fauna as it provides important foraging habitat to migratory waders and waterbirds, many of which are CS1 species.

Figure 18. Example of the Samphire Wetland.

Figure 19. Example of the Samphire Wetland.

3.2.9 River

The Swan River has been included here as a VSA as it is an important habitat type. However, as discussed previously the Swan River has been assessed as part of a separate report.

a) Representation. The river takes up approximately 17ha of the area provided in Figure 2. Large rivers are rare in the region.
b) Conservation Significance for Fauna. The river has high conservation significance for fauna. Impacts to the river can be important to species within the project area as well as those downstream right to the ocean. The river is particularly vulnerable to increased siltation, pollution and rubbish from runoff during and after works.

3.3 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 Appendix 4 for descriptions and other ecological processes). These include:

3.3.1 Local hydrology

Interruptions of hydro-ecological processes can have massive effects because they underpin primary production in ecosystems and there are specific, generally rare habitats that are hydrology-dependent. There is surface and probably sub-surface drainage into the river and wetland areas. These patterns are important wetland and swamplands especially VSAs 2, 3, 5, 7, 8 and 9 that are reliant on damp soils and runoff. Roads and construction may alter both surface and sub-surface hydrology. Any runoff from the site is also likely to pollute the river and wetlands through increase siltation, chemical and oil pollution and rubbish.

3.3.2 Fire

There was some evidence of fire affecting native vegetation in the Degraded Swamp VSA at the time of the site inspection. Fire is however recognised as a factor in the dynamics of fauna populations in the south-west of Western Australia; it is also one of the factors that has contributed to the decline and local extinction of some mammal and bird species (Bamford 1986 and Burbidge and McKenzie 1998). In general the vegetation is patchy and wet and therefore less likely to carry a fire. Fire would likely degrade riparian and wetland VSAs if they were to occur. 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.

3.3.3 Feral predators and interactions with over-abundant introduced and native species

Feral predators are a major factor in the decline and local extinction of some mammal and bird species (Burbidge and McKenzie 1998), and there is growing evidence that over-abundant native species can adversely affect biodiversity (e.g. Harrington 2002). The increase in the abundance of Galahs and Corellas and the introduction of Rainbow Lorikeets and Feral Honeybees into Perth may have contributed to the decline of some other cockatoo and parrot species (Saunders and Ingram 1995). The fauna assemblage of the project areas has already been impacted by feral species (loss of a major component of the mammal fauna, reptiles and woodland birds Appendix 6), and several feral species are present. Development activity is unlikely to alter the abundance of feral and overabundant species, but it could be a good opportunity to reduce their numbers to assist declining native species.

3.3.4 Habitat degradation due to weed invasion

The majority of the site had a high level of weed invasion except the Samphire Wetland, which had little evidence of weeds. Construction and development of the area, particularly with the movement of equipment and vehicles along roads raises the potential for weed invasion and habitat degradation particularly in the wetland and river VSAs. Currently the vegetation along the river is providing a buffer for weed invasion and rubbish disposal.

3.3.5 Landscape connectivity

The project area lies between two Bush Forever sites (Figure 3) and is part of the corridor of native vegetation that the river provides through the suburbs. Such connectivity is important in supporting urban wildlife.

3.4 Summary of fauna values

Fauna values within the study area can be summarised as follows:

Fauna assemblage. Moderately rich but with some obvious gaps (See Section 3.1.3 for more detail). For example, the bird assemblage lacked most of the more sensitive

species, while a proportion of the original reptile and mammal assemblages is considered no longer to be present. While likely to be typical of the fauna assemblages in the Perth region, it may be slightly unusual because of the variety of environments present and the proximity of the project area to the river. As a result, the assemblage could have a combination of species not always seen across a small area.

Species of conservation significance. These include at least 33 bird species and two mammal species. Species of note are the Rakali or Water-rat, Carnaby's Black-Cockatoo, migratory waders and waterbirds, and a suite of declining woodland birds.

Vegetation and Substrate Associations. Nine VSAs were identified across the project area. Clearing of native vegetation on the Swan Coastal Plain makes remnant patches of bush even more important. Vegetation along the Swan River is also of vital importance for its habitat value as well as its function in reducing pollution and waste entering the river.

Patterns of biodiversity. Biodiversity is likely to be spread across the VSAs and the landscape, but areas of particular significance are the uncleared vegetation around wetlands and along the river.

Key ecological processes. Main processes currently affecting the fauna assemblage in the project area include connectivity, local hydrology and fauna interactions (feral predators, over-abundant introduced and native species). Local hydrology may be particularly significant because of reliance of some of the vegetation on wetter areas and the proximity of the project area to the river.

4 IMPACT ASSESSMENT

4.1 Overview of Impacts

At the time of writing BCE was provided with the project area but not details of the proposed project. Therefore the assessment of impacts is general in nature and based on the VSAs identified and the fauna likely to be present.

If restricted to previously cleared and degraded areas, impacts on fauna are generally considered to be only minor, and this is also consistent for the majority of the conservation significant species. This is due to the relatively small footprint of the area, which is located adjacent to larger areas of native bush along the river.

The main processes affecting the fauna assemblage include: fauna mortality, loss of habitat, habitat degradation, fragmentation of habitats, changes in hydrology, changes to the fire regime and impacts of dust, noise, light and disturbance.

4.1.1 Loss of habitat leading to population decline

The loss of significant habitat may be detrimental to local fauna populations. If the project is restricted to the Tonkin Highway bridge and the Road Revegetation, Degraded Swamp and Grassland VSAs, this impact is likely to be minor. Impacts to Riparian and Samphire Wetland VSAs are likely to have a greater significance.

Clearing of the project area and project works could impact on the conservation value of the neighbouring river as the vegetation currently acts as a buffer and there is the potential for increased silt, chemicals, oil and rubbish in runoff or directly dropped into the river.

4.1.2 Loss of habitat leading to population fragmentation

The survey area contains VSAs that extend into and connect the neighbouring reserves and Bush Forever sites. If the works are restricted to the bridge and cleared areas, and loss of riparian vegetation is minimal, fragmentation of populations leading to isolation and reduced movement/gene flow is anticipated to be minimal. Fragmentation of dense riparian vegetation may impact the conservation significant Rakali or Water-rat.

4.1.3 Degradation of habitat due to weed invasion

Weed invasion poses a significant threat to the fauna and flora values not only in some of the VSAs within the survey area but also along the Swan River and lower estuary. Several weed species occur in the region. Invasive weed species can replace native species and degrade fauna habitats. Weeds can be spread by vehicles, earthworks as well as road and rail construction. The project area is already experiencing a high degree of weed invasion, these could be deposited into the river during works impacting habitats further downstream. However, proper weed management would make the impact of the project minor.

4.1.4 Ongoing mortality

Direct mortality of common species during clearing is unavoidable but can be minimised (see recommendations below). In general, the project area is small within the context of the regional landscape so mortality during any possible clearing is likely to represent only small proportions of regional populations. However, the viability of species that occur at low population densities in areas adjacent, such as waterbirds and waders, to the survey area may be compromised by ongoing mortality. Ongoing mortality may arise through collision with overhead lines. Bird species linked to water bodies like the river and likely to fly over the rail line while travelling along the river may be susceptible to wire strike.

Coues (1876) identified bird mortality through bird strike with powerlines over 130 years ago by. Despite this, bird deaths due to collision with transmission lines is not well understood, particularly in Australia, and even less is known about overhead rail lines. Concerns are both for the conservation of species likely to strike overhead lines as well as issues to rail infrastructure and power outages.

4.1.5 Species interactions

Feral and overabundant native species are a major conservation concern in general and evidence of feral cats, foxes, dogs, honeybees, Rainbow Lorikeets and Galahs have been identified in the area. Foxes, cats (both domestic and feral) and dogs are likely to be attracted by recent disturbance, possibly leading to increased local impacts on native fauna in disturbed areas. Inappropriate waste management may also attract foxes and feral cats, as well as native predators and scavengers, which may exacerbate localised impacts on other native fauna. The project is unlikely to increase the impact of Lorikeets, Galahs or Honeybees which are already a major contributor to loss of available hollows for other locally native species.

4.1.6 Hydroecology

Interruptions of hydroecological processes are a concern where disturbances are associated with creeks, riparian vegetation and groundwater-reliant systems. The Wetland, Riparian and River VSAs are likely to be negatively impacted if overland flow is altered. It is anticipated that changes to waterflows will be minor, however a silt, chemical and rubbish management plan is vital to reduce impacts on these important areas.

4.1.7 Altered fire regimes

Some conservation significant fauna are particularly susceptible to fire. However changes to the local fire regimes arising from any development are anticipated to be negligible providing management measures are in place.

4.1.8 Disturbance

Impacts of dust, light, disturbance and noise upon fauna are difficult to predict. Due to its location these are already factors influencing the fauna of the site. Silt and

chemical runoff into the river however could become a negative issue, however with proper management plans this is anticipated to be minor.

4.1.9 Summary of impacts

Impacts of development upon key fauna values (important VSAs and conservation significant fauna of interest) are summarised in Table 6. Impacts upon ecological processes are summarised in Table 7. Most ecological processes are expected to have only negligible or minor impacts, providing management measure are in place, and disturbance to wetland, riparian and river VSA is minimised. Impacts upon fauna values are generally considered to be only minor, even upon the majority of significant species (see Table 6). This is because of the relatively small footprint of the project area. The one area which could become an issue and may need further research is bird strike on the overhead lines of the rail line. This is particularly important to CS1 species of waterbirds and migratory waders.

Table 6. Summary of potential impacts upon key fauna values, including conservation significant species that are expected to occur in the survey area should it be developed.
Criteria for significance of impacts are outlined in Appendix 3.

Fauna Value	Nature and Significance of Proposal Impact		Action required
	Impacts from Proposal	Significance	
Fauna assemblage	Small loss of habitat that, if kept to previously cleared areas, is already highly degraded. Loss or degradation of Wetland or Riparian habitat would be of higher significance.	Minor	Avoid clearing Wetland and Riparian VSAs. Develop and implement a runoff and rubbish management plan.
VSAs	Unknown as plans for proposed development not provided at time of writing report. If development and clearing are restricted to Road Revegetation and Degraded Swamp VSAs, potential impacts will be reduced.	Unknown	It is recommended to avoid disturbances of Wetland, Riparian and River VSAs.
CS3 Birds	Potential loss of habitat and disturbance.	Minor	Avoid clearing vegetation Wetland and Riparian VSAs. Develop and implement a runoff and rubbish management plan.
EPBC Migratory listed birds	Potential loss of habitat and disturbance, increase in mortality due to birdstrike.	Probably Minor	Avoid disturbance to Wetland and Mudflat VSAs. Investigate measures to reduce birdstrike on overhead wires.
Peregrine Falcon	Likely in survey area only as an occasional visitor and minor loss of habitat	Negligible to Minor	None. Unlikely but possible visitor.
Black-Cockatoos	Likely in survey area only as an occasional visitor and minor loss of habitat. Only small number of foraging trees.	Minor	Keep large trees as possible roost sites.
Rakali or Water-rat	Potential loss of habitat and susceptible decrease in water quality.	Probably Minor	Avoid clearing Wetland and Riparian VSAs. Develop and implement a runoff and rubbish management plan.

Table 7. Summary of potential impacts upon ecological processes.

Impacting process	Impact
Habitat loss leading to population decline	**Minor.** Only localised as small area of habitat loss with minor impact upon significant species anticipated.
Population fragmentation and disruption of movement and gene flow due to habitat fragmentation	**Minor.** Limited fragmentation or disruption of movement is anticipated with development of the project area. A reduction in the quality of the river and neighbouring wetlands is possible without a runoff and rubbish management plan.
Increased mortality leading to population decline; e.g. due to ongoing overhead wire birdstrke.	**Probably Minor.** Bird strike on powerlines over wetland and river areas can be significant. Measures should be taken to reduce the possibility of birdstrike on overhead wires associated with the new rail infrastructure.
Habitat degradation due to weed invasion	**Moderate to Minor.** The project area is already fairly weedy. There is the potential for weeds to be spread downstream during development works. This could be reduced if proper management measures are in place.
Hydroecology	**Unknown**. Impacts to hydrology are largely unknown. The presence of wetland areas suggests that some of the vegetation on the site is reliant on surface and ground water.
Species interactions due to feral or over-abundant native species	**Minor.** Low risk of increased feral species beyond what is current. Opportunity to reduce impacts of Lorikeets and honeybees using hollows in the Parkland Cleared VSA.
Altered fire regimes	**Minor.** There should be little risk of a change in the fire regime, provided management measures are in place.
Effects of disturbance, dust and light	**Probably Minor.** Some disturbance may result, in particular to silt and chemical runoff into the river. This could be reduced if proper management measures are in place.

5 CONCLUSIONS

The desktop study identified 176 vertebrate species as potentially occurring in the project area, 35 of which are considered to be of conservation significance. Despite some gaps, the project area supports a moderately rich fauna assemblage, particularly in the context of the surrounding urban landscape. The assemblage is likely to be similar to that of many bushland remnants in the Perth urban area, but with the addition of species associated with riverine environments, such as the conservation significant Rakali or Water-rat and migratory waders.

The assemblage is also expected to include a suite of conservation significant birds which have declined around Perth, such as Splendid and White-winged Fairy-wrens, White-browed Scrubwren, Inland and Yellow-rumped Thornbills, Western Wattlebird, White-cheeked and New Holland Honeyeaters, Rufous Whistler and Varied Sittella. Despite this, there are some species that may have declined and even disappeared from the area in recent years, while there are also species that would have been present but are now locally extinct.

Development of the project area, if restricted to the previously cleared road verge and Degraded Swamp and Grassland VSA is likely to have a minor impact on local species and ecological processes. However without proper management plans for runoff and rubbish it is likely to reduce the quality of the river, including downstream habitats.

Recommendations

- Minimise vegetation clearing, particularly the quality habitat in the Wetland and Riparian VSAs;
- Minimise the disturbance footprint;
- Clearly delineate areas to be cleared;
- Avoid disturbance to the river, develop and implement a runoff and rubbish management plan;
- Where possible, retain riparian vegetation to maintain linkages between remnant patches along the river.
- Discourage the presence of feral species, particularly the feral Cat and Fox, by the use of appropriate waste management procedures;
- Develop an understanding of the surface and sub-surface drainage in order to identify the potential for hydrological changes that could potentially impact fauna habitats;
- Where practicable, implement management actions where it is expected that changes to hydrology may affect significant fauna habitats.
- Develop a weed management/hygiene plan, including runoff into the river;
- Develop a fire management plan.
- Minimise the production of dust, noise and light spill.

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7 APPENDICIS

7.1 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 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, for example, by the sorts of species present.

Vegetation/substrate associations (VSAs)

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. 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 Wildlife Conservation Act 1950* (Wildlife Conservation Act). In addition, the Western Australian DEC 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.

Conservation Significance (CS) 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 recognized 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 Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals). The Wildlife Conservation Act uses a series of Schedules to classify status, but also recognizes the IUCN categories.

Conservation Significance (CS) 2: Species listed as Priority by the DEC but not listed under State or Commonwealth Acts.
In Western Australia, the DEC has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the Wildlife Conservation Act but for which the DEC feels there is cause for concern. Some Priority species are also assigned to the Conservation Dependent category of the IUCN.

Conservation Significance (CS) 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, 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 recognized 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 DEC (2000), used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan.

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.

7.2 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 and under the EPBC Act, in which threatening processes are listed (see Appendix 4). 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. 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 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 from 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; Letnic *et al.* 2004). 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. Fire management may be considered the responsibility of managers of large tracts of land.

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.

7.3 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 *Wildlife Conservation Act* 1950.

Extinct	Taxa not definitely located in the wild during the past 50 years.
Extinct in the Wild	Taxa known to survive only in captivity.
Critically Endangered	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
Endangered	Taxa facing a very high risk of extinction in the wild in the near future.
Vulnerable	Taxa facing a high risk of extinction in the wild in the medium-term 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 Wildlife Conservation Act

Schedule 1	**T**	Rare and Likely to become Extinct.
Schedule 2	**X**	Extinct.
Schedule 3	**IA**	Migratory species listed under international treaties.
Schedule 4	**S**	Other Specially Protected Fauna

WA Department of Environment and Conservation Priority species (species not listed under the Wildlife Conservation Act 1950, but for which there is some concern).

Priority 1	Taxa with few, poorly known populations on threatened lands.
Priority 2	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3	Taxa with several, poorly known populations, some on conservation lands.
Priority 4	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	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).

7.4 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 issue of ecological processes, 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 19 key threatening processes listed by the federal Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC):

- Competition and land degradation by feral/unmanaged Goats (*Capra hircus*);
- Competition and land degradation by feral Rabbits (*Oryctolagus cuniculus*);
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*);
- Incidental catch (bycatch) of Sea Turtles 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;
- Predation by exotic rats on Australian offshore islands of less than 1000 km2 (100 000 ha);
- Predation by feral Cats (*Felis catus*);

- Predation by the European Red Fox (*Vulpes vulpes*);
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (*Sus scrofa*);
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species;
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Bufo marinus*); and
- The reduction in the biodiversity of Australian native fauna and flora due to the imported Red Fire Ant, *Solenopsis invicta*.

General processes that threaten biodiversity across Australia (The National Land and Water Resources Audit):

- 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 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 listed below.

- Will the proposed action lead to a long-term decrease in the size of a population?
- Will the proposed action will 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 will 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 will interfere with the recovery of the species?

7.5 Appendix 5. Fauna species recorded or expected in the project area.

Cons. Signif. – Conservation Significance.
Database – Species returned in database search (see Section 2.2) that would be expected in the area.
BCE – Recorded in the area during the survey or from previous BCE visits.

Table 1. Frogs recorded or expected in the Project Area.

Frog Species	Cons. Signif.	Database	BCE
Hylidae (tree-frogs)			
Slender Tree-Frog *Litoria adelaidensis*		√	
Motorbike Frog *Litoria moorei*		√	√
Myobatrachidae (ground frogs)			
Clicking Frog *Crinia glauerti*		√	
Squelching Froglet *Crinia insignifera*		√	
Moaning Frog *Heleioporus eyrei*		√	
Banjo Frog *Limnodynastes dorsalis*		√	
Total expected (recorded in brackets) **6 (1)**	0		

Table 2. Reptiles recorded or expected in the Project Area.

Reptile Species	Cons. Signif	Database	BCE
Cheluidae (side-necked tortoises)			
South-West Long-necked Tortoise *Chelodina oblonga*		√	√
Gekkonidae (geckoes)			
Marbled Gecko *Christinus marmoratus*			
Spiny-tailed Gecko *Strophurus spinigerus*		√	
Pygopodidae (legless lizards)			
Sandplain Worm Lizard *Aprasia repens*		√	
Agamidae (dragon lizards)			
Western Bearded Dragon *Pogona minor*		√	
Varanidae (monitors or goannas)			
Gould's Sand Goanna *Varanus gouldii*		√	
Scincidae (skinks)			
South-west Cool Skink *Acritoscincus trilineatum*			
Fence Skink *Cryptoblepharus buchananii*		√	
West Coast Ctenotus *Ctenotus fallens*		√	
King's Skink *Egernia kingii*			
Mourning Skink *Egernia luctuosa*			
Two-toed Skink *Hemiergis quadrilineata*		√	
Four-toed Lerista *Lerista elegans*			
Common Dwarf Skink *Menetia greyii*		√	
Spotted Morethia *Morethia lineoocellata*			
Shrubland Morethia *Morethia obscura*		√	
Bobtail *Tiliqua rugosa*		√	

Reptile Species	Cons. Signif	Database	BCE
Typhlopidae (blind snakes)			
Southern Blind Snake *Ramphotyphlops australis*			
Elapidae (front-fanged snakes)			
Tiger Snake *Notechus scutatus*			
Dugite *Pseudonaja affinis*		√	
Total expected (recorded in brackets)**: 20 (1)**	**0**		

Table 3. Birds recorded or expected in the Project Area.

Bird Species	Cons. Signif.	Database	BCE
Phasianidae (quails)			
Brown Quail *Coturnix ypsilophora*			
Stubble Quail *Coturnix pectoralis*		√	
Anatidae (ducks, geese, teal)			
Black Swan *Cygnus atratus*		√	
Chestnut Teal *Anas castanea*		√	
Grey Teal *Anas gracilis*		√	
Domestic Waterfowl	INT	√	
Australasian Shoveler *Anas rhynchotis*		√	
Pacific Black Duck *Anas superciliosa*		√	√
Hardhead (White-eyed Duck) *Aythya australis*		√	
Musk Duck *Biziura lobata*	CS3	√	
Australian Wood Duck *Chenonetta jubata*		√	√
Pink-eared Duck *Malacorhynchus membranaceus*	CS3	√	
Australian Shelduck *Tadorna tadornoides*		√	
Anhingidae (darters)			
Darter *Anhinga melanogaster*		√	√
Phalacrocoracidae (cormorants)			
Great Cormorant *Phalacrocorax carbo*		√	
Pied Cormorant *Phalacrocorax varius*		√	
Little Black Cormorant *Phalacrocorax sulcirostris*		√	√
Little Pied Cormorant *Phalacrocorax melanoleucos*		√	√
Podicepididae (grebes)			
Great Crested Grebe *Podiceps cristatus*		√	
Hoary-headed Grebe *Poliocephalus poliocephalus*		√	
Australasian Grebe *Tachybaptus novaehollandiae*		√	
Pelecanoididae (pelicans)			
Australian Pelican *Pelecanus conspicillatus*		√	√
Ardeidae (herons and egrets)			
White-faced Heron *Egretta novaehollandiae*		√	√
White-necked Heron *Ardea pacifica*		√	

Bird Species		Cons. Signif.	Database	BCE
Great Egret	*Ardea alba*	CS1	√	
Cattle Egret	*Ardea ibis*	CS1	√	
Little Egret	*Egretta garzetta*		√	
Nankeen Night Heron	*Nycticorax caledonicus*		√	
Threskionithidae (ibis and spoonbills)				
Australian White Ibis	*Threskiornis molucca*		√	√
Straw-necked Ibis	*Threskiornis spinicollis*		√	
Yellow-billed Spoonbill	*Platalea flavipes*		√	√
Rallidae (crakes and rails)				
Buff-banded Rail	*Rallus philippensis*			√
Baillon's Crake	*Porzana pusilla*		√	
Australian Spotted Crake	*Porzana fluminea*		√	
Spotless Crake	*Porzana tabuensis*		√	
Dusky Moorhen	*Gallinula tenebrosa*	CS3	√	
Purple Swamphen	*Porphyrio porphyrio*		√	
Eurasian Coot	*Fulica atra*		√	
Recurvirostridae (stilts and avocets)				
Black-winged Stilt	*Himantopus himantopus*		√	√
Banded Stilt	*Cladorhynchus leucocephalus*		√	
Red-necked Avocet	*Recurvirostra novaehollandiae*		√	
Charadriidae (lapwings and plovers)				
Grey Plover	*Pluvialis squatarola*		√	
Red-capped Plover	*Charadrius ruficapillus*		√	
Black-fronted Dotterel	*Elseyornis melanops*		√	
Red-kneed Dotterel	*Erythrogonys cinctus*			
Banded Lapwing	*Vanellus tricolor*		√	
Scolopacidae (sandpipers and stints)				
Common Sandpiper	*Acticus hypoleucos*	CS1	√	√
Red-necked Stint	*Calidris ruficollis*	CS1	√	
Sharp-tailed Sandpiper	*Calidris acuminata*	CS1	√	
Curlew Sandpiper	*Calidris ferruginea*	CS1	√	
Common Greenshank	*Tringa nebularia*	CS1	√	
Laridae (gulls and terns)				
Whiskered Tern	*Chilidonias hybrida*			
Crested Tern	*Thalasseus bergii*			
Caspian Tern	*Hydroprogne caspia*	CS1	√	√
Silver Gull	*Chroicocephalus novaehollandiae*		√	√
Columbidae (pigeons and doves)				
Rock Dove (Domestic Pigeon)	*Columba livia*	INT	√	
Laughing Dove	*Streptopelia senegalensis*	INT	√	√
Spotted Dove	*Streptopelia chinensis*	INT	√	√

Bird Species		Cons. Signif.	Database	BCE
Common Bronzewing	*Phaps chalcoptera*	CS3	√	
Crested Pigeon	*Ocyphaps lophotes*		√	
Podargidae (frogmouths)				
Tawny Frogmouth	*Podargus strigoides*		√	
Apodidae (swifts)				
Fork-tailed Swift	*Apus pacificus*	CS1	√	
Pandionidae (ospreys)				
Eastern Osprey	*Pandion cristatus*		√	
Accipitridae (kites, hawks and eagles)				
Black-shouldered Kite	*Elanus axillaris*		√	
Square-tailed Kite	*Lophoictinia isura*			
Whistling Kite	*Haliastur sphenurus*		√	
Swamp Harrier	*Circus approximans*		√	
Brown Goshawk	*Accipiter fasciatus*	CS3	√	
Collared Sparrowhawk	*Accipiter cirrhocephalus*	CS3	√	
White-bellied Sea-Eagle	*Haliaeetus leucogaster*		√	
Little Eagle	*Hieraaetus morphnoides*	CS3	√	
Falconidae (falcons)				
Peregrine Falcon	*Falco peregrinus*	CS1	√	
Australian Hobby	*Falco longipennis*		√	√
Brown Falcon	*Falco berigora*			
Nankeen Kestrel	*Falco cenchroides*		√	
Cacatuidae (cockatoos)				
Carnaby's Black-Cockatoo	*Calyptorhynchus latirostris*	CS1	√	√
Baudin's Black-Cockatoo	*Calyptorhynchus baudinii*	CS1	√	
Forest Red-tailed Black-Cockatoo	*Calyptorhynchus banksii naso*	CS1		
Sulphur-crested Cockatoo	*Cacatua galerita*	INT	√	
Galah	*Cacatua roseicapilla*		√	√
Eastern Long-billed Corella	*Cacatua tenuirostris*	INT	√	
Western Corella	*Cacatua pastinator*		√	
Little Corella	*Cacatua sanguinea*		√	√
Psittacidae (lorikeets and parrots)				
Rainbow Lorikeet	*Trichoglossus haematodus*	INT	√	√
Australian Ringneck	*Barnardius zonarius*		√	√
Red-capped Parrot	*Purpureicephalus spurius*		√	
Cuculidae (cuckoos)				
Fan-tailed Cuckoo	*Cacomantis flabelliformis*		√	
Pallid Cuckoo	*Cuculus pallidus*		√	
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*		√	
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*		√	

Bird Species		Cons. Signif.	Database	BCE
Strigidae (hawk-owls)				
Southern Boobook	*Ninox novaeseelandiae*			
Tytonidae (barn owls)				
Barn Owl	*Tyto alba*		√	
Halcyonidae (forest kingfishers)				
Sacred Kingfisher	*Todiramphus sanctus*		√	
Laughing Kookaburra	*Dacelo novaeguineae*	INT	√	√
Meropidae (bee-eaters)				
Rainbow Bee-eater	*Merops ornatus*	CS1	√	
Maluridae (fairy-wrens)				
Splendid Fairy-wren	*Malurus splendens*	CS3	√	
White-winged Fairy-wren	*Malurus leucopterus*	CS3	√	
Pardalotidae (pardalotes)				
Striated Pardalote	*Pardalotus striatus*		√	√
Spotted Pardalote	*Pardalotus punctatus*		√	
White-browed Scrubwren	*Sericornis frontalis*	CS3	√	
Weebill	*Smicrornis brevirostris*	CS3	√	√
Western Gerygone	*Gerygone fusca*		√	
Inland Thornbill	*Acanthiza apicalis*	CS3	√	
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	CS3	√	
Meliphagidae (honeyeaters)				
Red Wattlebird	*Anthochaera carunculata*		√	
Western Wattlebird	*Anthochaera lunulata*	CS3	√	
Singing Honeyeater	*Lichenostomus virescens*		√	√
Brown Honeyeater	*Lichmera indistincta*		√	
Western White-naped Honeyeater	*Melithreptus chloropsis*		√	
White-cheeked Honeyeater	*Phylidonyris nigra*	CS3	√	
New Holland Honeyeater	*Phylidonyris novaehollandiae*	CS3	√	
White-fronted Chat	*Epthianura albifrons*		√	
Acrocephalidae (reed-warblers)				
Australian Reed-Warbler	*Acrocephalus australis*			
Megaluridae (grassbirds)				
Little Grassbird	*Megalurus gramineus*		√	
Rufous Songlark	*Cincloramphus mathewsi*		√	
Brown Songlark	*Cincloramphus cruralis*		√	
Zosteropidae (white-eyes)				
Silvereye	*Zosterops lateralis*		√	
Pachycephalidae (whistlers)				
Rufous Whistler	*Pachycephala rufiventris*	CS3	√	

Bird Species		Cons. Signif.	Database	BCE
Dicruridae (flycatchers)				
Magpie-lark	*Grallina cyanoleuca*		√	√
Grey Fantail	*Rhipidura fuliginosa*		√	
Willie Wagtail	*Rhipidura leucophrys*		√	
Neosittidae (sittella)				
Varied Sittella	*Daphoenositta chrysoptera*	CS3	√	
Campephagidae (cuckoo-shrikes)				
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		√	√
White-winged Triller	*Lalage sueurii*		√	
Artamidae (woodswallows)				
Black-faced Woodswallow	*Artamus cinereus*	CS3	√	
Dusky Woodswallow	*Artamus cyanopterus*			
Grey Butcherbird	*Cracticus torquatus*		√	
Australian Magpie	*Gymnorhina tibicen*		√	√
Corvidae (ravens and crows)				
Australian Raven	*Corvus coronoides*		√	√
Motacillidae (pipits and true wagtails)				
Australian Pipit	*Anthus novaeseelandiae*		√	
Dicaeidae (flower-peckers)				
Mistletoebird	*Dicaeum hirundinaceum*		√	√
Hirundinidae (swallows)				
White-backed Swallow	*Cheramoeca leucosternus*			
Welcome Swallow	*Hirundo neoxena*		√	
Tree Martin	*Petrochelidon nigricans*		√	
Fairy Martin	*Petrochelidon ariel*		√	
Total expected (recorded in brackets): 136 (31)		**24**		

Table 4. Mammals recorded or expected in the Project Area.

Mammal Species	Cons. Signif.	Database	BCE
Phalangeridae (brushtail possums)			
Brush-tailed Possum *Trichosurus vulpecula*	CS3	√	
Mollosidae (mastiff bats)			
White-striped Bat *Tadarida australis*			
Vespertilionidae (vesper bats)			
Southern Forest Bat *Vespadelus (Eptesicus) regulus*		√	
Gould's Wattled Bat *Chalinolobus gouldii*		√	
Chocolate Wattled Bat *Chalinolobus morio*		√	
Lesser Long-eared Bat *Nyctophilus geoffroyi*		√	
Muridae (rats and mice)			
House Mouse *Mus musculus*	INT	√	
Water-rat or Rakali *Hydromys chrysogaster*	CS2	√	√
Brown Rat *Rattus norvegicus*	INT	√	
Black Rat *Rattus rattus*	INT	√	
Leporidae (rabbits and hares)			
Rabbit *Oryctolagus cuniculus*	INT	√	
Canidae (foxes and dogs)			
European Red Fox *Vulpes vulpes*	INT	√	√
Dog *Canis lupus*	INT	√	√
Felidae (cats)			
Feral Cat *Felis catus*	INT	√	√
Total expected (recorded in brackets): 14 (4)	**2**		

7.6 Appendix 6. Species returned in database search which are unlikely to be present in Project Area due to lack of habitat.

Cons. Signif. – Conservation Significance.
Locally Ex. – Species which would be expected in this area but which are locally extinct.

Species		Cons. Signif.	Locally Extinct
Myobatrachidae (ground frogs)			
Hooting Frog	*Heleioporus barycragus*		
Quacking Frog	*Crinia georgiana*		
Sand Frog	*Heleioporus psammophilus*		
Turtle Frog	*Myobatrachus gouldii*		
Humming Frog	*Neobatrachus pelobatoides*		
Guenther's Toadlet	*Pseudophryne guentheri*		
Cheluidae (side-necked tortoises)			
Western Swamp Tortoise	*Pseudemydura umbrina*	CS1	
Pygopodidae (legless lizards)			
Granite Worm-lizard	*Aprasia pulchella*		
Gekkonidae (geckoes)			
Clawless Gecko	*Crenadactylus ocellatus*		
White-spotted Gecko	*Diplodactylus alboguttatus*		
Speckled Stone Gecko	*Diplodactylus polyophthalmus*	CS3	
Variegated Dtella	*Gehyra variegata*		
Bynoe's Gecko	*Heteronotia binoei*		
Barking Gecko	*Underwoodisaurus milii*		
Pygopodidae (legless lizards)			
Javelin Legless Lizard	*Delma concinna*		
Fraser's Legless Lizard	*Delma fraseri*		
Gray's Legless Lizard	*Delma grayii*		
Burton's Legless Lizard	*Lialis burtonis*		
Keeled Legless Lizard	*Pletholax gracilis*		
Common Scaleyfoot	*Pygopus lepidopodus*		
Agamidae (dragon lizards)			
Sandhill Dragon	*Ctenophorus adelaidensis*		
Varanidae (monitors or goannas)			
Black-tailed Tree Goanna	*Varanus tristis*		
Scincidae (skinks)			
Limestone Ctenotus	*Ctenotus australis*		
Jewelled Ctenotus	*Ctenotus gemmula*	CS2	
Odd-striped Ctenotus	*Ctenotus impar*		
Western Slender-bluetongue	*Cyclodomorphus celatus*		
Salmon-bellied Skink	*Egernia napoleonis*		

Species		Cons. Signif.	Locally Extinct
Lowlands Earless Skink	*Hemiergis peronii*		
Lined Skink	*Lerista lineata*	CS2	
Line-spotted Lerista	*Lerista lineopunctulata*		
Western Worm Lerista	*Lerista praepedita*		
Western Bluetongue	*Tiliqua occipitalis*		
Typhlopidae (blind snakes)			
Fat Blind Snake	*Ramphotyphlops pinguis*		
Boidae (pythons)			
Carpet Python	*Morelia spilota imbricata*	CS1	Locally Ex.
Elapidae (front-fanged snakes)			
Narrow Banded Snake	*Brachyurophis fasciolata*		
Half-ringed Snake	*Brachyurophis semifasciata*		
Yellow-faced Whip-Snake	*Demansia psammophis*		
Bardick	*Echiopsis curtus*		
Black-naped Snake	*Neelaps bimaculatus*		
Black-striped Snake	*Neelaps calonotos*	CS2	
Gould's Snake	*Parasuta gouldii*		
Jan's Bandy-Bandy	*Simoselaps bertholdi*		
Dromaiidae (emus)			
Emu	*Dromaius novaehollandiae*		Locally Ex.
Anatidae (ducks, geese, teal)			
Blue-billed Duck	*Oxyura australis*		
Freckled Duck	*Stictonetta naevosa*		
Ardeidae (herons and egrets)			
Australasian Bittern	*Botaurus poiciloptilus*		
Australian Little Bittern	*Ixobrychus dubius*	CS2	
Black Bittern	*Ixobrychus flavicollis*	CS2	
Eastern Reef Egret	*Egretta sacra*		
Scolopacidae (sandpipers and stints)			
Eastern Curlew	*Numenius madagascariensis*	CS1	
Marsh Sandpiper	*Tringa stagnatalis*		
Wood Sandpiper	*Tringa glareola*	CS1	
Otididae (bustards)			
Australian Bustard	*Ardeotis australis*	CS2	
Haematopodidae (oystercatchers)			
Pied Oystercatcher	*Haematopus longirostris*		
Columbidae (pigeons and doves)			
Brush Bronzewing	*Phaps elegans*		Locally Ex.
Caprimulgidae (nightjars)			
Spotted Nightjar	*Eurostopodus argus*		Locally Ex.

Species	Cons. Signif.	Locally Extinct
Aegothelidae (owlet-nightjars)		
Australian Owlet-nightjar *Aegotheles cristatus*		Locally Ex.
Accipitridae (kites, hawks and eagles)		
Wedge-tailed Eagle *Aquila audax*		
Turnicidae (button-quails)		
Little Button-quail *Turnix velox*		
Painted Button-quail *Turnix varia*		
Psittacidae (lorikeets and parrots)		
Western Rosella *Platycercus icterotis*		Locally Ex.
Elegant Parrot *Neophema elegans*		Locally Ex.
Regent Parrot *Polytelis anthopeplus*		Locally Ex.
Rock Parrot *Neophema petrophila*		
Purple-crowned Lorikeet *Glossopsitta porphyrocephala*		
Strigidae (hawk-owls)		
Barking Owl *Ninox* connivens		Locally Ex.
Tytonidae (barn owls)		
Masked Owl *Tyto novaehollandiae*		Locally Ex.
Maluridae (fairy-wrens)		
Variegated Fairy-wren *Malurus lamberti*	CS3	Locally Ex.
Pardalotidae (pardalotes and allies)		
Western Thornbill *Acanthiza inornata*	CS3	
Meliphagidae (honeyeaters)		
Yellow-throated Minor *Manorina flavigula*		Locally Ex
Yellow-plumed Honeyeater *Ptilotula ornatus*		
Tawny-crowned Honeyeater *Phylidonyris melanops*		
Spiny-cheeked Honeyeater *Acanthagenys rufogularis*		
Western Spinebill *Acanthorhynchus superciliosus*		
Petroicidae (Australian robins)		
Scarlet Robin *Petroica multicolor*	CS3	Locally Ex.
Red-capped Robin *Petroica goodenovii*	CS3	Locally Ex.
Hooded Robin *Melanodryas cucullata*	CS3	Locally Ex.
White-breasted Robin *Eopsaltria georgiana*	CS3	Locally Ex.
Western Yellow Robin *Eopsaltria griseogularis*	CS3	Locally Ex.
Pachycephalidae (whistlers)		
Golden Whistler *Pachycephala pectoralis*	CS3	
Grey Shrike-thrush *Colluricincla harmonica*	CS3	Locally
Artamidae (woodswallows)		
Masked Woodswallow *Artamus personatus*		
Estrildidae (waxbills, grass-finches, manikins)		
Red-eared Firetail *Stagonopleura oculata*		Locally Ex.

Species	Cons. Signif.	Locally Extinct
Tachyglossidae (echidnas)		
Echidna *Tachyglossus aculeatus*		Locally Ex.
Dasyuridae		
Chuditch *Dasyurus geoffroii*	CS1	Locally Ex.
Southern Brush-tailed Phascogale *Phascogale tapoatafa*	CS1	Locally Ex.
White-tailed Dunnart *Sminthopsis granulipes*		Locally Ex.
Grey-bellied Dunnart *Sminthopsis griseoventer*		Locally Ex.
Myrmecobiidae (numbat)		
Numbat *Myrmecobius fasciatus*	CS1	Locally Ex.
Peramelidae (bandicoots)		
Quenda or Southern Brown Bandicoot *Isoodon obesulus*	CS2	Locally Ex.
Phalangeridae (brushtail possums)		
Western Ringtail Possum *Pseudocheirus occidentalis*	CS1	Locally Ex.
Burramyidae (pygmy possum)		
Western Pygmy-possum *Cercartetus concinnus*		Locally Ex.
Tarsipedidae (honey possum)		
Honey Possum *Tarsipes rostratus*		Locally Ex.
Potoroidae (potoroos and bettongs)		
Woylie *Bettongia penicillata*	CS1	Locally Ex.
Macropodidae (kangaroos and wallabies)		
Western Grey Kangaroo *Macropus fuliginosus*		Locally Ex.
Brush or Black-gloved Wallaby *Macropus irma*	CS3	Locally Ex.
Tammar Wallaby *Macropus eugenii*	CS1	Locally Ex.
Quokka *Setonix brachyurus*	CS1	Locally Ex.
Mollosidae (mastiff bats)		
Western Freetail Bat *Mormopterus planiceps*		
Vespertilionidae (vesper bats)		
Gould's Long-eared Bat *Nyctophilus gouldi*		
Western Long-eared Bat *Nyctophilus major*		
Muridae (rats and mice)		
Noodji or Ashy-grey Mouse *Pseudomys albocinereus*		Locally Ex.
Moodit or Bush-Rat *Rattus fuscipes*		Locally Ex.
Total: 107	**28**	