Whim Creek
Fauna Assessment

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Executive Summary

Bamford Consulting Ecologists (BCE) was commissioned by Tetris Environmental Pty Ltd to conduct a Basic (*sensu* EPA 2020) fauna assessment (desktop review and site inspection), with some targeted survey for selected significant species, of the Anax Metals Ltd Whim Creek mine survey area. The purposes of this report are therefore to provide information on the fauna values of the project area, particularly with respect to the status of significant species, an overview of the ecological function of the site within the local and regional context, and to provide discussion on the interaction of proposed development on the site with these fauna values and functions.

BCE uses a 'values and impacts' assessment process with the following components:

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

Description of project area

Anax is working within lease areas between Roebourne and Port Hedland, in the vicinity of Whim Creek, and is proposing to expand existing mine workings at Mons Cupri with an estimated additional footprint of up to 60 ha. Future mining is planned at the Whim Creek deposit via a small pit cutback and associated waste dumping, anticipated to be less disturbance than Mons Cupri. The existing disturbance footprint is c. 23 ha. The Anax lease lies mostly within the Chichester (PIL01) subregion of the Pilbara bioregion, with small parts in the north in the Roebourne (PIL04). There are no known Ramsar Sites, Important Wetlands, Threatened Ecological Communities, Bush Forever Sites, Key Biodiversity Areas or Environmentally Sensitive Areas within the lease area.

Key fauna values

Vegetation and Substrate Associations (VSAs) that provide habitat for fauna. Five major Vegetation and Substrate Associations were identified in the project area: Rocky hills (VSA 1), Gravelly hills (VSA 2), Stony plains and lower slopes (VSA 3), and Sandy to sandy loam plains (VSA 4) and drainage lines (VSA 5).

Fauna assemblage. The desktop study identified 271 vertebrate fauna species as potentially occurring in the project area (4 fish, 7 frogs, 83 reptiles, 136 birds and 41 mammals). The presence of 49 species (one frog, seven reptiles, 31 birds and ten mammals) was confirmed during the 2021 site inspection. The assemblage is moderately rich and almost intact, but some mammal species are locally extinct. The assemblage is distinctive in that it includes several species that are restricted to rocky hills, although this component of the assemblage is typical of the broader region.

Species of conservation significance. Three broad levels of conservation significance are used in this report:

- Conservation Significance 1 (CS1) – species listed under State or Commonwealth Acts.
- Conservation Significance 2 (CS2) – species listed as Priority by DBCA but not listed under State or Commonwealth Acts.
- Conservation Significance 3 (CS3) – species not listed under Acts or in publications but considered of at least local significance because of their pattern of distribution.

Of the 25 species of conservation significance recorded or that may be present in the project area, fifteen are expected to occur as residents, two conservation significant species are expected as regular visitors, and the remaining species are expected to be irregular visitors or vagrants; the majority of these are waterbirds that will visit the claypans and drainage lines when they flood. Five potential SRE invertebrate fauna have been recorded within 20km of the survey area but the SRE status of all five is unconfirmed. Targeted surveys were carried out on three significant species: the Northern Quoll, Ghost Bat and Pilbara Leaf-nosed Bat. The Northern Quoll was found to be abundant within and around the project area and was found at the majority of sampling (motion-sensitive camera) locations up to 8km from the proposed mining area. A temporary (non-maternal) roost of the Ghost Bat, occupied by up to four animals, was found in a mine adit c. 500m outside the proposed disturbance footprint, and there were no records of the Pilbara Leaf-nosed Bat. There is one probable record of the latter species from 2010, suggesting it occurs in the project area only occasionally.

Patterns of biodiversity. The north eastern part of the survey area is likely to support a high diversity of fauna as it forms a complex mosaic of several different VSAs. The rocky hills (VSA1) provide habitat for a number of significant species, such as Northern Quoll. Claypans, drainage lines and their margins will be seasonally or intermittently important for waterbirds and while the numbers are not expected to be high, this will contribute to waterbird abundance in the area.

Key ecological processes. The ecological processes that currently have major effects upon the fauna assemblage include hydrology, the presence of feral species, fire, and habitat degradation (due to weeds).

Potential impacts upon fauna

Threatening processes reviewed in relation to the proposed development included: habitat loss, habitat fragmentation, degradation due to weed invasion, direct mortality, impacts of feral and overabundant native species, hydrological change, fire and disturbance (dust, noise and light). Most potential impacts are considered to be minor because of the small areas involved and the fauna

assemblage being well-represented in the general region. However, due to the presence of conservation significant species, mortality during construction will need to be managed appropriately.

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1 Introduction

Anax is proposing to begin operations and expansions at existing mines at Mons Cupri and later at Whim Creek (see Figure 1). Bamford Consulting Ecologists (BCE) was commissioned by Anax to conduct a Basic (*sensu* EPA 2020) fauna assessment (desktop review and site inspection), and targeted survey on some significant species, of the Whim Creek survey area. This report presents the results of that fauna desktop review, site inspection and targeted surveys.

1.1 General approach to fauna impact assessment

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, and to provide information to proponents to help them to develop appropriate strategies for avoiding and minimising impacts of their activities. This relies on information on the fauna assemblage and its environment, and BCE uses an approach with the following components:

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

Based on the impact assessment process above, the objectives of the study are therefore to:

1. Conduct a literature review and searches of Commonwealth and State fauna databases;
2. Review the list of fauna expected to occur on the site in the light of fauna habitats present, with a focus on investigating the likelihood of significant species being present;
3. Identify significant or fragile fauna habitats within the project area;
4. Identify any ecological processes in the project area upon which fauna may depend;
5. Identify general patterns of biodiversity within or adjacent to the project area, and
6. Identify potential impacts upon fauna and propose recommendations to minimise 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.

1.2 Description of project area and background environmental information

1.2.1 Project area

For spatial terminology (i.e. definitions of project, survey and study areas) see Section 2.1.1 below.

Anax is operating within a lease area of 11,500 ha between Roebourne and Port Hedland (Figure 1). This area makes up the study area over which most field investigations in this environmental impact assessment were conducted. Some sampling took place just outside the lease where landscapes of interest were accessible. The actual development area around the existing Mons Cupri mine is approximately 60 hectares, and the future Whim Creek expansion is expected to be less than this.

1.2.2 Interim Biogeographic Regionalisation of Australia (IBRA) and landscape characteristics

The Interim Biogeographic Regionalisation of Australia (IBRA) has identified 26 bioregions in Western Australia which are further divided into subregions (DAWE 2020b). Bioregions are classified on the basis of climate, geology, landforms, vegetation and fauna (Thackway and Cresswell 1995). IBRA Bioregions are affected by a range of different threatening processes and have varying levels of sensitivity to impact (EPA 2016c). The project area is mostly within the Chichester (PIL01) subregion of the Pilbara bioregion, with small parts in the north in the Roebourne (PIL04), as mapped in Figure 2. This bioregion falls within the Bioregion Group 2 (Eremaean Botanical Province) classification of EPA (2016c) where "native vegetation is largely contiguous but used for commercial grazing".

The Pilbara bioregion and Chichester and Roebourne subregions are described by McKenzie (2002) and a summary of their work follows here. The Pilbara bioregion is composed of semi-desert tropical climate, with active drainage in the Fortescue, De Grey and Ashburton River systems.

The Chichester (PIL01) subregion comprises of undulating Archaean granite and basalt plains including significant areas of basaltic ranges. Plains support a shrub steppe characterised by *Acacia pyrifolia* over *Triodia pungens* hummock grasslands, while *Eucalyptus leucophloia* tree steppes occur on the ranges.

The Roebourne (PIL04) subregion consists of Quaternary alluvial and older colluvial coastal and sub-coastal plains, with a grass savanna of mixed bunch and hummock grasses, and dwarf shrub steppe. Resistant linear ranges of basalts occur across the coastal plains. These uplands are dominated by Triodia hummock grasslands. Ephemeral drainage lines support Eucalyptus woodlands, Samphire, Sporobolus grasslands and mangal occur on the marine alluvial flats and river deltas. The islands are Quaternary sand accumulations, basalt and/or limestone.

1.2.3 Land systems

Payne (2004) identified 102 land systems for the Pilbara region, with the project area located across eight of these:

- Ruth Land System – Hills and ridges of volcanic and other rocks;

- Rocklea Land System – Basalt hills, plateaux, lower slopes and minor stony plains;
- Boolgeeda Land System – Stony lower slopes and plains below hill systems;
- Macroy Land System – Stony plains and occasional tor fields based on granite;
- Mallina Land System – Sandy surfaced alluvial plains;
- Calcrete Land System – Low calcrete platforms and plains;
- Horseflat Land System – Gilgaied clay plains; and
- River Land System – Active floodplains and major rivers.

These systems fall within Payne's (2004) broader 'Land Type' categories 1 (hills and ranges with spinifex grasslands), 8 (Stony plains with spinifex grasslands), 13 (Alluvial plains with soft spinifex grasslands), 14 (Alluvial plains with tussock or grassy shrublands), 17 (River plains with grassy woodlands and shrublands and tussock grasslands) and 18 (Calcreted drainage plains with shrublands or spinifex grasslands). Land systems in the vicinity of the project area are mapped in Figure 3. The majority of the project area is the Ruth Land System, with Boolgeeda Land System in the west and around the proposed development area, and small areas of several other systems on the margins and in the north of the project area.

1.2.4 Land use and tenure

The dominant land uses within the Chichester (PIL01) subregion are grazing – native pastures, Aboriginal lands and Reserves, UCL & Crown Reserves, Conservation, and Mining leases. The dominant land uses within the Roebourne (PIL04) subregion are Grazing – native pastures, Aboriginal lands and Reserves, Conservation, Mining leases and Urban (Kendrick and Mau 2003). The project area lies in the north of the Chichester subregion with small parts of the project area crossing the border to lie within the southern part of the Roebourne subregion.

1.2.5 Recognised sensitive sites

There are no known Ramsar Sites (DBCA 2020d), Important Wetlands (DBCA 2020b), Threatened Ecological Communities (DBCA 2020e, f), Bush Forever Sites (Dell and Banyard 2000), Key Biodiversity Areas (KBA 2020) or Environmentally Sensitive Areas (DWER 2020a, b) within the project area.

1.2.6 Climate information

For the Eremaean Botanical Province, temperatures increase along a northward latitudinal gradient and rainfall is summer-dominated in the north and more evenly spread across the year in the south (EPA 2020). Episodic summer thunderstorms and rain-bearing depressions are key bioclimatic activators and hence drive vertebrate activity (EPA 2020).

For the Chichester (PIL01) subregion, climate is semi-desert-tropical and receives 300mm of rainfall annually. The Roebourne (PIL04) subregion's climate is arid (semi-desert) tropical with highly variable rainfall, falling mainly in summer. Cyclonic activity is significant, with several systems affecting the coast and hinterland annually.

Climate averages (temperate, rainfall, sunshine) for the project area, as provided by BOM (2021), are presented in Table 1.

Table 1. Climate averages for the nearest meteorological station to the project area.

Data from BOM (2021) for:
Site name = ROEBOURNE
Site number = 004035

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years		Plot	Map
Temperature																	
Mean maximum temperature (°C)	38.7	38.0	37.6	35.4	30.5	27.0	26.8	29.1	32.6	35.7	38.0	39.0	34.0	95	1919 2015		
Mean minimum temperature (°C)	26.2	26.2	25.3	22.2	18.3	15.3	13.6	14.5	16.8	19.7	22.6	24.9	20.5	95	1919 2015		
Rainfall																	
Mean rainfall (mm)	61.3	66.6	63.6	28.2	28.4	30.9	13.5	4.9	1.3	0.8	1.5	12.2	314.6	125	1887 2015		
Decile 5 (median) rainfall (mm)	18.8	36.2	18.5	1.5	8.6	15.2	3.5	0.0	0.0	0.0	0.0	0.5	283.4	116	1887 2015		
Mean number of days of rain ≥ 1 mm	2.4	3.4	2.6	1.0	1.7	1.7	1.1	0.6	0.2	0.2	0.2	0.7	15.8	116	1887 2015		
Other daily elements																	
Mean daily sunshine (hours)																	
Mean number of clear days	13.9	11.1	16.1	17.2	18.1	18.2	22.5	24.5	24.6	25.6	23.0	19.7	234.5	53	1957 2010		
Mean number of cloudy days	5.8	6.4	5.0	4.4	5.7	5.1	3.2	2.1	1.4	0.8	1.4	2.5	43.8	53	1957 2010		

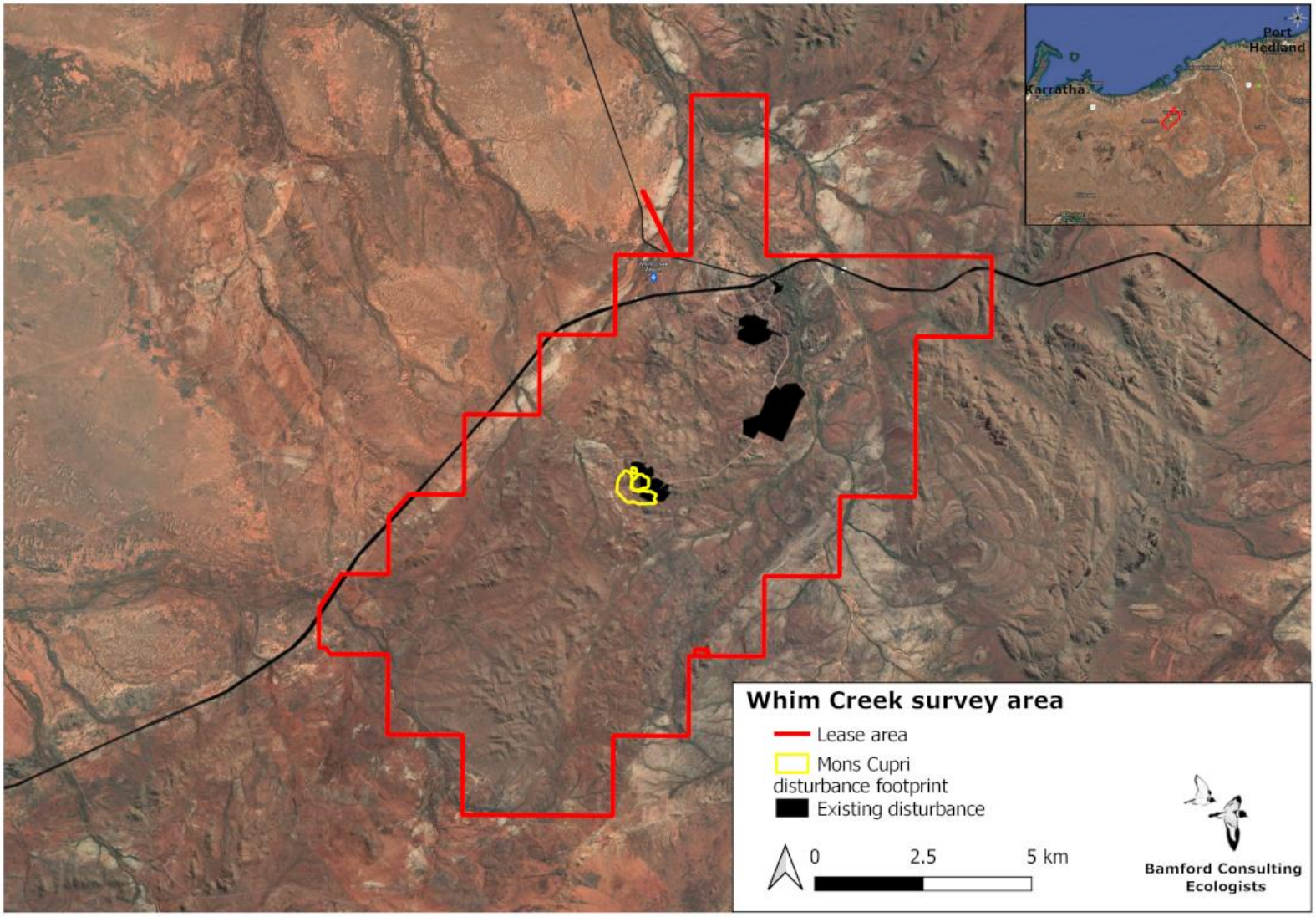
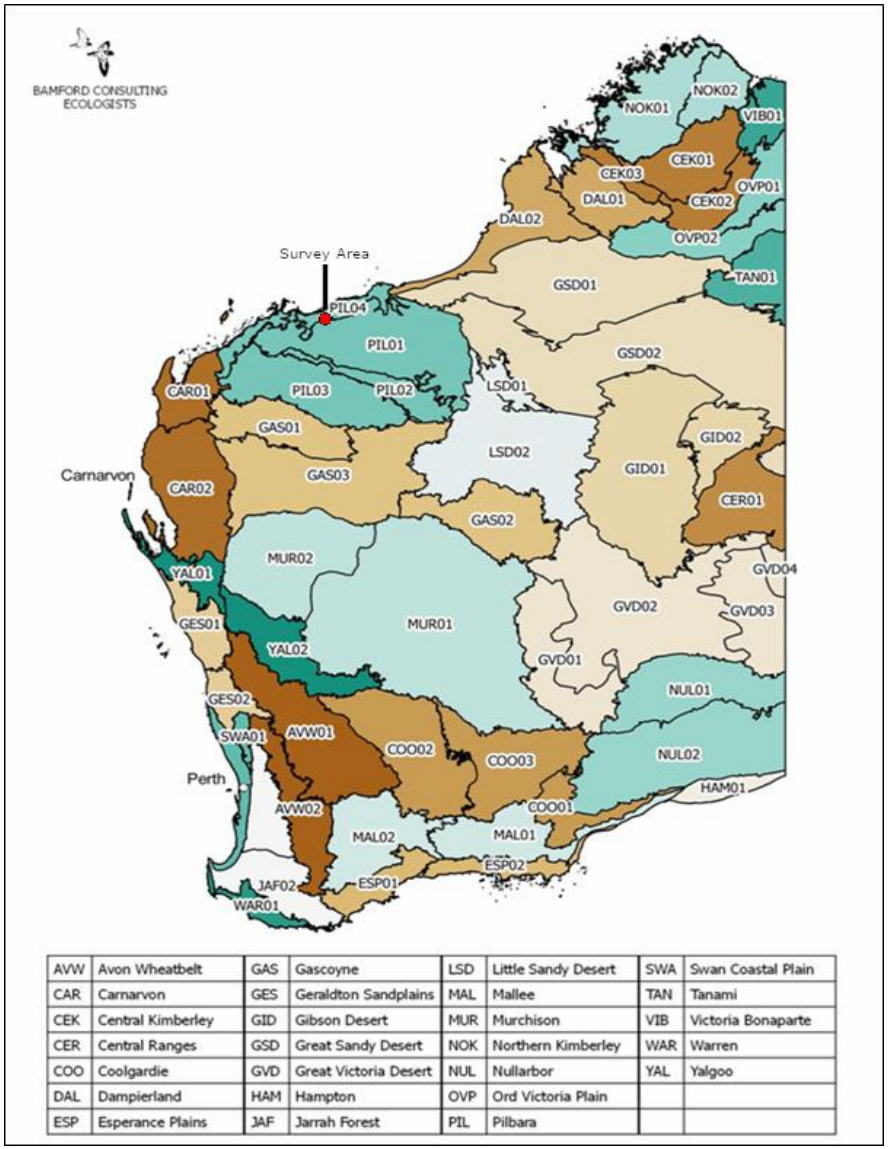


Figure 1. Location of the Project Area. Yellow indicates proposed Mons Cupri development area.



AVW	Avon Wheatbelt	GAS	Gascoyne	LSD	Little Sandy Desert	SWA	Swan Coastal Plain
CAR	Carnarvon	GES	Geraldton Sandplains	MAL	Mallee	TAN	Tanami
CEK	Central Kimberley	GID	Gibson Desert	MUR	Murchison	VIB	Victoria Bonaparte
CER	Central Ranges	GSD	Great Sandy Desert	NOK	Northern Kimberley	WAR	Warren
COO	Coolgardie	GVD	Great Victoria Desert	NUL	Nullarbor	YAL	Yalgoo
DAL	Dampierland	HAM	Hampton	OVP	Ord Victoria Plain		
ESP	Esperance Plains	JAF	Jarrah Forest	PIL	Pilbara		

Figure 2. Project location within the Interim Biogeographic Regionalisation of Australia (IBRA).

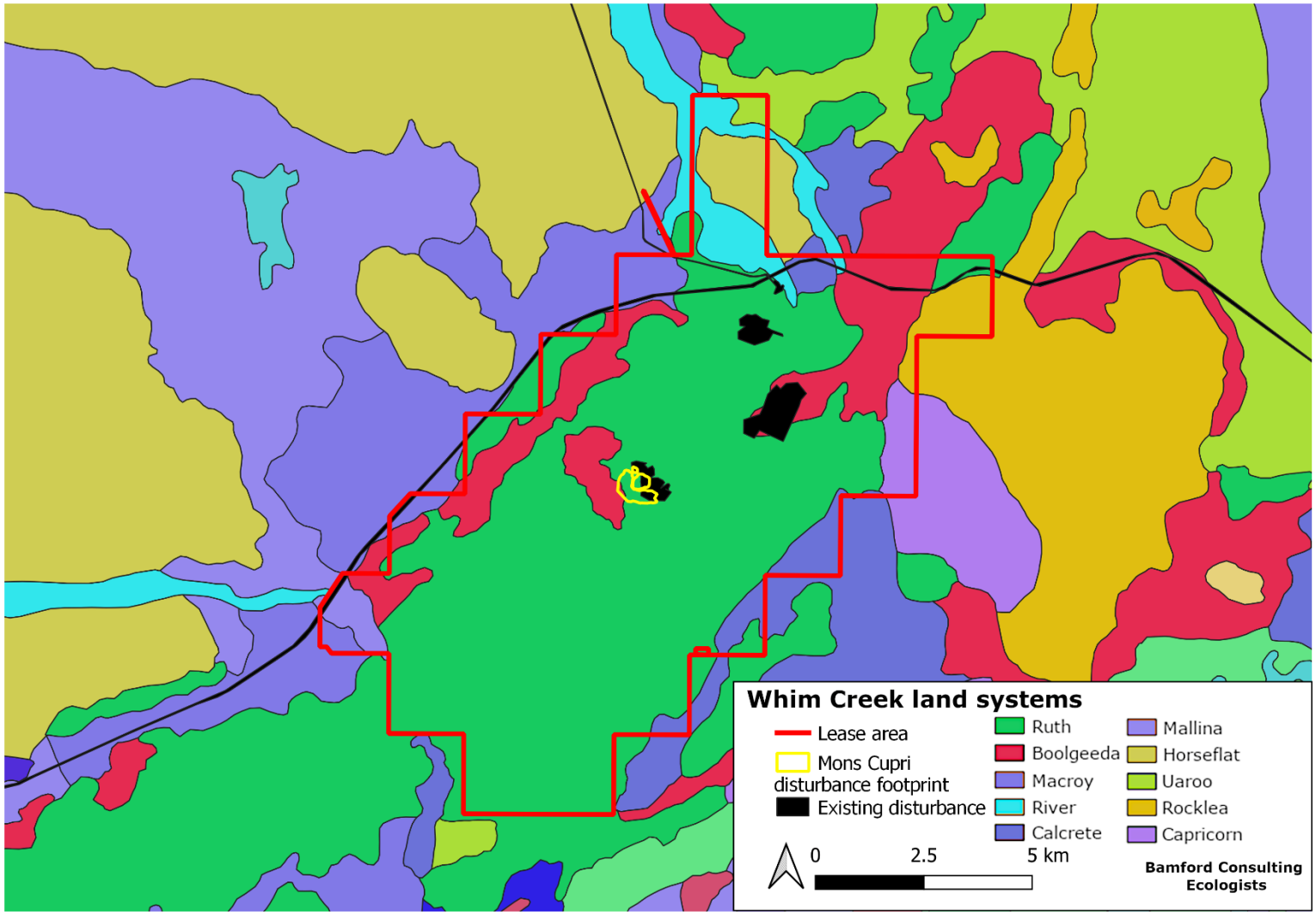


Figure 3. Land systems (Payne 2004) in the vicinity of the Survey Area.

2 Methods

2.1 Overview

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

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

The level of assessment recommended by the EPA (2020) is determined by geographic position, with a generic statement that detailed surveys are expected across all of the state except the south-west, but also recommending that site and project characteristics be considered, such as the survey objectives, existing available data, information required, the scale and nature of the potential impacts of the proposal and the sensitivity of the surrounding environment in which the disturbance is planned. These aspects should be considered in the context of the information acquired by the desktop study. When determining the type of survey required, the EPA (2020) suggested that the following be considered:

- level of existing regional knowledge
- type and comprehensiveness of recent local surveys
- degree of existing disturbance or fragmentation at the regional scale

- extent, distribution and significance of habitats
- significance of species likely to be present
- sensitivity of the environment to the proposed activities
- scale and nature of impact.

Guidance for field investigations methods is provided by the EPA (2016c, 2020) and by Bamford *et al.* (2013).

The approach taken in the Whim Creek project area was a 'basic' level survey (desktop review, fauna habitat identification and a site inspection), based upon the availability of data from several previous level 2 (detailed) and targeted surveys, supplemented with targeted surveys on key significant species. This is based upon the level of existing knowledge (which is extensive; see Section 2.3 below), the extent, distribution and significance of habitats (widespread), and the significance of species likely to be present (generally a limited assemblage of significant species but with some of particular importance in this general area).

The approach and methods utilised in this report are divided into three groupings that relate to the stages and the objectives of impact assessment:

- **Desktop assessment.** The purpose of the desktop review is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the project area based on unpublished and published data using a precautionary approach.
- **Field investigations.** The purpose of the field investigations carried out for a Basic assessment is to gather information on the vegetation and soil associations ('habitats') that support the fauna assemblage and place the list generated by the desktop review into the context of the environment of the project area. The brief field investigations that form part of a Basic assessment also allow for some fauna observations to be made and assist the consultant to develop an understanding of the ecological processes that may be operating in the project area.
- **Impact assessment.** Determine how the fauna assemblage may be affected by the proposed development based on the interaction of the project with a suite of ecological and threatening processes.

2.1.1 Spatial terminology

A range of terms is used through this report to refer to the spatial environment around the proposed development, and these are defined below:

- Development (impact) footprint – the expected extent of land clearing and/or development. This is the 60 ha expansion of the existing Mons Cupri mine. Usually, a subset of the *project area* but in some cases this will be equivalent to *project area* (where the entire *project area* is proposed to be developed). For the Whim Creek project, the development footprint is a very small portion of the study area.
- Lease area – the Anax lease area that encompasses the development footprint (Figure 1).
- Study area – the area within which field investigations were conducted. This is more or less equivalent to the lease area but with some sampling carried out just outside the lease area.

- Regional area – the outermost boundary of the desktop assessment and therefore the area from which databases were sourced.

Note that the term '*survey area*' is used throughout the guidance provided by EPA (2020) but does not appear to be explicitly defined and, therefore, the above definitions has been developed with interpretation of both the guidance and BCE report structure.

2.2 Identification of vegetation and substrate associations (VSAs)

Vegetation and substrate associations (VSAs) combine 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.

BCE deliberately makes the distinction between 'habitat' (a species-specific term that may encompass the whole or part of one or more VSAs and is the physical subset of an ecosystem that a given species, or species group, utilises) and 'VSA' (a general, discrete and mutually exclusive spatial division of a target area, based on soil, vegetation and topography). It is recognised, however, that, within the broader EIA literature/guidance, the former term is used more or less synonymously to indicate the latter (e.g.' habitat assessment' used by EPA 2020). Further discussion is provided in Appendix 1.

For the current assessment, VSAs were identified based on the consultants' previous experience in the area and on observations made during the field investigations.

2.3 Desktop assessment of expected species

2.3.1 Sources of information

As per the recommendations of EPA (2020), information on the fauna assemblage of the project area was drawn from a range of sources including databases (as listed in Table 2) and reports from other fauna surveys in the region (as listed in Table 3). Information from these sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns are listed in Table 4.

Table 2. Databases searched for the desktop review; accessed May 2021.

Database	Type of records held in database	Area searched
Previous studies	Fauna recorded by previous studies in the vicinity of the project area.	20 km buffer around the centre point of the project area.
Atlas of Living Australia (ALA)	Fauna records from Australian museums and conservation/research bodies, including records from BirdLife Australia's Atlas (Birdata) Database.	20 km buffer around the centre point of the project area.
NatureMap (DBCA)	Records from the Western Australian Museum (WAM) and Department of Biodiversity, Conservation and Attractions (DBCA) databases, including historical data and Threatened and Priority species in WA.	20 km buffer around the centre point of the project area.
EPBC Protected Matters Search Tool	Records on Matters of National Environmental Significance (MNES) protected under the EPBC Act.	20 km buffer around the centre point of the project area.
Birdata (BA)	Bird records held by Birdlife Australia.	20 km buffer around the centre point of the project area.
DBCA Threatened Fauna Search	DBCA records of threatened fauna.	50 km buffer around the centre point of the project area.

Table 3. Literature sources for the desktop review.

Author	Title	Survey type
Ecologia Environment (1991)	Whim Creek Mons Cupri Copper Mine Project – Biological Assessment Survey	Level 1 (Basic) vertebrate fauna survey.
Ecologia Environment (2004)	Whim Creek Copper Project – Biological Survey	Targeted conservation significant fauna survey.
Env. Australia (2007)	Whim Creek Fauna Assessment Phase II	Level 2 (detailed) vertebrate fauna survey including trapping, opportunistic searching and bat recording in one season. Trapping included pitfall, funnel, cage and Elliott traps across each major habitat type
Dight *et al.* ((2014)	Terrestrial fauna surveys for the Balla Balla Railway Project	Level 1 vertebrate fauna survey, level 2 SRE invertebrate survey and targeted conservation significant vertebrate fauna survey in adjacent areas to west.

Table 4. Sources of information used for general patterns of fauna distribution.

Taxa	Sources
Fish	Morgan *et al.* (1998), Allen *et al.* (2003), Morgan *et al.* (2014), DoF (2020).
Frogs	Tyler and Doughty (2009), Anstis (2017).
Reptiles	Storr *et al*. (1983, 1990, 1999, 2002), Bush and Maryan (2011), Wilson and Swan (2017).
Birds	Johnstone and Storr (1998, 2005), Menkhorst *et al*. (2017).
Mammals	Van Dyck and Strahan (2008), Churchill (2009), Menkhorst and Knight (2011).

2.3.2 Previous fauna surveys

A list of fauna surveys used in the literature review here is presented in Table 3. There have been three surveys in the project area since 1991, one of these a site inspection, one a targeted survey for significant species and one a level 2 (detailed) survey that included targeted survey for significant species. The level 2 survey (ENV Australia 2007) sampled across the project area in all major vegetation types. It concluded that the vertebrate fauna assemblage had been well-documented, but it took place before motion-sensitive cameras were widely available. The Phoenix Environmental (2014) survey was the most recent previous survey and took place immediately to the west.

2.3.3 Nomenclature and taxonomy

As per the recommendations of the EPA (2020), the nomenclature and taxonomic order presented in this report are generally based on the Western Australian Museum's (WAM) Checklist of the Fauna of Western Australia 2019. The authorities used for each vertebrate group were: fish (Morgan *et al.* 2014), frogs (Doughty *et al.* 2019a), reptiles (Doughty *et al.* 2019b), birds (BirdLife Australia 2019; Gill and Donsker 2020), and mammals (Travouillon 2019). In some cases, more widely-recognised names and naming conventions have been followed, particularly for birds where there are national and international naming conventions in place (e.g. the BirdLife Australia working list of names for Australian Birds, and the International Ornithological Congress' 'World Bird List'). English common names of species, where available, are used throughout the text; Latin names are presented with corresponding English names in tables in the appendices. The use of subspecies is limited to situations where there is an important (and relevant) geographically distinct population, or where the taxonomic distinction has direct relevance to the conservation status or listing of a taxon.

2.3.4 Interpretation of species lists

2.3.4.1 Expected occurrence

Species lists generated from the review of sources of information are generous as they include records drawn from a large region (the study area, see Figure 1) and possibly from environments not represented in the project area. Therefore, some species that were returned by one or more of the database and literature searches have been excluded because their ecology, or the environment within the project area, determine that it is highly unlikely that these species will be present. Such species can include, for example, seabirds that might occur as extremely rare vagrants at a terrestrial, inland site, but for which the site is of no importance. Species returned from the databases and not excluded on the basis of ecology or environment are therefore considered potentially present or expected to be present in the project area at least occasionally, whether or not they were recorded during field surveys, and whether or not the project area is likely to be important for them. This list of expected species is therefore subject to interpretation by assigning each a predicted status, the expected occurrence, in the project area. The status categories used are:

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

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

The results of the database searches were reviewed and interpreted, and obvious errors and out of date taxonomic names were deleted.

2.3.4.2 Conservation significance

All expected species were assessed for conservation significance as detailed in Appendix 1. Three broad levels of conservation significance are used in this report:

- Conservation Significance 1 (CS1) – species listed under State or Commonwealth Acts such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Western Australian *Biodiversity Conservation Act 2016* (BC Act);
- Conservation Significance 2 (CS2) – species listed as Priority by DBCA but not listed under State or Commonwealth Acts; and
- Conservation Significance 3 (CS3) – species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution.

See Appendix 1 for an expanded discussion of these categories and Appendix 2 for a description of the categories used in the legislation (EPBC and BC Acts) and by the DBCA.

2.4 Field investigations

2.4.1 Overview

A site inspection was conducted to familiarise the consultants with the project area. This involved looking around as much of the project area as possible; including walking through areas that did not have direct vehicle access. This enabled:

- identification of VSAs (that provide fauna habitats);
- targeted searches for significant fauna and an assessment of their likelihood of occurrence based on VSAs present;
- motion cameras and bat detectors (see Appendix 5 for details);
- continuous recording of bird species encountered; and
- opportunistic fauna observations.

2.4.2 Dates

The project area was visited on the 7th to 9th of April and 9th to 11th of May 2021. The early visit was a site inspection with some bat detectors and motion-sensitive cameras set for a short period. The second visit involved setting 19 motion-sensitive cameras which were collected by Anax staff on 20th May.

2.5 Personnel

Personnel involved in the field investigations and report preparation (including desktop review) are listed in Table 5. Additional personnel who assisted with data analysis were Brendan Metcalf (BSc. Hons.) for the analysis of bat recordings, and Jakob Bamford (BA) and Joshua Bamford (BA Hons Masters Mus. Psych.) who conducted the initial review of photographs from motion-sensitive cameras, which were then verified by Dr Mike Bamford.

Table 5. Personnel involved in the field investigations and report preparation.

Personnel	EIA Experience	Field Investigations	Report Preparation
Dr Mike Bamford *BSc (Biol.), Hons (Biol.), PhD (Biol.)*	40 years	+	+
Dr Wes Bancroft *BSc (Zool./Microbiol.), Hons (Zool.), PhD (Zool.)*	23 years	+	+
James Hesford *BSc (Biol., Env. Sc.)*	25 Years	+	
Katherine Chuk *BSc (Zool./Microbiol.), Hons (Zool.)*	8 years		+

2.6 Bat detectors and motion-sensitive cameras

Previous studies have made extensive use of bat detectors to target two species of conservation significance, the Ghost Bat and the Pilbara Leaf-nosed Bat, and therefore use of bat detectors was limited to one Anabat Swift set at beside water at the existing Mons Cupri pit for two nights in April. Previous surveys made no use of motion sensitive cameras (they were not widely available at the time of previous surveys). This had led to the conclusion by ENV Australia (2007) that the Northern Quoll, a key significant species in the Pilbara, was either absent or scarce in the project area, with this conclusion based upon limited cage trapping in suitable habitat. Dunlop *et al.* (2020) have demonstrated that cameras are more reliable means of detecting the species than traps, and therefore extensive use of motion-sensitive cameras was carried out. Three camera locations were sampled briefly in April (total of four camera-nights), and 19 locations were sampled more extensively in May (170 camera nights; but two cameras failed and thus actual sampling effort was 150 camera nights). The camera locations were dispersed widely across the landscape to determine the extent of the local distribution of the Northern Quoll, with the potential to detect other species. Cameras were set with a non-accessible lure: tinned tuna with perforations in the tin, as recommended by Moore *et al.* (2020). Details of dates and locations of the bat detector and cameras are given in Appendix 5.

2.7 Survey limitations

The EPA Guidance Statement 56 (EPA 2004) and the EPA (2020) outline a number of limitations that may arise during field investigations for Environmental Impact Assessment. These survey limitations are discussed in the context of the BCE investigation of the project area in Table 6. No limitations were identified.

The lack of detailed survey (i.e. intensive sampling of the fauna assemblage) is not considered a limitation as this assemblage is well-understood in the area due to multiple previous field investigations. Furthermore, EPA guidance does not consider limitations related to the effectiveness of field sampling for fauna but appears to make an assumption that the purpose of such sampling is to confirm the fauna assemblage. This is implicit in the EPA (2020) technical guidance that does provide suggestions for sampling techniques, but the level of field investigations suggested cannot confirm the presence of an entire assemblage, or confirm the absence of a species. This requires far more work than is possible (or recommended) for studies contributing to the EIA process because

fauna assemblages vary seasonally and annually, and often have high levels of variation even over short distances (Beta diversity). For example, in an intensive trapping study, How and Dell (1990) recorded in any one year only about 70% of the vertebrate species found over three years. In a study spanning over two decades, Bamford *et al.* (2010) found that the vertebrate assemblage varies over time and space, meaning that even complete sampling at a set of sites only defines the assemblage of those sites at the time of sampling. The limited effectiveness of short periods of fauna sampling is not a limitation for impact assessment *per se*, as long as database information is interpreted effectively and field investigations are targeted appropriately. That is the approach taken by BCE.

Table 6. Survey limitations as outlined by EPA (2020).

EPA Survey Limitations	BCE Comment
Availability of data and information	Abundant information from databases and previous studies (see Section 2.3.1). Not a limitation.
Competency/experience of the survey team, including experience in the bioregion surveyed	The ecologists have had extensive experience in conducting desktop reviews and reconnaissance surveys for environmental impact assessment fauna studies, and have undertaken a number of studies within the immediate region. See also Table 4 for further details. Not a limitation.
Scope of the survey (e.g. were faunal groups were excluded from the survey)	The survey focused on terrestrial vertebrate fauna and fauna values. Some information on threatened invertebrates was available from databases. Not a limitation.
Timing, weather and season	Timing is not of great importance for Basic level field investigations and targeted survey Northern Quoll in this region. Not a limitation.
Disturbance that may have affected results	None. Not a limitation.
The proportion of fauna identified, recorded or collected	All fauna observed were identified. Not a limitation.
Adequacy of the survey intensity and proportion of survey achieved (e.g. the extent to which the area was surveyed)	The site was adequately surveyed to the level appropriate for a Basic level and targeted assessment. Fauna database searches covered a 20 km radius beyond the centroid of the project area. The Basic level assessment was completed. Not a limitation.
Access problems	There were no access problems encountered. Not a limitation.
Problems with data and analysis, including sampling biases	There were no data problems. Not a limitation.

2.8 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 (2012) (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 1.1, but modified to suit the characteristics of the site. 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) and includes:

- Recognition of ecotypes or vegetation/substrate associations (VSAs);
- Assemblage characteristics (uniqueness, completeness and richness);
- Species of conservation significance;
- Patterns of biodiversity across the landscape; and
- Ecological processes upon which the fauna depend.

Impact assessment

This section reviews impacting processes (as described in detail in Appendix 3) with respect to the proposed development and examines the potential effect these impacts may have on the faunal biodiversity of the project area. It thus expands upon Section 1.1 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 section 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; or

    - Disturbance (dust, light, noise)?
- Summary of impacts upon significant species, and other fauna values.

The impact assessment concludes with recommendations for impact mitigation, based upon predicted impacts. Note that the terms direct and indirect impacts are not used in this report; for further explanation see Appendix 2.

2.8.1 Criteria for impact assessment

Impact assessment criteria are based on the severity of impacts on the fauna assemblage and conservation significant fauna, and quantified on the basis of predicted population change (Table 7). Population change can be the result of direct habitat loss and/or impacts upon ecological processes.

The significance of population change is contextual. The EPA (2016c) suggested that the availability of fauna habitats within a radius of 15 km can be used as a basis to predict low, moderate or high impacts. In this case, a high impact is where the impacted environment and its component fauna are rare (less than 5% of the landscape within a 15 km radius or within the Bioregion), whereas a low impact is where the environment is widespread (e.g. >10% of the local landscape). Under the Ramsar Convention, a wetland that regularly supports 1% of a population of a waterbird species is considered to be significant. These provide some guidance for impact assessment criteria. In the following criteria (Table 7), the significance of impacts is based upon percentage population decline within a 15 km radius (effectively local impact) and upon the effect of the decline upon the conservation status of a recognised taxon (recognisably discrete genetic population, sub-species or species). Note that percentage declines can usually only be estimated on the basis of the distribution of a species derived from the extent of available habitat while for a few species, such as the Black-Cockatoos, there is guidance for the assessment of impact significance.

The impact assessment concludes with recommendations based upon predicted impacts and designed to mitigate these.

Table 7. Assessment criteria for impacts upon fauna.

Impact Category	Observed Impact
Negligible	Effectively no population decline; at most few individuals impacted and any decline in population size within the normal range of annual variability.
Minor	Population decline temporary (recovery after end of project such as through rehabilitation) or permanent, but < 1% within 15 km radius of centre-point of impact area (or within bioregion if this is smaller). No change in viability or conservation status of taxon.
Moderate	Permanent population decline 1-10% within 15 km radius. No change in viability or conservation status of taxon.
Major	Permanent population decline 10-50% within 15 km radius. No change in viability or conservation status of taxon.
Critical	Taxon decline > 50% (including local extinction) within 15 km and/or change in viability or conservation status of taxon.

3 Fauna values

3.1 Vegetation and substrate associations (VSAs) ['Habitat assessment ']

Vegetation and substrate associations within the project area are a complex mosaic, largely reflecting soil types and landscape position. Five major vegetation and substrate associations (VSAs) from high to low in the landscape were identified in the study area and in some cases correspond with land systems (Figure 3). The actual development area and the exiting Mons Cupri mine, and existing impact areas, lie largely within the Ruth Land System and some overlap with the Boolgeeda Land System. The vegetation in the immediate vicinity of Mons Cupri was mapped by Astron (2006) and where available vegetation types are assigned to VSAs as outlined below. VSAs are mapped on Figure 4

VSA 1. Rocky hills. Rocky hills with steeply incised valleys. Boolgeeda Land System; corresponds with vegetation types of Hill ridge and crests HR1 and HR2 (Astron 2006). Acacia open shrubland and shrubland with spinifex on gravelly slopes and rises. The rocky hills do not have large caves but some overhangs are present. There are some old mine adits in some of the hills. See Plate 1.

VSA 2. Gravelly hills. Ruth Land System (part); corresponds with vegetation types of Hill slopes H1 to H16 (Astron 2006). Undulating gravelly hills supporting acacia open shrubland and spinifex on gravel. See Plate 2.

VSA 3. Lower slopes and stony plains. Ruth Land System (part); corresponds with vegetation types of Flat stony plains P1 to P8 and Minor drainage lines D1 to D14 (Astron 2006). These lie around the rocky and gravelly hills. Gravelly with acacia shrubland (ie denser than on most slopes) and spinifex. See Plate 3.

VSA 4. Sandy to sandy-loam plains. Lies within the Ruth Land System but includes several other land systems where sand overlies other geology. No corresponding Astron (2006) vegetation mapping. The plains of VSA 4 lie low in the landscape and are effectively alluvial floodplains of the drainage

systems. The vegetation is acacia open shrubland over spinifex, often patchy in density and becoming more dense close to drainage lines. See Plate 4.

VSA 5. Drainage lines. River Land System. No corresponding Astron (2006) vegetation mapping. Several major drainage lines occur in the project area, including Balla Balla Creek. These are seasonal to intermittent, lined with *Eucalyptus victrix* and have a substrate that varies from gravel to loam or clay. Minor drainage lines intersect other VSAs.

3.1.1 Regional development

The landscape in which the project area is located is extensive in the region and with the exception of roads and some linear infrastructure, almost all existing development is associated with the current project. Figure 5 illustrates the existing extent of development in a 15 km buffer around the project area. Existing developments (c. 523 ha) impact c. 0.7% of the total land area within this buffer (c. 70,686 ha). The proposed development footprint has a total area of up to c. 60 ha, however 12.7 ha of this overlaps with existing clearing and, therefore, would, contribute 0.05% to the land clearing within the region, taking the total development within 15 km to c. 0.75% of the land area.

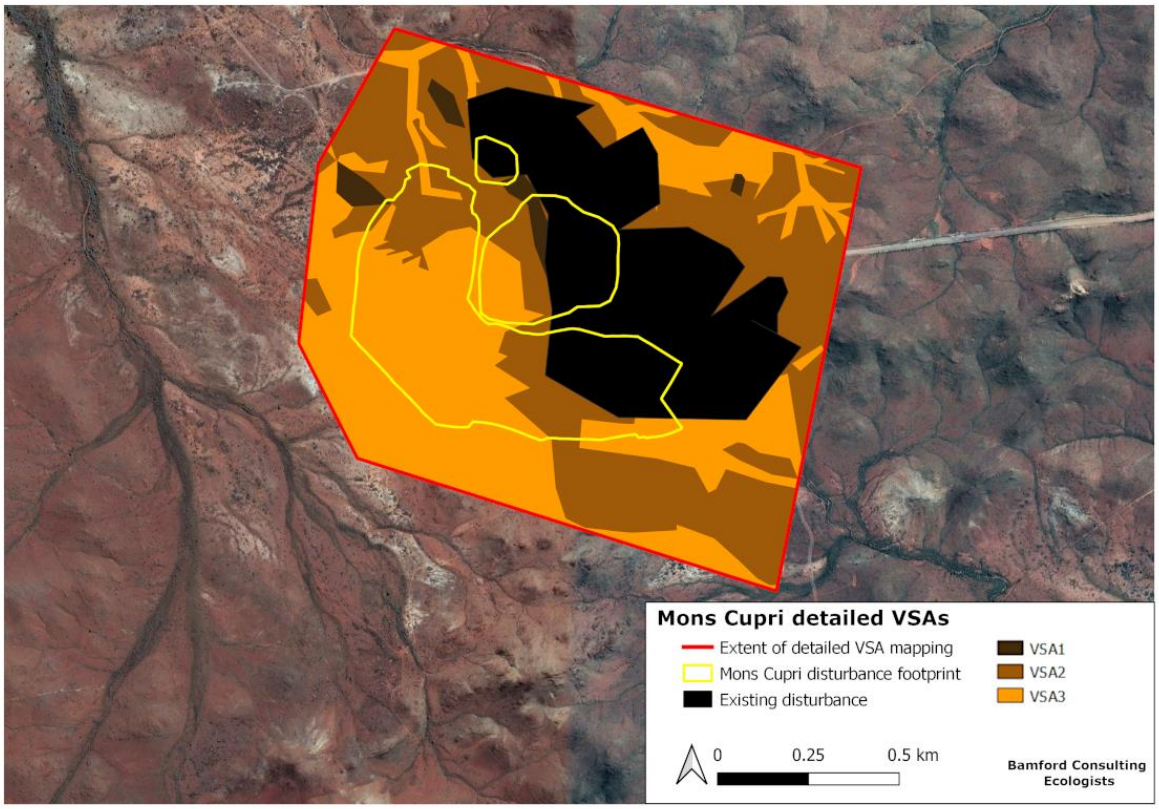


Figure 4. VSA mapping in the immediate vicinity of the Mons Cupri development area.

Plate 1. VSA 1: Rocky hills.

Plate 2. VSA 2: Gravelly hills.

Plate 3. VSA 3: Stony plains and lower slopes.

Plate 4. VSA 4 (Sandy to sandy loam plain) along side Balla Balla Creek (line of trees in middle distance).

Plate 5. VSA 5: drainage lines.

Plate 6. VSA 5: temporary pool along Balla Balla Creek.

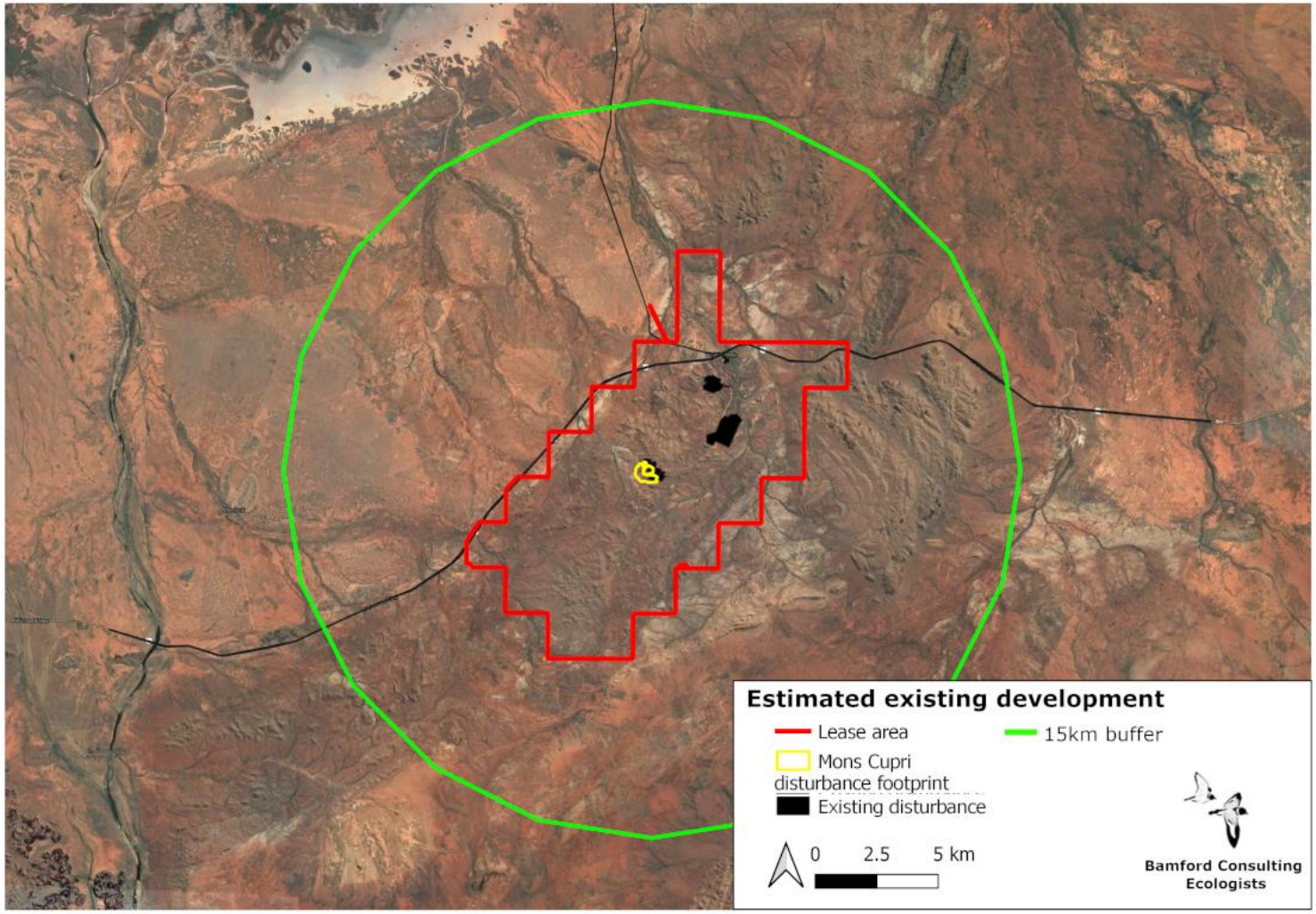


Figure 5. Estimated existing development (black) within the region (15 km).

3.2 Fauna assemblage

3.2.1 Overview of vertebrate fauna assemblage

The desktop study identified 271 vertebrate fauna species as potentially occurring in the project area: 4 fish, 7 frogs, 83 reptiles, 136 birds and 41 mammals. These species are listed in Appendix 6. The presence of nearly 50 species was confirmed during the 2021 site inspections (as presented in Appendix 7, but also indicated in Appendix 6).

Fifty-nine species (one fish, 6 reptiles, 50 birds and 2 mammals) that were returned by the database searches and/or literature review have been omitted from the expected species list because of habitat or range limitations. These species are listed in Appendix 8. Note that the databases returned no species believed to be locally extinct in the area, but this is almost certainly due to lack of records.

The composition of the vertebrate fauna is summarised in Table 8.

Table 8. Composition of vertebrate fauna assemblage of the project area.

Taxon	Number of species expected	Number of species in each category				
		Resident	Regular visitor or migrant	Irregular visitor	Vagrant	Locally extinct
Fish	4	0	3	1	0	0
Frogs	7	7	0	0	0	0
Reptiles	83	83	0	0	0	0
Birds	136	71	24	32	9	0
Native Mammals	34	29	3	3	2	?
Introduced Mammals	7	5	2	0	0	0
Total	**271 (including 7 int.)**	**195**	**32**	**36**	**11**	**?**

There is limited information on invertebrate fauna in the area; this fauna is discussed in Section 3.2.3.

3.2.2 Expected vertebrate fauna

Fish

The four fish species will occur along the major drainage lines but will be regular to irregular visitors depending on the availability of water. They will be resident in any pools that persist and will disperse into seasonal waters when available. None of the fish species is of conservation significance.

Frogs

The seven frog species are all considered to be residents and are likely to breed in seasonal freshwater pools along drainage lines, in claypans and possibly even rockholes. Most of the species disperse

widely from wetlands outside the breeding season. None of the frog species is of conservation significance.

Reptiles

The 87 reptile species are all considered to be residents. Note that this is effectively a precautionary assessment and means that if a reptile species is present, it is likely to be a resident. This is a very rich assemblage and reflects the great variety of environments present, ranging from rock to gravelly hills to sand and major drainage lines, with many species specialist in particular environments. ENV (2007) recorded 40 reptile species and considered their survey had been comprehensive, but they did not detect several species that are simply hard to find. For example, they did not detect the Pilbara Rock Monitor but this was recorded in the current survey (on a motion-sensitive camera). Two species are of conservation significance and are discussed further below.

Birds

The bird assemblage of 136 species includes about 40 wetland-dependent species that are only likely to occur as regular visitors, irregular visitors or vagrants when suitable conditions prevail within the project area. Many of the landbirds are also considered to be visitors or vagrants, reflecting the high seasonal and annual variation in conditions, but 71 species (52% of the assemblage) are considered to be resident in the project area. The majority of the 31 bird species observed during the current surveys were considered to be residents. ENV (2007) recorded 46 species, and the total number of bird species recorded is less than half the predicted assemblage, but this reflects the nature of the site. The bird assemblage may include 11 species of conservation significance, but many of these are irregular visitors or vagrants. These are discussed further below.

Mammals

Most of the 41 mammal species (34 native and seven introduced) are considered to be residents. Several species are closely associated with rocky environments and their presence was confirmed through the use of cameras (Northern Quoll, Rothschild's Rock-Wallaby, Woolley's Pseudantechinus, Common Rock-Rat). These had mostly not been detected in previous surveys that relied on trapping. Most of the bat species roost in small caves and mine adits, and *Vespadelus finlaysoni* was present in large numbers on the bar recorder set at Mons Cupri. Some bats will also roost in tree hollows along the larger drainage lines. While there is no information available on extinct mammals in the area, the general literature suggests that the Golden Bandicoot *Isoodon auratus* and the Paler Field Rat *Rattus tunneyi* would have been present historically. Nine species of conservation significant mammals are expected to use the survey area, although two of these only as vagrants. All conservation significant mammals are discussed below.

The key features of the fauna assemblage expected in the project area are:

- **Uniqueness:** The fauna assemblage is probably widespread across similar soils and vegetation in the western Pilbara.
- **Completeness:** The assemblage is likely to be substantially complete.
- **Richness:** The assemblage is rich, particularly so for reptiles and mammals, as the study area has a variety of VSAs to provide habitat for fauna. The rocky hills are a particularly important feature for the fauna assemblage.

3.2.3 Invertebrate fauna of conservation significance

The project area sits within DBCA's Pilbara management region (DBCA 2021a). DBCA (2021b) listed 49 threatened or priority invertebrate fauna in this region, as outlined in Appendix 9. At least 46 of these species can be immediately ruled out from occurring within the study area and the reasons for exclusion are presented in Appendix 1 (e.g. absence of suitable habitat in the project area, distance from known populations). To help ascertain the status of the remaining three species, all location records from ALA (2020) and WAM (2021h) were compiled, collated and mapped in relation to the study area. A map of these DBCA-listed threatened and priority species is provided in Figure 6.

There are no records of threatened invertebrate fauna within the study area, nor within the regional (15 km) buffer. One threatened invertebrate species is known to occur within 50 km of the project area: Depuch Island Charopid Land Snail (*Dupucharopa millestriata*). This snail is known only from Depuch Island, off the coast adjacent to Balla Balla Creek, as shown in Figure 6 (Solem 1984; Slack-Smith and Humphreys 1993). Therefore, this species is unlikely to occur in the project area. The remaining two species, the dragonfly *Antipodogomphus hodgkini* (Pilbara Dragon) and the damselfly *Nosoticta pilbara* (Pilbara Threadtail), are known from sites beyond 50 km from the project area. Watson (1974) and Theischinger and Hawking (2012) listed both of these species as occurring within the north-west of Western Australia (NWA) region that does include the project area, but finer examination of available records (Figure 6; Appendix 9) shows that the nearest Pilbara Dragon and Pilbara Threadtail populations are know from c. 170 km and c. 70 km away from the study area, respectively. In addition, both species occur in rivers, streams, and riverine pools (Theischinger and Hawking 2012) and while these are present within the project area there is no planned impacts on these habitats. It is uncertain as to whether seasonally flooded claypan areas would support these species but given that their larvae inhabit the stony beds of flowing water (Theischinger and Hawking 2012) it seems highly unlikely. From the above range and habitat considerations, neither of these species is expected to occur in the study area and, thus, they have not been included as expected conservation significant species.

In a survey of the proposed Balla Balla Railway Project, Dight *et al.* (2014) recorded several invertebrate taxa in the vicinity of the project area that they considered to be potential short-range endemic species. Five of these taxa were recorded within 20 km of the study area:

- *Conothele* sp. indet. (Ctenizidae) – a spider
- *Dampetrus* sp. indet. (Assamiidae) – a harvestman
- *Buddelundia* '10 1016a' (Armadillidae) – a slater
- *Buddelundia* '94' (Armadillidae) – a slater
- *Quistrachia* sp. indet. (Camaenidae) – a land snail

These species were associated with at least slightly rocky landscapes except for *Conothele* sp., associated with sandy loam plains (Dight *et al.* 2014). Dight *et al.* (2014) recorded a further six potential short-range endemic species more than 20km from the study area: a spider (*Karaops* sp.), two centipedes (*Sepedonophilus* sp. and *Cryptops* sp.), and three slaters *Buddelundia* 92, 93 and 95). These were also largely associated with rocky environments.

Therefore, while none of the presently DBCA-listed threatened invertebrate species are considered likely to occur within the project area, there may still be some short-range endemic invertebrates in the vicinity as there is suitable habitat for them. It should be noted that the ecology and distribution of short-range endemic invertebrates is often poorly understood or documented, and the project area occurs in a region that is remote and likely to be poorly-surveyed for these groups. Thus there may be undetected SRE species present.

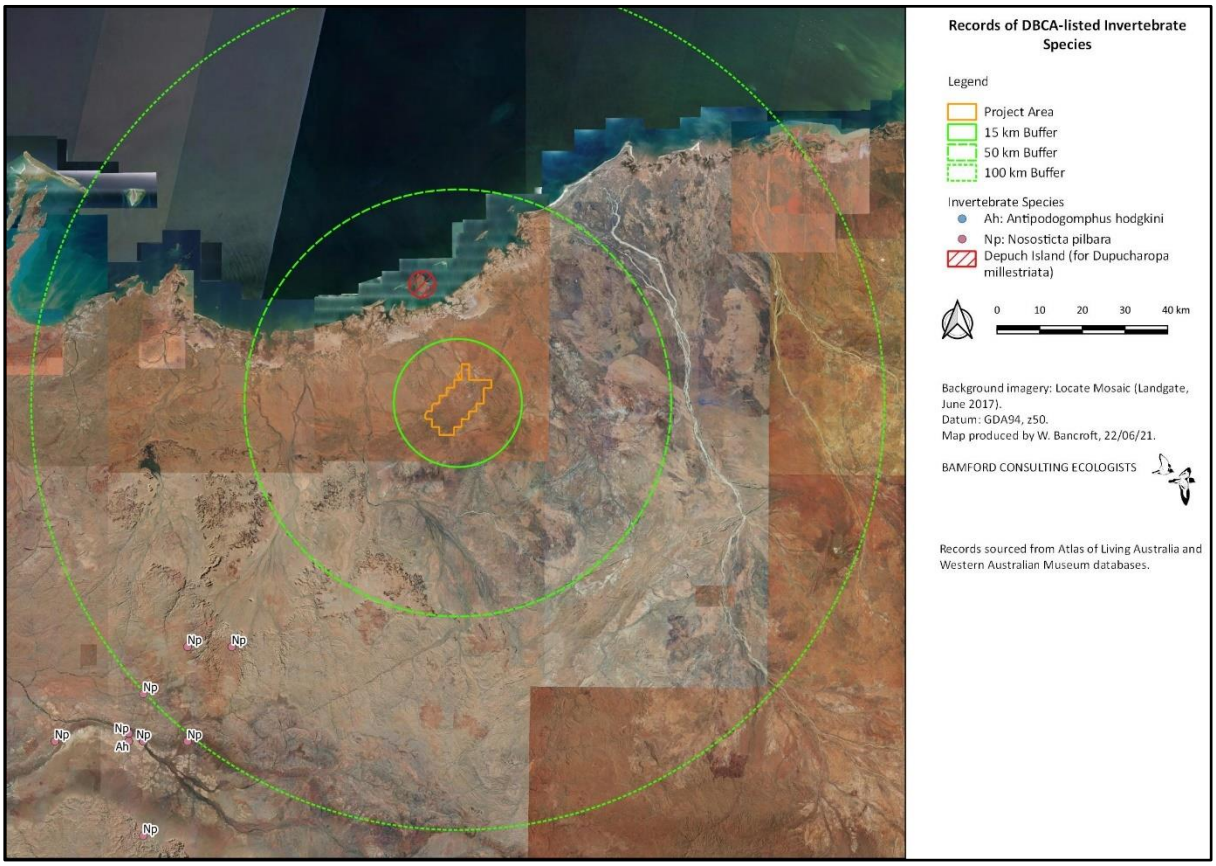


Figure 6. Records of DBCA-listed (threatened or priority) invertebrate species within 100 km of the study area.

3.2.4 Vertebrate fauna of conservation significance

Of the 271 species of vertebrate fauna that are expected to occur in the project area (Section 3.2.1 above), 25 are considered to be of conservation significance (12 CS1, seven CS2 and six CS3; see Appendix 1 for descriptions of these CS (conservation significance) levels. A summary of the numbers in each vertebrate class is presented in Table 9. These species of conservation significance are indicated in the complete species list (Appendix 6) but are also listed with details of their conservation significance in Table 10. Fifteen conservation significant species are expected as residents, two species are expected to be regular visitors, three species are expected to be irregular visitors, and eight species are expected to be vagrants. They are discussed in further detail below.

Table 9. The number of conservation significant species in each vertebrate class.

See Appendix 1 for full explanation of Conservation Significance (CS) levels: CS1 = listed under WA State and/or Commonwealth legislation; CS2 = listed as Priority by DBCA; CS3 = considered locally significant.

Taxon	Conservation Significant (CS) fauna		
	CS1	CS2	CS3
Fish	0	0	0
Frogs	0	0	0
Reptiles	1	1	0
Birds	7	1	4
Native Mammals	4	5	2

Table 10. Conservation significant fauna species expected to occur within the project area.

Species are listed in taxonomic order.
CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.
EPBC Act listings: C = Critically Endangered, E = Endangered, V = Vulnerable, M = Migratory (see Appendix 2).
WA *Biodiversity Conservation Act 2016* (BC Act) listings: S1 to S7 = Schedules 1 to 7 (see Appendix 2).
DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 2).
LS = considered by BCE to be of local significance (see Appendix 1).

CS Species		Status	CS Level	Confirmed	Expected Status	Expected VSA
REPTILES						
Notoscincus butleri	Lined Soil-Crevice Skink	P4	CS2		Resident	VSA1, 2, 3, 5
Liasis olivaceus subsp. barroni	Pilbara Olive Python	V, S3	CS1		Resident	VSA1, 2 3, 5
BIRDS						
Oxyura australis	Blue-Billed Duck	P4	CS2		Vagrant	VSA 5
Plegadis falcinellus	Glossy ibis	M S5	CS1		Vagrant	VSA 5
Pandion cristatus	Eastern Osprey	M S5	CS1		Irregular Visitor	VSA 5
Apus pacificus	Fork-tailed Swift	M, S5	CS1		Irregular Visitor	Any
Falco hypoleucos	Grey Falcon	V, S3	CS1		Regular Visitor	Any
Falco peregrinus	Peregrine Falcon	S7	CS1		Resident	Any
Pezoporus occidentalis	Night Parrot	E S1	CS1		Vagrant	VSA 3, 4
Phaps histrionica	Flock Bronzewing		CS3			VSA 3, 4, 5
Amytornis striatus	Striated Grasswren		CS3		Resident	VSA4
Stipiturus ruficeps	Rufous-crowned Emu-wren		CS3		Resident	VSA 3, 4
Hirundo rustica	Barn Swallow	M, S5	CS1		Vagrant	Any
Neochmia ruficauda	Star Finch		CS3		Resident	VSA 4, 5
MAMMALS						
Dasycercus blythi	Brush-tailed Mulgara	P4	CS2		Vagrant	VSA 4
Dasyurus hallucatus	Northern Quoll	E, S2	CS1	X	Resident	VSA 1, 2
Macrotis lagotis	Greater Bilby	V, S3	CS1		Vagrant	VSA 3, 4
Trichosurus vulpecula	Brushtail Possum		CS3		Irregular visitor	VSA 5
Lagorchestes conspicillatus	Spectacled Hare-Wallaby	P4	CS2		Vagrant	VSA 4
Petrogale rothschildi	Rothschild's Rock-Wallaby		CS3	X	Resident	VSA 1, 2
Leggadina lakedownensis	Short-tailed Mouse	P4	CS2		Resident	VSA 4

CS Species		Status	CS Level	Confirmed	Expected Status	Expected VSA
Hydromys chrysogaster	Water-rat, rakali	P4	CS2		Vagrant	VSA 5
Pseudomys chapmani	Ngadji or Western Pebble-mound Mouse	P4	CS2		Regular visitor	VSA 1, 2, 3
Rhinonicteris aurantia	Pilbara Leaf-nosed bat	V, S3, P4	CS1	X?	Irregular visitor	Caves and mines May forage anywhere
Macroderma gigas	Ghost Bat	V, S3	CS1	X	Regular visitor	Caves and mines May forage anywhere
Total Number of Species:	**28**			**3 (4?)**		

3.2.5 Conservation significant species accounts

A list of all 19 conservation significant vertebrate species expected within the project area is provided in Table 10 (see also Section 3.2.4). Information on the conservation status, distribution and habitat, salient ecology and expected occurrence within the project area is provided for each of these species is below.

3.2.5.1 Conservation Significance 1

Pilbara Olive Python (*Liasis olivaceus barroni*) CS1 (V,S3)

Conservation status: Vulnerable under the EBPC Act and Schedule 3 under the BC Act.

Distribution and habitat: This subspecies is restricted to ranges within the Pilbara region and Mount Augustus in the Gascoyne and is often recorded near waterholes (Wilson and Swan 2017). Usually associated with rocky substrates (Burbidge 2004; Wilson and Swan 2017).

Ecology: Usually found in proximity to water, although breeding males and juveniles may disperse widely (Burbidge 2004). An ambush predator that feeds predominately on mammals and birds (Burbidge 2004). Probably cathemeral.

Expected occurrence: Resident. It has been recorded in the general area and suitable habitat is present within the study area, particularly where rocky landscapes are adjacent to drainage lines. The actual development area is unlikely to support the species but individuals may move through.

Fork-tailed Swift (*Apus pacificus*) CS1 (M,S5)

Conservation status: Migratory under the EPBC Act and Schedule 5 under the BC Act.

Distribution and habitat: The swift is a largely aerial species of unpredictable occurrence in Western Australia. There are scattered records from the south coast, widespread in coastal and subcoastal areas between Augusta and Carnarvon, scattered along the coast from south-west Pilbara to the north and east Kimberley region. Sparsely scattered inland records, especially in the Wheatbelt, but more common in the north and north-west Gascoyne Region, north through much of the Pilbara Region, and the south and east Kimberley (Higgins 1999; DAWE 2020a). Aerial, usually flying from as low as one metre to in excess of 300 m above the ground.

Ecology: A diurnal, aerial insectivore, this species often forages along the edge of low pressure systems in flocks of ten to 1000 birds (Higgins 1999; DAWE 2020a). Breeds in Siberia (April to July) and spends the non-breeding season (October to mid-April) in Australia. Being aerial, it is effectively independent of terrestrial ecosystems when in Australia.

Expected occurrence: The Fork-tailed Swift may be an irregular visitor to the study and development areas.

Blue-billed Duck and Glossy Ibis CS2 (P4) and CS1 (M, S5)

Conservation status: The Blue-billed Duck is Priority 4 and the Glossy Ibis is Migratory under the EPBC Act and Schedule 5 under the BC Act.

Distribution and habitat: The Blue-billed Duck is primarily a southern waterbird that will occasionally disperse north. It favours deep water bodies. The Glossy Ibis is most abundant on wet grasslands across northern Australia but occasionally appears from the Pilbara and south.

Ecology: The Blue-billed Duck forages under water on aquatic invertebrates and small vertebrates. Thew Glossy Ibis feed mainly on invertebrates on the margins of wetlands and on damp grassland. .

Expected occurrence: Vagrants in small numbers. May occasionally visit flooded mine pits and pools along drainage lines in the region.

Eastern Osprey (*Pandion cristatus*) CS1 (M,S5)

Conservation status:	Migratory under the EPBC Act and Schedule 5 under the BC Act.
Distribution and habitat:	Occurs around coasts and inshore waters.
Ecology:	Diurnal piscivore that forages aerially.
Expected occurrence:	Irregular Visitor or possibly vagrant; individuals may fly along drainage lines occasionally.

Grey Falcon (*Falco hypoleucos*) CS1 (S3)

Conservation status:	Schedule 3 under the BC Act.
Distribution and habitat:	Sparsely distributed through central, northern and north-western Australia, this species appears to have a distribution that is centred around wooded ephemeral or permanent drainage lines (Menkhorst *et al.* 2017).
Ecology:	An aerial, diurnal predator that predominantly forages on pigeons and parrots, although may also take invertebrates, reptiles and small mammals (Debus 2019). Resident when seasonal conditions are favourable, nomadic in times of drought (Debus 2019).
Expected occurrence:	Regular visitor. The study area may form part of the territory of an individual or pair and thus birds could fly over the development area occasionally, but it provides little habitat for them.

Peregrine Falcon (*Falco peregrinus*) CS1 (S7)

Conservation status:	Schedule 7 under the BC Act.
Distribution and habitat:	More or less cosmopolitan (Menkhorst *et al.* 2017). This species occurs in a variety of environments but is usually reliant on cliff faces or tall trees for nesting (Debus 2019).
Ecology:	A highly adept aerial predator that predominantly forages on birds, although will also occasionally take invertebrates, fish, reptiles and mammals (Debus 2019). Mostly diurnal or crepuscular.

Expected occurrence: Resident. The study area is likely to be within the home range of a pair, and the birds could breed on rocky cliffs in the survey area. They are known to nest on ledge on the walls of open cut pits, but there was no evidence of current breeding in either the Mons Cupri or Whim Creek pits.

Night Parrot (*Pezoporus occidentalis*) CS1 (End, S2)

Conservation status: Endangered under the EBPC Act and Schedule 1 (Endangered) under the BC Act.

Distribution and habitat: Highly elusive and known from only a very small number of records, it is difficult to ascertain the distribution and habitat of this species. DAWE (2020c) lists central Western Australia, north-eastern South Australia and south-western Queensland as 'core' areas, although the Night Parrot may occur throughout any part of inland Australia. Habitat associations are also tenuous but the species may occur in areas of spinifex grassland and/or chenopod shrublands, or in areas of shrubby samphire (TSSC 2016).

Ecology: The Night Parrot was recorded more or less regularly through the late 19th Century but appeared to decline early in the 20th Century, with a lack of reliable records from the 1930s to the end of the century leading to some speculation that it was extinct. In the early 20th Century, however, there have been multiple records including in the eastern Pilbara, northern Murchison and western deserts of Western Australia (Davis and Metcalf 2008; Hamilton *et al.* 2017; Jackett *et al.* 2017), and a population has been studied in south-western Queensland since 2013 (DAWE 2020c). The species has been mired in controversy due to the implications of records close to development proposals, and after researchers falsified recordings and subsequently retracted recent Night Parrot records from South Australia (Jones *et al.* 2019). It is likely to be predominantly nocturnal and granivorous.

Expected occurrence: Vagrant. There are no recent or historical records of the Night Parrot in the Western Pilbara. Locations where the species has been found recently in Australia have had big, long-unburnt spinifex and extensive areas of chenopod shrublands associated with broad drainage systems, and therefore the environment of the study area and the Western Pilbara in general seems unlikely to be suitable.

Barn Swallow (*Hirundo rustica*) CS1 (M, S5)

Conservation status:	Migratory under the EPBC Act and Schedule 5 under the BC Act.
Distribution and habitat:	A northern hemisphere species that reaches northern Australia in small numbers in summer each year, and often seems to congregate around towns (M. Bamford pers. obs.).
Ecology:	An aerial insectivore that forages over a range of environments, but is often seen close to water and built structures.
Expected occurrence:	Vagrant. Occurs only in small numbers in Pilbara coastal towns each year, and rarely seems to venture inland.

Greater Bilby (*Macrotis lagotis*) CS1 (V,S3)

Conservation status:	Vulnerable under the EBPC Act and Schedule 3 under the BC Act.
Distribution and habitat:	Found in a wide range of arid environments and formerly occurred as far south as the WA Wheatbelt; now restricted to central to north-western Australia, including the northern Pilbara.
Ecology:	The Greater Bilby is a nocturnal omnivore which feeds on seeds, fruits, roots, fungi, invertebrates and very small animals. They live in burrows and have multiple burrows within their home range.
Expected occurrence:	Vagrant. The study area lies within the former range of the species and there are records to the north (east of Port Hedland), and therefore while it is very unlikely that resident animals are present, there is the possibility of vagrant animals reaching the project area. The species favours sandy to sandy loam plains so VSA 4 provides suitable habitat. This lies outside the development area, but exiting developed areas and roads pass through VSA 4.

Northern Quoll (*Dasyurus hallucatus*) CS1 (E,S2)

Conservation status: Endangered under the EBPC Act and Schedule 2 under the BC Act.

Distribution and habitat: In Western Australia this species is often associated with rocky areas in the Pilbara (but also occurs along watercourses and beaches) and occurs through forests, savannahs and dissected rocky environments in the Kimberley (Van Dyck and Strahan 2008; DAWE 2020d). It also occurs, patchily, across northern Australia to Queeensland (Van Dyck and Strahan 2008; DAWE 2020d). This species formerly occurred across much of northern Australia, from the Pilbara to south-east Queensland, but now only occurs in a number of fragmented populations across its former range, largely due to poisoning by Cane Toads.

Ecology: A predominantly nocturnal predator of invertebrates, amphibians, reptiles, birds and small mammals (Van Dyck and Strahan 2008). Northern Quoll may be both terrestrial and arboreal (Van Dyck and Strahan 2008). This species undergoes a partial post-breeding male-die off (semelparity), with most individuals (including females) only surviving for one or two breeding seasons (Van Dyck and Strahan 2008).

Expected occurrence:

Resident. This species is confirmed to be resident in the study and development areas. Of 20 locations where cameras were successfully set, Northern Quoll were recorded at 14 (see Plate 7 for an example photograph), and these were widespread across the landscape (Figure 7). In addition, tracks of a Northern Quoll were found in damp mud at CamWC15 (Plate 8). This was along Balla Balla Creek several hundred metres from the nearest rocky area. This indicates that Northern Quoll are moving across the landscape between rocky hills. Northern Quoll were also reported by Anax staff to be see regularly around the Whim Creek Hotel and to have been seen around camp buildings at times. Several of the confirmed records were close to the existing pits. Rocky environments are extensive in the study area and include existing waste rock dumps, which are likely to provide denning habitat for the animals. The total area of new development, up to 60 ha, represents habitat for a small number of animals. The Northern Quoll is reported to have overlapping home ranges of 35 ha (females) to 100 ha (males) (Van Dyck and Strahan 2008). This means that perhaps two or three individuals might lose part of their home range.

Plate 7. Northern Quoll at location CamWC08.

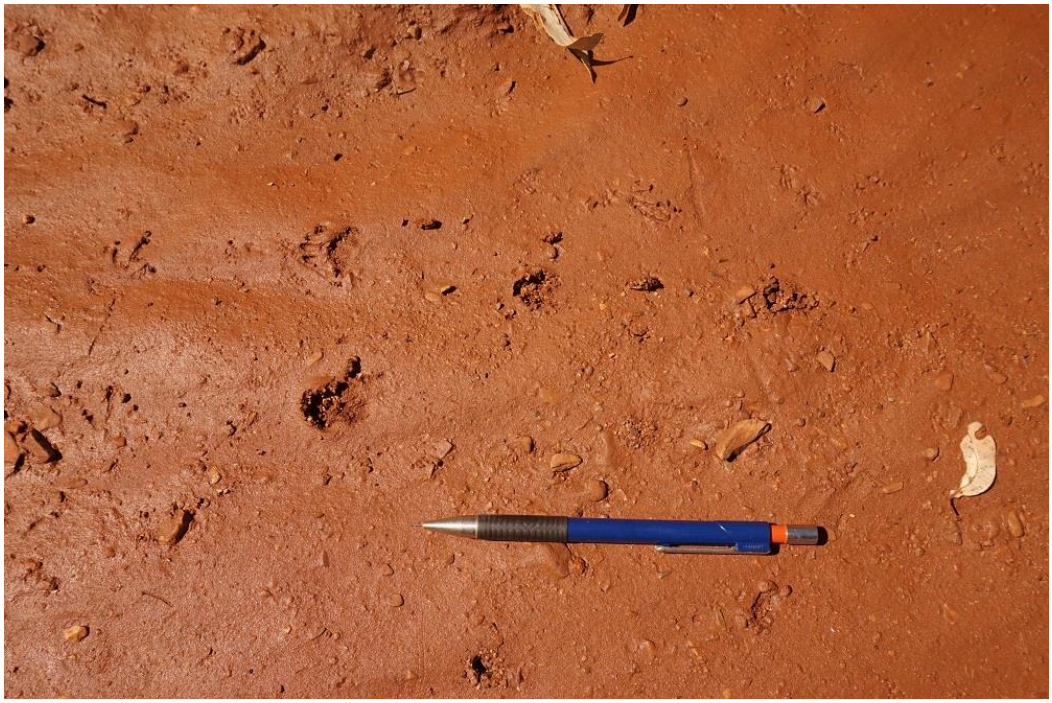


Plate 8. Northern Quoll footprints in damp mud at CamWC15, May 2021.

Ghost Bat (*Macroderma gigas*) CS1 (V,S3)

Conservation status:	Vulnerable under the EBPC Act and Schedule 3 under the BC Act.
Distribution and habitat:	The Ghost Bat occurs in the Pilbara, northern and north-eastern Australia. They roost in caves, crevices, disused mines and occasionally abandoned buildings.
Ecology:	A nocturnal, aerial insectivore.
Expected occurrence:	Regular visitor. Four Ghost Bats were found in a mine adit just south of the proposed Mons Cupri development in April 2021, and at least one was present in the same adit in May; this was at CamWC11 (Figure 5). The species had also been found consistently but always in small numbers in previous surveys, and Anax staff familiar with the area confirmed that the hills do not contain large caves, with the adit where the four Ghost Bats were found being the most substantial potential roost site in the project area. The pattern of observations and the nature of the landscape suggest that the Ghost Bat is regularly present in small numbers in the study area and in the vicinity of the development area, but that a significant maternity roost is highly unlikely.

Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* (Pilbara)) CS1 (V,S3)

Conservation status:	Vulnerable under the EBPC Act and Schedule 3 under the BC Act.
Distribution and habitat:	The Pilbara Leaf-nosed Bat occurs within the Pilbara where it is limited by the availability of very hot (28-32 °C) and very humid (96-100%) roost sites in caves and/or abandoned mine voids (Armstrong 2001; Van Dyck and Strahan 2008). There are also populations of the non-Pilbara form of the Orange Leaf-nosed Bat (*R. aurantia*) in the Kimberley and Northern Territory (Van Dyck and Strahan 2008).
Ecology:	A nocturnal, aerial insectivore (DAWE 2020k).
Expected occurrence:	Irregular visitor. There is only one unconfirmed record of the species in the study area (ecologia 2004), which lacks the sort of caves that the species requires for shelter. Individuals may occasionally occur in the study and development areas but they are unlikely to roost on a regular basis.

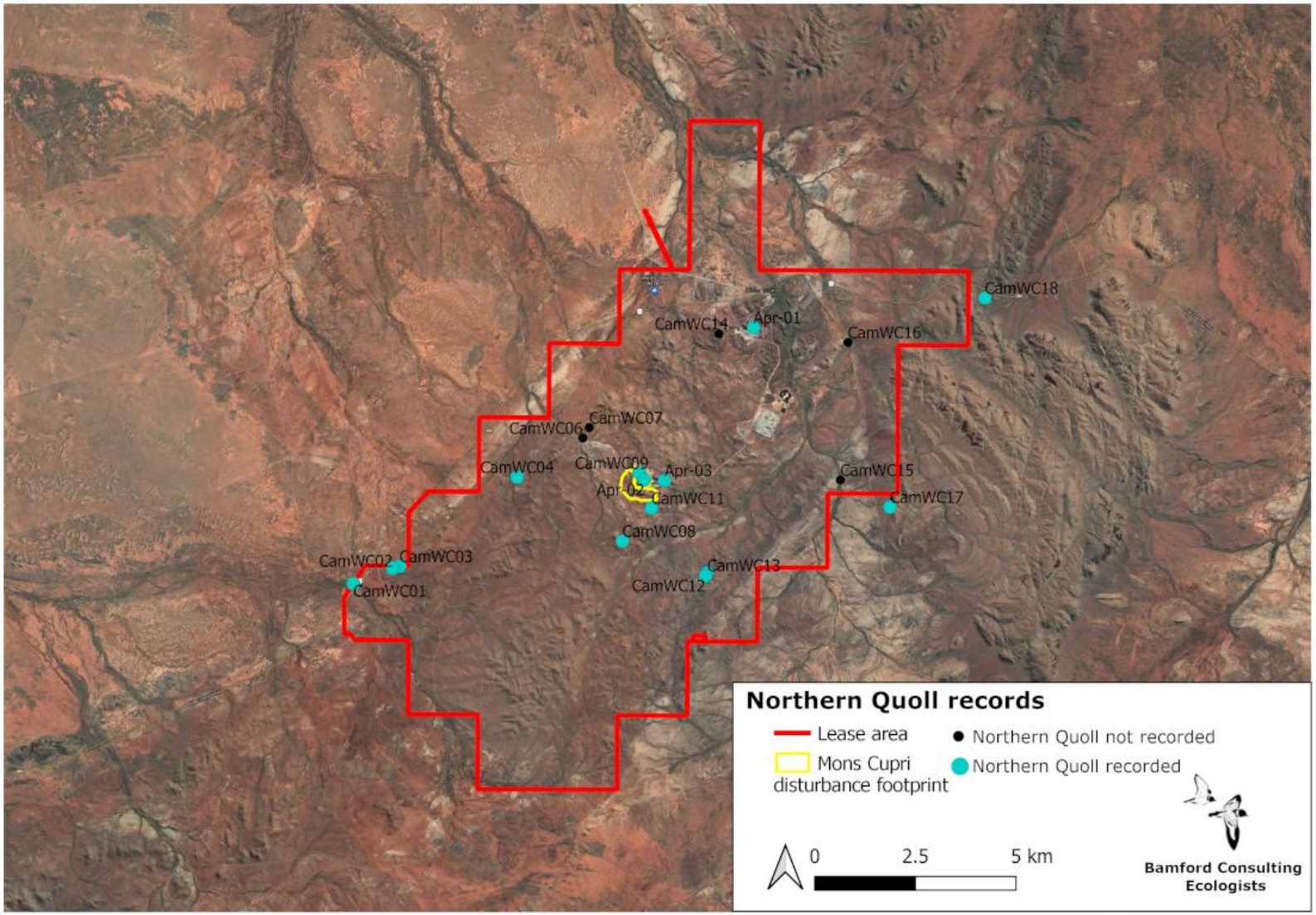


Figure 7. Camera locations, indicating those where Northern Quoll were recorded in April and May 2021. Tracks were found at CamWC15.

3.2.5.2 Conservation Significance 2

Lined Soil-Crevice Skink *(Notoscincus butleri)* CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA.

Distribution and habitat: This species is restricted to the Roebourne area and the survey area is at the eastern edge of its occurrence. It is associated with spinifex near creeks and rivers.

Ecology: A species that forages in leaf litter and feeds on invertebrates.

Expected occurrence: Resident. If present, this species is most likely to occur in the sandy to sandy-loam soils close to drainage lines.

Brush-tailed Mulgara *(Dasycervus blythi)* CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA.

Distribution and habitat: Pilbara and inland, central Western Australia, as well as central Australia (southern Northern Territory and northern South Australia). This species is often compared with its congener, the Crest-tailed Mulgara (*D. cristicauda*), as the two are sympatric over parts of their range (Van Dyck and Strahan 2008). In general, the Brush-tailed Mulgara is less closely associated with the dune fields than the Crest-tailed Mulgara (Woolley *et al.* 2013). Where the two co-occur, the Crest-tailed Mulgara is restricted to sandridges with an understorey dominated by spinifex (*Triodia*), whereas the Brush-tailed Mulgara occupies sand plain and gibber plain (Pavey *et al.* 2011). Distribution in the Pilbara is patchy.

Ecology: A nocturnal predator, its main prey include rodents, other dasyurid marsupials, reptiles, small birds and a wide range of invertebrate taxa (Pavey *et al.* 2011). Generally solitary (Van Dyck and Strahan 2008). This species constructs characteristic burrows for shelter (Triggs 1996; Van Dyck and Strahan 2008).

Expected occurrence: Vagrant. Very few recent records in the western Pilbara but may be present in the general region in sandy to sandy loam soils supporting spinifex (VSA 4).

Ngadji or Western Pebble-mound Mouse (*Pseudomys chapmani*) CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA.

Distribution and habitat: This species is found through much of the Pilbara and prefers rocky soils in grassland and acacia woodland.

Ecology: The western Pebble-mound Mouse lives in groups in burrows surrounded by mounds of pebbles. Mounds are typically found on low gravelly and stony rises, such as in VSA 2 and VSA 3.

Expected occurrence: Resident. There is suitable habitat in the survey area for this species but very few records. Several very old mounds were found in May 2021 near CamWC17, and old and a few active mounds were recorded in 1991 (ecologia 1991) and 2005/2006 (ENV 2007). The latter record was of a single active mound near the Whim Creek waste dump. This suggests that the species was present until recently and it has to be assumed that small numbers are still resident.

Short-tailed Mouse (*Leggadina lakedownensis*) CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA.

Distribution and habitat: Northern Pilbara through the Kimberley and into northern Australia (Van Dyck and Strahan 2008), inhabiting a range of environments including spinifex and tussock grasslands, samphire and sedgelands, *Acacia* shrublands, tropical *Eucalyptus* and *Melaleuca* woodlands and stony ranges (Van Dyck and Strahan 2008). Usually associated with areas that are seasonally inundated on red or white sandy-clay soils (Van Dyck and Strahan 2008). The Pilbara population, which may represent a distinct taxon (Van Dyck and Strahan 2008), has a preference for sandy and cracking clay/gilgai soils (B. Metcalf pers. obs.).

Ecology: Nocturnal and solitary, the Short-tailed Mouse feeds predominately on invertebrates but may also supplement its diet with plant material (Van Dyck and Strahan 2008). Populations of the Short-tailed Mouse appear to fluctuate dramatically, probably in response to environmental conditions and food availability.

Expected occurrence: Resident. Not recorded in any survey but the sandy-loam soils supporting spinifex of VSA4 may provide suitable habitat.

Rakali or Water-Rat (*Hydromys chrysogaster*) CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA.

Distribution and habitat: The Rakali has a fragmented distribution around the Australian coastline and along some inland waterways. It occurs around Barrow Island off the Pilbara coast, but is scarce along the Pilbara mainland coast. It rarely enters Pilbara drainage systems.

Ecology: Nocturnal and semi-aquatic, a carnivore that eats shellfish, crustacea and fish.

Expected occurrence: Vagrant. While doubtful the species occurs in major drainage systems in the project area, the possibility exists of animals moving upstream along systems like Balla Balla Creek.

3.2.5.3 Conservation Significance 3

Flock Bronzewing (*Phaps histrionica*) CS3 (LS)

Conservation status:	Formerly listed as a priority species by DBCA, probably due to a decline in its range in WA.
Distribution and habitat:	Usually found in broad grasslands of floodplains in the Kimberley and Northern Territory, but occurs consistently, albeit in small numbers, along river flats in the western Pilbara.
Ecology:	A granivore that often moves around in large flocks.
Expected occurrence:	Irregular visitor. Most likely to be seen in small numbers along drainage systems.

Striated Grasswren (*Amytornis striatus*) and Rufous-crowned Emu-wren (*Stipiturus ruficeps*) CS3 (LS)

Conservation status:	These species are patchily distributed in the Pilbara and often associated with long-unburnt spinifex.
Distribution and habitat:	Both species prefer tall, dense unburnt spinifex on plains and rocky hills.
Ecology:	Insectivorous and granivorous, both species are secretive and stay close to cover.
Expected occurrence:	Resident. Although not recorded, both these species can be difficult to detect and are therefore potentially present in long- unburnt spinifex in the project area.

Star Finch (*Neochmia ruficauda*) CS3 (LS)

Conservation status:	This species is patchily distributed and was formerly listed as priority by DBCA.
Distribution and habitat:	Distributed patchily from the Pilbara to north-eastern Queensland. Its preferred habitat is grasslands associated with drainage systems.
Ecology:	A granivore that often feeds on the ground.
Expected occurrence:	Resident. This species may be resident in suitable habitat close to drainage lines in the survey area.

CS3 (LS)

Rothschild's Rock-Wallaby (*Petrogale rothschildi*)

Conservation status: This species is considered locally significant due to its restricted distribution.

Distribution and habitat: Distributed patchily in the Pilbara region. Its preferred habitat is rocky hills.

Ecology: A nocturnal herbivore which prefers to shelter in caves and rocky outcrops during the day but may forage away from rocky hills at night.

Expected occurrence: Resident. Rock-Wallaby scats were found regularly in rocky areas, including around Mons Cupri pit, and the species was confirmed to be present from the camera survey with several photographs at CamWC04 (Figure 6).

CS3 (LS)

Spectacled Hare-Wallaby (*Lagorchestes conspicillatus*)

Conservation status: This species is considered locally significant as it is recorded very infrequently in mainland Western Australia and is within the size range of mammals that have declined.

Distribution and habitat: Distributed patchily in the Pilbara region. Often associated with dense, long-unburnt spinifex.

Ecology: A nocturnal herbivore which prefers to shelter in caves and rocky outcrops during the day but may forage away from rocky hills at night.

Expected occurrence: Vagrant. There are no nearby, recent records and the species is possibly locally extinct. If still present, it would favour areas of dense vegetation cover such as long drainage lines.

CS3 (LS)

Common Brushtail Possum (*Trichosurus vulpecula*)

Conservation status: This species is considered locally significant as it is recorded infrequently in the Pilbara (Anderson *et al.* in prep.). It has declined throughout its range in Western Australia.

Distribution and habitat: Distributed patchily in the Pilbara region. Often associated with large trees along drainage lines (VSA 5) but may also shelter in rock piles (VSA 1).

Ecology: A nocturnal, mostly arboreal omnivore that shelters in tree hollows and potentially rock piles during the day.

Expected occurrence: Irregular visitor. There are no records from the project area or nearby, but it is potentially present along major drainage lines with large trees.

Plate 9. Rothschild's Rock-Wallaby at CamWC04

3.3 Patterns of biodiversity

Investigating patterns of biodiversity can be complex and are often beyond the scope even of detailed or targeted investigations (see Section 2.1 above), but it is possible to draw some general conclusions based upon the different landscapes in the project area and on the number of previous studies that have taken place in the survey area. The following several patterns of biodiversity can be concluded:

- The margins of the study area in the west, east and north are likely to have a locally high fauna species richness due to the presence of a mosaic of Land Systems. The north, with a large area of the River Land System, may be particularly rich. The development area of the Ruth and Boolgeeda Land Systems, and VSAs 1 and 2, is not expected to have such high species richness.
- The rocky hills (VSA 1 and blending with VSA 2) supports rock-adapted species including a number of conservation significance such as the Northern Quoll.
- Drainage lines and their margins will be seasonally or intermittently important for waterbirds and a range of fauna both because of the presence of water, but also because of the sand to sandy loam soils that support species not adapted to rockier substrates.

3.4 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 the aspects discussed below.

Local hydrology. The project area has strong relief from rocky hills to drainage lines, and broad areas of sandy to sandy loam flats that may be seasonally damp (parts of VSA 4). There is a network of small

to large drainage lines with associated vegetation and fauna. Surface hydrology is therefore complex, likely to be important for local biodiversity and also likely to be sensitive to altered flows and spills (discussed below under impacts).

Fire. Native vegetation throughout the project area is subject to fire and while appropriate fire regimes can benefit biodiversity, inappropriate regimes can lead to a loss of biodiversity. There is probably no current managed fire regime. Several of the significant species are known to favour long-unburnt spinifex (Striated Grasswren, Rufous-crowned Emu-wren, Spectacled Hare-Wallaby).

Feral species and interactions with over-abundant native species. Feral species occur throughout Western Australia and are a major component of the current mammal fauna of the project area. They have contributed to local extinctions and may be affecting populations of extant species. A feral Cat was detected on a camera and Foxes are likely to be present at least occasionally. Domestic Cattle are degrading drainage lines.

Habitat degradation due to weed invasion. Weed invasion is already occurring along the drainage lines (VSA 5) and in the lower areas of VSA 4; the main weed is Buffel Grass and soils in other VSAs may be les suitable for this species. Weed invasion can be exacerbated by earthworks and developments (discussed further in Section 4).

Connectivity and landscape patterns

Except for the main highway, large tracks and areas of existing mine disturbance, the landscape is intact and continuous. Major drainage lines are linear features that may support movement of some fauna across the landscape, with some evidence (tracks) that the Northern Quoll are using drainage lines as 'corridors'. The Boolgeeda Land System in the west of the project area is also a linear feature, although it blends with the surrounding land systems. For some rock-dependent species, this linear pattern in the Boolgeeda Land System may facilitate movement across the landscape.

3.5 Summary of fauna values

The desktop study identified 271 vertebrate fauna species as potentially occurring in the project area (4 fish, 7 frogs, 83 reptiles, 146 birds and 41 mammals). The presence of 49 species (one frog, seven reptiles, 31 birds and 10 mammals) was confirmed during the 2021 site inspection.

Fauna assemblage. The assemblage is rich and almost intact, with local extinction of some mammal species uncertain. The assemblage is distinctive in that it includes several species that are restricted to rocky hills, but this is typical of the broader region.

Species of conservation significance. Of the 25 species of conservation significance recorded or that may be present in the study area, most are expected only as irregular visitors or vagrants. Species of most interest with respect to the proposed development are those associated with rocky landscapes and that appear to be resident or at least present regularly. The Northern Quoll and Ghost Bat are of particular importance as both are of high conservation significance, with the Northern Quoll apparently common and widespread in the area, and the Ghost Bat making regular use of small caves

and adits for seasonal (non-breeding) roosts). At least one Northern Quoll was recorded within the development area, and a mine adit used by up to four Ghost Bats lies about 500 m outside the development area. d. A suite of potential SRE invertebrate fauna has been recorded within 20 km of the project area, with most associated with rocky environments. Such environments are present in the development area but are extensive in the study area and region.

Vegetation and Substrate Associations (VSAs). The project area encompasses five VSAs which reflect landscape position and soil type. All of the VSAs are widespread in the region.

Patterns of biodiversity. The north eastern part of the survey area is likely to support a high richness of fauna as it forms a complex mosaic of several different VSAs, while the rocky hills (VSA 1 and merging with VSAs 2 and 3) support a number of species that are dependent on such rocky landscapes. Drainage lines, and especially the larger systems with at least semi-permanent pools and large trees, will have distinctive fauna and function.

Key ecological processes. The ecological processes that currently have major effects upon the fauna assemblage are local hydrology, feral species and fire. Habitat degradation due to weed invasion is a concern along drainage lines.

4 Impact assessment

Threatening processes have to be considered in the context of fauna values and the nature of the proposed action, and are examined below. Impact categories are defined in Table 7. The threatening processes are derived from the literature and guidance and are described in Appendix 3. The notes below include some recommendations.

Habitat loss leading to population decline. *Minor*

The proposed action will result in a small loss of native vegetation; an area of up to 60 ha in addition to the existing footprint of 515 ha. There are effectively no other developments within 15 km (only roads and the Whim Creek Hotel). The proposed Mons Cupri development occurs on a rocky hill and its slopes mostly in the Ruth and partly in the Boolgeeda Land System (VSA 1 and VSA 2), which are extensive in the region (Figure 3). The impact on significant species such as the Northern Quoll would be in the order of a few individuals as the species is reported to have an overlapping home range of 35 ha (females) to 100 ha (males) (Van Dyck and Strahan 2008). A mine adit used as a temporary roost by a small number of Ghost Bats is located about 500 m south of the proposed development area and is on the side of a hill facing way from this.

Habitat loss leading to population fragmentation. *Minor*

The development footprint is compact and adjacent to existing disturbance, and should have little if any impact on linear landscape features such as drainage lines or the linear Boolgeeda Land System in the west.

Degradation of habitat due to weed invasion. *Minor*

There is potential for development to increase the spread of weeds but standard hygiene measures are likely to be in place to reduce this risk.

Mortality during construction. *Minor*

This is a concern mostly on animal welfare grounds, however a few individuals of the conservation significant Northern Quoll may be present in the development area. Removal and translocation of Northern Quoll from the impact area would reduce the risk of individual mortality. There are also standard practices for reducing fauna mortality during development, such as managing trenches. Increased traffic also poses an increased risk to fauna, particularly close to drainage lines where Olive Pythons may be present. Signage and education as part of inductions can reduce the risk to fauna.

Ongoing mortality. *Minor*

This results mainly from roadkill, fauna striking infrastructure and effects of lighting. Impacts of additional lighting upon invertebrates is largely unknown but Read *et al.* (2016) found a change in bird assemblages around remote mine sites that they considered to be linked to an increase in food supply (dead insects around lights) for predatory species. Roadkill can be reduced through education and signage.

Species interactions. *Minor*

Some of the fauna is sensitive to feral species such as Cats. These are present already, but during construction in particular, feral species may be attracted to work-sites and may gain improved access into native vegetation. Impacts can be kept to Minor through standard practices such as not feeding wildlife, managing waste and even implementing some feral species control.

Hydrological change. *Minor*

There may be some risk of hydrological change affecting vegetation outside areas of direct impact. There are many small drainage lines that coalesce into the major systems and these could be sensitive to altered flows. Hydrological change can probably be minimised through design and planning. Culverts under roads may also provide underpasses for small animals..

Altered fire regimes. *Negligible*

The vegetation of the project area is generally fire-dependent and probably already subject to regular fires. Some fire sensitive bird and mammal species may be present and could be affected by a change in fire frequency or intensity. The project may lead to an increase in fire frequency, but could also lead to improved fire management such as a reduction in the area of each fire

Disturbance (dust, noise, light). *Minor*

The level of dust, noise and light during construction and operation has the potential to result in some impacts, but there are standard management procedures to minimise these. As noted above, impacts of additional lighting upon invertebrates is largely unknown. Education of personnel as part of inductions can be an effective way of ensuring staff are familiar with the fauna of the area and how to avoid negative impacts.

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6 Appendices

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 and 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.

VSA assessment was made with reference to the key attributes provided by (EPA 2020):

- soil type and characteristics
- extent and type of ground surfaces and landforms
- height, cover and dominant flora within each vegetation stratum
- presence of specific flora or vegetation of known importance to fauna
- evidence of fire history including, where possible, estimates of time since fire
- evidence and degree of other disturbance or threats, e.g. feral species
- presence of microhabitats and significant habitat features, such as coarse woody debris, rocky
- outcrops, tree hollows, water sources and caves
- evidence of potential to support significant fauna
- function of the habitat as a fauna refuge or part of an ecological linkage.

Patterns of biodiversity across the landscape

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

Species of conservation significance

Species of conservation significance are of special importance in impact assessment. The conservation status of fauna species in Australia is assessed under Commonwealth and State Acts such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Western Australian *Biodiversity Conservation Act 2016* (BC Act). In addition, the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) recognises priority levels, while local populations of some species may be significant even if the species as a whole has no formal recognition. Therefore, three broad levels of conservation significance can be recognised and are used for the purposes of this report, and are outlined below. A full description of the conservation significance categories, schedules and priority levels mentioned below is provided in Appendix 2.

<u>Conservation Significance (CS) 1: Species listed under State or Commonwealth Acts</u>.

Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN 2012), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the Convention on the Conservation of Migratory Species of Wild Animals (CMS; also referred to as the Bonn Convention). The *Wildlife Conservation Act 1950* uses a series of seven Schedules to classify conservation status that largely reflect the IUCN categories (IUCN 2012).

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

In Western Australia, DBCA has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the *Wildlife Conservation Act 1950* but for which DBCA feels there is cause for concern.

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

Marine-listed species

Some conservation significant species may also be listed as 'Marine' under the EPBC Act. This listing protects these species in 'Commonwealth areas' which include "marine areas beyond the coastal waters of each State and the Northern Territory, and includes all of Australia's Exclusive Economic Zone (EEZ)" (DAWE 2020i). The EEZ extends to 200 nautical miles (approximately 350 kilometres) from the coast (DAWE 2020i). This may mean that the 'Marine' listing does not apply to the project/survey area (depending on its location). Therefore, when a species is otherwise protected (under the EPBC Act or BC Act) or priority-listed (by the DBCA) then the Marine listing is also noted but it does not have site-specific relevance. In cases where a species is solely Marine-listed (for a list see DAWE 2020g) and a project/survey area is not within a Commonwealth area then it is treated like all other fauna.

Invertebrates

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 in Appendix 3 are effectively the ecological processes that can be altered to result in impacts upon fauna.

Appendix 2. Categories used in the assessment of conservation status.

IUCN (International Union for the Conservation of Nature) categories, as outlined by IUCN (2012), and as used for the *Environment Protection and Biodiversity Conservation Act 1999* and the Western Australian *Biodiversity Conservation Act 2016*.

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

Schedules used in the WA *Biodiversity Conservation Act 2016*

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

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

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

Appendix 3. 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.

Note that the terms direct and indirect impacts are used by the DotE (2013), DSEWPaC (2013b) and EPA (2016a), but there is some inconsistency in how these are defined. The federal guidance does not define direct impact but has a very broad definition of indirect, and makes the statement (DotE 2013) '*Consideration should be given to all adverse impacts that could reasonably be predicted to follow from the action, whether these impacts are within the control of the person proposing to take the action or not. Indirect impacts will be relevant where they are sufficiently close to the proposed action to be said to be a consequence of the action, and they can reasonably be imputed to be within the contemplation of the person proposing to take the action*.' Indirect impacts therefore can even include what the DotE (2013) calls facilitated impacts, which are the result of third party actions triggered by the primary action. In contrast, the EPA (2016a) defines direct impacts to '*include the removal, fragmentation or modification of habitat, and mortality or displacement of individuals or populations.*' This document then lists as indirect impacts what in many cases are the consequences of the removal, fragmentation or modification of habitat. For example, '*disruption of the dispersal of individuals required to colonise new areas inhibiting maintenance of genetic diversity between populations'* is a consequence of habitat fragmentation. Impacts of light, noise and even roadkill are defined as indirect but they are clearly the result of the action and in control of the person taking the action. Roadkill is as direct a form of mortality as can be observed, but it is considered as an indirect impact in the context of a development presumably because it is not directly linked to land clearing. The EPA (2016a) makes a strong distinction between removal of vegetation (direct impact) and the consequences of such clearing and other aspects of a development (indirect impacts). It is not obvious how this distinction between direct and indirect impacts is helpful in the EIA process, as the key aim is to ensure that all impacts that result from a project are addressed in this assessment process. Interestingly, Gleeson and Gleeson (2012), in a major review of impacts of development on wildlife, do not use the terms direct or indirect. In the following outlines of threatening processes that can cause impacts, the emphasis is upon interpreting how a threatening process will cause an impact. For example, loss of habitat (threatening process) can lead to population decline and to population fragmentation, which are two distinct impacts, with population decline considered a direct impact and fragmentation an indirect impact by the EPA (2016a).

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 (Soule *et al.* 2004; Gleeson and Gleeson 2012). Obstructions associated with the development, such as roads, pipes and drainage channels, may also affect movement of small, terrestrial species. Fragmented populations may not be sustainable and may be sensitive to effects such as reduced gene flow.

Degradation of habitat due to weed invasion leading to population decline

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

Increased mortality

Increased mortality can occur during project operations; for example 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. Similarly, Read *et al.* (2015) found a decline in some bird species but an increase in others in the vicinity of active mines and concluded this was due to the mine attracting large and aggressive species that displaced other 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). It is also one of the factors that has contributed to the decline and local extinction of some mammal and bird species (Burbidge and McKenzie 1989). Fire is a natural feature of the environment but frequent, extensive fires may adversely impact some fauna, particularly mammals and short-range endemic species. Changes in fire regime, whether to more frequent or less frequent fires, may be significant to some fauna. Impacts of severe fire may be devastating to species already occurring at low densities or to species requiring long unburnt habitats to survive. In terms of conservation management, it is not fire *per se* but the fire regime that is important, with evidence that infrequent, extensive and intense fires adversely affect biodiversity, whereas frequent fires that cover small areas and are variable in both season and intensity can enhance biodiversity. Fire management may be considered the responsibility of managers of large tracts of land, including managers of mining tenements.

Dust, light, noise and vibration

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

The death of very large numbers of insects has been observed around some remote mine sites and attracts other fauna, notably native and introduced predators (M. Bamford pers. obs). The abundance of some insects can decline due to mortality around lights, although this has previously been recorded in fragmented landscapes where populations are already under stress (Rich and Longcore 2006). Artificial night lighting may also lead to disorientation of migratory birds. Aquatic habitats and open habitats such as grasslands and dunes may be vulnerable to light spill.

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 20 key threatening processes listed by the federal Department of the Environment (DotE 2014b):

- Competition and land degradation by rabbits.
- Competition and land degradation by unmanaged goats.
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*).
- Incidental catch (bycatch) of Sea Turtle during coastal otter-trawling operations within Australian waters north of 28 degrees South.
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations.
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis.
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris.
- Invasion of northern Australia by Gamba Grass and other introduced grasses.
- Land clearance.
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.
- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean.
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases.
- Novel biota and their impact on biodiversity.
- Predation by European red fox.
- Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha).
- Predation by feral cats.
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs.
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species.
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Bufo marinus*).
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta* (fire ant).

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

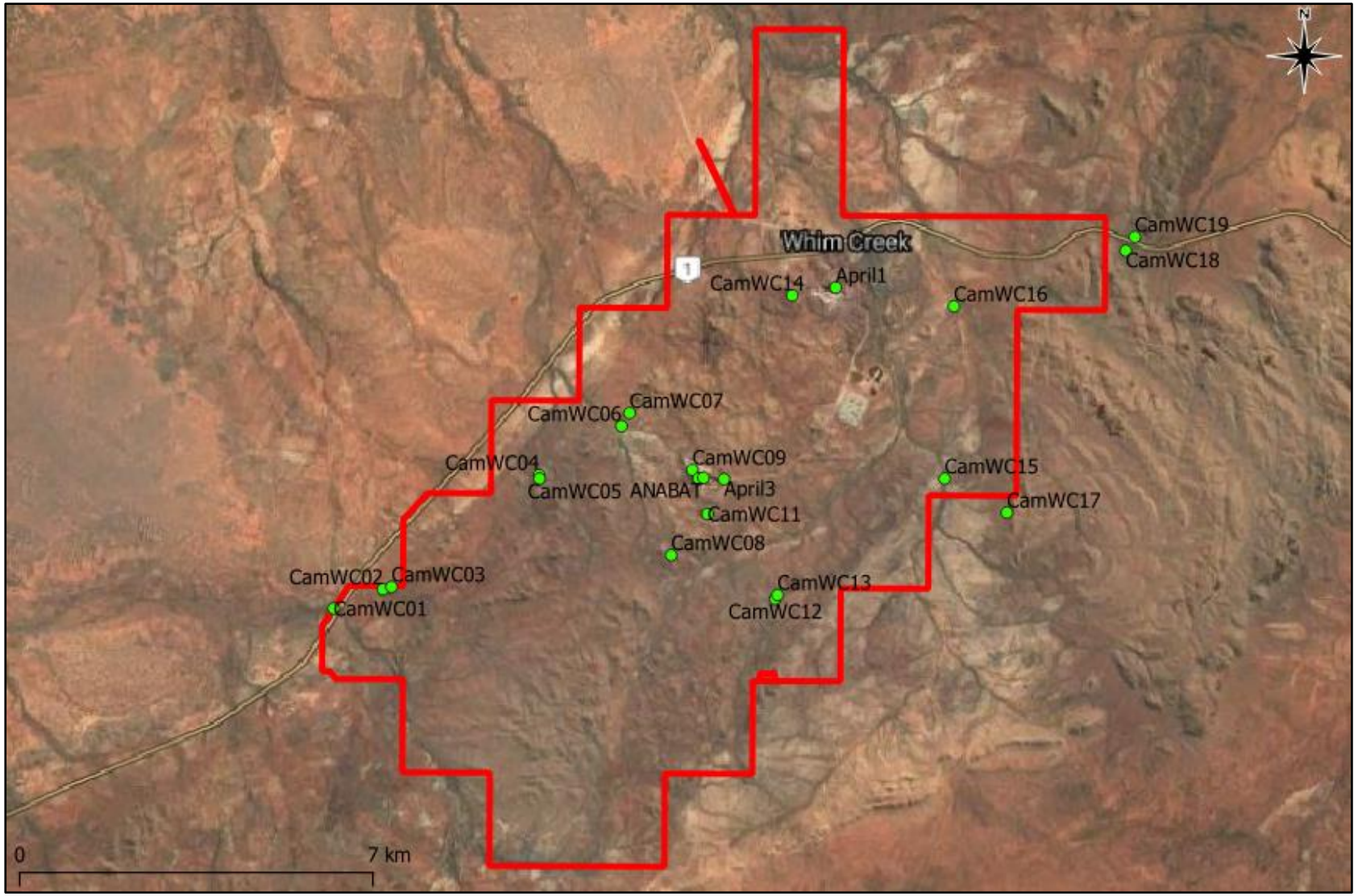
- Vegetation clearing;
- Increasing fragmentation, loss of remnants and lack of recruitment;
- Firewood collection;
- Grazing pressure;
- Feral animals;
- Exotic weeds;
- Changed fire regimes;
- Pathogens;
- Changed hydrology—dryland salinity and salt water intrusion;
- Changed hydrology— such as altered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

In addition to the above processes, the federal Department of Agriculture, Water and the Environment (DAWE) 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 reduce the area of occupancy of the species?
- Will the proposed action fragment an existing population?
- Will the proposed action adversely affect habitat critical to the survival of a species?
- Will the proposed action disrupt the breeding cycle of a population?
- Will the proposed action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?
- Will the proposed action result in introducing invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat?
- Will the proposed action introduce disease that may cause the species to decline?
- Will the proposed action interfere with the recovery of the species?

Appendix 5. Locations, camera codes and dates on motion cameras and ANABAT.

Zone	Easting	Northing		Camera	Camera location code	Start Date	End Date
50	586566	7694650		BCE04	April1	7/04/21	8/04/21
50	583853	7690862		BCE04	April2	8/04/21	9/04/21
50	584356	7690855		BCE10	April3	7/04/21	9/04/21
50	576623	7688293		BIOTC030	CamWC01	9/05/21	20/05/21
50	577602	7688673		BCE16	CamWC02	9/05/21	20/05/21
50	577771	7688722		BCE10	CamWC03	9/05/21	20/05/21
50	580693	7690937		BCE23	CamWC04	9/05/21	20/05/21
50	580701	7690865		BCE13	CamWC05	9/05/21	20/05/21
50	582324	7691906		BIOTC025	CamWC06	9/05/21	20/05/21
50	582485	7692164		BCE02	CamWC07	9/05/21	20/05/21
50	583310	7689348		BCE14	CamWC08	9/05/21	20/05/21
50	583729	7691039		BCE04	CamWC09	9/05/21	20/05/21
50	583853	7690869		BIOTC027	CamWC10	9/05/21	20/05/21
50	584030	7690166		BIOTC034	CamWC11	9/05/21	20/05/21
50	585371	7688485		BIOTC031	CamWC12	9/05/21	20/05/21
50	585415	7688561		BCE11	CamWC13	9/05/21	20/05/21
50	585707	7694493		C2	CamWC14	9/05/21	20/05/21
50	588724	7690865		BIOTC032	CamWC15	9/05/21	20/05/21
50	588908	7694279		BIOTC033	CamWC16	9/05/21	20/05/21
50	589957	7690192		BCE20	CamWC17	9/05/21	20/05/21
50	592313	7695382		BIOTC024	CamWC18	10/05/21	20/05/21
50	592492	7695653		BCE03	CamWC19	10/05/21	20/05/21
50	583949	7690883		ANABAT	ANABAT	7/04/21	9/04/21



Motion camera and ANABAT locations

Motion camera results.

Location	Date	Time (24hr)	Species	Photos
CamWC07	2021-05-10	9:21	Torresian Crow	10
CamWC19			Null	
CamWC09	2021-05-11	23:16	Northern Quoll	3
CamWC09	2021-05-11	23:38	Northern Quoll	3
CamWC09	2021-05-12	5:05	Northern Quoll	3
CamWC03	2021-05-11	14:52	Whistling Kite	1
CamWC03	2021-05-12	21:34	Northern Quoll	7
CamWC03	2021-05-13	4:49	Northern Quoll	1
CamWC03	2021-05-13	5:33	Northern Quoll	1
CamWC03	2021-05-14	4:18	Northern Quoll	1
CamWC03	2021-05-15	4:45	Northern Quoll	1
CamWC03	2021-05-15	5:10	Northern Quoll	1
CamWC03	2021-05-16	4:09	Northern Quoll	2
CamWC03	2021-05-16	23:20	Northern Quoll	1
CamWC03	2021-05-17	9:45	*Varanus pilbarensis*	1
CamWC03	2021-05-17	21:46	Northern Quoll	1
CamWC03	2021-05-18	3:20	Northern Quoll	2
CamWC03	2021-05-18	6:12	*Psuedoantechinus woolleyae*	1
CamWC03	2021-05-19	23:19	Northern Quoll	1
CamWC13	2021-05-10	18:08	Northern Quoll	4
CamWC13	2021-05-14	17:49	Northern Quoll	1
CamWC13	2021-05-17	3:41	Northern Quoll	1
CamWC13	2021-05-17	17:55	Northern Quoll	1
CamWC13	2021-05-18	3:38	Northern Quoll	3
CamWC05			Null	
CamWC08	2021-05-10	19:44	Common Rock Rat	5
CamWC08	2021-05-11	0:23	Northern Quoll	32
CamWC08	2021-05-11	5:58	Feral Cat	7
CamWC08	2021-05-11	18:30	Common Rock Rat	1
CamWC08	2021-05-11	19:37	Northern Quoll	6
CamWC08	2021-05-12	5:14	House Mouse	2
CamWC08	2021-05-12	17:37	*Gehyra punctata*	3
CamWC08	2021-05-13	0:35	Common Rock Rat	1
CamWC08	2021-05-13	18:22	Common Rock Rat	1
CamWC08	2021-05-14	0:15	Northern Quoll	3
CamWC08	2021-05-14	1:29	Common Rock Rat	1
CamWC08	2021-05-14	19:32	Northern Quoll	19
CamWC08	2021-05-15	0:48	Northern Quoll	6
CamWC08	2021-05-18	3:47	Northern Quoll	2

Location	Date	Time (24hr)	Species	Photos
CamWC08	2021-05-18	5:37	*Psuedoantechinus woolleyae*	1
CamWC08	2021-05-19	22:37	Northern Quoll	3
CamWC02	2021-05-11	20:56	Northern Quoll	16
CamWC02	2021-05-11	21:31	Northern Quoll	4
CamWC02	2021-05-12	4:24	Northern Quoll	3
CamWC02	2021-05-12	8:19	*Ctenotus robustus*	1
CamWC02	2021-05-12	20:20	Northern Quoll	1
CamWC02	2021-05-14	2:18	Northern Quoll	1
CamWC02	2021-05-17	20:04	Northern Quoll	3
CamWC02	2021-05-19	11:06	Spinifex Pigeon	5
CamWC17	2021-05-11	1:57	Common Rock Rat	1
CamWC17	2021-05-11	3:47	Northern Quoll	8
CamWC17	2021-05-11	17:59	Northern Quoll	2
CamWC17	2021-05-16	23:47	Northern Quoll	2
CamWC04	2021-05-16	6:18	Northern Quoll	2
CamWC04	2021-05-16	17:25	Rothschild's Rock-Wallaby	1
CamWC04	2021-05-18	6:06	Rothschild's Rock-Wallaby	1
CamWC04	2021-05-19	5:30	Northern Quoll	6
CamWC04	2021-05-20	7:45	Rothschild's Rock-Wallaby	8
CamWC18	2016-01-03	16:01	Northern Quoll	18
CamWC18	2016-01-04	17:02	Northern Quoll	6
CamWC18	2016-01-05	9:44	Northern Quoll	6
CamWC18	2016-01-07	15:13	Northern Quoll	3
CamWC18	2016-01-10	11:58	Northern Quoll	3
CamWC18	2016-01-12	8:53	Northern Quoll	9
CamWC06	2016-01-03	4:13	Torresian Crow	26
CamWC06	2016-01-04	4:01	Torresian Crow	9
CamWC06	2016-01-09	3:32	Torresian Crow	3
CamWC10	2016-01-04	14:02	Perentie	12
CamWC10	2016-01-05	0:50	Northern Quoll	21
CamWC01	2016-01-04	15:39	Australian Magpie	4
CamWC01	2016-01-04	4:02	Northern Quoll	3
CamWC01	2016-01-05	12:40	Australian Magpie	5
CamWC01	2016-01-08	22:06	Northern Quoll	3
CamWC01	2016-01-10	14:59	Australian Magpie	4
CamWC12	2016-01-03	21:29	Northern Quoll	6
CamWC12	2016-01-05	6:19	Northern Quoll	2
CamWC12	2016-01-06	8:24	Northern Quoll	3
CamWC15	2016-01-03	15:51	Torresian Crow	2
CamWC15	2016-01-04	11:24	Australian Magpie	2

Location	Date	Time (24hr)	Species	Photos
CamWC15	2016-01-06	11:47	Cow	2
CamWC15	2016-01-08	14:55	Spinifex Pigeon	2
CamWC15	2016-01-09	14:14	Australian Magpie	2
CamWC15	2016-01-10	11:58	Cow	4
CamWC16			No animal images	
CamWC11	2016-01-04	3:36	Northern Quoll	3
CamWC11	2016-01-05	20:03	Northern Quoll	15
CamWC11	2016-01-06	2:00	Northern Quoll	23
CamWC11	2016-01-06	20:05	Northern Quoll	51
CamWC11	2016-01-07	2:57	Northern Quoll	6
CamWC11	2016-01-08	20:04	Northern Quoll	24
CamWC11	2016-01-09	2:27	Euro	6
CamWC11	2016-01-09	5:05	Northern Quoll	9
CamWC11	2016-01-10	21:03	Northern Quoll	6

Appendix 6. Vertebrate fauna expected to occur in the project area.

The list is derived from the results of database and literature searches, and from previous field surveys conducted in the local area. The sources are: 1 = Previous fauna surveys (Section 2.3.2); 2 = Atlas of Living Australia; 3 = Naturemap; 4 = EPBC Protected Matters Search Tool; 5 = Birdata; 6 = DBCA Threatened Fauna Search.
CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.
EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory (see Appendix 2).
Wildlife Conservation Act 1950 listings: S1 to S7 = Schedules 1 to 7 (see Appendix 2).
DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 2).
LS = considered to be of local significance by Bamford Consulting Ecologists (see Appendix 1).
Int = introduced species.
See Section 2.2.4 for explanation of expected occurrence categories.
Expected Occurrence in bold = recorded in current survey.
Species returned from the literature review but omitted from the expected species list because of habitat or range limitations, or because they are considered locally extinct are listed in Appendix 6.

	Species	Common Name	Source	Status	Expected Occurrence
Melanotaeniidae					
	Melanotaenia australis	Western Rainbowfish	2		Regular visitor
Plotosidae					
	Neosilurus hyrtlii	Hyrtl's Catfish	2		Regular visitor
Tetrapontidae					
	Amniataba percoides	Barred Grunter	2		Irregular visitor
	Leiopotherapon unicolor	Spangled Perch	2		Regular visitor
Hylidae (Tree frogs)					
	Litoria rubella	Little Red Tree Frog	1 2 3		**Resident**
Myobatrachidae (Ground frogs)					
	Limnodynastes spenceri	Spencer's Frog	1		Resident
	Neobatrachus aquilonius	Northern Burrowing Frog	1		Resident
	Notaden nichollsi	Desert Spadefoot	1		Resident
	Uperoleia glandulosa	Glandular Toadlet	1		Resident

	Uperoleia russelli	Russell's Toadlet	1		Resident
Carphodactylidae (Carphodactylid geckoes)					
	Nephrurus levis		1 2 3		Resident
Diplodactylidae (Diplodactylid geckoes)					
	Diplodactylus bilybara	Western Fat-tailed Gecko	2		Resident
	Diplodactylus conspicillatus	Fat-tailed Gecko	1 3		Resident
	Diplodactylus galaxias	Northern Pilbara Beak-faced Gecko	2 3		Resident
	Diplodactylus laevis	Desert Fat-tailed Gecko	2		Resident
	Diplodactylus savagei	Southern Pilbara Beak-faced Gecko	1		Resident
	Lucasium stenodactylum	Crowned Gecko	1 2 3		Resident
	Lucasium wombeyi	Pilbara Ground Gecko	1 2 3		Resident
	Oedura marmorata	Marbled Velvet Gecko	1		Resident
	Rhynchoedura ornata	Western Beaked Gecko	1 2 3		Resident
	Strophurus elderi	Jewelled Gecko	1 2 3		Resident
Gekkonidae (Gekkonid geckoes)					
	Gehyra incognita	Northern Pilbara Cryptic Gehyra	2		Resident
	Gehyra media	Medium Pilbara Spotted Rock Gehyra	2		Resident
	Gehyra micra	Small Pilbara Spotted Rock Gehyra	2		Resident
	Gehyra pilbara	Pilbara Dtella	1 3		Resident
	Gehyra punctata	Spotted Dtella	1 2 3		**Resident**
	Gehyra purpurascens	Purplish Dtella	3		Resident
	Gehyra variegata	Variegated Dtella	1 2 3		**Resident**
	Heteronotia binoei	Bynoe's Gecko	1 2 3		Resident
	Heteronotia spelea	Pilbara Cave Gecko	2 3		Resident
Pygopodidae (Legless lizards)					
	Delma pax	Peace Delma	1 2 3		Resident
	Delma tincta	Excitable Delma	1 2 3		Resident
	Lialis burtonis	Burton's Snake-lizard	1		Resident
	Pygopus nigriceps	Western Hooded Scaly-foot	1		Resident
Agamidae (Dragons)					

	Amphibolurus gilberti	Gilbert's Dragon	3		Resident
	Ctenophorus caudicinctus	Ring-tailed Dragon	1 2 3		**Resident**
	Ctenophorus isolepis	Central Military Dragon	1 2 3		Resident
	Ctenophorus nuchalis	Central Netted Dragon	1 2 3		Resident
	Diporiphora valens	Southern Pilbara Tree Dragon	3		Resident
	Diporiphora vescus	Northern Pilbara Tree Dragon	3		Resident
	Gowidon longirostris	Long-nosed Dragon	1 2 3		**Resident**
	Pogona minor	Dwarf Bearded Dragon	1 2 3		Resident
	Tympanocryptis cephalus	Pebble Dragon	1 2 3		Resident
Scincidae (Skinks)					
	Carlia munda	Shaded-litter Rainbow-Skink	1		Resident
	Carlia triacantha	Desert Rainbow Skink	1 3		Resident
	Cryptoblepharus buchananii		3		Resident
	Ctenotus duricola	Pilbara Ctenotus	1 2 3		Resident
	Ctenotus grandis		1 2 3		Resident
	Ctenotus helenae	Clay-soil Ctenotus	1 2 3		Resident
	Ctenotus inornatus	Bar-shouldered Ctenotus	2		Resident
	Ctenotus pantherinus	Leopard Ctenotus	1 2 3		Resident
	Ctenotus robustus	Robust Ctenotus	2		**Resident**
	Ctenotus rubicundus	Ruddy Ctenotus	1 2 3		Resident
	Ctenotus saxatilis	Rock Ctenotus	1 3		Resident
	Ctenotus schomburgkii	Barred Wedge-snout Ctenotus	3		Resident
	Ctenotus serventyi		2 3		Resident
	Cyclodomorphus melanops	Northern Slender Blue-Tongue	1		Resident
	Egernia cygnitos	Western Pilbara Spiny-tailed Skink	2 3		Resident
	Egernia eos	Central Pygmy Spiny-tailed Skink	3		Resident
	Egernia epsisolus	Eastern Pilbara Spiny-tailed Skink	3		Resident
	Eremiascincus fasciolatus	Narrow-banded Sand Swimmer	1		Resident
	Eremiascincus musivus	Mosaic Desert Skink	3		Resident
	Eremiascincus pallidus	Western Narrow-Banded Skink	2 3		Resident

	Lerista bipes	North-Western Sandslider	1 2 3		Resident
	Lerista clara	Sharp-Blazed Three-Toed Slider	3		Resident
	Lerista jacksoni	Jackson's Three-toed Slider	2 3		Resident
	Lerista muelleri		1 2 3		Resident
	Lerista verhmens	Powerful Lerista	2 3		Resident
	Menetia greyii	Common Dwarf Skink	1 2 3		Resident
	Morethia ruficauda		1 2 3		Resident
	Notoscincus butleri	Lined Soil-Crevice Skink	1	CS2 (P4)	Resident
	Notoscincus ornatus		1 3		Resident
	Proablepharus reginae	Spinifex Snake-eyed Skink	1 2 3		Resident
	Tiliqua multifasciata	Central Blue-tongue	1 3		Resident
Varanidae (Monitors and goannas)					
	Varanus acanthurus	Spiny-tailed Monitor	1 2 3		Resident
	Varanus brevicauda	Short-tailed Pygmy Monitor	1 2 3		Resident
	Varanus eremius	Pygmy Desert Monitor	1 3		Resident
	Varanus giganteus	Perentie	1		**Resident**
	Varanus gouldii	Gould's Sand Monitor	1 3		Resident
	Varanus panoptes	Yellow-spotted Monitor	1 3		**Resident**
	Varanus pilbarensis	Pilbara Rock Monitor	1 3		**Resident**
	Varanus tristis	Racehorse Monitor	1 2 3		Resident
Typhlopidae (Blind snakes)					
	Anilios ammodytes		1 2		Resident
	Anilios grypus	Beaked Blind Snake	1 2		Resident
Pythonidae (Pythons)					
	Antaresia perthensis	Pygmy Python	1 3		Resident
	Antaresia children	Children's Python	1 2 3		Resident
	Liasis olivaceus barroni	Pilbara Olive Python	2 3 4 6	CS1 (V, S3)	Resident
Elapidae (Venomous land snakes)					
	Demansia rufescens	Rufous Whipsnake	1 2 3		Resident
	Pseudechis australis	Mulga Snake	2 3		Resident

	Pseudonaja mengdeni	Western Brown Snake	2 3		Resident
	Pseudonaja nuchalis	Gwarder	1		Resident
	Suta fasciata	Rosen's Snake	2 3		Resident
	Suta punctata	Spotted Snake	2 3		Resident
	Vermicella snelli	Pilbara Bandy-bandy	2 3		Resident
Casuariidae (Emus and Cassowaries)					
	Dromaius novaehollandiae	Emu	1 2 3 5		Regular Visitor
Anatidae (Ducks, Swans and Geese)					
	Anas gracilis	Grey Teal	2 3 5		Regular Visitor
	Anas superciliosa	Pacific Black Duck	1 2 3 5		Regular Visitor
	Aythya australis	Hardhead	2 3		Irregular Visitor
	Chenonetta jubata	Australian Wood Duck	2 3 5		Irregular Visitor
	Cygnus atratus	Black Swan	1 2 3 5		Irregular Visitor
	Dendrocygna eytoni	Plumed Whistling-Duck	2 3		Vagrant
	Oxyura australis	Blue-Billed Duck	2	CS2 (P4)	Vagrant
Phasianidae (Pheasants and Quail)					
	Coturnix pectoralis	Stubble Quail	2 3 5		Irregular Visitor
	Coturnix ypsilophora	Brown Quail	1 2 3 5		Resident
Turnicidae (Button-quails)					
	Turnix velox	Little Button-quail	1 2 3 5		Resident
Podicipedidae (Grebes)					
	Tachybaptus novaehollandiae	Australasian Grebe			**Irregular Visitor**
	Poliocephalus poliocephalus	Hoary-headed Grebe	5		Irregular Visitor
Threskiornithidae (Ibis and Spoonbills)					
	Platalea flavipes	Yellow-billed Spoonbill	2 3		Irregular Visitor
	Platalea regia	Royal Spoonbill	2 3 5		Vagrant
	Plegadis falcinellus	Glossy ibis	6	CS1 (M, S5)	Vagrant
	Threskiornis moluccus	Australian White Ibis	2		Irregular Visitor
	Threskiornis spinicollis	Straw-necked Ibis	2 3 5		Irregular Visitor

Ardeidae (Herons, Bitterns and Egrets)					
	Ardea garzetta	Little Egret	1 2 3 5		Irregular Visitor
	Ardea ibis	Cattle Egret	4		Vagrant
	Ardea modesta	Eastern Great Egret	2 3 4 5		Irregular Visitor
	Ardea novaehollandiae	White-faced Heron	1 2 3 5		Regular Visitor
	Ardea pacifica	White-necked Heron	1 2 3 5		Irregular Visitor
	Nycticorax caledonicus	Nankeen Night Heron	1 2 3 5		Regular Visitor
Ciconiidae (Storks)					
	Ephippiorhynchus asiaticus	Black-necked Stork	2 3 5		Irregular visitor
Phalacrocoracidae (Cormorants)					
	Phalacrocorax melanoleucos	Little Pied Cormorant	1 2 3 5		Regular Visitor
Accipitridae (Kites, Eagles, Goshawks)					
	Accipiter cirrocephalus	Collared Sparrowhawk	2 3 5		Resident
	Accipiter fasciatus	Brown Goshawk	1 2 3 5		Resident
	Aquila audax	Wedge-tailed Eagle	1 2 3 5		**Resident**
	Circus approximans	Swamp Harrier	1 2 3 5		Irregular Visitor
	Circus assimilis	Spotted Harrier	1 2 3 5		**Resident**
	Elanus caeruleus	Black-shouldered Kite	2 3 5		Resident
	Haliaeetus leucogaster	White-Bellied Sea-Eagle	2 3 4 5		Irregular Visitor
	Haliastur indus	Brahminy Kite	2 3 5		Irregular Visitor
	Haliastur sphenurus	Whistling Kite	2 3 5		**Resident**
	Hieraaetus morphnoides	Little Eagle	1 2 3 5		Resident
	Milvus migrans	Black Kite	1 2 3 5		Resident
	Pandion cristatus	Eastern Osprey	2 3 4 5 6	CS1 (M, S5)	Irregular Visitor
Otididae (Bustards)					
	Ardeotis australis	Australian Bustard	1 2 3 5		Resident
Gruidae (Cranes)					
	Grus rubicunda	Brolga	2 3 5		Irregular visitor
Rallidae (Rails, Crakes, Coots)					

	Fulica atra	Eurasian Coot	2 3 5		Irregular Visitor
	Porphyrio porphyrio	Purple Swamphen	2 3 5		Vagrant
	Tribonyx ventralis	Black-tailed Native-hen	2		Irregular Visitor
Burhinidae (Stone-curlews)					
	Burhinus grallarius	Bush Stone-curlew	1 2 3 5		**Resident**
Recurvirostridae (Stilts)					
	Cladorhynchus leucocephalus	Banded Stilt	2 3 5		Vagrant
	Himantopus himantopus	Black-winged Stilt	2 3 5		Irregular Visitor
	Recurvirostra novaehollandiae	Red-necked Avocet	2 3 5		Irregular Visitor
Charadriidae (Plovers)					
	Charadrius ruficapillus	Red-capped Plover	2 3 5		Irregular visitor
	Elseyornis melanops	Black-fronted Dotterel	1 2 3 5		Resident
	Erythrogonys cinctus	Red-kneed Dotterel	2 3 5		Regular Visitor
	Vanellus tricolor	Banded Lapwing	2 3		Irregular Visitor
Columbidae (Pigeons and Doves)					
	Geopelia cuneata	Diamond Dove	1 2 3 5		Resident
	Geopelia striata	Peaceful Dove	1 2 3 5		**Resident**
	Geophaps plumifera	Spinifex Pigeon	1 2 3 5		**Resident**
	Ocyphaps lophotes	Crested Pigeon	1 2 3 5		**Resident**
	Phaps chalcoptera	Common Bronzewing	1 2 3 5		Resident
	Phaps histrionica	Flock Bronzewing	2 3 5	CS3	Irregular Visitor
Cuculidae (Cuckoos)					
	Cacomantis pallidus	Pallid Cuckoo	2 3 5		Regular Visitor
	Centropus phasianinus	Pheasant Coucal	2 3 5		Resident
	Chrysococcyx basalis	Horsfield's Bronze-Cuckoo	2 3 5		Regular Visitor
	Chrysococcyx osculans	Black-eared Cuckoo	2 4 5		Regular Visitor
Tytonidae (Barn Owls)					
	Tyto javanica	Barn Owl	2 5		Resident

Strigidae (Hawk Owls)					
	Ninox boobook	Southern Boobook	1 2 5		Resident
	Ninox connivens	Barking Owl			Irregular visitor
Caprimulgidae (Nightjars)					
	Eurostopodus argus	Spotted Nightjar	1 2 3 5		**Resident**
Podargidae (Frogmouths)					
	Podargus strigoides	Tawny Frogmouth	1 2 3 5		Resident
Aegothelidae (Owlet-nightjars)					
	Aegotheles cristatus	Australian Owlet-nightjar	1 2 3 5		**Resident**
Apodidae (Swifts)					
	Apus pacificus	Fork-tailed Swift	2 4 6	CS1 (M, S5)	Irregular Visitor
Alcedinidae (Kingfishers)					
	Dacelo leachii	Blue-winged Kookaburra	1 2 3 5		Resident
	Todiramphus pyrrhopygius	Red-backed Kingfisher	1 2 3 5		Resident
	Todiramphus sanctus	Sacred Kingfisher	1 2 3 5		Regular Visitor
Meropidae (Bee-eaters)					
	Merops ornatus	Rainbow Bee-eater	1 2 3 4 5		**Regular Visitor**
Falconidae (Falcons)					
	Falco berigora	Brown Falcon	1 2 3 5		**Resident**
	Falco cenchroides	Nankeen Kestrel	1 2 3 5		**Resident**
	Falco hypoleucos	Grey Falcon	2 3 4 6	CS1 (V, S3)	Irregular Visitor
	Falco longipennis	Australian Hobby	1 2 3 5		Resident
	Falco peregrinus	Peregrine Falcon	6	CS1 (S7)	Resident
Cacatuidae (Cockatoos)					
	Cacatua roseicapilla	Galah	1 2 3 5		**Resident**
	Cacatua sanguinea	Little Corella	1 2 3 5		Resident
	Nymphicus hollandicus	Cockatiel	1 2 3 5		Regular Visitor
Psittacidae (Parrots)					
	Platycercus zonarius	Australian Ringneck	1 2 3 5		Resident
	Melopsittacus undulatus	Budgerigar	1 2 3 5		**Regular Visitor**

	Pezoporus occidentalis	Night Parrot	4	CS1 (E, S1)	Vagrant
Ptilonorhynchidae (Bowerbirds)					
	Ptilonorhynchus maculatus	Western Bowerbird	1 2 3 5		**Resident**
Climacteridae (Tree-creepers)					
	Climacteris melanurus	Black-tailed Treecreeper			Regular Visitor
Maluridae (Fairy-wrens)					
	Amytornis striatus	Striated Grasswren	1 2 3 5	CS3	Resident
	Malurus lamberti	Purple-backed Fairy-wren	1 2 3 5		Resident
	Malurus leucopterus	White-winged Fairy-wren	1 2 3 5		Resident
	Stipiturus ruficeps	Rufous-crowned Emu-wren		CS3	Resident
Meliphagidae (Honeyeaters)					
	Acanthagenys rufogularis	Spiny-cheeked Honeyeater	1 2 3		Resident
	Certhionyx variegatus	Pied Honeyeater	3		Regular Visitor
	Epthianura aurifrons	Orange Chat	5		Irregular Visitor
	Epthianura tricolor	Crimson Chat	2 3 5		Regular Visitor
	Gavicalis virescens	Singing Honeyeater	1 2 3 5		**Resident**
	Lichmera indistincta	Brown Honeyeater	1 2 3 5		Resident
	Manorina flavigula	Yellow-throated Miner	1 2 3 5		Resident
	Melithreptus gularis	Black-chinned Honeyeater	1 2 3 5		Irregular Visitor
	Ptilotula keartlandi	Grey-headed Honeyeater	1 2 3 5		**Resident**
	Ptilotula penicillata	White-plumed Honeyeater	1 2 5		**Resident**
Pardalotidae (Pardalotes)					
	Pardalotus rubricatus	Red-browed Pardalote	1 2 3 5		Resident
	Pardalotus striatus	Striated Pardalote	1 2		Resident
Acanthizidae (Thornbills, Gerygones)					
	Gerygone fusca	Western Gerygone	2 3 5		Resident
	Smicrornis brevirostris	Weebill	1 2 3 5		Resident
Pomatostomidae (Babblers)					
	Pomatostomus temporalis	Grey-crowned Babbler	1 2 3		Resident
Artamidae (Woodswallows)					

	Artamus cinereus	Black-faced Woodswallow	1 2 3 5		**Resident**
	Artamus leucorynchus	White-breasted Woodswallow	2 3 5		Regular Visitor
	Artamus minor	Little Woodswallow	1 3		Resident
	Artamus personatus	Masked Woodswallow	1 2 3		Irregular Visitor
Cracticidae (Butcherbirds and Magpie)					
	Cracticus nigrogularis	Pied Butcherbird	1 2 3 5		**Resident**
	Cracticus tibicen	Australian Magpie	1 2 3 5		**Resident**
	Cracticus torquatus	Grey Butcherbird	1		Resident
Campephagidae (Cuckoo-shrikes and Trillers)					
	Coracina novaehollandiae	Black-faced Cuckoo-shrike	1 2 3 5		**Resident**
	Lalage tricolor	White-winged Triller	1 2 3 5		Resident
Oreoididae (Bellbirds)					
	Oreoica gutturalis	Crested Bellbird	1		Resident
Pachycephalidae (Whistlers)					
	Colluricincla harmonica	Grey Shrike-thrush	1 2 3 5		Resident
	Pachycephala rufiventris	Rufous Whistler	1 2 3 5		Resident
Rhipiduridae (Fantails)					
	Rhipidura albiscapa	Grey Fantail	2 3 5		Resident
	Rhipidura leucophrys	Willie Wagtail	1 2 3 5		**Resident**
Monarchidae (Monarchs)					
	Grallina cyanoleuca	Magpie-Lark	1 2 3 5		**Resident**
Corvidae (Crows and Ravens)					
	Corvus bennetti	Little Crow	2 3 5		Resident
	Corvus orru	Torresian Crow	1 2 3 5		**Resident**
Petroicidae (Australian Robins)					
	Melanodryas cucullata	Hooded Robin	1		Resident
	Petroica goodenovii	Red-capped Robin	2 3 5		Resident
Hirundinidae (Swallows and Martins)					
	Cheramoeca leucosterna	White-backed Swallow	2 3 5		Regular Visitor
	Hirundo rustica	Barn Swallow	4	CS1 (M, S5)	Vagrant

	Petrochelidon ariel	Fairy Martin	1 2 3 5		Regular Visitor
	Petrochelidon nigricans	Tree Martin	1 2 3 5		**Regular Visitor**
Acrocephalidae (Reed-warblers)					
	Acrocephalus australis	Australian Reed-Warbler	2 3 5		Irregular Visitor
Alaudidai (Larks)					
	Mirafra javanica	Horsfield's Bushlark	1 2 3 5		**Resident**
Locustellidae (Songlarks and Grassbirds)					
	Cincloramphus cruralis	Brown Songlark	2 5		Regular Visitor
	Cincloramphus mathewsi	Rufous Songlark	1 2 5		Regular Visitor
	Poodytes carteri	Spinifexbird	1 2 3 5		**Resident**
Estrildidae (Finches and Mannikins)					
	Emblema pictum	Painted Finch	1 2 3 5		**Resident**
	Neochmia ruficauda	Star Finch	2 3	CS3	Regular Visitor
	Taeniopygia guttata	Zebra Finch	1 2 3 5		**Resident**
Motacillidae (Pipits)					
	Anthus australis	Australian Pipit	1 2 3 5		Resident
Tachyglossidae (Echidna)					
	Tachyglossus aculeatus	Short-beaked Echidna	1		Resident
Dasyuridae (Carnivorous Marsupials)					
	Dasycercus blythi	Brush-tailed Mulgara	1	CS2 (P4)	Vagrant
	Dasykaluta rosamondae	Kaluta	2 3		Resident
	Dasyurus hallucatus	Northern Quoll	1 2 3 4 6	CS1 (E, S2)	**Resident**
	Ningaui timealeyi	Pilbara Ningaui	1 2 3		Resident
	Pseudantechinus woolleyae	Woolley's Pseudantechinus	2 3		Resident
	Sminthopsis hirtipes	Hairy-footed Dunnart	3		Resident
	Sminthopsis macroura	Stripe-faced Dunnart	2 3		Resident
	Sminthopsis youngsoni	Lesser Hairy-footed Dunnart	2 3		Resident
Thylacomyidae (Bilbies)					
	Macrotis lagotis	Greater Bilby	4	CS1 (V, S3)	Vagrant

Phalangaridae (Possums)					
	Trichosurus vulpecula	Common Brushtail Possum	1	CS3	Irregular visitor
Macropodidae (Kangaroos and Wallabies)					
	Lagorchestes conspicillatus	Spectacled Hare-Wallaby	1	CS2 (P4)	Vagrant
	Osphranter robustus	Euro	1 2 3		**Resident**
	Osphranter rufus	Red Kangaroo	3		Resident
	Petrogale rothschildi	Rothschild's Rock-Wallaby	1	CS3	**Resident**
Muridae (Rats and Mice)					
	Leggadina lakedownensis	Short-tailed Mouse	6	CS2, (P4)	Resident
	Mus musculus	House Mouse	1 3	Int	Resident
	Notomys alexis	Spinifex Hopping-Mouse	1		Resident
	Hydromys chrysogaster	Water-rat, Rakali	6	CS2 (P4)	Vagrant
	Pseudomys chapmani	Ngadji or Western Pebble-mound Mouse	1 2 3 6	CS2 (P4)	Resident
	Pseudomys delicatulus	Delicate Mouse	3		Resident
	Pseudomys desertor	Desert Mouse	1		Resident
	Pseudomys hermannsburgensis	Sandy Inland Mouse	1 2 3		Resident
	Zyzomys argurus	Common Rock-Rat	1 2 3		**Resident**
Rhinonycteridae (Leaf-nosed Bats)					
	Rhinonicteris aurantia	Pilbara Leaf-nosed bat	4	CS1 (V, S3, P4)	Irregular Visitor
Megadermatidae (Ghost Bat)					
	Macroderma gigas	Ghost Bat	1 3 4 6	CS1 (V, S3)	**Regular Visitor**
Emballonuridae (Sheath-tail Bats)					
	Saccolaimus flaviventris	Yellow-bellied Sheath-tail Bat	1 3		Resident
	Taphozous georgianus	Common Sheath-tail Bat	1 2 3		**Resident**
Molossidae (Free-tail Bats)					
	Chaerephon jobensis	Greater Northern Free-tail Bat	1		Resident
	Mormopterus beccarii	Beccari's Free-tail Bat	1		Resident
Vespertilionidae (Vespertilionid Bats)					
	Chalinolobus gouldii	Gould's Wattled Bat	1 3		Resident

	Nyctophilus arnhemensis	Arnhem Land Long-eared Bat	3		Irregular Visitor
	Nyctophilus geoffroyi	Lesser Long-eared Bat	1 3		Resident
	Scotorepens greyii	Little Broad-nosed Bat	1 3		Resident
	Vespadelus finlaysoni	Finlayson's Cave Bat	1 2 3		**Resident**
Leporidae (Rabbits)					
	Oryctolagus cuniculus	European Rabbit	4	Int	Resident
Canidae (Dogs and Foxes)					
	Vulpes vulpes	Red Fox	1 3 4	Int	Irregular Visitor
	Canis lupus	Dingo/dog	1 4	Int	Resident
Felidae (Cats)					
	Felis catus	Cat	1 3 4	Int	**Resident**
Equidae (Horses)					
	Equus caballus	Horse	3	Int	Irregular Visitor
Bovidae (Horned ruminants)					
	Bos taurus	European Cattle	1 3	Int	**Resident**

Appendix 7. Species recorded in the field investigations.

Litoria rubella. In camp.
Gehyra sp. Strongly spotted but in variagata group. Seen on rocks at Whim Creek pit.
Gehyra punctata. Motion cameras.
Ctenophorus caudicinctus. Seen regularly along tracks on gravelly and rocky soils. One hatchling seen.
Gemmatophora longirostris. Abundant along creeklines with small eucalypts. About four seen in 50m.
Ctenotus robustus. Motion cameras.
Varanus giganteus. Motion cameras.
Varanus panoptes. Hatchling seen along Balla Balla Creek near Whim Creek pit (8/04).

1. Australasian Grebe. Four in Whim Creek pit (7/04).
2. Spinifex Pigeon. Seen regularly throughout in groups of up to about 10 birds.
3. Crested Pigeon. Two seen at Mons Cupri (7/04).
4. Peaceful Dove. Heard along Balla Balla Creek.
5. Galah. Flock of about 10 about 2km east of Whim Creek pit (8/04).
6. Budgerigar. Small groups (5-10 birds) foraging on flats about 2km east of Whim Creek it (8/04).
7. Nankeen Kestrel. Pair in Mons Cupri pit.
8. Brown Falcon. One about 2km east of Whim Creek pit (8/04).
9. Spotted Harrier. One near highway just east of Whim Creek Hotel (8/04).
10. Whistling Kite. Motion Camera.
11. Wedge-tailed Eagle. One adult (very black) perched on top of rocky hill about 2km east of Whim Creek pit (8/04).
12. Spotted Nightjar. One flushed along minor creekline at Mons Cupris.
13. Owlet-nightjar. Several heard just after sunset at Whim Creek pit (7/04).
14. Bush Stone-curlew. Fresh tracks close to Balla Balla Creek about 2km east of Whim Creek pit (8/04).
15. Rainbow Bee-eater. Few along Balla Balla Creek near Whim Creek pit.
16. Tree Martin. About 10 foraging around offices.
17. Singing Honeyeater. Seen regularly in acacia shrubland throughout.
18. Grey-headed Honeyeater. Seen regularly in acacia shrubland throughout.
19. White-plumed Honeyeater. Common along creeklines with eucalypts.
20. Willie Wagtail. Pair around camp.

21. Magpie-lark. One seen near camp.
22. Black-faced Cuckoo-shrike. Pairs seen at Mons Cupri and Whim Creek.
23. Black-faced Woodswallow. Few on power lines near camp.
24. Western Bowerbird. One near Mons Cupri (7/04).
25. Zebra Finch. Flocks of 5-10 birds regularly near camp.
26. Painted Finch. Several along Balla Balla Creek.
27. Pied Butcherbird. Singles and pairs seen regularly along creeklines throughout.
28. Australian Magpie. Motion Cameras.
29. Torresian Crow. One and occasionally two birds seen; little calling but most likely Torresian based on what was heard. Several caught on camera.
30. Spinifexbird. One seen in dense spinifex at Mons Cupri (7/04).
31. Singing Bushlark. Seen occasionally on flats.

Northern Quoll. Reported to have been abundant round camp and workshops two years previously, when there was more human activity, more lights, more insects and more food scraps (Billy-Joe and Daniel pers. comm.). Track a few weeks old at Whim Creek. Multiple records on cameras.
Woolley's False Antechinus. Motion Camera.
Euro. Dead animal at Mons Cupri and one seen active at Whim Creek. One sheltering in Ghost Bat adit at Mons Cupri and a dead animal in a nearby adit.
Rothschild's Rock Wallaby. Motion Cameras.
Common Rock Rat. Motion cameras.
Feral Cat. Motion Cameras.
Cattle. Motion Cameras.
Bats in small breakaway cave at Mon Cupri. A small species such as *Vespedalus.* Confirmed *Vespadelus finlaysoni* from bat detector.
Taphozous ?georgianus. About 10 roosting in adit north of Mons Cupri (8/04).
Macroderma gigas. Four roosting in adit north of Mon Cupri (8/04).

Appendix 8. Species returned from the literature review that have been omitted from the expected species list because of habitat or range limitations.

Note that some birds (particularly waterbirds) could still occur as extremely rare vagrants.

UNLIKELY	
FISH	
Eucrossorhinus dasypogon	Tasselled Wobbegong
REPTILES	
Caretta caretta	Loggerhead Turtle
Chelonia mydas	Green Turtle
Dermochelys coricea	Leatherback Turtle
Eretmochelys imbricata	Hawksbill Turtle
Natator depressus	Flatback Turtle
Ramphotyphlops braminus	Flowerpot Blind Snake
BIRDS	
Anhinga novaehollandiae	Australasian Darter
Pelecanus conspicillatus	Australian Pelican
Phalacrocorax sulcirostris	Little Black Cormorant
Phalacrocorax varius	Pied Cormorant
Chlidonias hybrida	Whiskered Tern
Chroicocephalus novaehollandiae	Silver Gull
Gelochelidon nilotica	Gull-billed Tern
Hydroprogne caspia	Caspian Tern
Onychoprion anaethetus	Bridled Tern
Sterna dougallii	Roseate Tern
Sterna hirundo	Common Tern
Sternula albifrons	Little Tern
Sternula nereis nereis	Fairy Tern
Thalasseus bergii	Crested Tern
Haematopus fuliginosus	Sooty Oystercatcher
Pluvialis squatarola	Grey Plover
Actitis hypoleucos	Common Sandpiper
Arenaria interpres	Ruddy Turnstone
Calidris acuminata	Sharp-tailed Sandpiper
Calidris alba	Sanderling
Calidris canutus	Red Knot
Calidris ferruginea	Curlew Sandpiper
Calidris melanatos	Pectoral Sandpiper
Calidris ruficollis	Red-necked Stint

UNLIKELY	
Calidris subminuta	Long-toed Stint
Calidris tenuirostris	Great Knot
Limicola falcinellus	Broad-billed Sandpiper
Limosa lapponica	Bar-tailed Godwit
Limosa limosa	Black-tailed Godwit
Numenius madagascariensis	Eastern Curlew
Numenius minutus	Little Curlew
Numenius phaeopus	Whimbrel
Tringa brevipes	Grey-tailed Tattler
Tringa glareola	Wood Sandpiper
Tringa nebularia	Greenshank
Tringa stagnatilis	Marsh Sandpiper
Xenus cinereus	Terek Sandpiper
Rostratula australis	Australian Painted-snipe
Rostratula benghalensis	Painted-snipe
Glareola maldivarum	Oriental Pratincole
Ardenna pacifica	Wedge-tailed Shearwater
Pavo cristatus	Indian Peafowl
Pachycephala melanura	Mangrove Golden Whistler
Rhipidura phasiana	Mangrove Grey Fantail
Eopsaltria pulverulenta	Mangrove Robin
Motacilla cinerea	Grey Wagtail
Motacilla flava	Yellow Wagtail
MAMMALS	
Camelus dromedarius	Camel
Equus asinus	Donkey

Appendix 9. Conservation significant invertebrate fauna species expected to occur in the Pilbara management region (as per DBCA 2019, 2020), including conservation status and likely residency status in the project area.

Status codes:

CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.

EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory, Mar = Marine (see Appendix 2).

Biodiversity Conservation Act 2016 listings: S1 to S7 = Schedules 1 to 7 (see Appendix 2).

DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 2).

Species *immediately* considered as unlikely to occur in the project area are listed in grey font.

Other exclusions (plain black text) followed spatial analysis of current records.

Expected species are highlighted.

Species	Common Name	Status	Expected Occurrence
Antichiropus sp. 'DIP004'	Roy Hill Antichiropus millipede	CS2 (P1)	Absent. Restricted to Roy Hill area (c. 90 km NE of Newman) and nearby (WAM 2021a). Project area more than 300 km outside of the species' known range.
Antichiropus sp. 'DIP005'	Abydos Antichiropus millipede	CS2 (P1)	Absent. Restricted to Abydos Plain (near Marble Bar) and nearby (WAM 2021b). Project area more than 200 km outside of the species' known range.
Antichiropus sp. 'DIP006'	Area C Antichiropus millipede	CS2 (P1)	Absent. Restricted to Area C (c. 80 km NW of Newman) and nearby (WAM 2021c). Project area more than 200 km outside of the species' known range.
Antichiropus sp. 'DIP007'	Bond's Antichiropus millipede	CS2 (P1)	Absent. Restricted to Area C (c. 80 km NW of Newman) and nearby (WAM 2021d). Project area more than 200 km outside of the species' known range.
Antichiropus sp. 'DIP008'	Flinders Antichiropus millipede	CS2 (P1)	Absent. Restricted to Flinders (c. 100 km NW of Tom Price) and nearby (WAM 2021e). Project area more than 100 km outside of the species' known range.

Species	Common Name	Status	Expected Occurrence
Antichiropus sp. 'DIP013'	Cloudbreak Antichiropus millipede	CS2 (P1)	Absent. Restricted to Cloudbreak area (WAM 2021f). Project area more than 200 km outside of the species' known range.
Antichiropus sp. 'DIP029'	Mt Bruce Antichiropus millipede	CS2 (P1)	Absent. Restricted to Mt Bruce area (near Tom Price) and nearby (WAM 2021g). Project area more than 200 km outside of the species' known range.
Antipodogomphus hodgkini	Pilbara dragonfly (Pilbara Dragon)	CS2 (P3)	Probably absent. Restricted to the "the Millstream area of Western Australia" (Hawking 1999; Theischinger and Hawking 2012).
Bamazomus subsolanus	eastern Cape Range bamazomus	CS1 (S2)	Absent. Restricted to the "eastern side of Cape Range peninsula" (Harvey 2001). Project area more than 400 km outside of the species' known range.
Bamazomus vespertinus	western Cape Range bamazomus	CS1 (S2)	Absent. Restricted to the "the western side of Cape Range peninsula" (Harvey 2001). Project area more than 400 km outside of the species' known range.
Bogidomma australis	Barrow Island bogidomma amphipod	CS1 (S3)	Absent. Restricted to Barrow Island. Project area more than 200 km outside of the species' known range.
Bunderia misophaga	a copepod (Bundera Sinkhole)	CS1 (S1)	Absent. Restricted to the Bundera sinkhole, on the south-western coastline of the Cape Range peninsula (Jaume and Humphreys 2001). Project area more than 400 km outside of the species' known range.
Draculoides bramstokeri	Barrow Island draculoides	CS1 (S3)	Absent. Restricted to Barrow Island (Harvey *et al.* 2008). Project area more than 200 km outside of the species' known range.
Draculoides brooksi	northern Cape Range draculoides	CS1 (S2)	Absent. Restricted to "the north-eastern portion of Cape Range Peninsula" (Harvey 2001; Harvey *et al.* 2008).

Species	Common Name	Status	Expected Occurrence
			Project area more than 400 km outside of the species' known range.
Draculoides julianneae	western Cape Range draculoides	CS1 (S2)	Absent. Restricted to "the western edge of Cape Range Peninsula" (Harvey 2001; Harvey *et al.* 2008). Project area more than 400 km outside of the species' known range.
Draculoides mesozeirus	Middle Robe draculoides	CS1 (S3)	Absent. Restricted to middle of Robe Valley. Project area more than 100 km outside of the species' known range.
Dupucharopa millestriata	Depuch Island charopid land snail	CS2 (P2)	Probably absent. Restricted to Depuch Island (and nearby islands?).
Ideoblothrus linnaei	Linnaeus' pseudoscorpion (Mesa A)	CS2 (P1)	Absent. Restricted to Mesa A and nearby. Project area more than 200 km outside of the species' known range.
Ideoblothrus sp. 'Mesa A' (WAM T81374)	an Ideoblothrus pseudoscorpion (Mesa A)	CS2 (P1)	Absent. Restricted to Mesa A and nearby. Project area more than 200 km outside of the species' known range.
Indohya damocles	Cameron's Cave pseudoscorpion	CS1 (S1)	Absent. Restricted to Camerons Cave, near the Exmouth townsite, on the Cape Range peninsula (Harvey and Volschenk 2007). Project area more than 400 km outside of the species' known range.
Kumonga exleyi	Cape Range remipede	CS1 (S1)	Absent. Restricted to the Bundera sinkhole, on the south-western coastline of the Cape Range peninsula (Black *et al.* 2001). Project area more than 400 km outside of the species' known range.
Lagynochthonius asema	Mesa A Lagynochthonius pseudoscorpion	CS2 (P1)	Absent. Restricted to Mesa A and nearby. Project area more than 200 km outside of the species' known range.
Liagoceradocus branchialis	Cape Range liagoceradocus amphipod	CS1 (S2)	Absent. Restricted to the Bundera sinkhole, on the south-western coastline of the Cape Range peninsula (Bradbury

Species	Common Name	Status	Expected Occurrence
			and Williams 1996). Project area more than 400 km outside of the species' known range.
Liagoceradocus subthalassicus	Barrow Island liagoceradocus amphipod	CS1 (S3)	Absent. Restricted to Barrow Island. Project area more than 200 km outside of the species' known range.
Nedsia chevronia	Chevron's freshwater amphipod (Barrow Island)	CS2 (P2)	Absent. Restricted to Barrow Island. Project area more than 200 km outside of the species' known range.
Nedsia fragilis	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 200 km outside of the species' known range.
Nedsia humphreysi	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 200 km outside of the species' known range.
Nedsia hurlberti	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 200 km outside of the species' known range.
Nedsia macrosculptilis	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 200 km outside of the species' known range.
Nedsia sculptilis	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 200 km outside of the species' known range.
Nedsia straskraba	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 200 km outside of the species' known range.

Species	Common Name	Status	Expected Occurrence
Nedsia urifimbriata	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 200 km outside of the species' known range.
Nocticola flabella	Cape Range blind cockroach, Cape Range delicate cockroach	CS2 (P4)	Absent. Restricted to "Cape Range" (Roth 1991). Project area more than 400 km outside of the species' known range.
Nososticta pilbara	Pilbara threadtail	CS2 (P2)	Probably absent. Restricted to "only the oasis of permanent waters, fed by the Millstream aquifer, along the Fortescue River in the Pilbara region of Western Australia" (Watson and Theischinger 1984; Hawking 1999).
Paradraculoides anachoretus	Mesa A paradraculoides	CS1 (S3)	Absent. Restricted to Mesa A and nearby (Harvey *et al.* 2008). Project area more than 200 km outside of the species' known range.
Paradraculoides bythius	Mesa B/C paradraculoides	CS1 (S3)	Absent. Restricted to Mesa B/C and nearby (Harvey *et al.* 2008). Project area more than 200 km outside of the species' known range.
Paradraculoides gnophicola	Mesa G paradraculoides	CS1 (S3)	Absent. Restricted to Mesa G and nearby (Harvey *et al.* 2008). Project area more than 200 km outside of the species' known range.
Paradraculoides kryptus	Mesa K paradraculoides	CS1 (S3)	Absent. Restricted to Mesa K and nearby (Harvey *et al.* 2008). Project area more than 200 km outside of the species' known range.
Prionospio thalanji	Bundera Sinkhole worm	CS1 (S1)	Absent. Restricted to the Bundera sinkhole, on the south-western coastline of the Cape Range peninsula (Wilson and Humphreys 2001). Project area more than 400 km outside of the species' known range.

Species	Common Name	Status	Expected Occurrence
Speleophria bunderae	a copepod (Bundera Sinkhole)	CS1 (S1)	Absent. Restricted to the Bundera sinkhole, on the south-western coastline of the Cape Range peninsula (Jaume *et al.* 2001). Project area more than 400 km outside of the species' known range.
Speleostrophus nesiotes	Barrow Island millipede	CS1 (S3)	Absent. Restricted to Barrow Island. Project area more than 200 km outside of the species' known range.
Stygiocaris lancifera	lance-beaked cave shrimp	CS1 (S3)	Absent. Restricted to the "western side" of Cape Range (Knott 1993; Page *et al.* 2008). Project area more than 400 km outside of the species' known range.
Stygiocaris stylifera	spear-beaked cave shrimp	CS2 (P4)	Absent. Restricted to the "eastern side" of Cape Range (with some sympatric sites with S. *lancifera* on the northwest of the peninsula), and Barrow Island (Knott 1993; Page *et al.* 2008). Project area more than 400 km outside of the species' known range.
Stygiochiropus isolatus	a stygiochiropus millipede (Cape Range)	CS1 (S3)	Absent. Restricted to Camerons Cave and Loop Cave, near the Exmouth townsite, on the Cape Range peninsula (Humphreys and Brooks 2015). Project area more than 400 km outside of the species' known range.
Stygiochiropus peculiaris	Cameron's Cave millipede	CS1 (S1)	Absent. Restricted to Camerons Cave, near the Exmouth townsite, on the Cape Range peninsula (Shear and Humphreys 1996). Project area more than 400 km outside of the species' known range.
Stygiochiropus sympatricus	a stygiochiropus millipede (Cape Range)	CS1 (S3)	Absent. Restricted to a single cave on the north-west of the Cape Range peninsula (Humphreys and Adams 1993; Shear and Humphreys 1996). Project area more than 400 km outside of the species' known range.

Species	Common Name	Status	Expected Occurrence
Stygocyclopia australis	a copepod (Bundera Sinkhole)	CS1 (S1)	Absent. Restricted to the Bundera sinkhole, on the south-western coastline of the Cape Range peninsula (Jaume *et al.* 2001). Project area more than 400 km outside of the species' known range.
Tyrannochthonius sp. 'Mesa A' (WAM T81480)	a Tyrannochtonius pseudoscorpion (Mesa A)	CS2 (P1)	Absent. Restricted to Mesa A and nearby. Project area more than 200 km outside of the species' known range.
Welesina kornickeri	Kornicker's Bundera Sinkhole ostracod	CS1 (S1)	Absent. Restricted to the Bundera sinkhole, on the south-western coastline of the Cape Range peninsula (Iglikowska and Boxshall 2013). Project area more than 400 km outside of the species' known range.