NOVEMBER 2013

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POLARIS METALS PTY LTD

J4 MINE AND HAUL ROAD

TERRESTRIAL AND SUBTERRANEAN FAUNA ASSESSMENT

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ACRONYMS

BoM	Bureau of Meteorology
CAMBA	China-Australia Migratory Bird Agreement
DEC	Department of Environment and Conservation (now DPaW)
DNA	Deoxyribonucleic acid
DPaW	Department of Parks and Wildlife (formerly DEC)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
JAMBA	Japan-Australian Migratory Bird Agreement
NHMRC	National Health and Medical Research Centre
SAC	Species Accumulation Curve
SRE	Short range endemic
WC Act	*Wildlife Conservation Act 1950*

EXECUTIVE SUMMARY

Polaris Metals Pty Ltd commissioned *ecologia* Environment to conduct a Level 2 terrestrial and subterranean fauna survey of the J4 mine and haul road project. This included a two-phase trapping survey for terrestrial vertebrate fauna, a two-phase (Level 2) troglofauna survey, a stygofauna Level 1 study and a single-phase epigean short range endemic (SRE) invertebrate fauna survey.

The J4 mine and haul road (impact area) was assessed and surveyed concurrently with sites in the Helena Aurora Range (the impact area) to provide additional information about the distribution of species recorded from inside the impact area.

This assessment was separated into the following areas:

1. Impact area: J4 deposit area and associated haul road (M77/1242;L77/250;L77/252;L77/254);
2. Survey area: surrounding tenements (E77/1076, E77/1097, E77/1542, E77/1076, E77/1589, E77/842, E77/919, E77/1099, E77/919, E77/1420, E77/1740, E77/1589, M77/1095, M77/1097, E77/1739, E77/842, M77/1095 and M77/1096); and
3. Local region (within 100 km of survey area).

All survey methods are consistent with following guidelines:

- *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment*;
- EPA Guidance Statement No. 20: *Sampling of Short range endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009);
- Guidance Statement No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004);
- Environmental Assessment Guideline No. 12: *Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia* (EPA 2013);
- Guidance Statements 54a: *Guidance for the Assessment of Environmental Factors* (EPA 2007); and
- EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002).

The key outcomes and results of the assessments are as follows:

- Six habitat types were recorded from within the survey area: rocky ridge, Mallee woodland on rocky plain and footslopes, mixed eucalypt woodland, sandy plain with shrubland, drainage line, and seasonal swamp. Of these, five habitat types (rocky ridge, Mallee woodland on rocky plain and footslopes, mixed eucalypt woodland, sandy plain with shrubland and drainage line) are present within the J4 impact area. The seasonal swamp was only recorded from the north-east of the survey area and does not exist within the impact area.
- Database searches and the consultation of eight publications reporting on vertebrate fauna identified a total of 41 species of native mammal, nine species of introduced mammal, 213 species of native bird, three species of introduced bird, 111 species of reptile and 19 species of amphibian that have been recorded from the local region. Of these, 41 vertebrate species of conservation significance were recorded in the local region and therefore could potentially occur within the J4 impact area and survey area: six mammals, 33 bird and two reptile species. A presumably extinct species (Lesser Stick-nest Rat) was excluded.

- Database searches and the consultation of four troglofauna assessment reports, three SRE reports and four stygofauna reports identified a total of 305 terrestrial invertebrate species from the local region, of which 29 represent potential SRE species, one stygobitic species (*Harpacticoida* sp.) and a total of 19 troglobitic species, all potentially representing short range endemics.
- During the current survey, a total of 10 native and two introduced mammal species, 46 bird and 28 reptile species were recorded from the J4 impact area. In addition, seven native and one introduced mammal species, 44 bird species, 20 reptile species and two species of frog were recorded from the survey area (outside the J4 impact area). Thus a total of 17 native and three introduced species of mammal, 90 species of bird, 48 species of reptile and two species of amphibian were recorded during the current assessment.
- Four species of conservation significance were sighted within the impact area: Crested Bellbird, Shy Heathwren, Major Mitchells' Cockatoo and Rainbow Bee-eater. In addition, the Malleeffowl was recorded through secondary evidence (fresh tracks & old mounds) within the impact area. The Fork-tailed Swift and Peregrin Falcon were recorded outside the impact area. In addition, secondary evidence of either the Australian Bustard or the Bush Stone-curlew was recorded from the survey area.
- A large number of terrestrial invertebrate species were collected during the survey. They comprised 23 morphospecies of spider (including two likely SRE, 12 potential SRE species), eleven morphospecies of scorpion (including four potential SREs), 17 morphospecies of pseudoscorpion (including 11 potential SREs), 14 morphospecies of isopod (including one confirmed SRE, seven potential SREs and two likely SRE), ten morphospecies of snail (including three potential SREs), five morphospecies of millipedes (including four confirmed SREs). One species of centipede (potential SRE) and three morphospecies of geophilomorph (including two potential SREs). Of these, one likely SRE (*Idiosoma* sp. indet) and three potential SREs (*Aname* 'MYG279', *Kwonkan* sp. indet. and `PSEAAD PSE076'), of which latter one represents a new genus and species of pseudoscorpion, were recorded from within the J4 impact area only.
- During this survey, a total of 40 potential SREs, four likely SREs and five confirmed SRE species were collected from the survey area and impact area. It is likely that the high level of short range endemism identified in the impact area is to a large part due to the low taxonomic resolution resulting from the lack of mature males in the sample. This is due to the fact that SRE are dominated by invertebrate species, which are historically understudied and in many cases lack formal descriptions. An extensive, reliable taxonomic evaluation of these species has begun only relatively recently and thus the availability of literature relevant to SREs is relatively scarce.
- Very few subterranean invertebrate species were collected during the survey. The stygofauna Level 1 study at the J4 impact area, comprising sampling of nine bore holes, resulted in no stygofauna records. Five troglobitic morphospecies were collected from the J4 impact area during the Level 2 troglofauna sampling.

1 INTRODUCTION

1.1 PROJECT BACKGROUND

Polaris Metals Pty Ltd (Polaris) operates the Carina Iron Ore mine, 130 km west of Kalgoorlie at a rate of 4 Million tonnes per annum (Mtpa). To expand the life of the mine, Polaris intends to develop the J4 deposit and utilise of the existing processing facilities and rail siding of the Carina mine (Figure 1.1).

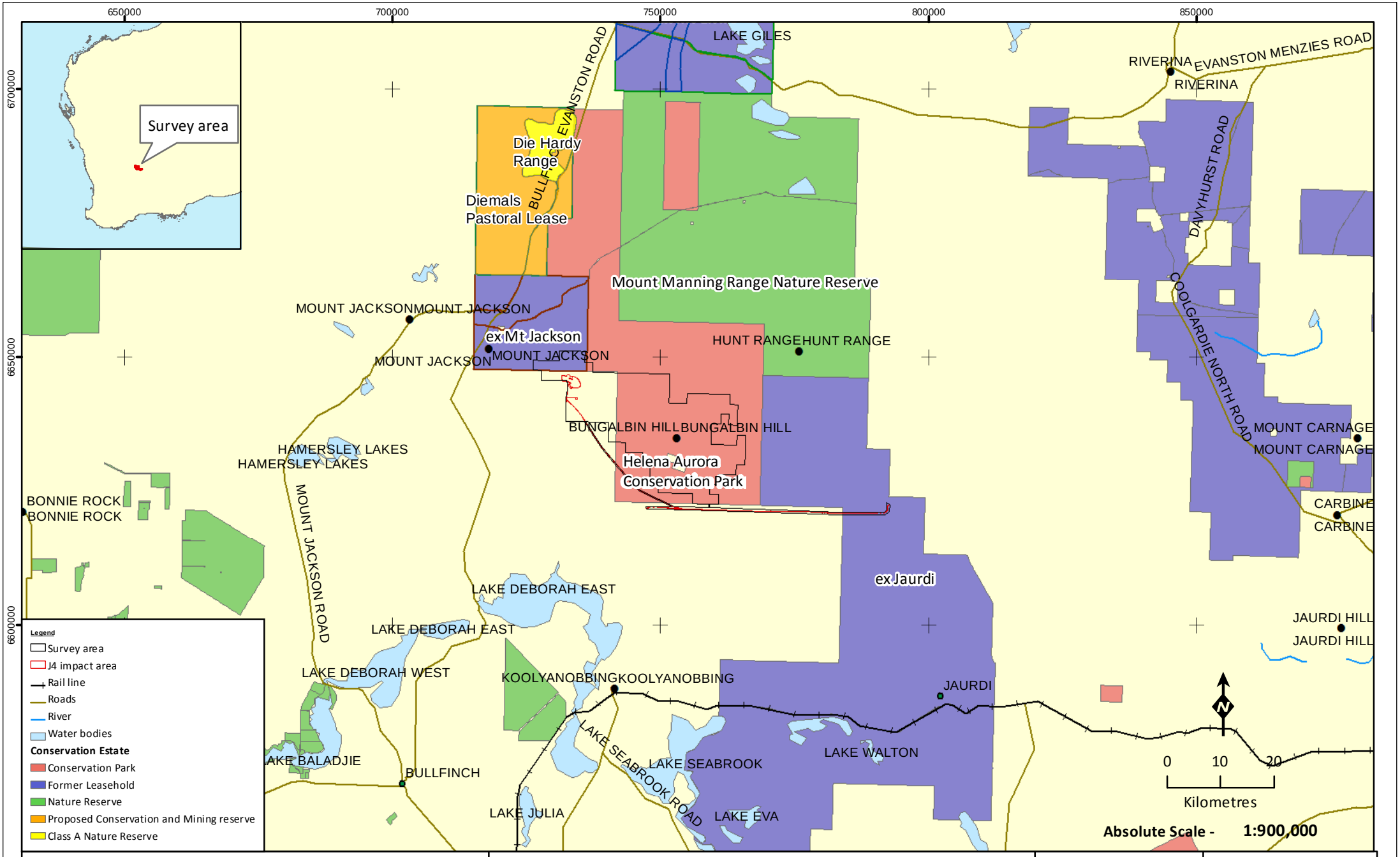
The impact area is located approximately 100 km north of Southern Cross and approximately 180 km west of Kalgoorlie, Western Australia.

The J4 mine and haul road (impact area) was assessed and surveyed concurrently with sites in the Helena Aurora Range (the impact area) to provide additional information about the distribution of species recorded from inside the impact area.

This assessment is separated into the following two areas:

1. Impact area: J4 deposit area and associated haul road (M77/1242;L77/250;L77/252;L77/254 and
2. Survey area: surrounding tenements E77/1076, E77/1097, E77/1542, E77/1076, E77/1589, E77/842, E77/919, E77/1099, E77/919, E77/1420, E77/1740, E77/1589, M77/1095, M77/1097, E77/1739, E77/842, M77/1095 and M77/1096.
3. Local region (within 100 km of survey area).

The survey area supports the assessment based on regional data and local populations recorded from within the impact area.



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Location of the survey area

Figure: 1.1
Project ID: 1479

Drawn: AH
Date: 20/11/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

A4

1.2 LEGISLATION AND POLICY

The *Environmental Protection Act 1986* (EP Act) is "an Act to provide for an Environmental Protection Authority, for the prevention, control and abatement of environmental pollution, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing." Section 4A of this Act outlines five principles that are required to to ensure that the objectives of the Act are addressed. Three of these principles are relevant to native fauna and flora:

- *The Precautionary Principle*

  Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

- *The Principle of Intergenerational Equity*

  The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

- *The Principle of the Conservation of Biological Diversity and Ecological Integrity*

  Conservation of biological diversity and ecological integrity should be a fundamental consideration.

In addition to these principles, projects undertaken as part of the Environmental Impact Assessment (EIA) process are required to address guidelines produced by the Environmental Protection Authority (EPA), in this case principles outlined in following guidelines:

- EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002);
- *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010)*;*
- Guidance for the Assessment of Environmental Factors, Statement No. 20: *Sampling of Short range endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009);
- Guidance for the Assessment of Environmental Factors, Statement No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004);
- Environmental Assessment Guideline No. 12: *Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia* (EPA 2013); and
- Guidance for the Assessment of Environmental Factors, Statement No. 54a (Technical Appendix to Guidance Statement no. 54): Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia (EPA 2007).

In relation to terrestrial short range endemic (SRE) fauna, the EPA Guidance Statement No. 56 states that:

> *"Comprehensive systematic reviews of different faunal groups often reveal the presence of short range endemic species (Harvey 2002). Among the terrestrial fauna there are numerous regions that possess short range endemics. Mountainous terrains and freshwater habitats often harbour short range endemics, but the widespread aridification and forest contraction that have occurred since the Miocene has resulted in the fragmentation of populations and the evolution of many new species. Particular attention should be given to these types of species in environmental impact assessment because habitat loss and degradation will further decrease their prospects for long-term survival."*

The State is committed to the principles and objectives for the protection of biodiversity as outlined in *The National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth Government 1996).

Native flora and fauna formally recognised as rare, threatened with extinction, or as having high conservation value are protected at a Commonwealth level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and at a state level under the *Wildlife Conservation Act 1950* (WC Act).

The EPBC Act also takes into consideration four international agreements related to migratory species which include the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), the Japan-Australian Migratory Bird Agreement, the China-Australia Migratory Bird Agreement and the Republic of Korea-Australian Migratory Bird Agreement.

The EPBC Act provides for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance, to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources, and to promote the conservation of biodiversity. The EPBC Act includes provisions to protect native species (and in particular to prevent the extinction and promote the recovery of threatened species) and to ensure the conservation of migratory species. In addition to the principles outlined in Section 4A of the EPBC Act, Section 3A includes a principle of ecologically sustainable development dictating that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. Schedule 1 of the EPBC Act contains a list of species that are considered Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable and Conservation Dependent. Definitions of categories relevant to fauna occurring or potentially occurring in the project area are provided in Appendix A.

The Western Australian WC Act provides for the conservation and protection of wildlife in Western Australia. Under Section 14 of this Act, all flora and fauna within Western Australia is protected; however, the Minister may, via a notice published in the *Government Gazette*, declare a list of fauna identified as rare, likely to become extinct, or otherwise in need of special protection (Appendix A). These species are considered Threatened Fauna. The current listing was gazetted on 17 September 2013.

In addition, the Department of Parks and Wildlife (DPaW), maintains a ranked list of specially protected fauna, which includes Threatened Fauna and Priority Fauna. These rankings dictate which species should receive the highest priority for conservation management. Threatened fauna that are listed as Schedule 1 under the WC Act are further ranked by the DPaW according to their level of threat using IUCN Red List categories and criteria. Schedule 1 species can be ranked as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU).

Priority Fauna are placed into five categories. The first three Priority Fauna categories are species that have not yet been adequately surveyed to be listed under Schedule 1 or 2, and are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna. Species that are adequately known and are rare but not threatened, meet IUCN criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Species meeting criteria for the IUCN category of Conservation Dependent are placed in Priority 5. The three Threatened Fauna codes and five Priority codes are also summarised in Appendix A.

Some better known SRE species are listed as threatened or endangered under State or Commonwealth legislation in the WC Act and/or EPBC Act, but the majority are not. Often the lack of knowledge about these species precludes their consideration for listing as threatened or

endangered. Listing under legislation should therefore not be the only conservation consideration in environmental impact assessment.

1.3 SURVEY OBJECTIVES

Polaris commissioned *ecologia* Environment (*ecologia*) to undertake a comprehensive survey of the terrestrial and subterranean fauna of the J4 impact area to facilitate the EIA of the project. Faunal groups assessed include vertebrate fauna, terrestrial epigean SRE invertebrate fauna, troglofauna and stygofauna.

The aim of this study was to document and describe the fauna of the impact area and provide sufficient information to enable an assessment of the impact of the project on fauna populations, .

This report satisfies the requirements of relevant EPA Guidance documents by providing:

- a review of background information (including literature and database searches);
- an inventory of fauna species occurring in the impact area, incorporating recent published and unpublished records;
- a discussion related to the species of biological and conservation significance recorded or likely to occur within the project area and the surrounding region;
- a description of fauna habitats occurring in the impact area;
- a description of the characteristics of the invertebrate and vertebrate fauna assemblage;
- an appraisal of the current knowledge base for the area, including a review of previous surveys conducted in the area that are relevant to the current study; and
- a review of regional and biogeographical significance, including the conservation status of species recorded in the impact area.

1.4 BACKGROUND SUMMARY OF FAUNAL GROUPS

1.4.1 Terrestrial Fauna

1.4.1.1 Terrestrial Vertebrate Fauna

Australia's terrestrial vertebrate fauna assemblages are dominated by reptiles (917 species), birds (828 species), amphibians (227 species), and mammals (386 species); which in turn are dominated by marsupials, bats, and rodents (Chapman 2009). The majority (80%) of Australia's terrestrial vertebrate fauna are endemic to Australia, with many species endemic to small areas or regions. The cause of this high level of endemism is attributed to Australia's long period of geographic isolation after the break up of Gondwana.

Australia's vertebrate fauna, in particular mammal and bird species, have experienced a high rate of decline and extinction over the last two hundred years (Johnson 2006) with approximately thirty species of mammals and birds becoming extinct and a further 57 species of mammals, birds, reptiles, frogs and fish, many hundreds of species of invertebrate considered endangered and likely to become extinct in near future.

Changes in fire regime and the introduction of feral animals, such as the Fox and the Cat resulted in a decrease and the extinction of several species (Short and Smith 1994). A number of ground dwelling birds, such as the Night Parrot and the Ground Parrot, and small to medium sized mammals (Lesser Bilby and Greater Stick-nest Rat) have reduced drastically in numbers or even became extinct. With the onset of progressively more impact by human activity, already rare fauna species that are

generally restricted to a particular habitat or microhabitat, are identified and protected to preserve the existing populations within their habitat (Brown and Saunders 2013).

1.4.1.2 Terrestrial Epigean Invertebrate Fauna (Short Range Endemics)

Invertebrate fauna is characterized by the lack of a vertebral column. The vast majority of animal species are invertebrates with over 90% of all fauna belonging to species without a back bone.

Endemism refers to the restriction of species to a particular area, whether it is at the continental, national or local level (Allen *et al.* 2002). This review focuses on SREs, outlines the major paths to short range endemism, the current knowledge of short range endemism in Australia and the conservation significance of such species. It is important to note that the individual taxa and broader groups discussed are not an exhaustive list of all SREs. This is due to the fact that SRE are dominated by invertebrate species, which are historically understudied and in many cases lack formal descriptions. An extensive, reliable taxonomic evaluation of these species has begun only relatively recently and thus the availability of literature relevant to SREs is relatively scarce.

Short range endemism is influenced by numerous processes, which generally contribute to the isolation of a species. A number of factors, including the ability and opportunity to disperse, life history, physiology, habitat requirements, habitat availability, biotic and abiotic interactions, and historical conditions, influence not only the distribution of a taxon, but also the tendency for differentiation and speciation (Ponder and Colgan 2002).

Many SREs are considered to be relict taxa (remnants of species that have become extinct elsewhere) and are confined to certain habitats, and in some cases, single geographic areas (Main 1996). Relict taxa include extremely old species that can be traced back to the Gondwanan periods (180-65 million years ago) and have a very restrictive biology (Harvey 2002).

With the onset of progressively dryer and more seasonal climatic conditions since this time, suitable habitats have become increasingly fragmented in Western Australia. Relict species now generally persist in habitats characterised by permanent moisture and shade, maintained by high rainfall and/or prevalence of fog (Main 1996; Main 1999).

1.4.2 Subterranean Fauna

Subterranean fauna are characterized by the following traits (from Cho 2010):

1. High endemism but low local diversity relative to regional diversity;
2. A relatively small number of genetic lineages resulting in species dissimilar in appearance to related groups;
3. Many relicts from previous climatic conditions; and
4. Truncated food webs.

Traditionally, arid and semi-arid areas were considered poor potential habitat for subterranean fauna as these organisms are moisture-dependent (Harvey *et al.* 2008). However, recent descriptions of subterranean fauna in the arid and semi-arid zone of WA have indicated the presence of a diverse fauna, with an estimate of 4,140 subterranean taxa found in the western half of Australia (Biota 2008). A total of 403 species has been described to date and additional 367 are known but undescribed (EPA 2012). Based on this estimate, over 80% of the subterranean fauna likely to be present has not yet been documented (Biota 2008).

1.4.2.1 Troglofauna

Troglofauna are terrestrial subterranean animals that inhabit air chambers in underground caves or small, humid voids. They are divided into three ecological categories (Howarth 1983):

- troglobites, obligate underground species that are unable to survive outside their subterranean environment;
- troglophiles, facultative species that live and reproduce underground but that are also found in similar dark, humid microhabitat on surface; and
- trogloxenes, species that regularly inhabit underground caves and cavities for refuge but normally return to surface environment to feed.

A fourth group, 'accidentals', are vagrant individuals that might have wandered into a cave system but cannot survive there (Howarth 1983).

A species is considered truly troglobitic if it displays characteristics that appear to restrict it to subterranean habitats (Howarth 1983, 1993). These include a significant reduction or a complete loss of eyes, pigmentation, wings and circadian rhythm (24-hour biological cycle), as well as development of elongated appendages, slender body form and, in some species, a lower metabolism.

True troglobites are often spatially restricted because they are incapable of dispersing on the surface. Troglobitic species have extremely limited capacity for dispersal and are typically isolated within the extent of their habitat. Such dispersal limitations result in extremely small, fragmented species ranges and high levels of endemism (EPA 2003), and are a typical characteristic of subterranean fauna worldwide(Strayer 1994).

The presence of troglofauna in Western Australia is still poorly documented. To date, troglofauna have been recorded from karst limestone systems at Cape Range, Barrow Island and in the Kimberley (Biota 2005; Harvey 1988; Humphreys 2001), pisolitic mesa formations in the Pilbara (Biota 2006) and in the cave systems of Yanchep (EPA 2005), Margaret River (Eberhard 2006) and across the Nullarbor (Moore 1995).

1.4.2.2 Stygofauna

Stygofauna are generally thought of as fauna that live in subterranean water, however they are composed of three groups that relate to the species affinity with the groundwater. Stygofauna occurring in groundwater are either accidentals (termed stygoxenes) or with varying degrees of affinity for groundwater, inhabiting it on a permanent or temporary basis (termed stygophiles), but only stygobites are obligate inhabitants of groundwater (Gilbert *et al.* 1994)..

The subterranean environment is devoid of light, may have restricted available space (i.e. porous or fissured rock) and has a relatively constant temperature. These species have evolved unique features such as a lack of pigmentation, elongated appendages, filiform body shape (worm like) and reduced or absent eyes. Many species are believed to be relict taxa with affinities with Tethys, Pangea and derived landmasses (Danielopol and Stanford 1994; Humphreys 1993, 1999, 2001; Knott 1993).

Stygofauna are known to be present in the groundwater associated with a variety of geologies. These include (but are not limited to) calcrete aquifers associated with palaeochannels, haematite sandstone aquifers (e.g. Koolan Island), clay-sandstone aquifers on the Swan and Scott Coastal Plains (ecologia 1998, 2006a, b; Humphreys 2001; Rockwater 2006), porous aquifers (e.g. alluvium) (Mamonier *et al.* 1993), fractured-rock aquifers, springs and hyporheic habitats (Eberhard *et al.* 2005). However, distribution patterns of stygofauna are determined by hydrogeological aquifer types rather than by affiliation of aquifers to a given geological unit. Two main types of aquifer relevant for stygofauna have been defined by Hahn and Fuchs (2009):

1. Compact aquifers (aquitard), comprise materials such as clay, loess, and very fine sands, as well as compact rocks, which have reduced pore spaces and thus a low hydraulic conductivity

(kf < 10 -6 m sec-1). Exchange with surface water for food and oxygen supply is reduced and living space is minimal in this type of aquifer, which is why these aquifers are either devoid of fauna or have depleted taxonomic richness and abundance.

2. Open aquifers, comprise of porous, fractured and karstic groundwater circulation systems with at least moderate hydraulic conductivity (kf > 10 -6 m sec-1). There is continuous exchange with surface water for food and oxygen supply and more abundant living space, which is why stygofauna communities are often found in this aquifer type (Hahn and Fuchs 2009). In addition, communities of porous and karstic aquifers have been found to be more similar to each other than the communities of compact and fractured aquifers (Hahn and Fuchs 2009).

Stygofauna are found in oxygenated groundwater, usually ranging from fresh to hyposaline, but they can occur in salinities up to seawater (EC = 54,000 µS/cm) (Humphreys 1999). Recent experience west of Lake Way near Wiluna has recently shown that palaeochannel aquifers with an EC of 60,000uS/cm can harbour diverse and abundant stygal assemblages (*ecologia* 2006a).

The presence of stygofauna in Western Australia has been well documented, especially from regions such as the Pilbara and Kimberley, and less so in the Midwest and South West regions of WA (Cho *et al.* 2005; De Laurentiis *et al.* 2001; Eberhard 2004; Humphreys 2001; Karanovic 2004; Wilson and Keable 2002). Australian stygofauna is dominated by crustaceans including Amphipoda (Bradbury and Williams 1997), Isopoda (Wilson 2001), Ostracoda (Karanovic 2005; Karanovic and Marmonier 2002, 2003; Martens and Rossetti 2002) and Speleogriphacea (Poore and Humphreys 2003; Poore and Humphreys 1998)

2 EXISTING ENVIRONMENT

2.1 CLIMATE

The impact area is located in the Coolgardie bioregion of Western Australia. The Coolgardie region experiences an arid to semi-arid climate with four distinct seasons; a hot summer from December to February, a mild autumn from March to May followed by a cool winter from June to August in which the highest rainfall is recorded and a mild spring from September to November. Temperatures are generally high, with summer temperatures frequently reaching the mid to high 30°C.

Rainfall is localised with a varying amount of rainfall being recorded throughout the year (McKenzie *et al.* 2002). The majority of the Coolgardie bioregion has a peak bimodal rainfall distribution; from December to March rains result from tropical storms producing sporadic thunderstorms formed in the north. Tropical cyclones moving south also can bring some rain. From May to August, extensive cold fronts move eastwards across the state reaching the Coolgardie bioregion. These fronts usually produce only light rains and thunderstorms.

The nearest Bureau of Meteorology (BoM) station for which both rainfall and temperature data are available is Southern Cross (Site No. 012320), 85 km to the south of the impact area. The Southern Cross station receives a mean annual rainfall of 351.6 mm(BoM 2013a, Table 2.1). This location demonstrates a typical Coolgardie climate of hot summers with sporadic summer storms and warm dry winters (BoM 2013a)

Recent rainfall at Southern Cross was above the long-term average with the total rainfall amounting to 68.4 mm for the period commencing November 2012 and December 2012 (long-term mean for this period is 28.1 mm) (BoM 2013a).

January is the hottest month with a mean maximum temperature of 34.5 °C and mean minimum of 17.2 °C. July temperatures range from a mean maximum temperature of 16.3 °C to a mean minimum of 4.4 °C (Table 2.1).

Table 2.1 – Rainfall averages for Southern Cross weather station (BoM 2013a)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Total Monthly Rainfall (mm)													
2010	0.2	6.0	9.0	5.6	34.6	15.6	26.2	20.2	14.8	3.2	4.6	11.4	151.4
2011	44.6	73.8	9.8	13.0	18.2	18.0	40.0	37.6	19.0	82.4	8.0	91.4	455.8
2012	5.4	13.8	23.2	0.2	14.2	54.2	13.0	16.6	18.2	3.6	46.8	21.6	230.8
Mean Monthly Rainfall (mm)													
1895-2007	16.3	20.9	24.2	24.5	34.9	40.7	38.6	31.2	19.4	15.6	15.5	12.6	294.5

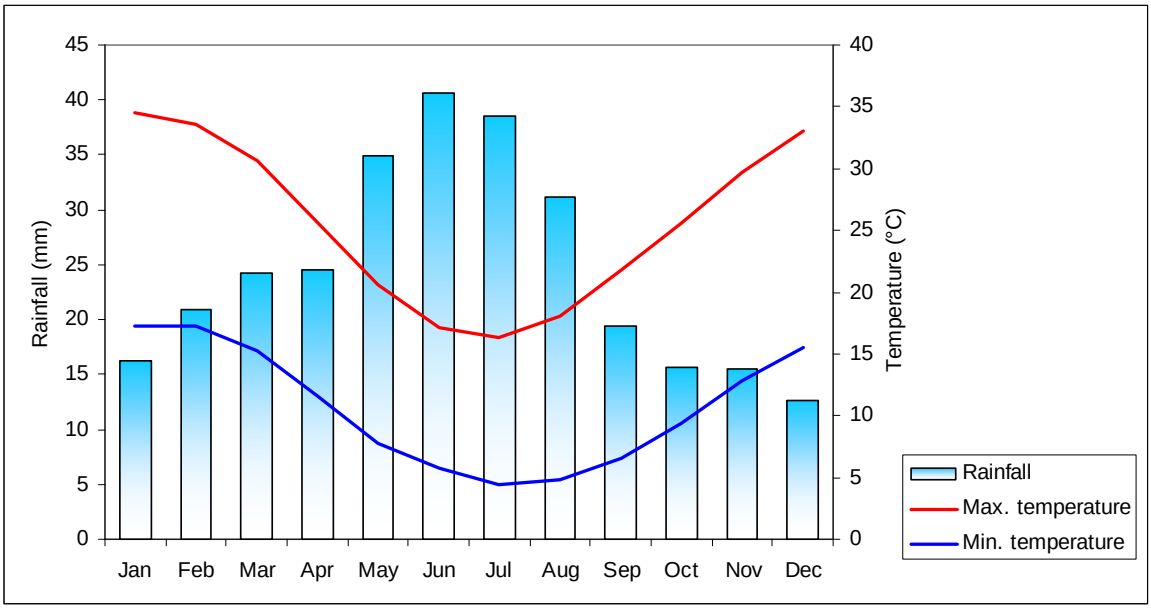

Figure 2.1 – Rainfall and temperature for the Southern Cross weather station (BoM 2013a)

2.2 BIOGEOGRAPHY, GEOLOGY AND SOILS

2.2.1 Biogeography

The J4 impact area is situated within the Coolgardie bioregion of the Interim Biogeographic Regionalisation of Australia, IBRA 7 (Australian Government Department of Sustainability 2012). The Coolgardie biogeographic region comprises three subregions: Eastern Goldfields, Southern Cross and the Mardabilla. The J4 impact area is situated in the Southern Cross subregion (Figure 2.2).

The Southern Cross subregion comprises the western section of the Yilgarn Craton. The Southern Cross subregion is comprised of gently undulating uplands dissected by broad valleys with bands of low greenstone hills. The granite strata of Yilgarn Craton are interrupted by parallel intrusions of Archaean Greenstone. Diverse *Eucalyptus* woodlands (*Eucalyptus salmonophloia*, *E. salubris*, *E. transcontinentalis*, *E. longicornis*) rich in endemic eucalypts that occur around salt lakes on the low greenstone hills, valley alluvials and broad plains of calcareous earths are characteristic of this subregion. Granite basement outcrops at mid-levels in the landscape and support swards of *Borya constricta*, with stands of *Acacia acuminata* and *Eucalyptus loxophleba*.

Upper levels in the landscape are the eroded remnants of a lateritic duricrust yielding yellow sandplains, gravelly sandplains and laterite breakaways. Mallees (*Eucalyptus leptopoda*, *E. platycorys* and *E. scyphocalyx*) and scrub-heaths (*Allocasuarina corniculata*, *Callitris preissii*, *Melaleuca uncinata* and *Acacia beauverdiana*) occur on these uplands (Cowan *et al.* 2001). The climate in this subregion is arid to semi-arid, with an average annual rainfall of 250-300 mm which is usually received in winter, although rain from isolated thunderstorms and cyclonic events in summer is not uncommon. Drainage is occluded. The area of the subregion is 70,412 km2 (Cowan *et al.* 2001).

2.2.2 Vegetation

The impact area lies within Beard's (1981) Coolgardie region of the Eremaean Botanical Province, part of a series of maps completed by Beard *et al.* from 1974 to 1981 throughout Western Australia. The vegetation mapping was subsequently reinterpreted to reflect the National Vegetation Information System (Department of Environment and Water Resources 2012) standards and revised taxonomy for some species and digitised (Shepherd *et al.* 2001), and are described in Table 2.2 and displayed in Figure 2.2.

Table 2.2 – Vegetation Association of the impact area

Shepherd Unit	Vegetation Description	Area within J4 impact area (ha)	Percentage of the J4 impact area (%)	Area within survey area (ha)	Percentage of the survey area (%)
8	Medium woodland of *Eucalyptus salmonophloia, E. salubris* and *E. longicornis* over open mixed acacia shrubland (*A. aciphylla, A. acuminate, A. brachystachya*) over Angianthus mixed open forbland (*A. tomentosus, nguillaria dioica, Podolepis gnaphalioides*)	-	-	124.09	0.2
141	Eucalypt woodland of York gum, Salmon gum and Gimlet (*Eucalyptus salmonophloia, E. loxophleba, E. salubris*) over *Acacia acuminata, Alyxia buxifolia, Choretrum* sp., *Cephalipterum drummondii, Helichrysum davenportii* and *Podolepis canescens*	1,744.37	47.1	40467.06	75.5
435	Dense shrubland of *Acacia neurophylla, A. beauverdiana* and *A. resinimarginea* thicket. *Calothamnus quadrifidus, Grevillea excelsior, Astroloma serratifolium, Baeckea ochropetala* and *Brachysema chambersii*	1,598.85	43.1	3,809.26	7.1
520	Acacia shrubland (*A. quadrimarginea*)	163.77	4.4	6,302.17	11.8
538	Acacia open shrubland (*Acacia brachystachya*) with isolated mixed *Casuarina* trees and *Helichrysum* open forbland	81.99	2.2	2,776.47	5.2
936	Medium Salmon gum woodland (*Eucalyptus salmonophloia*)	115.98	3.2	116.96	0.2

The vegetation of the survey area and impact area has been mapping in detail and is reported separately (*ecologia* 2013a, in prep.). The extent of each vegetation unit within the J4 impact area is listed in Table 2.3 and described in more detail in the flora and vegetation report of the impact area (*ecologia* in prep.). Information from these reports is included in sections relevant to habitat type descriptions (sections 4.1).

Table 2.3 – Vegetation units within the impact area

Vegetation code	Vegetation unit	Vegetation Description	Impact area	
			Area (ha)	% Total
YS7	*AaaArTuPc*	*Allocasuarina acutivalvis* subsp. acutivalvis low, open woodland, over *Acacia resinimarginea* tall shrubland, over *Thryptomene urceolaris* and *Phebalium canaliculatum* mid, open shrubland	55.71	6.70
YS1	*AcAsBAcc*	*Allocasuarina corniculata* low, open woodland and *Acacia sibina* tall, sparse shrubland, over *Baeckea elderiana* low, sparse shrubland, over *Amphipogon caricinus* var. *caricinus* open tussock grassland	24.03	2.89
YS6	*AcPcAcc*	*Acacia coolgardiensis* mid shrubland, over *Phebalium canaliculatum* low, sparse shrubland, over *Amphipogon caricinus* var. *caricinus* open tussock grassland	8.32	1.00
YS2	*AeBsp.Bac*	*Acacia effusifolia* tall, sparse shrubland, over *Baeckea* sp. Bungalbin Hill (B.J. Lepschi, L.A. Craven 4586) low, sparse shrubland, over *Amphipogon caricinus* var. *caricinus* open tussock grassland	20.36	2.45

Vegetation code	Vegetation unit	Vegetation Description	Impact area	
			Area (ha)	% Total
YS5	*AePcTuAcc*	*Acacia effusifolia* mid, sparse shrubland, over *Phebalium canaliculatum* and *Thryptomene urceolaris*, low, sparse shrubland, over *Amphipogon caricinus* var. *caricinus* open tussock grassland	13.11	1.58
RMR2	*AiEllNa*	*Acacia incurvaneura* tall, sparse shrubland, over *Eremophila latrobei* subsp. *latrobei* mid, sparse shrubland, over *Neurachne annularis* sparse tussock grassland	19.59	2.36
RMR3	*AqCpMnNa*	*Acacia quadrimarginea* tall, sparse shrubland, over *Calycopeplus paucifolius* and *Melaleuca nematophylla* mid, sparse shrubland, over *Neurachne annularis* sparse tussock grassland	0.00	0.00
RMR4	*AqPbbNa*	*Acacia quadrimarginea* tall, sparse shrubland, over *Philotheca brucei* subsp. *brucei*, mid, sparse shrubland, over *Neurachne annularis* tussock grassland	8.36	1.01
YS3	*ArPcTuAcc*	*Acacia resinimarginea* tall, sparse shrubland, over *Phebalium canaliculatum* and *Thryptomene urceolaris* mid, shrubland, over *Amphipogon caricinus* var. *caricinus* open tussock grassland	2.32	0.28
YS4	*ArPcTuAcc2*	*Acacia resinimarginea* tall, sparse shrubland, over *Phebalium canaliculatum* and *Thryptomene urceolaris* mid, sparse shrubland, over *Amphipogon caricinus* var. *caricinus* open tussock grassland	29.75	3.58
SGP7	*ArrPoMgAeAt*	*Acacia ramulosa* var. *ramulosa* tall, shrubland, over *Ptilotus obovatus* and *Maireana georgei* low, sparse shrubland, over *Austrostipa elegantissima* and *A. trichophylla* open tussock grassland	0.00	0.00
SGP1	*Asp.nAnOmSf*	*Acacia* sp. narrow phyllode (B.R. Maslin 7831) tall, sparse shrubland, over *Atriplex nummularia* and *Olearia muelleri* mid sparse shrubland, over *Sclerolaena fusiformis* low, sparse shrubland	58.72	7.06
RMR5	*Asp.nPbOmNa*	*Acacia* sp. narrow phyllode (B.R. Maslin 7831) tall, sparse shrubland, over *Ptilotus obovatus* and *Olearia muelleri*, low sparse shrubland, over *Neurachne annularis* tussock grassland	116.60	14.03
SGP4	*Asp.nPoAcAe*	*Acacia* sp. narrow phyllode (B.R. Maslin 7831) tall, shrubland, over *Ptilotus obovatus* low, sparse shrubland, over *Aristida contorta* and *Austrostipa elegantissima* open tussock grassland	51.61	6.21
SGP2	*Asp.nSafMgNa*	*Acacia* sp. narrow phyllode (B.R. Maslin 7831) tall, sparse shrubland, over *Senna artemisioides* subsp. *filifolia* mid, sparse shrubland, over *Maireana georgei* low sparse shrubland, over *Neurachne annularis* open *hummock grassland*	42.41	5.10
RMR1	*BgEgPbbAe*	*Brachychiton gregorii* low isolated trees, over *Eremophila georgei* and *Philotheca brucei* subsp. *brucei* mid, sparse shrubland, over *Austrostipa elegantissima* sparse tussock grassland	1.04	0.12
SF6	*EcAsp.nEaAe*	*Eucalyptus corrugata* mid, open woodland, over *Acacia* sp. narrow phyllode (B.R. Maslin 7831) and *Exocarpos aphyllus* mid, sparse shrubland, over *Austrostipa elegantissima* open tussock grassland	84.73	10.19
RMR8	*EcAtSafNa*	*Eucalyptus corrugata,* tall, open woodland, over *Acacia tetragonophylla* and *Senna artemisioides* subsp. *filifolia* mid, sparse shrubland, over *Neurachne annularis* tussock grassland	17.72	2.13
SF3	*EcEaSafAe*	*Eucalyptus corrugata* mid, open woodland, over *Eremophila alternifolia* and *Senna artemisioides* subsp. *filifolia,* mid, sparse shrubland, over *Austrostipa elegantissima* open tussock grassland	55.53	6.68
SF7	*ElEsSafOmAeAt*	*Eucalyptus longicornis* mid, open woodland, over *Eremophila scoparia* and *Senna artemisioides* subsp. *filifolia* mid, sparse shrubland, over *Olearia muelleri* low sparse shrubland, over *Austrostipa elegantissima and/or A. trichophylla opn* tussock grassland	17.93	2.16

Vegetation code	Vegetation unit	Vegetation Description	Impact area	
			Area (ha)	% Total
RMR7	*ElGzNa*	*Eucalyptus longicornis* tall, open woodland, over *Grevillea zygoloba* mid, sparse shrubland, over *Neurachne annularis* open tussock grassland	1.33	0.16
SGP3	*EllAsp.nEddAe*	*Eucalyptus loxophleba* subsp. *lissophloia mid,* open mallee woodland, over *Acacia* sp. narrow phyllode (B.R. Maslin 7831) tall sparse shrubland, over *Eremophila decipiens* subsp. *decipiens* mid, sparse shrubland, over *Austrostipa elegantissima* open tussock grassland grassland	35.35	4.25
SF2	*ErAnAvAe*	*Eucalyptus ravida mid, wodland,* over *Atriplex nummularia* and *Atriplex vesicaria* low, sparse shrubland, over *Austrostipa elegantissima* open tussock grassland	24.58	2.96
SGP6	*EsAeSsOmAe*	*Eucalyptus sheathiana* mid, open woodland, over *Acacia erinacea* mid, sparse shrubland, over *Scaevola spinescens* and *Olearia muelleri* low, sparse shrubland, over *Austrostipa elegantissima* open tussock grassland	28.41	3.42
SF1	*EsAvMtSdSd*	*Eremophila scoparia* mid, sparse shrubland, over *Atriplex vesicaria, Maireana trichoptera* and *Sclerolaena diacantha* low sparse shrubland *Sclerolaena drummondii*	3.40	0.41
SF4	*EsEsAvAe*	*Eucalyptus salubris,* tall woodland, over *Eremophila scoparia* mid, sparse shrubland, over *Atriplex vesicaria* low, sparse shrubland, over *Austrostipa elegantissima* open tussock grassland.	44.20	5.32
SF5	*EsEsSafAe*	*Eucalyptus salmonophloia* mid, open woodland, over *Eremophila scoparia* and *Senna artemisioides* subsp. *filifolia* mid, sparse shrubland, over *Austrostipa elegantissima* open tussock grassland	28.41	3.42
RMR6	*GzDrdNa*	*Grevillea zygoloba* tall/mid, sparse shrubland, over *Dianella revoluta* var. *divaricata* sparse *herbland,* over *Neurachne annularis* tussock grassland	17.86	2.15
SGP5	*OeWcTsAe*	*Olearia exiguifolia* and *Westringia cephalantha* mid, sparse shrubland, over *Triodia scariosa* open *hummock* grassland and/or *Austrostipa elegantissima* open tussock grassland	19.81	2.38
TOTAL			**831.20**	

2.2.3 Geology

The Coolgardie bioregion is situatedwithin the Yilgarn Craton and the Fraser Range Block. The Yilgarn Craton comprises granite basements which include Archaean Greenstone intrusions (Cowan 2001), the Fraser Range Block is derived from Proterozoic granite and gneiss frequented by ironstone outcrops and banded ironstone formations (Beard 1990). More specifically, the Coolgardie bioregion contains Eocene marine limestone plains with a granite basement and red-brown loams and aeolian sand soils in the north. To the south, gently undulating uplands on granite strata and low valleys of banded low greenstone hills occur. Undulating plains interrupted by hills and ridges of Archaean greenstones and Proterozoic basic can be found to the east. Drainage is mostly occluded (McKenzie *et al.* 2002).

The survey area comprises four geological units (A2b, A2g, A2x and A2f) of which three units are present within the impact area (Table 2.4). These units lay within the dominant mafic volcanics, granites, granulite-facies metamorphics and felsic volcanics from the Archaean era. The cover rocks are all sedimentary rocks from the Archaean Palaeoproterozoic era (Hickman and Kranendonk 2008) (Figure 2.3).

Table 2.4 – Geology of the impact area

Geological code	Lithology association	Area within impact area (ha)	Percentage of impact area (%)	Area within survey area (ha)	Percentage of survey area (%)	Definition of code
A2b	Mafic volcanics	625.34	75.2	47,272.79	88.2	Archaean
A2g	Granites	9.10	1.1	149.40	0.3	Archaean
A2x	Granulite-facies metamorphics	196.76	23.7	3,424.45	6.4	Archaean
A2f	Felsic volcanics	-	-	2,762.81	5.1	Archaean

Source: (Hickman and Kranendonk 2008)

2.2.4 Soils

Forty four broad soil groups have been identified in the Coolgardie bioregion (Bettenay *et al.* 1967). Soils are predominantly red-brown loams and aeolian sands.

The most extensive soils are yellow earthy sands and sandy yellow earths on depositional sites, and ironstone gravels together on erosional sites where they are underlain by hardened mottled-zone. The south is populated by undulating land with small valleys occasionally broken by low narrow rocky hills and ridges, some clay pans and salt lakes with dunes. The chief soils are brown and grey-brown calcareous earths, mostly with loamy surface soils, but there are some areas with sandy surface soils and gilgais (Bettenay *et al.* 1967).

The dominant soil type within the J4 impact area is neutral red earths with a variable content of ironstone gravel (Figure 2.3), which have been further classified into the following units (Bettenay *et al.* 1967):

My45: Undulating terrain with small gently sloping plains and some ranges on basic schists, gneisses, and allied rocks: chief soils seem to be neutral red earths with a variable content of ironstone gravel. Red-brown hardpan may occur in portions of the area, especially the northern portions.

AC1: Gently sloping to gently undulating plateau areas, or uplands on granites, gneisses, and allied rocks, with long gentle slopes and in places abrupt erosional scarps; some granitic bosses and tors; irregularly traversed by narrow shallow valleys and flats: chief soils are yellow earthy sands (Uc5.22) and sandy yellow earths on depositional sites, and ironstone gravels (KS-Uc4. 11) together with (Uc4. 11) and (Uc2. 12) both containing ironstone gravels on erosional sites where they are underlain by hardened mottled-zone material. Soil dominance varies locally. Associated are shallow valleys and flats of the various (Dy) soils of unit Ya28; small areas of other soils are likely.

A very small area of the third unit, AB7, is located in the far north-east of the survey area, and it's classified as follows:

AB7: Sandy outwash plains from granites, gneisses, and allied rocks with numerous small waterways: chief soils are shallow red earthy sands with small areas of shallow red earths and red earthy loams. A red-brown hardpan commonly occurs at depths of less than 40 inches. Some ironstone gravels may be present. Some pediments and breakaways of unit BE3 are present on ridges and slopes above the plains in a recurring pattern.

2.3 HYDROGEOLOGY

Within the Coolgardie region (particularly in the northern goldfields region), groundwater is contained within unconfined alluvial, calcrete and sedimentary basin aquifers, paleochannels and fractured rock aquifers. Drainage is internal, with flat bottomed paleodrainages discharging into discontinuous chains of salt lakes. Fresh groundwater occurs only in the uppermost tributaries of the paleochannels found in the northern Goldfields. This fresh water becomes more saline (2,000 – 35,000 mg/L TDS) further downstream. There is a sharp interface between the hyposaline (2,000 – 35,000 mg/L TDS) and the hypersaline groundwater (35,000 – 250,000 mg/L TDS) in the trunk of the paleochannels. Salinity levels in the vicinity of salt lakes can exceed 250,000 mg/L TDS (Kalaitzis *et al.* 2002).

Recent drilling at Carina encountered groundwater between depths of 60 to 120 m below ground level, with most groundwater present in paleochannels and fractured rock aquifers. Bennelongia (2009) reports that ground water salinity varies between 1,500 to 34,000 mg L-1 total dissolved solids (TDS) within the survey area.

2.4 PREVIOUS SURVEYS

Several databases were consulted in the preparation of potential fauna (and conservation significant fauna) lists (Table 2.5). In addition, eight publications reporting on vertebrate fauna surveys, four publications reporting on troglofauna assessments, three SRE reports and four reports on stygofauna assessments conducted within 35 km of the impact area were consulted (Table 2.6). The results of all database searches and previous surveys are presented in Appendix C. The online NatureMap database encompasses several datasets that include the WA Museum (WAM), DPaW/DEC threatened fauna database and DPaW/DEC survey return database.

Table 2.5 – Fauna databases

Field	Database	Custodian	Search Details
Vertebrate fauna/ Conservation significant fauna	NatureMap	DPaW/DEC	Search co-ords: Rectangle: 119°14' 08'' E, 119°55' 27'' E, 30°09' 24'' S, 30°34' 17'' S Date accessed: 08/11/12 URL:http://naturemap.dec.wa.gov.au
Vertebrate Fauna/ SRE Invertebrate fauna	Species Profile and Threats (SPRAT) Database	Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)	Records within 10 km of the project area
Vertebrate Fauna	Birdata	BirdLife Australia	Records within 1 degree square of the impact area 119.50276, -30.2939
Vertebrate Fauna	DPaW/DEC Threatened Fauna Database	DPaW/DEC	Records within 100 km of the project area
Vertebrate Fauna	WA Museum Arachnid Database	WAM	Search coordinates: 628985E 6729523N (left top) and 861715E 6527232N (bottom right) Zone 50, Date: 15 November 2012

Field	Database	Custodian	Search Details
SRE Invertebrate fauna	WA Museum Crustacea Database	WAM	Search coordinates: 628985E 6729523N (left top) and 861715E 6527232N (bottom right) , Zone 50, Date: 15 November 2012
SRE Invertebrate fauna	WA Museum Molluscs Database	WAM	Search coordinates: 628985E 6729523N (left top) and 861715E 6527232N (bottom right) ,Zone 50, Date: 15 November 2012

Table 2.6 – Previous biological survey reports within 35 km of the impact area

Survey Location and Author(s)	Distance to impact area (km)	Comments
ecologia internal database	22	One two-phase Level 2 vertebrate and invertebrate survey, one Level 1 vertebrate survey
Bungalbin Hill (Dell *et al.* 1985)	0-10	Three phase Level 2 vertebrate fauna survey
Mt Jackson (Dell *et al.* 1985)	10	Three phase Level 2 vertebrate fauna survey
Mt Jackson (Bennelongia 2008)	10	Troglofauna survey
Mt Jackson (Biota 2009)	10	Targeted SRE fauna survey
J1, Mt Jackson, Windarling and haul road (WRM 2008a)	1	Stygofauna survey
J1, Mt Jackson and haul road (WRM 2009)	1	Stygofauna survey
Carina Extended, Carina North and Chamaeleon Project Areas (Bamford 2012)	15	Two-phase Level 2 vertebrate survey
Carina (Bennelongia 2009)	25	Troglofauna and Stygofauna Assessment
Yilgarn Project (Bennelongia 2011)	25	Troglofauna survey
Regional Yilgarn Project (Rockwater 2009)	0-70	Troglofauna survey
Carina (Ninox 2009)	25	Two phase Level 2 vertebrate fauna and SRE fauna survey
Windarling Range (Bamford 2010)	27	Level 1 vertebrate fauna survey
W2 (WRM 2008b)	29	Stygofauna survey
Windarling Range W4 (Biota 2011b)	30	SRE fauna survey
Deception Deposit (Biota 2011a)	35	Two phase Level 2 vertebrate fauna survey

2.4.1 Potential Faunal Assemblage

2.4.1.1 Terrestrial Vertebrate Fauna

Previous surveys within 35 km of the impact area recorded a total of 41 species of native mammal, nine species of introduced mammal, 214 species of native bird, three species of introduced bird, 115 species of reptile and 19 species of amphibian..

A total of 41 fauna species of conservation significance have the potential to occur within the impact area: six mammals, 33 birds and two reptile species. One species of mammal, the Lesser Stick-nest Rat was excluded from this assessment as it is presumed extinct on the mainland. Of the 41 species of conservation significance, two mammals, nine bird species and two reptile species have a high or moderate likelihood of occurance in the impact area.

Several waterbirds have the potential to occur in the local region due to the proximity of the impact area to a number of large lakes (Lake Barlee, Lake Deborah, Lake Seabrook, Lake Giles, Hamersley Lakes, Lake Julia, Lake Eva, Lake Koorkoordine and Lake Polaris). However, the birds are not expected to utilise habitats within the impact area on a regular basis due to very limited wetland habitats, which may contain only small amounts of water after seasonal heavy rainfalls. Lakes and wetlands in the region will contain water at these times and therefore the importance of the seasonal wetlands within the impact area will be reduced. These species are, therefore, not included in this assessment due to a very low likelihood of their occurrence (Table 2.7).

Table 2.7 – Waterbirds with very low likelihood to occur within the impact area

Species	Conservation Status		
	EPBC Act	WC Act	DPaW
Hooded Plover *Thinornis rubricollis*			P4
Black-tailed Godwit *Limosa limosa*	M	S3	
Little Curlew *Numenius minutus*	M	S3	
Terek Sandpiper *Xenus cinereus*	M	S3	
Common Sandpiper *Actitis hypoleucos*	M	S3	
Common Greenshank *Tringa nebularia*	M	S3	
Marsh Sandpiper *Tringa stagnatilis*	M	S3	
Wood Sandpiper *Tringa glareola*	M	S3	
Ruddy Turnstone *Arenaria interpres*	M	S3	
Red-necked Stint *Calidris ruficollis*	M	S3	
Long-toed Stint *Calidris subminuta*	M	S3	
Pectoral Sandpiper *Calidris melanotos*	M	S3	

Species	Conservation Status		
	EPBC Act	WC Act	DPaW
Sharp-tailed Sandpiper *Calidris acuminata*	M	S3	
Curlew Sandpiper *Calidris ferruginea*	M	S3	
Caspian Tern *Hydroprogne caspia*	M	S3	
White-winged Black Tern *Chlidonias leucopterus*	M	S3	
Glossy Ibis *Plegadis falcinellus*	M	S3	
Cattle Egret *Ardea ibis*	M	S3	

2.4.1.2 Invertebrate Short Range Endemics

The following databases were consulted in the preparation of potential SRE invertebrate fauna lists:

- DPaw/DEC Threatened and Priority Fauna Database;
- NatureMap Database;
- WA Museum Arachnid Database;
- WA Museum Crustacea Database; and
- WA Museum Molluscs Database.

Results from following survey reports were taken in consideration:

- *ecologia* internal database;
- Biota (2009, 2011b);
- Ninox (2009);
- Wetland Research and Management (WRM 2008a, b, 2009);
- Bennelongia (2008, 2009, 2011); and
- Rockwater (2009).

A total of 305 terrestrial invertebrate species have been recorded from the local region (within 35 km of the impact area), representing six orders, 39 families and 40 genera. Of these records, 27 represented potential SRE species (Table 2.8). Major SRE groups within the local region include mygalomorph spiders (13 species), millipedes (five species), pseudoscorpions (four species), isopods (two species) and snails (three species).

One invertebrate species, the Arid Bronze Azure Butterfly, has been included in the assessment but its likelihood of occurrence cannot be determined at this stage due to the lack of information about its distribution and habitat requirements. The only previous records exist at two locations over 315 km apart with the impact area located between these two records (Figure 5.11).

Table 2.8 – Potential SRE species recorded from previous surveys

Class (Order)	Family	Taxa	SRE status
Arachnida (Araneae)			
	Dipluridae	*Cethegus* sp.	Potential
	Idiopidae	*Aganippe* 'sp.1'	Potential
		Eucyrtops `MYG150`	Potential
		Eucyrtops 'sp1'	Potential
		Gaius `MYG077`	Potential
		Idiommata sp.	Potential
		Synothele 'sp1'	Potential
		Synothele 'sp3'	Potential
		Teyl `MYG021	Potential
		Teyl `MYG217`	Potential
	Nemesiidae	*Aname* 'sp1'	Potential
		Aname 'sp2'	Potential
		Yilgarnia sp.	Potential
Arachnida (Pseudoscorpiones)			
	Chernetidae	*Conicochernes* `PSE024`	Potential
		Sundochernes `PSE027`	Potential
		Synsphyronus `PSE026`	Potential
	Chthoniidae	*Tyrannochthonius* `PSE047`	Potential
Diplopoda (Polydesmida)			
	Paradoxosomatidae	*Antichiropus* `koolyanobbing`	Potential
		Antichiropus `Mt Gibson 1`	Potential
		Antichiropus `Mt Jackson 2`	Potential
Diplopoda(Spirostreptida)			
	Lulomorphidae	*Atelomastix* `Yendilberrin (=Mt Manning)`	Potential
		Atelomastix sp. nov 'Koolyanobbing'	Potential
Malacostraca(Isopoda)			
	Armadillidae	*Buddelundia* sp. B1	Potential
		Troglarmardillo sp. B1	Potential
Mollusca (*Gastropoda*)			
	Bothriembryontidae	*Bothriembryon* sp.	Potential
	Camaenidae	*Pleuroxia* sp. nov. `Windarling Hill`	Potential
	Charopidae	unidentified	Potential

Despite several previous stygofauna surveys in the local region (Table 2.6), only one stygobitic species (*Harpacticoida* sp.) has been identified as occurring within 70 km radius of the impact area. The species was recorded as a by-catch during a troglofauna survey (Rockwater 2009).

The results of the literature review and database searches for troglofauna occurring in the wider region are listed in Table 2.9. A total of 19 troglobitic species have been recorded within 35 km of the impact area, of which all 19 species have a potential to be a short range endemic, including one arachnid, two centipedes, three millipedes, three arthropods, five isopods and one crustacean.

Table 2.9 – Troglofauna potentially occuring within the impact area

Class (order)	Family	Taxa	SRE status
Arachnida (Araneae)			
	Araneomorphae	sp. B4	Potential
Chilopoda (Geophilomorpha)			
	Chilenophilidae	sp. B1	Potential
Chilopoda (Scolopendromorpha)			
	Cryptopidae	*Cryptops* sp. B18	Potential
Diplopoda (Myriapoda)			
Symphyla	unknown	gen 1 sp. B1	potential
		Hanseniella sp. B3	potential
Polyxenida	unknown	Polyxenida sp. B1	Potential
Entognatha (Diplura)			
	Japygidae	sp. B12	Potential
	Parajapygidae	sp. B6	Potential
	Campodeidae	sp B2	Potential
Insecta (Coleoptera)			
	Carabidae	sp. B4	Potential
	Curculionidae	gen. 2 sp. B6	Potential
	Curculionidae	Sp. B4	Potential
Malacostraca (Isopoda)			
	Armadillidae	Troglarmardillo sp. B10	Potential
	Philosciidae	sp.B4	Potential
	Philosciidae	sp B8	Potential
	Philosciidae	sp B9	unlikely
	Platyarthridae	Trichorhinae sp B1	Potential
	Platyarthridae	Trichorhinae sp B2	Potential
Pauropoda (Pauropodina)			
		sp. B18	Potential

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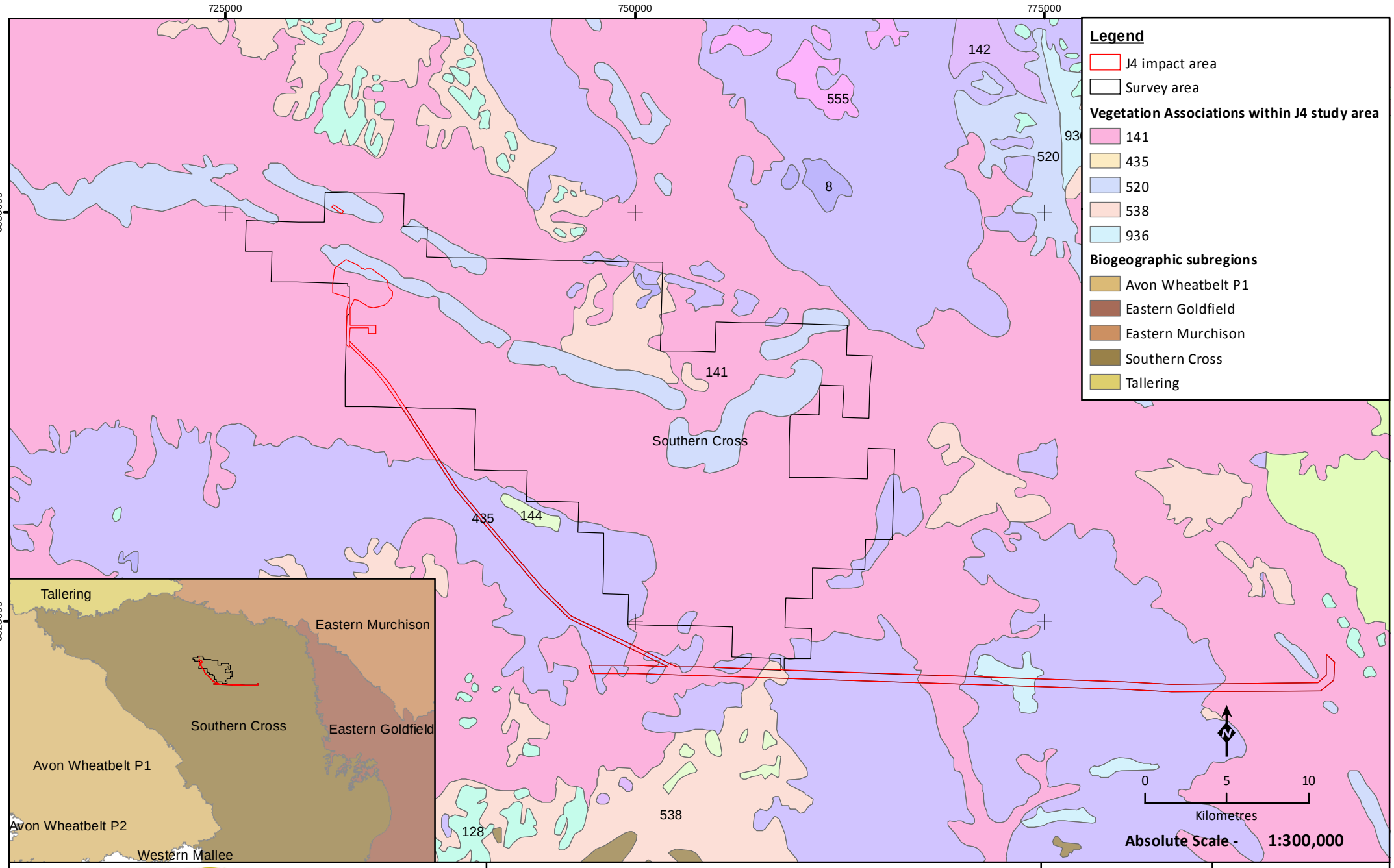

ecologia ENVIRONMENT

Biogeographic region and Vegetation associations of the survey area

Figure: 2.2
Project ID: 1479

Drawn: AH
Date: 30/01/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

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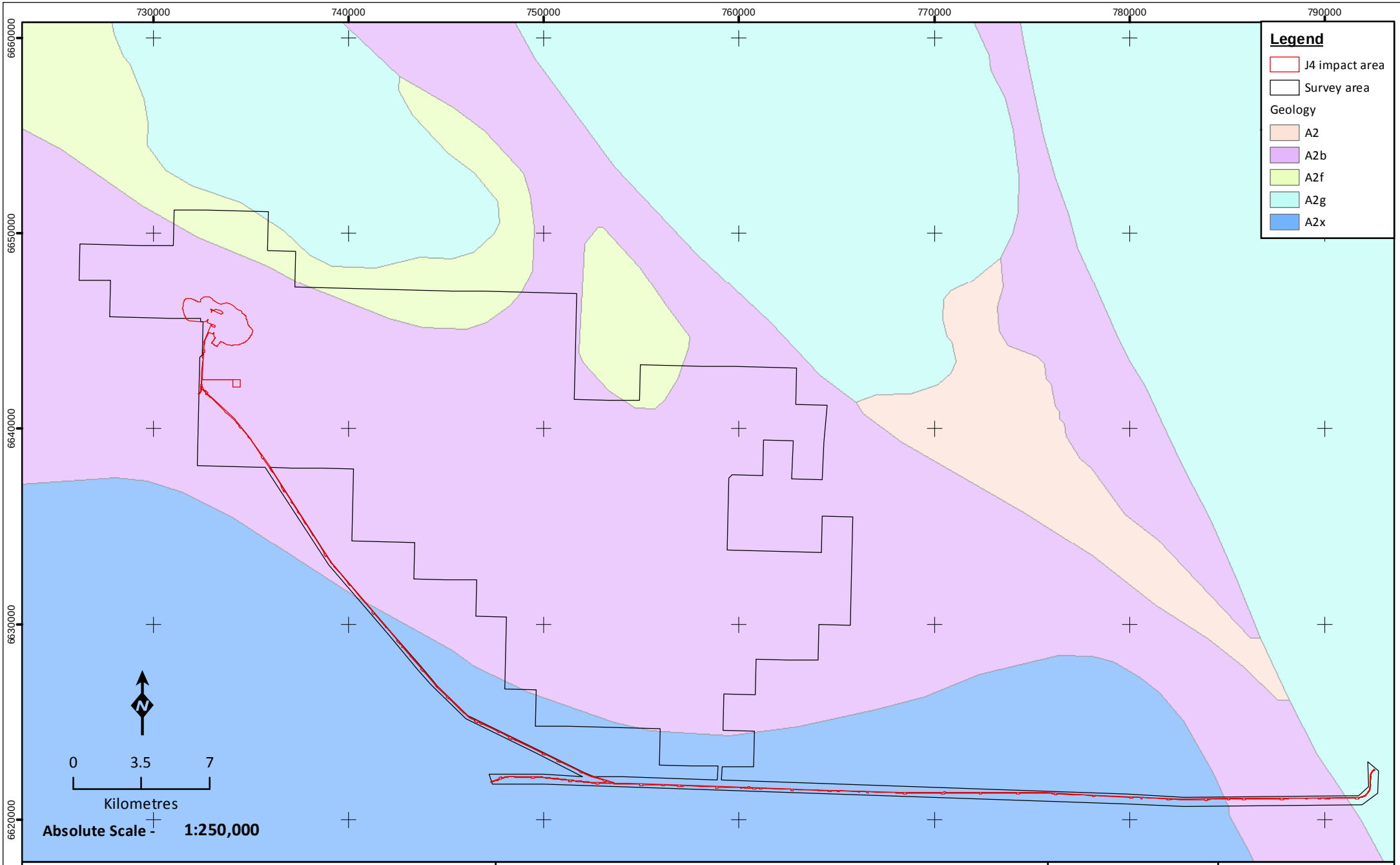

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Geology of the survey area

Figure: 2.3
Project ID: 1479

Drawn: AH
Date: 21/11/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

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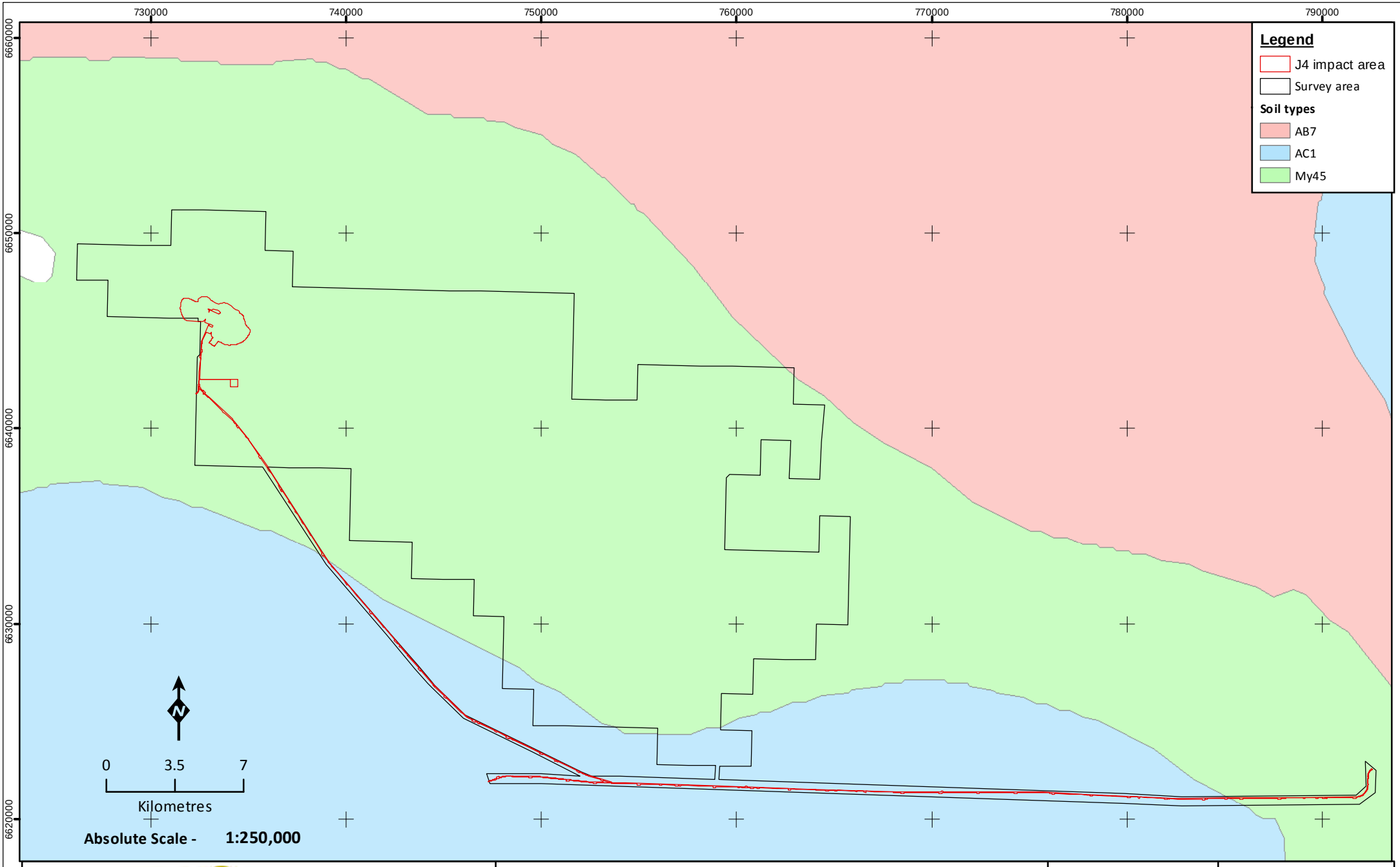

ecologia ENVIRONMENT

Soil of the survey area

Figure: 2.4
Project ID: 1479

Drawn: AH
Date: 21/11/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

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650000 700000 750000 800000 850000

6700000 6650000 6600000 6550000

BULFINCH EVANSTON ROAD
EVANSTON MB
DAVYHURST ROAD
COOLGARDIE NORTH ROAD
WIALKI ROAD
BONNIE ROCK LAKE BROWN ROAD
MOUNT JACKSON ROAD
LAKE SEABROOK ROAD
KOORDA SOUTHERN CROSS ROAD
RYANS FIND ROAD
GREAT EASTERN HIGHWAY
NEPEAN ROAD
KARRALAKIN ROAD

Legend

- Chuditch (Western Quoll)
- Australian Bustard
- Major Mitchell Cockatoo
- Malleefowl
- Peregrine Falcon
- Rainbow Bee-eater
- Shy Heathwren
- Woma
- Carpet Python
- J4 impact area
- Survey area
- Roads
- Rail
- River
- Conservation Estate

N

0 20 40

Kilometres

Absolute Scale - 1:730,000

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Previous records of conservation significant vertebrate fauna

Figure: 2.6
Project ID: 1479

Drawn: AH
Date: 15/03/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

A3

675000 700000 725000 750000 775000 800000 825000

6675000 6650000 6625000 6600000

Legend

- Tree-stem Trapdoor Spider (*Aganippe castellum*) - other consultancies
- Tree-stem Trapdoor Spider (*Aganippe castellum*) - NatureMap 2013
- J4 impact area
- Survey area
- Roads
- Rail
- River
- Conservation Estate

MOUNT JACKSON ROAD

BULLFINCH EVANSTON ROAD

N

0 0.9 1.8

Kilometres

Absolute Scale - 1:63,000

N

0 10 20

Kilometres

Absolute Scale - 1:400,000

ecologia ENVIRONMENT

Regional records of conservation significant invertebrate fauna

Figure: 2.7
Project ID: 1479

Drawn: AH
Date: 21/11/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

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3 METHODS

3.1 DETERMINATION OF SURVEY SAMPLING DESIGN AND INTENSITY

Prior to the development of field survey methods, a review was undertaken of factors likely to influence survey design and intensity (Table 3.1). Based on this review and consultation with the DPaW, it was deemed necessary to conduct a Level 2 terrestrial fauna survey, a Level 2 epigean SRE survey (one phase wet pitfall and additional searches over two phases), a Level 2 troglofauna survey comprising 40 sample holes (in addition to previous samples within impact area eastern section of the Jackson Range) and a Level 1 study for stygofauna within the impact area.

Table 3.1 – Factors likely to influence survey design (EPA 2004)

Factor	Relevance
Bioregion – level of existing survey-knowledge of the region and associated ability to predict accurately.	One previous survey has been completed within the survey area (Dell *et al.* 1985). Fifteen additional surveys have been conducted within 35 km of the J4 impact area and therefore within the Coolgardie bioregion (Southern Cross subregion).
Landform - special characteristics/specific fauna/specific context of the landform characteristics and their distribution and rarity in the region.	The survey area encompasses several features including banded iron formation (BIF) ranges and sandplain habitats that have been identified by DPaW (former DEC) as locally important due to high number of species present. BIF ranges and sandplain habitats are relatively limited in the wider region.
Lifeforms, life cycles, types of assemblages and seasonality (e.g. migration) of species likely to be present.	The best time to survey for all invertebrate fauna groups in the Coolgardie region is the wet season as most species are active and their life forms include adult specimens, which is often a pre-requisite for their taxonomic identification.
Level of existing knowledge and results of previous regional sampling (e.g. species accumulation curves, species/area curves).	Six vertebrate fauna assessments, three troglofauna assessments and one subterranean fauna survey have been conducted within 35 km of the three impact areas previously, which represents a relatively large amount of existing survey data for the immediate region. Stygofauna and troglofauna sampling in the local region suggest a Level 1 study for stygofauna and a Level 2 study for troglofauna would be appropriate within the impact area.
Number of different habitats or degree of similarity between habitats within a impact area.	Six habitat types (Mixed eucalypt woodland, rocky ridge, Mallee woodland on rocky plains and footslopes, sandy plain with shrubland, drainage line and seasonal swamp) were recorded from the survey area, of which the swamp was not recorded from within the impact area. These habitats are relatively distinct and surveying of each habitat within or in close proximity of the impact area is required.
Climatic constraints (e.g. temperature or rainfall that preclude certain sampling methods).	Rain events influenced the first phase of surveying, resulting in a delay of the survey in the south of the impact area (haul road) and the survey area, due to DPaW's requirement to avoid driving on wet tracks within the Helena and Aurora Conservation Park. The SRE and vertebrate trapping survey at the J4 impact area was postponed and conducted in late spring/early summer after weather conditions and tracks dried up.
Sensitivity of the environment to the proposed activities.	The habitat types present within the impact area are also found in the survey area and local region. Eucalypt trees with hollows, sandplain and the rocky ridge are anticipated to be the most sensitive habitat and therefore study efforts focused on these habitats. The rocky ridge comprising a section of a BIF range (Jackson Range) and is less common in the surrounding survey area and local region. A total of 13 BIF ranges are present within the Coolgardie Bioregion {Helena and Aurora Range Advocates Inc, 2012 #1488}.
Size, shape and location of the proposed activities.	The impact area is of linear shape consisting of a deposit and associated haul road. The survey area is of compact shape. The J4 impact area is located along the Jackson Range and south-west of the Helena and Aurora Range and occupies 831.20 ha. The survey area includes the Helena and Aurora Range, Bungalbin Hill and habitats south of the Range.

3.2 STUDY TEAM

The J4 terrestrial and subterranean fauna assessment described in this document was planned, coordinated, and executed by:

3.2.1 Project staff

Astrid Heidrich	M.Sc., Senior Zoologist
Damien Cancilla	BSc, Hon, Zoology Team Leader/Senior Zoologist
Dr Magdalena Davis	BSc, MSc, PhD, Senior Invertebrate Zoologist
Dr Lazaro Roque-Albelo	BSc, PhD, Principal Invertebrate Zoologist
Chris Knuckey	B.Sc., Hon, Zoologist

3.2.2 Field staff

Field survey team members are listed in Table 3.2. The survey was conducted under DEC Regulation 17 Licence SF008969 and Regulation 4 Licence CE0036788.

Table 3.2 – Experience and qualifications of staff involved in the survey

Survey Member	Expertise	Qualification	Experience
Dr Lazaro Roque-Albelo	Invertebrate Zoology	BSc, PhD	20 years
Russell Cannings	Ornithology	B. Sc.	10 years
Astrid Heidrich	Herpetology	M.Sc.	7 years
Farhan Bokhari	Invertebrate Zoology	B.Sc. (Hons)	7 years
Jordan Vos	Herpetology / Ornithology	-	7 years / 2 years
Sean White	Invertebrate Zoology	-	7 years
Frances Leng	Invertebrate Zoology	B.Sc. (Hons)	5 years
Chris Knuckey	Vertebrate Zoology/Botany	B.Sc. (Hons)	3 years
Anna Nowicki	Zoology	B.Sc. (Hons)	3 years
Jesse Forbes - Harper	Zoology	B.A., B.Sc. (Hons)	3 years
Leigh Smith	Herpetology	-	3 years

3.2.3 External specialists

Table 3.3 shows the list of external taxonomic specialists utilised for identification of SRE and subterranean fauna.

Table 3.3 – External specialists used for identification of select groups

External Consultant	Institution	Relevant Experience
Dr Mark Harvey	Western Australian Museum	Taxonomic specialist in arachnids and millipedes
Dr Amber Beavis	Western Australian Museum	Taxonomic specialist in pseudoscorpions
Corey Whisson	Western Australian Museum	Taxonomic specialist in molluscs
Dr Bill Humphreys	Western Australian Museum	Taxonomic specialist in subterranean fauna
Dr Erich Volschenk	Private consultant	Taxonomic specialist in scorpions
Dr Simon Judd	Private consultant	Taxonomic specialist in isopods
Dr Volker Framenau	Western Australian Museum	Taxonomic specialist in spiders
Bob Bullen	Bat Call WA	Bat call analysis specialist

3.3 SURVEY TIMING

The SRE and first phase of the troglofauna survey was conducted in spring between 12 October 2012 and 19 December 2012. This satisfies the recommendations of EPA Guidance Statement 54a, as one of the sampling phases should occur during wet season, with the other phase preceding or following after three months (EPA 2007). The second phase of troglofauna sampling was conducted between 6 February 2013 and 6 April 2013.

The subterranean environment (within which troglofauna is restricted) is generally stable throughout the year as the temperature and humidity are regulated by the depths of rock and soil. Some oscillation of humidity is likely to occur after rainfall events, which may lead to temporary expansions of troglofauna populations (B. Durrant, pers. comm.).

Phase one of the terrestrial vertebrate fauna assessment of the J4 impact area and surrounding was conducted from 13-25 December 2012 in early summer after regular rain events throughout October to December 2012. This satisfies the recommendations of EPA Guidance Statement No. 56. Phase two was conducted in conjunction with the phase one survey of the remainders of the regional survey from 3 – 11 April 2013. The second phase of the survey area was undertaken between 9 October and 17 Octobr 2013. The duration of each survey conducted to date is listed in Table 3.4.

Table 3.4 – Summary of survey timing and duration

Survey	Impact areas	Date	Duration (days)	Person Days
Troglofauna and SRE trap installation Ph1	J4 & survey area	9-17 Oct 2012	9	18
Vertebrate/invertebrate trapping installation Troglofauna and SRE trap collection	J4 & survey area	19-23 Nov 2012	5	30
Vertebrate/invertebrate trapping Ph 1 J4 and immediate surrounding	J4 & surrounding	13-25 Dec 2012	13	26
Troglofauna installation Ph 2	J4 & survey area	5-8 Feb 2013	4	8
Vertebrate/invertebrate trapping Phase 2 J4, Phase 1 survey area	J4 & survey area	3-11 April 2013	9	54
Stygofauna survey	J4 impact area	19-20 Jul 2013	2	4
Vertebrate/invertebrate trapping Phase 2 survey area	Survey area	9-17 Oct 2013	9	36
Total	-		**51**	**176**

3.4 SITE SELECTION

3.4.1 Terrestrial Fauna

Vertebrate Fauna

Terrestrial fauna survey sites were selected to achieve geographic spread over the impact area survey area and to be representative of the habitat types present within the impact area and the survey area. The location of areas of likely impacts was taken into consideration. However, due to access restrictions within the J4 haul road, representative habitat outside the impact area was sampled by trap sites and complimented with opportunistic searches inside the impact area. Habitat types occurring over a larger proportion of the impact area (dominant habitat types) were sampled by a larger number of trapping sites than less represented habitat types. Habitat types poorly represented by systematic sampling sites were further surveyed using opportunistic searches,

targeting potentially sensitive habitats and habitats likely to support conservation significant species. Locations, details and descriptions of all vertebrate fauna survey sites are listed in Appendix D, Appendix E and mapped in Figure 3.1 - Figure 3.3.

Short Range Endemic Invertebrate Fauna

Survey site locations were selected based on the vegetation associations, areas of impact and habitat types present in the impact area, focusing on the habitat types that were considered likely to support SRE invertebrates (south facing rocky hillslopes, drainage line, eucalypt woodland and sandy shrubland). A total of 12 SRE wet pitfall sites (comprising five wet pitfalls each) were established and 53 opportunistic sites were searched for potential SRE species in addition to the wet pitfall trap sites. Leaf litter was taken from near the 12 wet pitfall sites as well as from 16 of the 53 opportunistic sites, to increase the likelihood of detecting terrestrial SRE species. The locations of all SRE survey sites are provided in Appendix D, mapped in Figure 3.1 and site habitat descriptions are listed in Appendix E.

3.4.2 Subterranean Fauna

Stygofauna

Sample sites (drill holes) were selected based on ground water level information. A total of nine drill holes were sampled for stygofauna (Figure 3.4). In addition to this survey, a total of nine bore holes were previously sampled within 26 km of the impact area (Figure 3.4)

Troglofauna

The troglofauna sampling at the J4 impact area comprised a two phase trapping survey of ten drill holes (Appendix D). Sampling of these drill holes was repeated during phase two, with two traps installed at each drill hole to increase the likelihood of encountering troglofaunaimpact area. The locations of the drill holes are provided in Figure 3.5 and Appendix D.

Previous surveys conducted by Bennelongia (Bennelongia 2008, 2011) and Rockwater (2009) sampled an additional 52 drill holes within the local region (Table 3.5, Appendix F). The total number of troglofauna sample holes inside the impact area was 30 (n=30). The total sample size for outside the impact area was 32 (n=32).

Table 3.5 – Previous survey Troglofauna trapping methodology

Survey	Impact area	Method		
		Single trap	Double trap	Scraping
Bennelongia (2008)	J4 impact area	16	4	20
	Survey area	23	8	32
Bennelongia (2011)	Survey area	7	-	11
Rockwater (2009)	Survey area	5	-	-
Total		**49**	**12**	**63**

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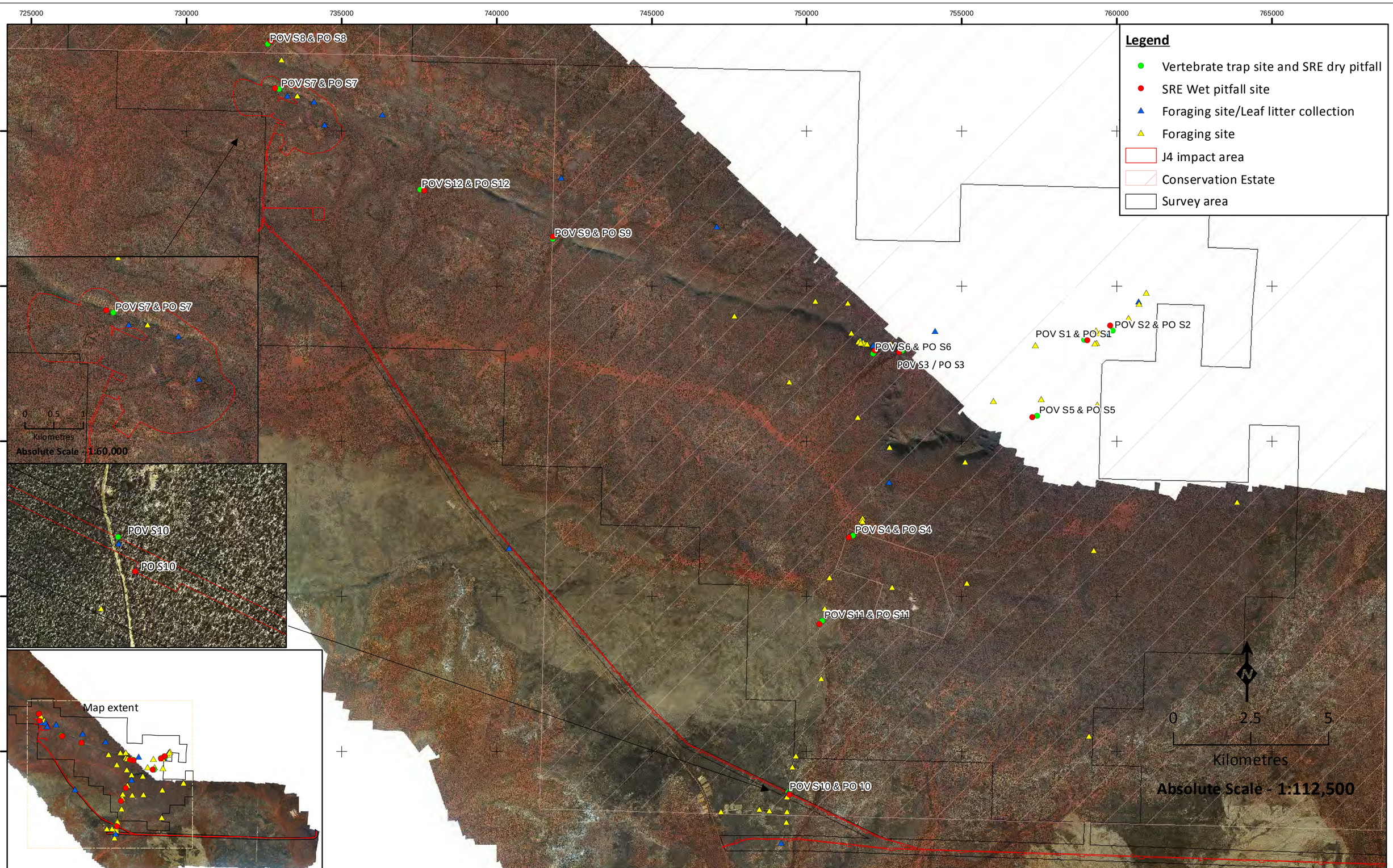

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Location of survey sites

Figure: 3.1
Project ID: 1479

Drawn: AH
Date: 21/11/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

A3

730000 740000 750000 760000 770000 780000 790000

6650000 6640000 6630000 6620000

Legend

- Bat recorder
- Motion Camera
- Motion Camera - longterm
- Survey area
- Conservation Estate
- J4 impact area

0 0.55 1.1
Kilometres
Absolute Scale - 1:60,000

N

0 3.5 7
Kilometres
Absolute Scale - 1:170,000

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Locations of SM2 Bat recorder and Motion Camera

Figure: 3.2
Project ID: 1479

Drawn: AH
Date: 15/04/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

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730000 740000 750000 760000 770000 780000 790000

6650000

6640000

6630000

6620000

Map extent 1

Map extent 2

Map extent 3

N

0 3.5 7

Kilometres

Absolute Scale - 1:160,000

Legend

- Flora Quadrats within vicinity of impact area
- Transect walked
- Targeted searches (Helicopter)
- J4 impact area
- Survey area

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Targeted survey effort for Malleefowl

Figure: 3.3
Project ID: 1479

Drawn: AH
Date: 21/11/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

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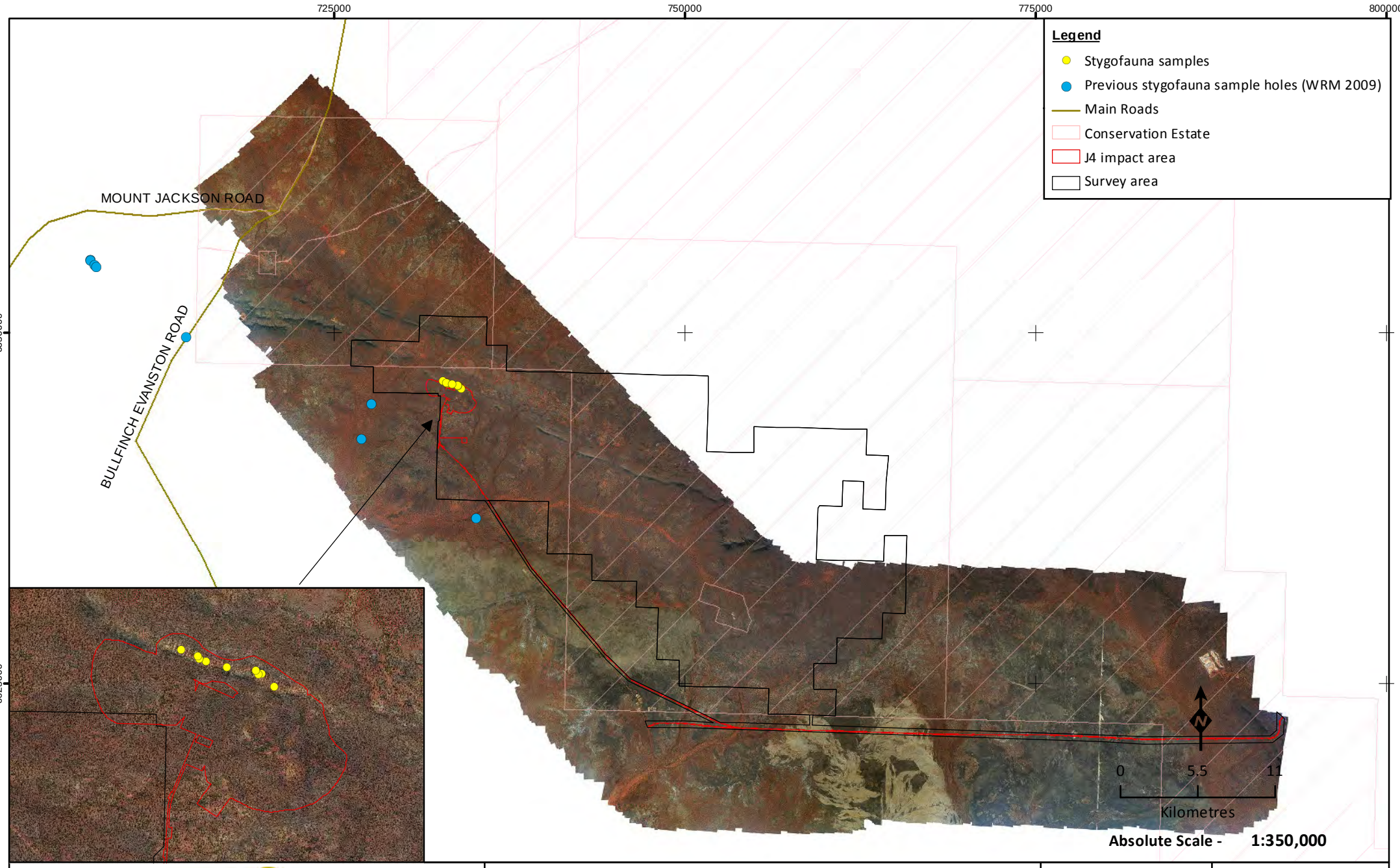

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Location of previous and current stygofauna sample sites

Figure: 3.4
Project ID: 1479

Drawn: AH
Date: 20/10/13

Coordinate System
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Projection: Transverse Mercator
Datum: GDA 1994

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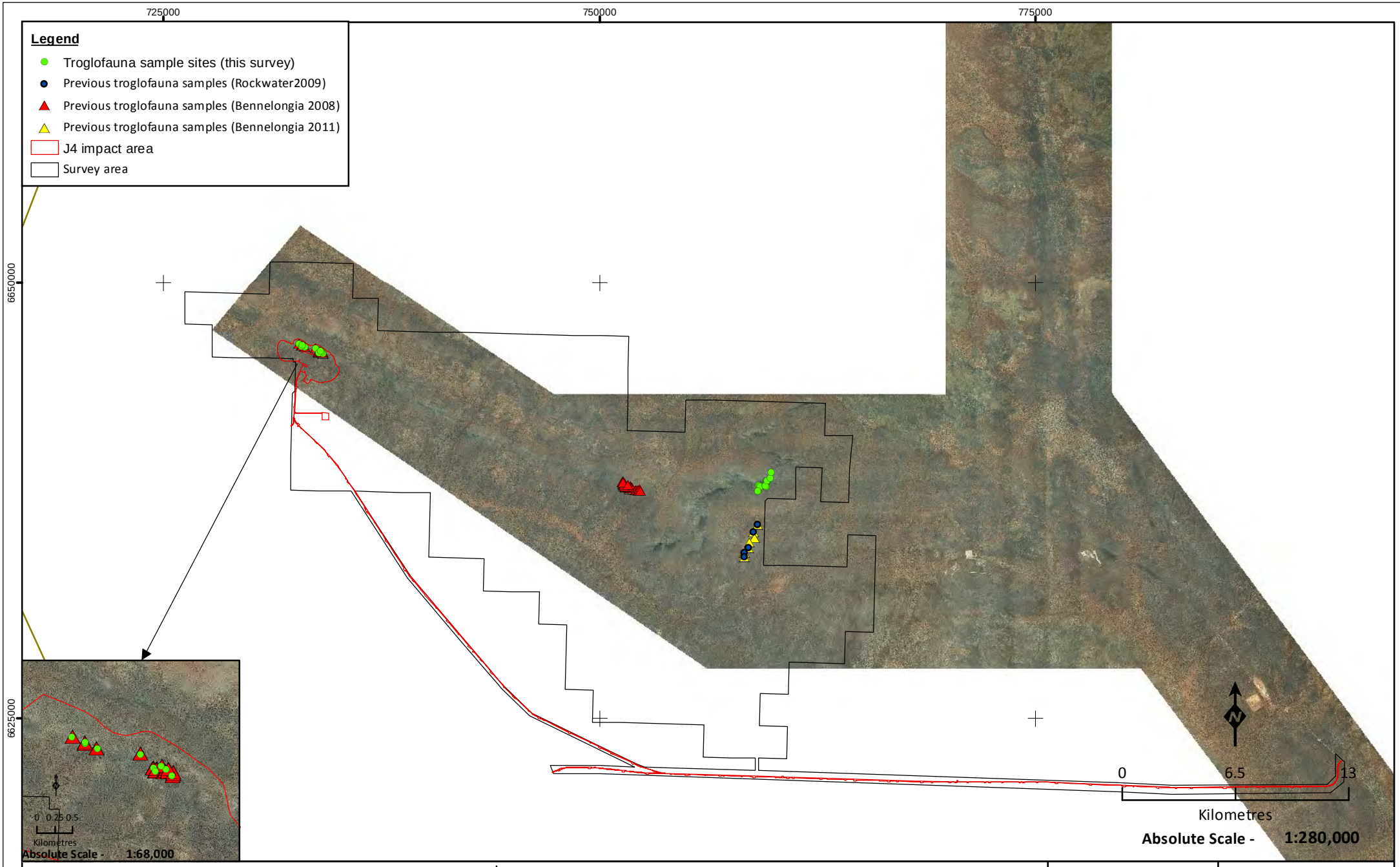

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Location of previous and current troglofauna sample sites

Figure: 3.5
Project ID: 1479

Drawn: AH
Date: 21/11/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

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3.5 FAUNA HABITAT MAPPING

A fauna habitat type broadly describes an area of vegetation and land features that are characteristic of that habitat type and distinguishable from other surrounding habitat types, and that is likely to support fauna assemblages which are different to those in other fauna habitats. Fauna habitat types were identified, described and mapped using following information:

- vegetation associations (Beard 1981; Shepherd *et al*. 2002);
- vegetation mapping {*ecologia,* 2013 #12646; *ecologia*, in prep. #12647}
- IBRA subregions;
- aerial photography; and
- on ground observations.

To determine fauna habitat types and their characteristics, the following parameters were taken into consideration:

- vegetation type and structure;
- soil characteristics (soil structure and substrate); and
- composition of terrestrial fauna species.

3.6 SAMPLING TECHNIQUES

The survey methods adopted by *ecologia* were aligned with the relevant guidelines (Section 1.2). The survey was undertaken using a variety of sampling techniques, both systematic and opportunistic. Systematic sampling refers to data methodically collected over a fixed time period in a discrete habitat type, using an equal or standardised sampling effort. The resulting information can be analysed statistically, facilitating comparisons between habitats. Opportunistic sampling includes data collected non-systematically from chance encounters with fauna.

The survey effort per sampling technique within the impact area and the survey area is summarised in Table 3.6 and described in detail in the following sections.

Table 3.6 – Survey effort per sampling technique

Fauna Habitat type	Pit Traps (trap nights)		Funnels (trap nights)		Elliotts (trap nights)		Cages (trap nights)		Leaf litter collection (no.)	Wet pitfall traps (trap nights)	Bird Survey (min)		Diurnal Opp Search (min)		Nocturnal Opp Search (min)		Bat Recording (hrs)		Camera Trapping (hrs)	
	Ph1	**Ph2**	**Ph1**	**Ph2**	**Ph1**	**Ph2**	**Ph1**	**Ph2**	**Ph1**	**Ph1**	**Ph1**	**Ph2**	**Ph1**	**Ph2**	**Ph1**	**Ph2**	**Ph1**	**Ph2**	**Ph1**	**Ph2**
J4 impact area																				
Total survey effort	150	140	300	280	150	140	30	28	21	420	300	400	380	1,280	180	160	84	24	1,452	1,380
Survey area																				
Total survey effort	750	700	1,480	1,400	750	700	148	140	63	2,100	1,290	1,380	1,980	2,035	480	620	204	204	4,020	4,044
Total	**900**	**840**	**1,780**	**1,680**	**900**	**840**	**178**	**168**	**84**	**2,520**	**1,590**	**1,780**	**2,360**	**3,315**	**660**	**780**	**288**	**228**	**5,472**	**5,424**

3.6.1 Terrestrial Vertebrate Fauna

3.6.1.1 Systematic survey

Non-volant Mammals and Herpetofauna

Trapping for terrestrial non-volant mammals and herpetofauna was undertaken using a standardised trapping format comprising a combination of pit-fall traps, Elliott box traps, funnel traps and cage traps. Each trapping site consisted of the following (Figure 3.6):

- Pit-trap and drift fence: Five PVC pipe (16 x 50 cm) and five 20 L plastic buckets (30 x 40 cm) were established at each site. A 10 metre flywire drift fence (30 cm high) bisected the pits, directing fauna into the traps.
- Elliott box traps: Ten medium sized Elliott box traps (9 x 9 x 32 cm) were placed at each site, and baited with Universal Bait (a mixture of peanut butter, rolled oats and sardines). Each Elliott trap was placed between the pit trap setups. Elliott traps were shaded using Air Cell roof insulation.
- Funnel traps: Funnel traps (Ecosystematica Type III) were placed in association with drift fences. Twenty funnel traps were used per site, with a trap being placed at each end of the drift fence. Funnel traps were shaded using Air Cell roof insulation.
- Cage traps: Two Sheffield small animal traps (22 cm x 22 cm x 55 cm) were used per site with one trap placed at each end of the trap line. Traps were baited with Universal Bait.

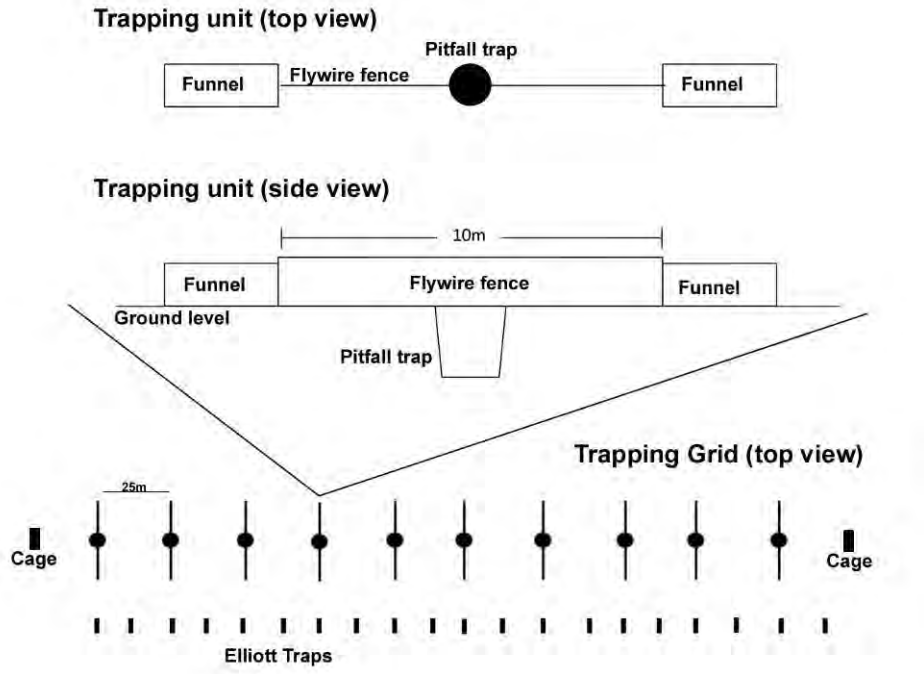

Figure 3.6 – Diagram of the systematic sampling trap arrangement

Figure 3.7 – Image of single *ecologia* trap point

Avifauna

Thirty minute set-time surveys were used to document the avifauna present at each of the fauna sites. During each set-time survey an ornithologist recorded the number of individuals of each species seen while actively searching similar habitat within 500 m of the survey site. This is aligned with survey methodology for the ongoing Birds Australia *Atlas of Australian Birds* project.

Survey effort was concentrated at survey sites within three hours of dawn, as this time is deemed to be optimal for recording most bird species. Opportunistic surveys during the day and near dusk were also conducted, as they may yield species less frequently observed in the early morning, e.g. diurnal raptors.

Two hours of bird surveys were conducted at each of the 12 systematic vertebrate sites. An additional 3.6 hours were spent at opportunistic sites within the J4 impact area and an additional 4.5 hours were spent surveying for birds at opportunistic sites within the survey area (Table 3.6).

Any bird species encountered during the vertebrate installations survey in November 2012 were noted opportunistically and included in the species list (Appendix G).

Bats

Bat echolocation calls were recorded using Song Meter SM2BAT+ 384 kHz ultrasonic acoustic recorders (SM2BAT). The SM2BATrecorder has a high sampling frequency, enabling the full spectrum of the bat calls to be recorded without being transformed allowing greater accuracy and sensitivity. The SM2BAT recorder was programmed to record from dusk to dawn for each night that surveyed.

A total of six SM2BAT recorders were set up at 19 locations (four locations within the J4 impact area and 15 locations within the survey area) resulting in a total of 516 hours of recording which were analysed by bat call analysis expert (B. Bullen) to determine the species assemblage. Of these, 516 hours, 108 hours were recorded within the J4 impact area, the remaining 408 hours were recorded within the survey area (Table 3.6).

3.6.1.2 Opportunistic Data

Nocturnal Searching

The impact area was searched at night using a combination of road transects and opportunistic ground searches using head torches and hand held spotlights to detect nocturnal species, including geckos, snakes, frogs and birds.

A total of 22.3 hours of nocturnal searches were conducted during the survey. Of these, 5.6 hours of nocturnal searches were conducted within the J4 impact area and the remaining 16.7 hours were spent within the survey area, outside the J4 impact area (Table 3.6).

Diurnal Searching

Both trapping and opportunistic sites were searched by hand for cryptic species, which comprised searching beneath the bark of dead trees, breaking open old logs, stumps and dead free-standing trees, investigating burrows and over-turning logs and stones. Sites were selected on the basis of fauna habitat (targeting uncommon habitats or habitats poorly represented by trapping sites) and the potential for them to support conservation significant fauna.

Fauna were also recorded while searching, travelling and during trap establishment within the project area during the day and night. Tracks, diggings, scats, burrows and nests were recorded where possible.

A total of 94.5 hours were spent on diurnal searches at systematic and opportunistic sites (Table 3.6, Figure 3.1). Of these, 27.6 hours were spent within the J4 impact area, the remaining 66.9 hours were spent on diurnal searches within the survey area. Each site was searched for one person hour for vertebrate and invertebrate fauna, targeting conservation significant species such as the Western Quoll, Malleefowl, Major Mitchell's Cockatoo, Woma, South-west Carpet Python, Arid Bronze Azure Butterfly, Tree-stem Trapdoor Spider or invertebrate SRE fauna.

Targeted Malleefowl Transects

Targeted searches were conducted to determine the presence or absence of Malleefowl, in particular active mounds within the impact area and the surrounding. In areas of interest, transects were walked with a distance of approximately 25m. All transects targeting Malleefowl are displayed in Figure 3.3 and listed in Appendix D. In addition, searches were conducted during the flora and vegetation surveys conducted in September and October 2013, in particular along suitable habitat in the south of the J4 impact area. Due to the inaccessibility of the proposed J4 haul road the completion of flora quadrats, priority flora searches and the travel by helicopter were utilised to conduct thorough searches for Malleefowl mounds within the suitable habitat of the impact area.

Within the impact area, a total of 31,8 km of transects were walked during flora and vegetation surveys, 64.5 km of transects were walked during the terrestrial fauna survey and 95.3 km were travelled by helicopter and utilised to search for Malleefowl mounds in inaccessible areas of the impact area (Figure 3.3).

Any evidence of Malleefowl (mounds and tracks) were recorded, their location noted and photographs taken. The activity of mounds was determined using the classifications by the Malleefowl Preservation Group (Table 3.7).

Table 3.7 – Activity of Malleefowl mounds as published by Malleefowl Preservation Group

Category	Description
Active	Fresh scratchings, loose soil and mound dug out in preparation for the breeding season or mounded for breeding. Mounds containing abundant but weathered plant material and shell fragments have been used regularly over at least the previous few years.
Recently used (1-5 years)	No signs of very recent activity, such as scratchings. Soil surface compacted and little plant material present. However, mound slopes still steep and no plants growing in mound.
Moderately old (5-25 years)	No recent activity, soil compacted and no plant material. Surface of mound showing some weathering, such as loose soil and debris accumulating in central depression, and some plant colonisation possibly present.
Old (26-100 years)	Mound moderately to very weathered, often with a veneer of gravel on the slopes because of removal of fine materials from the surface. Some bushes growing on mound.
Very old (l00+ years)	Mound very weathered. Profile low and central depression poorly defined. Bushes and even small trees growing on mound.

Camera Trapping

Motion sensor cameras (motion cameras) were deployed in areas likely to support conservation significant fauna species such as the Western Quoll and the South-west Carpet Python. The Bushnell Trophy Cam, model number 119415 was used. The camera is triggered by movement by a highly sensitive Passive Infra-Red motion sensor and functions day and night taking either video footage or photos (Bushnell Outdoor Products 2009). To attract carnivorous fauna species, universal bait and sardines were used.

A total of eight motion cameras were established at four locations within the J4 impact area and an additional 14 locations across the survey area totalling 10,896 hours of recording. Details, locations and duration of each camera trap are listed in Appendix D and displayed in Figure 3.2.

3.6.2 Short Range Endemic Invertebrate Fauna

3.6.2.1 Systematic survey

Wet Pitfall Trapping

Wet pitfall traps (Figure 3.8) consisting of a PVC tube (25 cm long) were dug into the ground so that the surface was flush with the ground level. A receptacle (containing 700 ml of pitfall trapping solution – 50% ethylene glycol and 5% formaldehyde) and funnel (fitting flush to the inside of the pitfall trap) were deployed into each tube. A cover was then fitted 3 cm above the tube with steel fittings to exclude medium sized vertebrate fauna species and rain, and to deter the attention of larger vertebrate fauna species.

Five wet-pitfall traps were installed at each of the 12 sites and left in the ground for 42 days before being removed and sent to *ecologia*'s Perth laboratory for further sorting and preliminary identification.

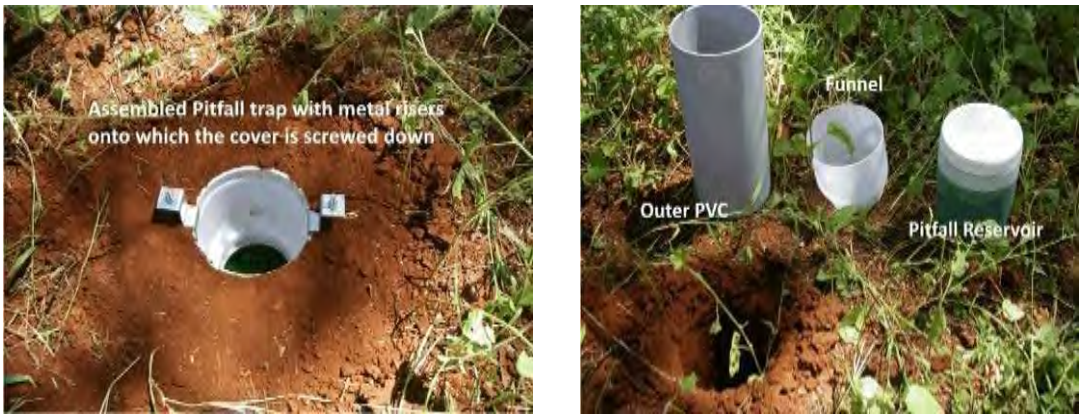

Figure 3.8 – Wet pitfall traps

Dry Pitfall Trapping

A total of 12 vertebrate fauna trap sites were established and utilised as dry pitfall sites for SRE invertebrate fauna, totalling 290 trapnights inside the impact area and an additional 1,450 trap nights within the survey area (Table 3.6). These sites were checked daily and all invertebrate fauna groups potentially containing SRE species collected.

Foraging

One person hour was spent foraging for SREs at 53 sites. Opportunistic foraging involved physically searching through microhabitats for SRE's. The underside of rocks and logs were closely investigated for SRE invertebrates. Snail shells and trapdoor spiders were collected and documented where found.

Leaf Litter Collection

Three quadrats (3 m^2) of leaf litter were collected at each of the 28 sites and separately placed into a leaf-litter reducer (Figure 3.9, Table 3.6). The contents from each collection was placed into a paper bag inside a zip-lock bag and kept separate. A small amount of wet tissue paper was placed into each sample to maintain humidity. Samples were then transported back to Perth in a cool, dark container where they were placed on Tullgren funnels to extract any specimens.

Figure 3.9 – Example of the leaf litter reducer

3.6.3 Subterranean Fauna

The survey effort per subterranean sampling technique within the impact area is summarised in Table 3.8 and described in detail in the following sections.

Table 3.8 – Survey effort for Subterranean fauna

Site	Traps (# drill holes)		Scraping (# holes)	
	Phase1	Phase2	Phase1	Phase2
Troglofauna				
J4 impact area	10	10 (20 traps)	10	-
Survey area	10	10 (20 traps)	10	-
Stygofauna				
J4 impact area	9		-	
Total Troglofauna	**10**	**20**	**20**	**-**
Total Stygofauna	**9**		**-**	**-**

3.6.3.1 Stygofauna

A total of nine drill holes were sampled within the impact area to complete a Level 1 stygofauna study. Haul nets were used to sample the holes in accordance with the methods described in the *EPA Guidance Statement 54a* (EPA 2007). This technique involved dragging modified plankton nets through the entire water column for a total of four times

A net of the appropriate diameter was chosen and slowly lowered to the bottom of the hole. When the net hit the bottom, it was gently raised and lowered approximately 1 m, six times, in order to stir

up sediments and then left for two minutes to allow sediments and potential stygofauna to re-settle. The net was then hauled up through the water column at a rate of <1 m per/second in order to reduce the chance of animals avoiding capture by riding the bow wave at the top of the net. Once the net was at the surface, all contents were immediately washed into a 50 µm Endicott sieve and the contents of the sieve were washed into a vial using absolute ethanol in order to preserve Deoxyribonucleic acid (DNA) of any potential specimens. Each vial was labelled with the drill hole location and name, the date and the names of the collectors.

After each drill hole was sampled, the sieve and nets were washed in Decon90® to prevent contamination between sites.

In addition, at each drill hole a 1 L water sample was collected in a sterile bailer and water chemistry measurements such as pH, temperature, salinity, conductivity, dissolved oxygen and oxygen reduction potential was recorded immediately using a 90 FL multi-parameter meter. The standing water level of each bore was obtained using a Solinst water level meter.

3.6.3.2 Troglofauna

Troglofauna Trapping Methods

Two phases of troglofauna trapping (Level 2) were conducted within the impact area. Each phase consisted of trap deployment, a nine-week colonisation period and trap collection. Each troglofauna trap (Figure 3.10) was filled with damp sterilised leaf litter, which had been soaked in water for seven days prior to trap installation. Anecdotal experience suggests that troglofauna can be encouraged to colonise the leaf litter within each trap with the addition of banana or sweet potato as bait (1 cm^3 each) (*ecologia* 2010) both of which were utilised during this survey.

At the end of the trapping period, contents were placed in plastic bags and the samples stored in insulated cooler boxes for transport to *ecologia* Environment in Perth.

Figure 3.10 – Custom built troglofauna trap

Troglofauna Scraping Methods

Troglofauna scraping involved dragging stygofauna haul nets along the walls of drill holes. The stygofauna net was placed down the drillhole and hauled back up three times, with the contents emptied into a vial after each haul. Each vial was then filled with 100% ethanol to preserve any animals present in the sample. These were then processed in the laboratory back in Perth.

3.6.4 Laboratory Sorting and Specimen Identification

3.6.4.1 Short Range Endemic Invertebrate Fauna

Tullgren funnels were used to extract any animals from the collected leaf litter samples (Figure 3.9). The general principle of Tullgren funnels is that a sample of leaf litter is suspended below an incandescent lamp or heat source. Animals inhabiting the sample are forced downwards by the progressive drying of the sample and ultimately fall into the collecting vessel which is located below the sample. Samples are preserved in ethanol to allow DNA extraction if required.

Figure 3.11 – Tullgren funnels

After the leaf litter samples were processed on the Tullgren funnels, each sample was examined for any other animals that were not collected during Tullgren funnel extraction. Each sample was emptied into a tray and examined using a light magnifier. Any animals found were collected and immediately preserved in ethanol.

All samples were examined under a Stereo microscope and sorted into related groups. Specimens were labelled with the project name, site number and coordinates, the trap number or leaf-litter sift number, date of collection and the initials of the collectors, and were sent to the relevant taxonomic expert for further identification. Table 3.3 shows the list of taxonomic specialists consulted for identification and experience of staff involved in the survey.

3.6.4.2 Stygofauna

Stygofauna samples were sorted at *ecologia*'s Perth laboratory under a compound microscope. Any potential stygobitic specimens collected were placed in individual vials with absolute ethanol and labelled with the date, location, coordinates and names of collectors. The specimens were identied by internal experts.

3.6.4.3 Troglofauna

Once processing of the samples on the Tullgren funnels was complete, all samples were sorted under a compound microscope and sorted into related groups. These specimens were labelled with the project name, site number, date of collection, coordinates and the initials of the collectors and were sent to the relevant taxonomic expert for further identification. Table 3.3 shows the list of taxonomic specialists consulted for identifications.

3.7 SURVEY EFFORT SUMMARY

Survey effort expended within the impact area and survey area included the following:

J4 impact area:

- Two vertebrate fauna trapping grids were open for 1,218 trapnights;
- Two SRE wet pitfall trap sites (comprising five traps each) were set up over 420 trapnights;
- Twenty-one leaf litter samples were collected from seven locations (two systematic sites and five opportunistic sites);
- Approximately 11.6 hours were spent surveying for birds;
- A total of 27.6 hours were invested in opportunistic diurnal searching;
- A total of 5.6 hours were invested in nocturnal searching;
- A total of 204 hours of SM2Bat recorded audio was analysed to determine bat assemblage and distribution;
- A total of 2,832 hours of camera trapping were analysed;
- Nine boreholes were sampled for stygofauna; and
- Nineteen drill holes were sampled for troglofauna.

Study area:

- Vertebrate fauna trapping grids were open for 6,068 trapnights;
- Ten SRE wet pitfall trap sites (comprising five traps each) were set up over 2100 trapnights;
- Sixty-three leaf litter sampels were collected from 21 locations (10 systematic sites and 11 opportunistic sites)
- A total of 44.5 hours were spent surveying for birds;
- A total of 66.9 hours were invested in opportunistic diurnal searching;
- A total of 18.2 hours were invested in nocturnal searching;
- A total of 408 hours of SM2Bat recorded audio was analysed to determine the bat assemblage and distribution; and
- A total of 8,064 hours of camera trapping were analysed.

Total survey effort per habitat type within the J4 impact area and survey area for vertebrate fauna and invertebrate SRE fauna is presented in Table 3.6. Details of stygofauna and troglofauna sampling are listed in Table 3.8.

3.7.1 Conservation Significant Terrestrial Vertebrate and SRE Invertebrate Fauna

Prior to the commencement of survey activity, the preferred habitat of the conservation significant fauna species that potentially occur in the impact area and survey area was determined. These habitats were identified and targeted during survey activities using both systematic sampling techniques and opportunistic surveys.

Searches were also undertaken to find conservation significant species within suitable habitat using the methods outlined in Table 3.9.

Table 3.9 – Survey effort for conservation significant fauna

Targeted Species	Survey technique	Time spent within J4 (hours)	Time spent within survey area (hours)
Mammals			
Chuditch	Targeted searches	6.3	12
	Camera trapping	2,520	7,560
Numbat	Targeted searches	6.3	12
	Camera trapping	2,520	7,560
Greater Bilby	Targeted searches	20.6	36.9
	Camera trapping	2,520	7,560
Black-footed Rock-wallaby	Targeted searches	4	11.5
	Camera trapping	240	288
Birds			
Malleefowl	Targeted searches	14.3	24.9
Major Mitchell Cockatoos	Targeted searches	7.3	33
Australian Bustards	Targeted searches	14.3	24.9
Bush Stone-curlew	Targeted searches	16.9	34.2
Masked Owl	Targeted searches	1	27.6
Shy Heathwren	Targeted searches	5.6	5
Reptiles			
Woma	Targeted searches	8.3	28.5
	Camera trapping	2,592	7,776
South-west Carpet Python	Targeted searches	24	33.1
	Camera trapping	2,760	7,848
Invertebrate SREs			
Tree-stem Trapdoor Spider	Targeted searches	7	30
Arid Bronze Azure Butterfly	Targeted searches for the Sugar ant *C. terebrans*	6.3	18.6
	Trapnights(wet and dry pitfalls)	-	1,770

Four species (Fork-tailed Swift, Rainbow Bee-eater, Peregrine Falcon and Crested Bellbird) were not targeted specifically during searches within certain habitat types due to their ability to occur within a variety of habitats. However, observations of these species were noted and their location documented.

3.8 DATA ANALYSIS

3.8.1 Survey Adequacy

There are three general methods of estimating species richness from sample data: extrapolating species-accumulation curves (SACs), fitting parametric models of relative abundance, and using non-parametric estimators (Bunge and Fitzpatrick 1993; Colwell and Coddington 1994; Gaston 1996). The level of survey adequacy was estimated using SACs, graphically illustrating the accumulation of new species as more individuals are recorded. Ultimately, the asymptote is reached at the level at which no new species are present. To eliminate features caused by random or periodic temporal variation, the sample order was randomised 1,000 times using EstimateS (version 8, Colwell 2009). In order to estimate the theoretical maximum for each fauna group, a Michaelis-Menten enzyme kinetic curve was calculated and used as a stopping rule technique.

The results of trapping and systematic foraging were included in SAC analysis, as this form of analysis assumes a standard sampling effort. Separate analyses were carried out for each species group (mammal, reptile, bird and invertebrates).

3.8.2 Habitat Assessment

Analysis of the fauna survey data was undertaken to determine the similarities in faunal communities and identify any unique fauna habitats. Habitat types have been established in the literature as playing an important role in SRE invertebrate and vertebrate fauna diversity. Variability of habitats has been strongly linked with invertebrate and vertebrate species richness and composition. The expectation of this study was to find a relationship between species richness and habitat type, with higher species richness in moister habitats and less in drier habitats.

Statistical analyses were carried out on the systematic data set from the sites sampled during the survey.

All habitat types recorded within the J4 impact area were sampled systematically for terrestrial trappable vertebrates, avifauna and SRE invertebrate fauna inside or outside the impact area during the current survey.

Habitat analysis for trapped terrestrial vertebrate fauna (mammals, reptiles, amphibians) and avifauna was conducted using the 12 systematic sites that were set up across the J4 impact area and the survey area. Of these sites, five sites were set up in the mixed eucalypt woodland habitat, which has the largest extent within the regional area; two sites within the sandplain with shrubland habitat, which has the largest extent within the J4 impact area; two sites within the mallee on rocky plain and Footslopes habitat type, which has the second largest extent within the J4 impact area; two sites within the the rocky ridge habitat type; and one site within the drainage habitat.

SRE habitat analysis was conducted using dry pitfall, wet pitfall and leaf litter data recorded from the 28 sites located within the J4 impact area and the survey area. Eight of these sampling sites were located within the (regionally) largest habitat type, the mixed eucalypt woodland, seven within the rocky ridge habitat type, five within the sandplain with shrubland habitat type, three within the mallee on rocky plain and footslopes and three within the drainage line habitat type.

To analyse differences in species diversity between habitats, the data was subjected to log+1 transformation. To test whether the differences in species diversity between habitat types were significant, analysis of similarity (ANOSIM) (Clarke 1993) comparisons were made using the one-way ANOSIM function. ANOSIM was calculated using the Bray-Curtis Similarity Index with 999 permutations for SRE fauna, trappable vertebrate fauna and avifauna. Non-metric multi-dimensional scaling (MDS) was applied to the Bray-Curtis similarity matrix for terrestrial SRE invertebrate fauna. Non-metric multi-dimensional scaling (MDS) of the trappable vertebrate fauna and avifauna was

applied to the Euclidean Similarity Index due to a very high stress value of the Bray-Curtis Similarity (0.728). The Euclidean similarity Index concentrates on absence rather than presence of fauna in comparison with the Bray-Curtis Similarity. Resulting stress values below 0.20 were considered to indicate a good fit of the scaling to the matrix. The dimensions that reduced the majority of the "raw stress" were chosen for the final scaling. Analysis was undertaken using the PAST software package (Hammer *et al.* 2001).

Separate analyses were carried out for terrestrial fauna (mammal and reptile), avifauna and invertebrate fauna.

3.9 LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT FAUNA

After the results of the literature review, database searches and survey results were compiled, fauna species that are listed under current legislative frameworks were identified. Three conservation lists have been developed at national (EPBC Act) and state level (WC Act and DEC priority list).

The likelihood of a conservation significant species being present within the project was determined by examining the following:

- fauna habitats and their condition known to exist within the impact area;
- distance of previously recorded conservation significant species from the impact area;
- frequency of occurrence of conservation significant species records in the region; and
- time passed since conservation significant species were recorded within, or surrounding, the impact area.

Each conservation or biologically significant species potentially occurring in the impact area, was assigned a likelihood of occurrence based on the below category (Table 3.10). The level of available information for each species was also taken into consideration so that species are not allocated a low likelihood of occurrence because of insufficient survey information or cryptic behaviours and ecology.

Table 3.10 – Likelihood of occurrence categories

RECORDED	Species recorded during current survey
HIGH	Species recorded within, or in proximity to, the impact area within 20 years; suitable habitat occurs in the impact area
MEDIUM	Species recorded within, or in proximity to, the impact area more than 20 years ago. Species recorded outside impact area, but within 50 km; suitable habitat occurs in the impact area
LOW	Species rarely, or not recorded, within 50 km, and/or suitable habitat does not occur in the impact area

Potential impacts based on the current project description are estimated for each conservation or biologically significant species (Table 5.1). The level of impact is based on the potential levels of disturbance of the project, the amount of habitat expected to be lost and the sensitivity of the species to disturbance.

3.10 DETERMINING SRE STATUS

SRE status of invertebrate fauna recorded is based on categories developed by the Western Australian Museum and modified by the consultant taxonomists in order to describe the SRE status of WA taxa using the current knowledge of the distribution and biology of each species. The likelihoods are defined in the categories as listed in Table 3.12. The newly released 2013 WAM SRE categories, which have been developed to describe the SRE status of WA taxa, are using: (a) unambiguous categories; and (b) explanations of uncertainty. This has been accomplished using a two-tier classification system. In the first tier of classification, geographic distribution and taxonomic certainty are the variables used to split taxa into "Confirmed SREs", "Widespread (not SREs)", and "Potential SREs". In the second tier of classification, "Potential SREs" are categorised according to the reasons why they have been placed into this category and the presence of proxy-indicators for Confirmed SRE or Widespread status. In addition, taxonomists from Phoenix Environmental Sciences adapted these categories and incorporated one addition category: "likely SRE". Taxonomists from both organisations (WAM and Phoenix) undertook the identification of invertebrate fauna collected during this survey and therefore both SRE categories have been used to determine the SRE status (Table 3.11, Table 3.12).

Table 3.11 – Western Australian Museum SRE categories (2013)

	Taxonomic Certainty	**Taxonomic Uncertainty**
Distribution < 10 000km^2	**Confirmed SRE** • A known distribution of <10 00km^2. • The taxonomy is well known. • The group is well represented in collections and/ or via comprehensive sampling.	**Potential SRE** • Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group. • We have incomplete taxonomic knowledge. • The group is not well represented in collections. • This category is most applicable to situations where there are gaps in our knowledge of the taxon. **Sub-categories for this SRE designation are outlined below**
Distribution > 10 000km^2	**Widespread (not an SRE)** • A known distribution of >10 000km^2. • The taxonomy is well known. • The group is well represented in collections and/ or via comprehensive sampling.	

SRE SUB-CATEGORIES

If a taxon is determined to be a "Potential SRE", the following sub-categories will further elucidate this status.

A. Data Deficient:

- There is insufficient data available to determine SRE status.
- Factors that fall under this category include:
    - Lack of geographic information;
    - Lack of taxonomic information;
    - The group may be poorly represented in collections; and
    - The individuals sampled (e.g. juveniles) may prevent identification to species level.

B. Habitat Indicators:

- It is becoming increasingly clear that habitat data can elucidate SRE status; and
- Where habitat is known to be associated with SRE taxa and vice versa, it will be noted here.

C. Morphology Indicators:

- A suite of morphological characters are characteristic of SRE taxa; and
- Where morphological characters are known to be associated with SRE taxa and vice- versa, it will be noted here.

D. Molecular Evidence:

- If molecular work has been done on this taxon (or a close relative), it may reveal patterns congruent or incongruent with SRE status.

E. Research & Expertise:

- Previous research and/ or WAM expertise elucidates taxon SRE status; and
- This category takes into account the expert knowledge held within the WAM.Taxonomy and nomenclature.

The SRE categories utilised by Phoenix include one additional category: "likely SRE". Fauna belonging to this category are included in WAM's "potential SRE" category (Table 3.11, Table 3.12).

Table 3.12 – Phoenix's SRE categories (2013)

SRE category	Criteria	Typical representative
Confirmed	Confirmed or almost certainly SRE; taxonomy of the group is well known (but not necessarily published); group well represented in collections, in particular from the region in question; high levels of endemism in documented species; inference is often possible from immature specimens.	*Antichiropus* millipedes (Paradoxosomatidae); scorpions in the genus *Aops* (Urodacidae)
Likely	Taxonomically poorly resolved group; unusual morphology for the group (i.e. some form of troglomorphism); often singleton in survey and few, if any, regional records.	Opiliones in the genus *Dampetrus*; some pseudoscorpions (*Synsphyronus*) and slaters (Philosciidae); araneomorph spiders in the genus *Karaops* (Selenopidae)
Potential	Taxonomically poorly resolved group; often common in certain microhabitats in SRE surveys (i.e. litter dwellers), but no other regional records; congeners often widespread.	Many mygalomorph spiders; some centipedes (Cryptopidae; Geophilomorpha)
Widespread/Not SRE	Taxonomically well resolved (but often not published) and demonstrated wide distribution (i.e. > 10,000 km2)	

All likely, potential and unknown SREs should be treated as confirmed SREs under the precautionary principle (Section 4a of the EP Act).

3.11 TAXONOMY AND NOMENCLATURE OF VERTEBRATE FAUNA

Nomenclature for mammals, reptiles and amphibians within this report is as per *Western Australian Museum Checklist of the Vertebrates of Western Australia*, birds according to Christidis and Boles (2008). References used for fauna identification are listed in Table 3.13.

Table 3.13 – References used for identification

Fauna Group	Reference
Mammals	Menkhorst and Knight (2011), Van Dyck and Strahan (2008)
Bats	Churchill (1998), Menkhorst and Knight (2011)
Birds	Simpson and Day (2004)
Reptiles	Cogger (2000), Wilson and Swan (2010)
Geckos	Storr *et al*. (1990), Wilson and Swan (2010)
Skinks	Storr *et al*. (1999), Wilson and Swan (2010)
Dragons	Storr *et al*. (1983), Wilson and Swan (2010)
Varanids	Storr *et al*. (1983), Wilson and Swan (2010)
Legless Lizards	Storr *et al*. (1990), Wilson and Swan (2010)
Snakes	Storr *et al*. (2002), Wilson and Swan (2010)
Amphibians	Tyler and Doughty(2009), Cogger (2000)

3.12 TAXONOMY AND NOMENCLATURE OF INVERTEBRATE FAUNA

All specimens collected during the SRE trapping, stygofauna and troglofauna sampling have been lodged with the WA Museum and identified by external specialists (see Section 3.13.3).

3.13 ANIMAL ETHICS

Surveying was conducted as per *ecologia*'s Animal Ethics Code of Practice, which conforms to Section 5 of the *Australian code of practice for the care and use of animals for scientific purposes*(NHMRC 2004).

In all cases, vertebrate fauna were identified in the field and released at the point of capture.

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4 RESULTS

4.1 FAUNA HABITATS

Four fauna habitat types were identified in the J4 impact area and the survey areas. One additional fauna habitat, the seasonal swamp, was only recorded from the north-east of the survey area. The area representation of each habitat within the J4 impact area and the survey area is shown in Table 4.1 and mapped in Figure 4.1.

The J4 impact area contains the following fauna habitat types:

- Rocky ridge;
- Mallee woodland on rocky plain and footslopes;
- Mixed eucalypt woodland;
- Sandy plain with shrubland; and
- Drainage line.

The dominant habitat type of the J4 impact area is the Mixed eucalypt woodland (59.5%) of which the majority is located within mine area and the haul road of this impact area. Sandy plain with shrubland and Mallee woodland on rocky plain and footslopes are also well represented. The rocky ridge habitat is located in the proposed pit and covers 1.2 % of the impact area (Table 4.1). All five habitat types were recorded from the survey area with the addition of one habitat type: seasonal swamp.

The fauna habitat types are associated, but not exclusive to, a number of vegetation units as listed in Table 4.1. These vegetation units are discussed in more detail in the vegetation and flora report of the impact and survey area (*ecologia* 2013a, in prep.).

Mixed eucalypt woodland covers 65.8 % of the survey area and is, therefore, the most common habitat type in this impact area (Table 4.1). The seasonal swamp is restricted to one area of approximately 52.4 ha which equates to 0.1 % of the survey area. Each of the habitat types are described in the following sections.

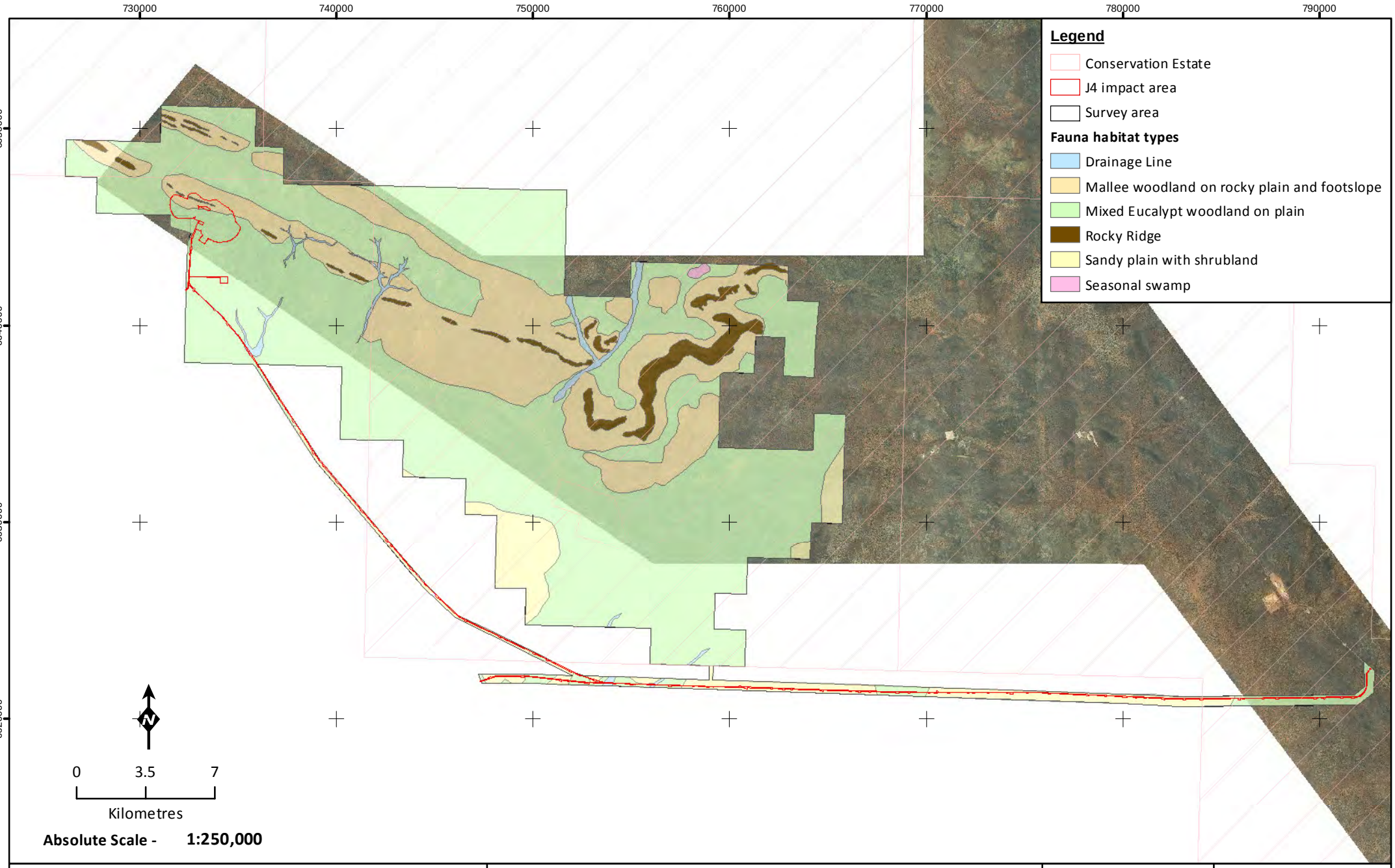
All habitat types were surveyed based on their coverage within the impact area and the survey area and the extent of the potential impacts. Dominant habitat types were sampled by a larger number of survey sites than less common habitats (Table 4.2).

Table 4.1 – Summary of fauna habitats

Fauna habitat	Vegetation unit	Area inside J4 impact area (ha)	Percentage of J4 impact area (%)	Area inside survey area (ha)	Percentage of survey area (%)
Rocky ridge	AqAaPhNa, EeeCpEgMnNa, EeeEgGzNa, EeeCpMnSnNa, EcEeeOmNa, EeeBaAbNa, EeeHmAeNa BgEgPbbAe, AqCpMnNa, AqPbbNa, Asp.nPbOmNa, GzDrdNa (*ecologia* 2013a, in prep.)	9.6	1.2	1,506.0	2.8
Mallee woodland on rocky plain and footslopes	AaNa, AeLspAcc, EcEeeMgPoAeNa, EcEeeOmNa, EeeEgGzNa, EeeEtEaEoaAeSs, EeeHmAeNa, EeeNa, ElEsEvAnAvAe, EsAvMtAe, AiEllNa, AqPbbNa, ArrPoMgAeAt, Asp.nAnOmSf, Asp.nPbOmNa, Asp.nPoAcAe, EcAtSafNa, ElGzNa, EllAsp.nEddAe, EsEsSafAe, GzDrdNa (*ecologia* 2013a, in prep.)	146.9	17.6	12,558.3	23.3
Mixed eucalypt woodland	EeeEtEaEoaAeSs, EeeHmAeNa, ElEsEvAnAvAe, EsAvMtAe, EsOm, (*ecologia* 2013a)(*ecologia* 2013a)(*ecologia* 2013a)AaaArTuPc, AqPbbNa, Asp.nAnOmSf, Asp.nPbOmNa, Asp.nPoAcAe, Asp.nSafMgNa, EcAsp.nEaAe, EcEaSafAe, EllAsp.nEddAe, ErAnAvAe, EsAvMtSdSd, EsEsAvAe (*ecologia* 2013a, in prep.)	494.5	59.5	35,337.4	65.8
Sandy plain with shrubland	AaaArTuPc, AcAsBAcc, AcPcAcc, AeBsp.Bac, AePcTuAcc, ArPcTuAcc2, Asp.nPbOmNa, Asp.nPoAcAe, Asp.nSafMgNa, EllAsp.nEddAe, EsAeSsOmAe, EsAvMtSdSd, EsEsSafAe, OeWcTsAe (*ecologia* in prep.)	175.2	21.1	3,661.5	6.8
Drainage line	AaNa, ElEsEvAnAvAe, EllSsAe, EsEsSafAe, EllAsp.nEddAe (*ecologia* 2013a, in prep.)	4.6	0.6	621.0	1.2
Seasonal swamp	EyEccMc (*ecologia* 2013a)	-		52.4	0.1
Total (ha)		**831.2**		**53,736.6**	**-**

Table 4.2 – Survey effort per habitat type

Fauna Habitat type	Pit Traps (trap nights)		Funnels (trap nights)		Elliotts (trap nights)		Cages (trap nights)		Leaf litter collection (no.)	Wet pitfall traps (trap nights)	Bird Survey (min)		Diurnal Opp Search (min)		Nocturnal Opp Search (min)		Bat Recording (hrs)		Camera Trapping (hrs)	
	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph1	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
J4 impact area																				
Rocky ridge	70	70	140	140	70	70	14	14	9	210	120	120	140	100	120	60	48	12	144	96
Mallee on rocky plain & footslopes	-	-	-	-	-	-	-	-	-	-	60	-	-	120	-	-	24	-	48	24
Sandy plain	80	70	160	140	80	70	16	14	9	210	120	220	180	680	60	100	12	12	-	-
Mixed eucalypt woodland	-	-	-	-	-	-	-	-	3	-	-	60	60	320	-	-	-	-	1260	1260
Drainage line	-	-	-	-	-	-	-	-	-	-	-	-	-	60	-	-	-	-	-	-
Survey area																				
Rocky ridge	70	70	140	140	70	70	14	14	15	210	210	150	500	190	60	120	24	24	192	96
Mallee on rocky plain & footslopes	160	140	300	280	160	140	30	28	9	420	240	240	600	390	200	160	36	36	48	168
Sandy plain	70	70	140	140	70	70	14	14	6	210	120	180	500	995	60	-	12	12	-	-
Mixed eucalypt woodland	370	350	740	700	370	350	74	70	24	1,050	600	660	320	400	160	240	120	120	3780	3780
Drainage line	80	70	160	140	80	70	16	14	9	210	120	150	60	60	-	100	12	12	-	-
Total	**900**	**840**	**1,780**	**1,680**	**900**	**840**	**178**	**168**	**84**	**2,520**	**1,590**	**1,780**	**2,360**	**3,315**	**660**	**780**	**288**	**228**	**5,472**	**5,424**



ecologia ENVIRONMENT

Fauna habitat types

Figure: 4.1
Project ID: 1479

Drawn: AH
Date: 21/11/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

A4

4.1.1.1 Rocky ridge

The rocky ridge habitat type comprises the ridge tops and cliff faces of the Jackson Range which occur in the north of the J4 impact area (Figure 4.1). This habitat type comprises a total of 1.2 % (9.59 ha) of the total J4 impact area and 2.8 % (1,506.0 ha) of the survey area (Table 4.1). The rocky ridge habitat type is associated with, but not exclusive to, 12 vegetation units (*ecologia* 2013a, in prep.) (Table 4.1) and Shepherd's vegetation association 520. The vegetation consists of occassional eucalypt trees (*Eucalyptus eolosa and E. corrugata*) and *Allocasuarina eriochlamys* subsp. *eriochlamys* occur over mixed shrubs (e.g. *Acacia quadrimarginea, Calycopeplus paucifolius, Melaleuca nematophylla, Amphipogon caricinus var. caricinus, Eremophila latrobei subsp. latrobei and Grevillea zygoloba*) and moderately open grasses (dominated by *Neurachne annularis* and *Austrostipa elegantissima*) (Figure 4.2). Soils are firm, sandy loams. This habitat includes areas of rocky outcrops with cliff faces and rock piles. Leaf litter was sparse and limited to patches underneath trees and shrubs.

Figure 4.2 – Rocky ridge habitat recorded from the impact area

4.1.1.2 Mallee woodland on rocky plain and footslopes

This habitat type includes the footslopes of the rocky ridges and associated rocky plains with Mallee woodland which dominate the north of the J4 impact area and the survey area (Figure 4.1, Figure 4.3). It occupies 17.6 % (146.92 ha) of the J4 impact area and 23.3 % (12,558.3 ha) of the survey area (Table 4.1). Some rock piles and small rock shelters may be found on the footslopes but are generally rare. The vegetation of this habitat type is moderately open, with scattered trees (*Eucalyptus corrugata*, *E. loxophleba* subsp. *lissophloia* and *E. longicornis*) over mixed shrubs (e.g. *Acacia quadrimarginea*, *A. incurvaneura*, *A. aneura, E. latrobei, Grevillea zygoloba, Ptilotus obovatus, Maireana georgei* and *Olearia muelleri*) over sparse tussock grasses (*Neurachne annularis*). Some wood litter is present, whereas leaf litter is generally sparse. The Mallee woodland on rocky plain and footslope habitat is associated with, but not exclusive to, 21 vegetation units (*ecologia* 2013a, in prep.) (Table 4.1).

Figure 4.3 – Mallee woodland on rocky plain and fooslope habitat recorded from the impact area

4.1.1.3 Mixed Eucalypt woodland

The mixed eucalypt woodland habitat is the most common habitat within the impact area (59.5 %; 494.5 ha) and survey area (65.8%; 35,337.04 ha) (Table 4.1). It comprises eucalypt mid woodland of *Eucalyptus corrugata*, *E. ravida, E. salmonophloia*, *E. ebbanoensis* subsp. *ebbanoensis, E. scoparia,* and *Eucalyptus salubris* with an open to very sparse shrub layer comprising species such as *Eremophila alternifolia, Senna artemisioides* subsp. *filifolia*, *Maireana georgei, Ptilotus obovatus, Olearia muelleri* and *Acacia* sp. narrow phyllode (B.R. Maslin 7831) and sparse grass cover (e.g. *Neurachne annularis* and *Austrostipa elegantissima*). This habitat type is associated with, but not exclusive to, 16 vegetation units (*ecologia* 2013a, in prep.) (Table 4.1) and Shepherd vegetation association 141. The trees and shrubs provide areas of leaf litter and woody debris. The soils of the eucalypt woodland habitat are sandy clay.

Figure 4.4 – Mixed eucalypt woodland habitat recorded from the impact area

4.1.1.4 Sandy plain with shrubland

The sandy plain with shrubland habitat makes up 21.1 % (175.2 ha) of the J4 impact area and represents the second most common habitat type for the impact area, however it only occupies 6.8 % (3,661.5ha) of the survey area (Table 4.1). This habitat type occurs mainly in the south of the impact area and survey area (Figure 4.1). It is associated with, but not exclusive to, 14 vegetation units (*ecologia* 2013a, in prep.) (Table 4.1) and Shepherd vegetation association 435 which is dominated by scattered *Eucalyptus sheathiana* over *Allocasuarina acutivalvis* subsp. *acutivalvis*, moderately dense to dense shrubland (*Acacia. neurophylla, A. effusifolia, A. beauverdiana* and *A. resinomarginea*) with some *Thryptomene urceolaris* and *Ptilotus obovatus* present (Figure 4.5). Some patches of *Triodia scariosa* hummock grasses, *Austrostipa elegantissima* and *Amphipogon caricinus* var. *caricinus* tussock grasses are present. The habitat is associated with a weak yellow sandy soil and some wood litter and moderate leaf litter is present particularly underneath shrubs.

Figure 4.5 – Sandy plain with shrubland habitat recorded from the impact area

4.1.1.5 Drainage line

The drainage line habitat type occupies 0.9 % (37.1 ha) of the J4 impact area and 1.2 % (52.4 ha) of the survey area (Table 4.1). It is associated with, but not exclusive to, five vegetation units (*ecologia* 2013a, in prep.) (Table 4.1). This habitat comprises depressions that form drainage lines (Figure 4.1). The drainage line habitat did not contain any water at the time during the current survey, but may do so intermittently, particularly after heavy rains. The substrate comprises clay, which may aid in water retention, though much of the water collected in this drainage line is expected to run off given the associated slopes and plains. The partly dense vegetation consists of *Eucalyptus loxophleba* subsp. *lissophloia* over *Pittosporum angustifolium*, *Acacia* sp. narrow phyllode (B.R. Maslin 7831), *Pimelea microcephala* subsp. *microcephala*, *Acacia tetragonophylla, Senna artemisioides* subsp. *filifolia* and *Atriplex vesicaria* over *Dianella revoluta* var. *divaricate, Rytidosperma caespitosum* and *Austrostipa elegantissima* grasses. The drainage lines are well-vegetated with eucalypt trees and shrubs and wood litter and leaf litter were plentiful (Figure 4.6).

Figure 4.6 – Drainage line habitat recorded from impact area

4.1.1.6 Seasonal swamp

The seasonal swamp was found to be the least common habitat type in the impact area, represented by only one area (52.4 ha) and recorded only from the north-east corner of the survey area (Table 4.1, Figure 4.1). This habitat type is expected to undergo seasonal changes in its composition depending on the local weather conditions and associated surface water presence. The seasonal swamp is associated with the vegetation unit EyEccMc (*ecologia* 2013, Table 4.1). It consists of sparse eucalypt trees (*Eucalyptus yilgarnensis* and *E. celastroides* subsp. *celastroides*) over low lignum (*Muehlenbeckia florulenta*) and an open shrubland with occasional larger lignum covering the fringe of this habitat type (Figure 4.7). The substrate is fine and loose with very sparse wood debris and leaf litter due to seasonal flooding events after heavy rainfall occurs.

Figure 4.7 – Seasonal swamp habitat recorded from the survey area

4.2 FAUNA HABITAT ANALYSIS

A one-way ANOSIM test and MDS plot of the systematic trapping sites within the different habitat types was completed for data collected systematically for terrestrial vertebrate trapped fauna, avifauna and invertebrate SRE species. The results from these statistical analyses are shown in Figure 4.8 -Figure 4.10.

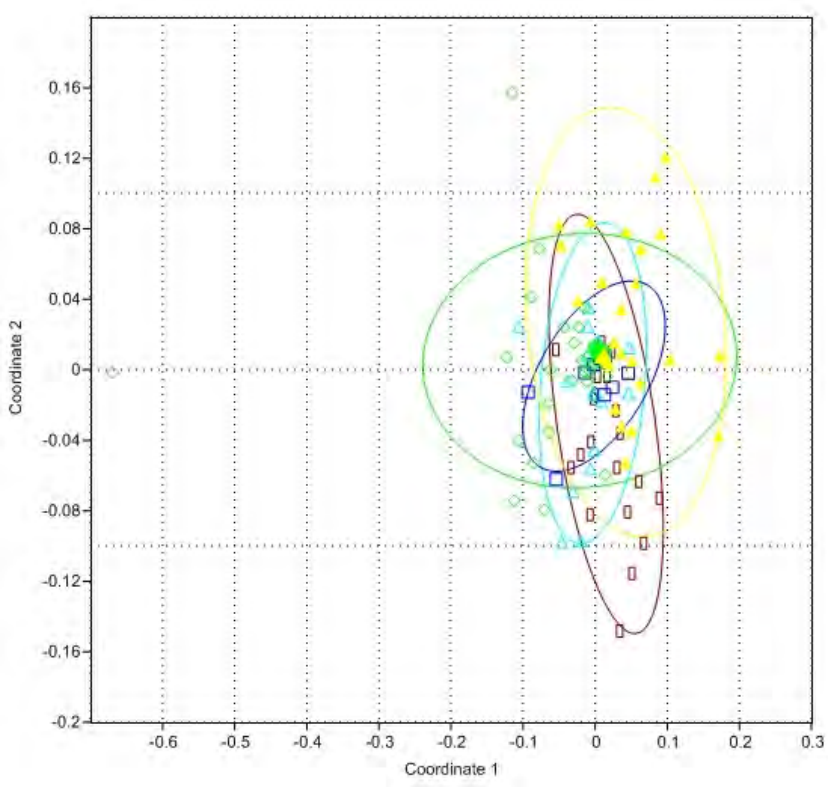
When comparing trapped terrestrial fauna data against the different habitat types, the one-way ANOSIM test determined an R-value of 0.1296 (R-value ranges from -1 to 1, with 1 indicating that the groups are dissimilar and -1 indicating that the groups are similar) and a p-value of 0.0001 (p-value of <0.05 indicating a significant difference). The positive R-value, close to 0 and the very low p-value from this analysis suggests some differences between habitat types, although they are not highly different, and that the data are sufficient to make this analysis. The MDS plot for trapping data provides a visual illustration, showing a large overlap between habitats, but, overall, a difference between faunal assemblages is noticeable particularly for the sandplain with shrubland, rocky ridge and mixed eucalypt woodland habitat types (Figure 4.8). A stress value of 0.1544 for this test indicates that the MDS shows an accurate visual representation of the habitat dissimilarity.

Statistical analysis of the avifauna recorded shows a similar level of difference between habitat types and avifauna recorded. The one-way ANOSIM test determined an R-value of 0.1666 and a p-value of 0.0002. These results indicate that there is only a slight difference in species recorded between habitat types and the results are statistically significant. The MDS plot reflects the results from the ANOSIM showing a distinct difference between the sandplain with shrubland habitat and all other habitat types. All other habitat types show little differences in species composition (Figure 4.9). A stress value of 0.166 for this test indicates a reasonable fit of the scaling to the matrix.

The one-way ANOSIM test for SRE data determined an R-value of 0.1781 and a p-value of 0.0067. These results indicate that there is only a slight difference in species recorded between habitat types and that the results are statistically significant. A visual representation is displayed in the MDS (Figure 4.10) which shows that there is a strong overlap of the species recorded from all habitat types.

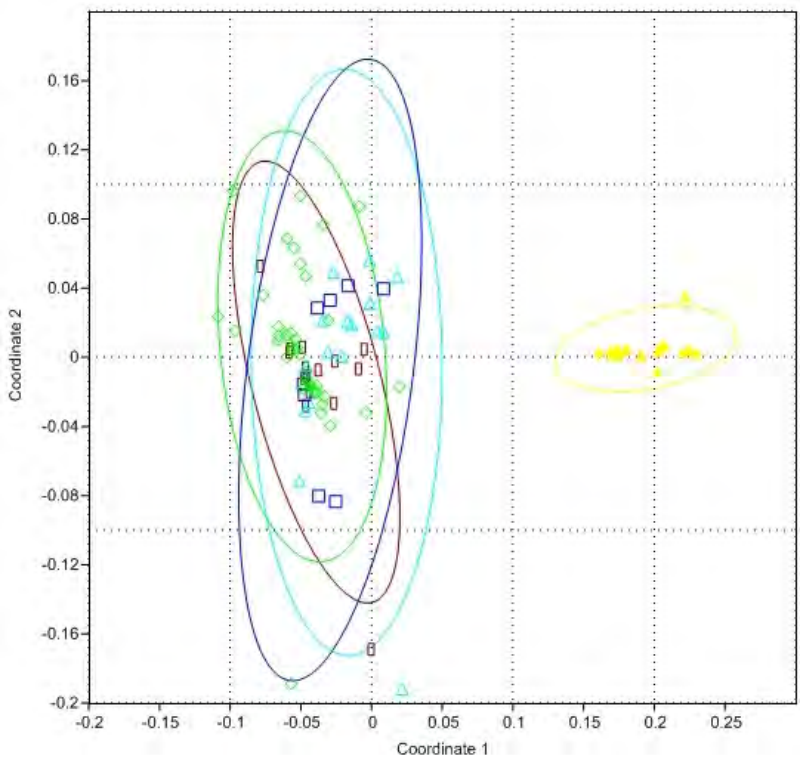
Table 4.3 – One-way ANOSIM test results for fauna habitat comparisons

Fauna group	R-value	p-value
Trapped terrestrial vertebrates	0.1296	0.0001
Avifauna	0.1666	0.0002
SREs collected (traps and leaf litter)	0.1781	0.0067



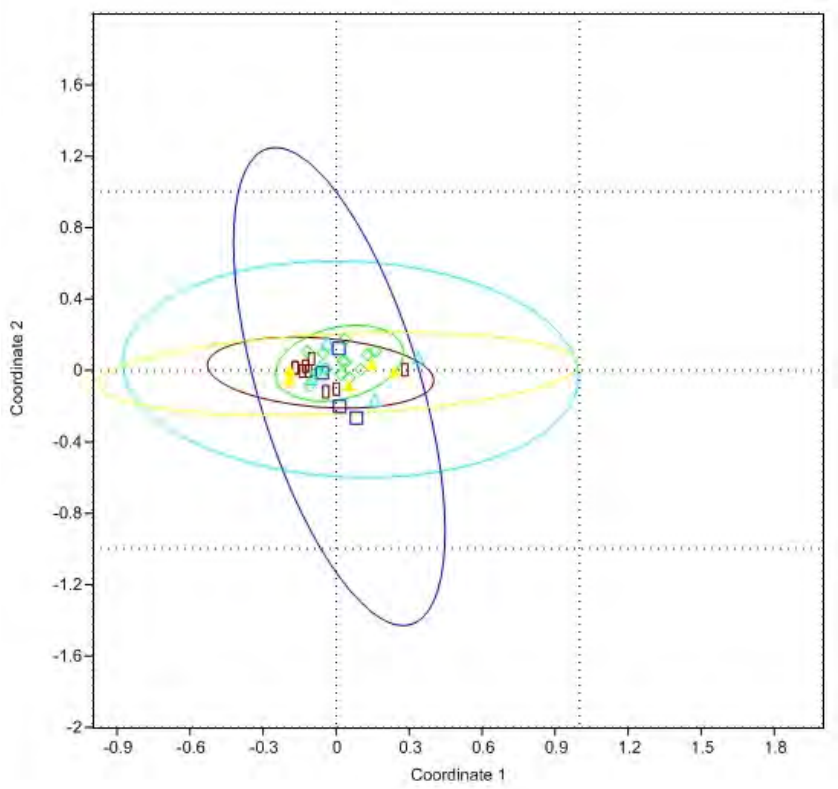
Δ Sandy plain with shrubland; ▯ Rocky ridge, ☐ Drainage line,
Δ Mallee woodland on rocky plain and footslope, ◊ Mixed Eucalypt woodland

Figure 4.8 – Trappable terrestrial vertebrate fauna MDS plot



Δ Sandy plain with shrubland; ▯ Rocky ridge, ☐ Drainage line,
Δ Mallee woodland on rocky plain and footslope, ◊ Mixed Eucalypt woodland

Figure 4.9 – Avifauna MDS plot



Δ Sandy plain with shrubland; ▯ Rocky ridge, ☐ Drainage line,
Δ Mallee woodland on rocky plain and footslope, ◊ Mixed Eucalypt woodland

Figure 4.10 – MDS of fauna habitats for SREs collected

4.3 FAUNA ASSEMBLAGE

During the current survey, a total of 10 native and two introduced mammal species, 46 bird and 28 reptile species were recorded from the J4 impact area. In addition, seven native and one introduced mammal species, 44 bird species, 21 reptile sspecies and two species of frog were recorded from the survey area which were not observed at the J4 impact area. This equates to a total of 17 native and three introduced species of mammal, 90 species of bird, 49 species of reptile and two species of amphibian. Of these species recorded, six species (all birds) are species of conservation significance. A site by species matrix of the results of the survey is provided in Appendix G.

4.3.1 Mammals

The 17 native mammal species recorded from the survey area and the J4 impact area consisted of four dasyurids (small, carnivorous marsupials), two murids (mice), one burramid (pygmy possum) and nine bats. The three introduced species of mammal included the house mouse, cat and rabbit (Appendix G). The smaller mammals were captured in pitfall and Elliott traps at systematic trapping sites, whilst the rabbits and cats were observed during opportunistic searches and from camera traps (Appendix J). Bat species were identified from calls recorded on SM2BAT systems. All of the bat species were recorded at the majority of the systematic trapping sites, suggesting they are commonly occur in all habitat types.

The species recorded most were the two introduced species, with 31 records of the House Mouse and 17 records of the Rabbit plus secondary evidence identified.

4.3.2 Birds

In total, 90 native bird species were recorded during systematic and opportunistic searches. The more abundant species include Weebill (325 records), Striated Pardalote (146), Yellow-plumed Honeyeater (134), Spiny-cheeked Honeyeater (133), White-fronted Honeyeater (113), Brown Honeyeater (109) and Grey Shrike-Thrush (104). The most abundant family were found to be the Honeyeaters with 12 species and 885 records within the J4 impact area and the survey area. The family Armatidae was also commonly recorded with eight species and 176 records (Appendix G).

Four species of conservation significance were sighted within the impact area: Crested Bellbird (DEC Priority 4), Shy Heathwren (DEC Priority 4), Major Mitchells' Cockatoo (WC Act Schedule 4) and Rainbow Bee-eater (EPBC Act Migratory, WC Act Schedule 3). In addition, the Malleefowl (EPBC Act Vulnerable, WC Act Schedule 1, DEC Vulnerable) was recorded through secondary evidence (fresh tracks & old mounds) within the impact area. The Fork-tailed Swift and Peregrin Falcon (WC Act Schedule 4) were recorded outside the impact area. In addition, secondary evidence of either the Australian Bustard (DEC Priority 4) or the Bush Stone-curlew (DEC Priority 4) was recorded from the survey area.

4.3.3 Herpetofauna

A total of 28 reptile species and no amphibian species were recorded during the survey at J4 impact area. The survey of the survey area recorded a total of 48 species which include two amphibian species. The reptile assemblage comprised six agamids (dragon), nine geckos, five pygopods (legless lizard), 16 scincids (skink), three varanids (goanna), one typhlipidae (blindsnake) and eight elapid (front-fanged venomous snake) species (Appendix G). The most common species were *Gehyra variegata* (62 records), *Ctenotus uber* (31), *Diplodactylus granariensis* (38), *Oedura reticulata* (30), *Morethia butleri* (28), *Hemiergis initialis* (25) and Diplodactylus pulcher (23). Four species of reptile, Gould's Goanna (*Varanus gouldii*), Perentie (*Varanus giganteus*), Black-headed Monitor (*Varanus tristis*) and Crested Dragon (*Ctenophorus cristatus*) were also recorded by camera trapping (Appendix J).

Two species of amphibians were recorded from two sites within the survey area (POV S3 and POV S12). Four individuals of the Western Toadlet (*Pseudophryne occidentalis*) and one individual Humming Frog (*Neobatrachus pelopatoides*) were captured (Appendix G).

4.3.4 Conservation significant vertebrate fauna

Based on database searches and the results of previous biological surveys in the surrounding region, seven mammals, 33 birds, two reptile species and one spider of conservation significance could potentially occur in the impact area. One invertebrate species, the Arid Bronze Azure Butterfly, has been included in the assessment but its likelihood of occurrence cannot be determined at this stage due to the lack of information about its distribution and habitat requirements.

In total, 13 vertebrate species are assessed as having a medium to high likelihood of occurrence or were recorded, with the remaining species resulting from the desktop assessment determined to have a low likelihood. Species with medium to high likelihood of occurrence are described in greater detail in Section 5.3.5. One species of mammal, the Lesser Stick-nest Rat was excluded from this assessment as it is presumably extinct on the mainland.

Four species of conservation significance were sighted within the impact area: Crested Bellbird, Shy Heathwren, Major Mitchells' Cockatoo and Rainbow Bee-eater. In addition, the Malleefowl was recorded through secondary evidence (fresh tracks & old mounds) within the impact area. The Fork-tailed Swift and Peregrin Falcon were recorded outside the impact area. In addition, secondary evidence of either the Australian Bustard or the Bush Stone-curlew was recorded from the survey area. Details of these records are summarised in Table 4.4 and shown in Figure 4.11.

Table 4.4 – Conservation significant fauna recorded during the survey

Species	Conservation Status			Location			Comments[1]	Survey Site
	EPBC Act	WC Act	DPaW	Easting	Northing	Impact/survey area		
Malleefowl	VU	S1	VU	749381	6623700	J4 impact area	Tracks (fresh)	POV S10
Malleefowl	VU	S1	VU	747772	6622144	J4 impact area	Mound (recently active)	Opportunistic
Malleefowl	VU	S1	VU	748486	6622105	J4 impact area	Mound (recently active)	Opportunistic
Malleefowl	VU	S1	VU	747833	6621930	J4 impact area	Mound (old)	Opportunistic
Malleefowl	VU	S1	VU	763482	6621474	J4 impact area	Mound (old)	Opportunistic
Malleefowl	VU	S1	VU	770177	6636608	Approx. 4.5 km east of survey area	1 individual, tracks	Opportunistic
Australian Bustard/ Bush Stone-curlew			P4	750498	6629226	Survey area	Tracks	POV S11
Major Mitchell's Cockatoo		S4		744183	6639538	Survey area	2 individuals	POV S11
Major Mitchell’s Cockatoo		S4		735681	6638344	J4 impact area	2 individuals	Opportunistic
Peregrine Falcon		S4		741820	6642117	Survey area	1 individual	POV S9
Peregrine Falcon		S4		753085	6637920	J4 impact area	1 individual	POV S3
Fork-tailed Swift	M	S3		737536	6643114	Survey area	3 individuals	POV S12
Rainbow Bee-eater	M	S3		758949	6638266	Survey area	3 records	POV S1
Rainbow Bee-eater	M	S3		759856	6638579	Survey area	4 records	POV S2
Rainbow Bee-eater	M	S3		753073	6637905	Survey area	3 records	POV S3
Rainbow Bee-eater	M	S3		751493	6631953	Survey area	2 records	POV S4
Rainbow Bee-eater	M	S3		732633	6647827	Survey area	1 individual	POV S8

Species	Conservation Status			Location			Comments[1]	Survey Site
	EPBC Act	WC Act	DPaW	Easting	Northing	Impact/survey area		
Rainbow Bee-eater	M	S3		741820	6642117	Survey area	3 records	POV S9
Rainbow Bee-eater	M	S3		749381	6623700	J4 impact area	1 individual	POV S10
Rainbow Bee-eater	M	S3		737536	6643114	Survey area	1 individual	POV S12
Rainbow Bee-eater	M	S3		737524	6643131	Survey area	1 individual	Opportunistic
Shy Heathwren			P4	749381	6623700	J4 impact area	1 individual	POV S10
Shy Heathwren			P4	750497	6629226	Survey area	3 records	POV S11
Crested Bellbird (southern subspecies)			P4	758949	6638266	Survey area	1 individual	POV S1
Crested Bellbird (southern subspecies)			P4	753073	6637905	Survey area	2 records	POV S3
Crested Bellbird (southern subspecies)			P4	751493	6631953	Survey area	6 records	POV S4
Crested Bellbird (southern subspecies)			P4	757434	6635812	Survey area	1 individual	POV S5
Crested Bellbird (southern subspecies)			P4	752138	6637844	Survey area	5 records	POV S6
Crested Bellbird (southern subspecies)			P4	732991	6646350	J4 impact area	6 records	POV S7
Crested Bellbird (southern subspecies)			P4	732763	6647927	Survey area	15 records	POV S8
Crested Bellbird (southern subspecies)			P4	741970	6642317	Survey area	9 records	POV S9
Crested Bellbird (southern subspecies)			P4	749381	6623700	J4 impact area	7 records	POV S10
Crested Bellbird (southern subspecies)			P4	750498	6629226	Regional surveyarea,	3 records	POV S11
Crested Bellbird (southern subspecies)			P4	737666	6643254	Survey area	7 records	POV S12
Crested Bellbird (southern subspecies)			P4	734461	6645214	Survey area	3 records	Opportunistic
Crested Bellbird (southern subspecies)			P4	751493	6631953	Survey area	5 records	Opportunistic

Species	Conservation Status			Location			Comments[1]	Survey Site
	EPBC Act	WC Act	DPaW	Easting	Northing	Impact/survey area		
Crested Bellbird (southern subspecies)			P4	757434	6635812	Survey area	3 records	Opportunistic
Crested Bellbird (southern subspecies)			P4	751391	6631772	Survey area	1 individual	Opportunistic
Crested Bellbird (southern subspecies)			P4	733027	6641535	J4 impact area	1 individual	Opportunistic
Crested Bellbird (southern subspecies)			P4	734763	6639603	J4 impact area	1 individual	Opportunistic
Crested Bellbird (southern subspecies)			P4	736324	6637296	J4 impact area	1 individual	Opportunistic
Crested Bellbird (southern subspecies)			P4	760710	6639433	Survey area	1 individual	Opportunistic
Crested Bellbird (southern subspecies)			P4	751959	6638138	Survey area	2 individuals	Opportunistic

Datum: GDA 94
Zone: 50K
*Individuals = animals seen at the same time and, therefore, numbers are confirmed. Records = may be separate bird surveys or different days at a trap site and, therefore, some individuals may have been observed multiple times.

730000 740000 750000 760000 770000 780000

6650000 6640000 6630000 6620000

Legend

Species

- Malleefowl
- Malleefowl (mound)
- Malleefowl (tracks)
- Australian Bustard/ Bush Stone-curlew
- Crested Bellbird (southern subspecies)
- Fork-tailed Swift
- Major Mitchell's Cockatoo
- Peregrine Falcon
- Rainbow Bee-eater
- Shy Heathwren
- J4 impact area
- Survey area
- Conservation Estate

Fauna habitat types

- Drainage Line
- Mallee woodland on rocky plain and footslope
- Mixed Eucalypt woodland on plain
- Rocky Ridge
- Sandy plain with shrubland
- Seasonal swamp

N

0 2.5 5

Kilometres

Absolute Scale - 1:129,490

Map extent

ecologia ENVIRONMENT

Conservation significant vertebrate fauna recorded

Figure: 4.11
Project ID: 1479

Drawn: AH
Date: 21/11/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

A3

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4.3.5 Invertebrate Short Range Endemics

The results of this survey within the J4 impact area and survey area are listed in Table 4.5 and revealed:

- Twenty-three morphospecies of 13 genera from seven families of spiders (including two likely SRE, 12 potential SRE species);
- Eleven morphospecies of three genera from two families of scorpions (including four potential SREs);
- Seventeen morphospecies of pseudoscorpion of 12 genera from six families (including 11 potentail SREs);
- Fourteen morphospecies of isopod (including one confirmed SRE, seven potential SREs and two likely SRE) of five genera from three families;
- Ten morphospecies of snail of five genera from four families (including three potential SREs);
- Five morphospecies of millipedes (including four confirmed SREs) of two genera from two families;
- One morphospecies of centipede (potential SRE); and
- Three morphospecies of geophilomorph (including two potential SREs) of three genera from three families.

Figure 4.12 and Figure 4.13 display all locations (within and outside J4 impact area) of the potential, likely and confirmed SRE species recorded from the J4 impact area. SRE species recorded from within the survey area, which were not recorded from within the impact area have not been mapped in this report.

Table 4.5 – Results of the invertebrate SRE survey

Higher Taxon	Species	SRE status	Comment	Impact area/ survey area
Araneae (spiders)				
Actinopodidae	*Missulena* sp. indet.	Potential	May include several species	Survey area
Barychelidae	*Synothele howi*	Widespread/Not SRE	-	Survey area
	Synothele 'MYG278'	Potential	Currently only known from this location	Survey area
	Synothele sp. indet.	Potential	-	J4 impact area & survey area
	Idiommata'blackwalli cf'	Widespread/Not SRE	-	Survey area
	Idiommata sp. indet.	Widespread/Not SRE	-	J4 impact area & survey area
Dipluridae	*Cethegus* sp. juv	Potential	-	Survey area
Idiopidae	*Aganippe* sp. indet.	Potential	May include several species	J4 impact area & survey area
	Aganippe sp. indet. (A. *castellum*-group)	Potential	May include several species	Survey area
	Anidiops 'sp. juv.'	Potential	-	Survey area

Higher Taxon	Species	SRE status	Comment	Impact area/ survey area
	Gaius sp. indet.	Widespread/Not SRE	-	Survey area
	Idiosoma sp. indet.	Likely	Rarely recorded in region	J4 impact area
Nemesiidae	*Aname* 'MYG004'	Widespread/Not SRE	-	J4 impact area
	Aname 'MYG279'	Potential	-	J4 impact area
	Aname 'MYG386'	Potential	-	Survey area
	Aname sp. indet.	Potential	-	Survey area
	Aname tepperi (Hogg, 1902)	Widespread/Not SRE	-	Survey area
	Kwonkan 'MYG175'	Widespread/Not SRE	-	J4 impact area & survey area
	Kwonkan sp. indet.	Potential	-	J4 impact area
	Yilgarnia 'MYG272'	Potential	Currently only known from this location	Survey area
Selenopidae	*Karaops* sp. indet	Likely	First record of this genus from this location	Survey area
	Karaops jarrit	Widespread/Not SRE	-	Survey area
Theraphosidae	*Selenotholus foelschei*	Widespread/Not SRE	-	Survey area
Scorpiones (scorpions)				
Buthidae	*Isometroides* 'goldfields 1'	Widespread/Not SRE	-	Survey area
	Lychas 'adonis'	Widespread/Not SRE	-	Survey area
	Lychas 'annulatus'	Widespread/Not SRE	-	J4 impact area & survey area
	Lychas jonesae Glauert, 1925	Widespread/Not SRE	-	J4 impact area & survey area
	Lychas 'splendens'	Widespread/Not SRE	-	J4 impact area & survey area
Urodacidae	*Urodacus 'gibson 2'*	Widespread/Not SRE	-	Survey area
	Urodacus 'koolyanobbing 2'	Potential	Currently only known from this location	J4 impact area & survey area
	Urodacus 'koolyanobbing 3'	Potential	Currently only known from this location, likely to be lithophile	J4 impact area & survey area
	Urodacus 'koolyanobbing 4'	Potential	-	J4 impact area & survey area
	Urodacus novaehollandiae	Widespread/Not SRE	-	Survey area
	Urodacus sp. indet.	Potential	Morphologically unidentifiable, rating based on other records of SRE *Urodacus* species in	Survey area

Higher Taxon	Species	SRE status	Comment	Impact area/ survey area
			the area.	
Pseudoscorpiones (pseudoscorpions)				
Cheiridiidae	*Cheiridiidae `genus indet.* (juv)`	Potential	-	J4 impact area & survey area
Chernetidae	*Chernetidae* sp. indet	Not SRE	-	J4 impact area & survey area
	`PSEAAD PSE076'	Potential	Currently only known from this location	J4 impact area
Chtoniidae	*Austrochthonius* 'pilbara`	Widespread/Not SRE	-	Survey area
	Austrochthonius `similis`	Widespread/Not SRE	-	Survey area
	Austrochthonius `sp. indet. (female)`	Potential	-	Survey area
Garypidae	*Synsphyronus mimulus*	Widespread/Not SRE	-	Survey area
	Synsphyronus sp. indet.	Potential	-	Survey area
Garypidae	*Amblyolpium* `PSE077`	Potential	Currently only known from this location	J4 impact area & survey area
	Geogarypus taylori	Widespread/Not SRE	-	Survey area
Olpiidae	*Austrohorus* sp.	Potential	-	J4 impact area & survey area
	Beierolpium `sp. 8/3`	Potential	-	Survey area
	Beierolpium `sp. 8/4`	Widespread/Not SRE	-	J4 impact area & survey area
	Beierolpium sp. indet.	Potential	-	J4 impact area & survey area
	Euryolpium sp.	Potential	-	Survey area
	Indolpium sp.indet.	Potential	-	Survey area
	Olpiidae genus indet. sp. indet.	Potential	-	J4 impact area & survey area
Isopoda (slaters)				
Armadillidae	*Buddelundia cf. frontosa*	Widespread/Not SRE	-	J4 impact area & survey area
	Buddelundia '39'	Widespread/Not SRE	-	J4 impact area & survey area
	Buddelundia '71'	Confirmed	Currently only known from this location	Survey area
	Buddelundia sp. nov. A.	Potential	Currently only known from this location	Survey area
	Buddelundia sp. indet.	Potential	Morphologically unidentifiable, rating based on it possibly being *Buddelundia*	Survey area

Higher Taxon	Species	SRE status	Comment	Impact area/ survey area
			'71'	
	"*Cubaris*" sp. nov.	Widespread/Not SRE	-	J4 impact area & survey area
	Armadillidae unknown genus sp. nov. A	Potential	Currently only known from this location	J4 impact area & survey area
	Armadillidae unknown genus sp. nov. C	Potential	Currently only known from this location	J4 impact area & survey area
	Armadillidae 'EE1479S'	Likely	Currently only known from this location	Survey area
	Armadillidae unknown genus sp.	Potential	-	Survey area
Philosciidae	*Laevophiloscia* '1479'	Widespread/Not SRE	-	J4 impact area & survey area
Platyarthridae	*Trichorhina* sp. nov. A	Potential	-	Survey area
	Trichorhina sp. nov. B	Potential	-	Survey area
	Trichorhina '1510'	Likely	Currently only known from this location and the Chameleon project	Survey area
Molluscs (snails)				
Bothriembryontidae	*Bothriembryon* cf *sedgwicki*	Potential	-	J4 impact area & survey area
	Bothriembryon sp. nov. 'Marda'	Potential	-	Survey area
Camaenidae	*Sinumelon* ct. *tarcoolanum*	Potential	-	Survey area
	Sinumelon kalgum	Widespread/Not SRE	-	Survey area
Punctidae	*Westralaoma aprica*	Widespread/Not SRE	-	Survey area
	Westralaoma expicta	Widespread/Not SRE	-	J4 impact area
Pupilidae	*Gastrocopta bannertonensis*	Widespread/Not SRE	-	Survey area
	Pupilla australis	Widespread/Not SRE	-	Survey area
	Pupoides adelaidae	Widespread/Not SRE	-	Survey area
	Pupoides myoporinae	Widespread/Not SRE	-	Survey area
Polydesmida (keeled millipedes)				
Paradoxosomatidae	*Antichiropus* 'lake king'	Widespread/Not SRE	-	J4 impact area
	Antichiropus 'mt gibson 1'	Confirmed	-	Survey area
	Antichiropus 'mt gibson 3'	Confirmed	-	Survey area
	Antichiropus sp.	Confirmed	-	J4 impact area &

Higher Taxon	Species	SRE status	Comment	Impact area/ survey area
				survey area
Spirostreptida (millipedes)				
Iulomorphidae	*Atelomastix bamfordi*	Confirmed	-	Survey area
Scolopendromorpha (tropical centipedes)				
Cryptopidae	Cryptops sp. indet.	Potential	-	Survey area
Geophilomorpha (soil centipedes)				
Geophilidae	*Sepedonophilus* sp. Indet.	Potential	-	Survey area
Mecistocephalidae	*Mecistocephalus* sp. indet.	Potential	-	Survey area
Oryidae	*Orphnaeus brevilabiatus*	Widespread/Not SRE	-	Survey area

4.3.5.1 Spiders

A total of 21 morphospecies from 13 genera and seven families of spiders were recorded during the current survey. Of these, two species are considered likely SREs, of which one species (*Idiosoma* sp.) was only recorded from one location within the J4 impact area. The other likely SRE species (*Karaops* sp. indet) was recorded from the survey area. An additional 12 morphospecies are considered potential SREs, with two species (*Aname* 'MYG279' and *Kwonkan* sp. indet.) recorded only from inside the J4 impact area and two potential SRE species (*Aname* sp. indet. and *Synothele* sp. indet.) recorded from inside and outside the J4 impact area. The remaining six potential SRE morphospecies (*Aganippe* sp. indet (*A.castellum* group), *Missulena* sp. indet., *Synothele* 'MYG278', *Cethagus* 'sp. indet., *Anidiops.* 'sp. juv.', *Yilgarnia* sp. indet) were recorded from the survey area (Table 4.5, Figure 4.12).

4.3.5.2 Scorpions

A total of 11 morphospecies of scorpion from three genera and two families were recorded during the current survey (Table 4.5, Figure 4.12). A total of 78 specimens were collected during the survey, representing the fifth most collected group of invertebrate fauna. Four species of scorpion are considered potential SRE, all belonging to the genus *Urodacus* (*Urodacus* 'koolyanobbing 2', *Urodacus* 'koolyanobbing 3', *Urodacus* 'koolyanobbing 4' and *Urodacus* sp. indet.). Of these, two species are currently only know from this location (*U.* 'koolyanobbing 2' and *U.* 'koolyanobbing 3'). However, all three species of *Urodacus* 'koolyanobbing' were collected inside and outside the J4 impact area (Table 4.5, Figure 4.12). Specimens identified as *Urodacu*s sp. indet. could not be identified morphologically and therefore their SRE status (potential) is rated on the basis of previous records of this species in the region.

4.3.5.3 Pseudoscorpions

A total of 17 morphospecies of pseudoscorpion were recorded during the survey. Of these, eleven morphospecies are considered potential SREs. One of these species was recorded from inside the J4 impact area only: `PSEAAD PSE076'. It represents a new genus and a new species of which neither one have been recorded previously. Five species of potential SREs were recorded from inside and outside the J4 impact area (*Cheiridiidae `genus indet.* (juv)`, *Amblyolpium* `PSE077`, *Austrohorus* sp., *Beierolpium* sp. indet., Olpiidae genus indet. sp. indet.) and the remaining five species of potential SRE were recorded from the survey area and were not found inside the J4 impact area

(*Austrochthonius* `sp. indet., S*ynsphyronus* sp. indet., *Beierolpium* `sp. 8/3`, *Euryolpium* sp., *Indolpium* sp.indet.)(Table 4.5, Figure 4.13). Appendix H shows that 221 individuals of pseudoscorpion were collected during the current survey, representing the most collected group of invertebrates.

4.3.5.4 Malacostraca (Isopods)

A total of 115 specimens of 14 morpho-sprecies from five genera and three families were collected during the current survey, which represents the third most collected invertebrate group at the impact area and survey area (Appendix H). Of these, one species is a confirmed SRE and an additional seven species potential SRE and two likely SREs were recorded. The confirmed SRE (*Buddelundia* '71') was recorded from the survey area only (Table 4.5, Appendix H). Two potential SREs were collected from inside and outside the J4 impact area (Armadillidae unknown genus sp. nov. A and Armadillidae unknown genus sp. nov. C) and the remaining six potential SRE species were recorded from the survey area (*Buddelundia* sp. nov. A., *Buddelundia* sp. indet., Armadillidae unknown genus sp. nov. B, Armadillidae unknown genus sp., *Trichorhina* sp. nov. A, *Trichorhina* sp. nov. B). The two likely SRE species (Armadillidae 'EE1479S' and *Trichorhina* '1510' were recorded outside the J4 impact area. Armadillidae 'EE1479S' is currently only known from this location whereas *Trichorhina* '1510' is known only from this location and the Chameleon project (Table 4.5).

4.3.5.5 Molluscs

A total of 177 individuals were collected during the current survey which represents the second most collected group of invertebrates at the impact area and survey area. A total of ten morphospecies from four families were recorded from the current SRE survey. Of these, three species are considered potential SREs: *Bothriembryon* sp. nov. 'Marda', *Bothriembryon cf. sedgwicki* and *Sinumelon cf. tarcoolanum*. Of thee, one species was recorded from inside and outside the impact area (*Bothriembryon cf. sedgwicki (*(Table 4.5, Figure 4.13, Appendix H), the remaining two species were recorded from the survey area and were not found within the J4 impact area (Table 4.5,).

4.3.5.6 Diplopods

A total of five morphospecies of millipedes were recorded during the current survey (Table 4.5), of which four species represent a confirmed SRE (*Antichiropus* 'mt gibson 1', *Antichiropus* 'mt gibson 3', *Antichiropus* sp. indet., *Atelomastix bamfordi*). Three species were recorded within the survey area with one species (*Antichiropus* sp. indet.) recorded from inside and outside the impact area (Table 4.5). With 79 specimens of millipedes (from two groups) millipedes are the four most collected invertebrate fauna group collected during the current survey (Appendix H).

4.3.5.7 Chilopoda

One species of tropical centipede was recorded which represents a potential SRE species. It was only recorded from the survey area (Table 4.5)

In addition, six individuals of geophilomorph (soil centipede) from three families were collected during the current survey (Table 4.5, Appendix H). Two of the three morphospecies are considered potential SRE which were collected from the survey area and were not collected from within the J4 impact area: *Sepedonophilus* sp. indet. and *Mecistocephalus* sp. indet. (Table 4.5).

4.3.6 Subterranean Fauna

4.3.6.1 Stygofauna

No stygofauna were recorded from the J4 impact area.

Groundwater physico-chemistry was measured in eight of the nine bores sampled for stygofauna and extracted by sterile bailers. Results are presented in Table 4.6 Table 4.6 – Range of groundwater physico-chemistry data from the survey areabelow.

Overall, measured groundwater physico-chemistry parameters were within the habitable ranges for stygofauna (Humphreys 1999, 2008; Malard and Hervant 1999). Moreover, there was no consistent trend in the present data that would provide an obvious explanation for the absence of stygofauna in the locations sampled.

Table 4.6 – Range of groundwater physico-chemistry data from the survey area

Groundwater Parameters	Wet Season July 2013
Temperature (˚C)	
Mean	19.55
St.Dev	1.11
Range	20.01-23.01
Electrical Conductivity (mS/cm)	
Mean	4.64
St.Dev	3.36
Range	0.013-10.76
pH	
Mean	6.46
St. Dev	0.22
Range	6.86-7.5
Dissolved Oxygen (mg/L)	
Mean	4.01
St.Dev	1.17
Range	3.27-6.63
Redox (mV)	
Mean	192.15
St.Dev	94.35
Range	157-400
Depth to Groundwater (m.b.g.l)	
Mean	71.00
St.Dev	6.99
Range	70-92

4.3.6.2 Troglofauna

Five troglobitic morphospecies were collected from the J4 impact area and survey area during the troglofauna sampling. One additional troglobitic specimen was collected from the survey area. Details are listed in Table 4.5 described in the section below.

Table 4.7 – Results from troglofauna fauna sampling

Higher Taxon	Species	SRE status	Comments	Impact area
Isopoda (Isopods)				
Armadillidae	Unknown genus sp. nov	Likely	Troglobitic, tightly rolled	J4 impact area
	Troglarmadillo sp. indet.	Likely	Troglobitic	J4 impact area
Platyarthridae	*Trichorhina* sp. nov.	Unknown	Troglobitic, fragile specimens	J4 impact area
Philosciidae	Philosciidae 'bungalbin'	Likely	Troglobitic	Survey area
Indet	Unknown	Unknown	Troglobitic, specimen incomplete	J4 impact area
Polyxenida (Bristle Millipede)				
Polyxenidae	Polyxenidae 'sp. indet.'	Potential	Possible Troglobite	J4 impact area

730000 740000 750000 760000 770000

6650000

6640000

6630000

Legend

Species

- *Aganippe* sp. indet.
- *Aname* 'MYG279'
- *Idiosoma* sp. indet.
- *Kwonkan* sp. indet.
- *Synothele* sp. indet.
- *Urodacus* 'koolyanobbing 2'
- *Urodacus* 'koolyanobbing 3'
- *Urodacus* 'koolyanobbing 4'
- J4 impact area
- Survey area
- Conservation Estate

Fauna habitat types

- Drainage Line
- Mallee woodland on rocky plain and footslope
- Mixed Eucalypt woodland on plain
- Rocky Ridge
- Sandy plain with shrubland
- Seasonal swamp

0 0.4 0.8
Kilometres
Absolute Scale - 1:48,000

Map extent

0 0.085 0.17
Kilometres
Absolute Scale - 1:10,000

N

0 2.5 5
Kilometres

Absolute Scale - 1:121,740

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Locations of collected SREs (spiders and scorpions)

Figure: 4.12
Project ID: 1479

Drawn: AH
Date: 23/11/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

A3

730000 740000 750000 760000 770000

6650000

6640000

6630000

Legend

Species

- *Amblyolpium* 'PSE077'
- *Antichiropus* sp.
- Armadillidae unknown genus sp. nov. A
- Armadillidae unknown sp. nov. C
- *Austrohorus* sp.
- *Beierolpium* sp. indet
- *Bothriembryon* cf. *sedgwicki*
- Cheiridiidae `genus indet. (juv)`
- Olpiidae genus indet. sp. indet
- *`PSEAAD PSE076'*
- J4 impact area
- Survey area
- Conservation Estate

Fauna habitat types

- Drainage Line
- Mallee woodland on rocky plain and footslope
- Mixed Eucalypt woodland on plain
- Rocky Ridge
- Sandy plain with shrubland
- Seasonal swamp

0 0.4 0.8
Kilometres
Absolute Scale - 1:48,000

0 0.085 0.17
Kilometres
Absolute Scale - 1:10,000

Map extent

N

0 2.5 5
Kilometres

Absolute Scale - 1:121,740

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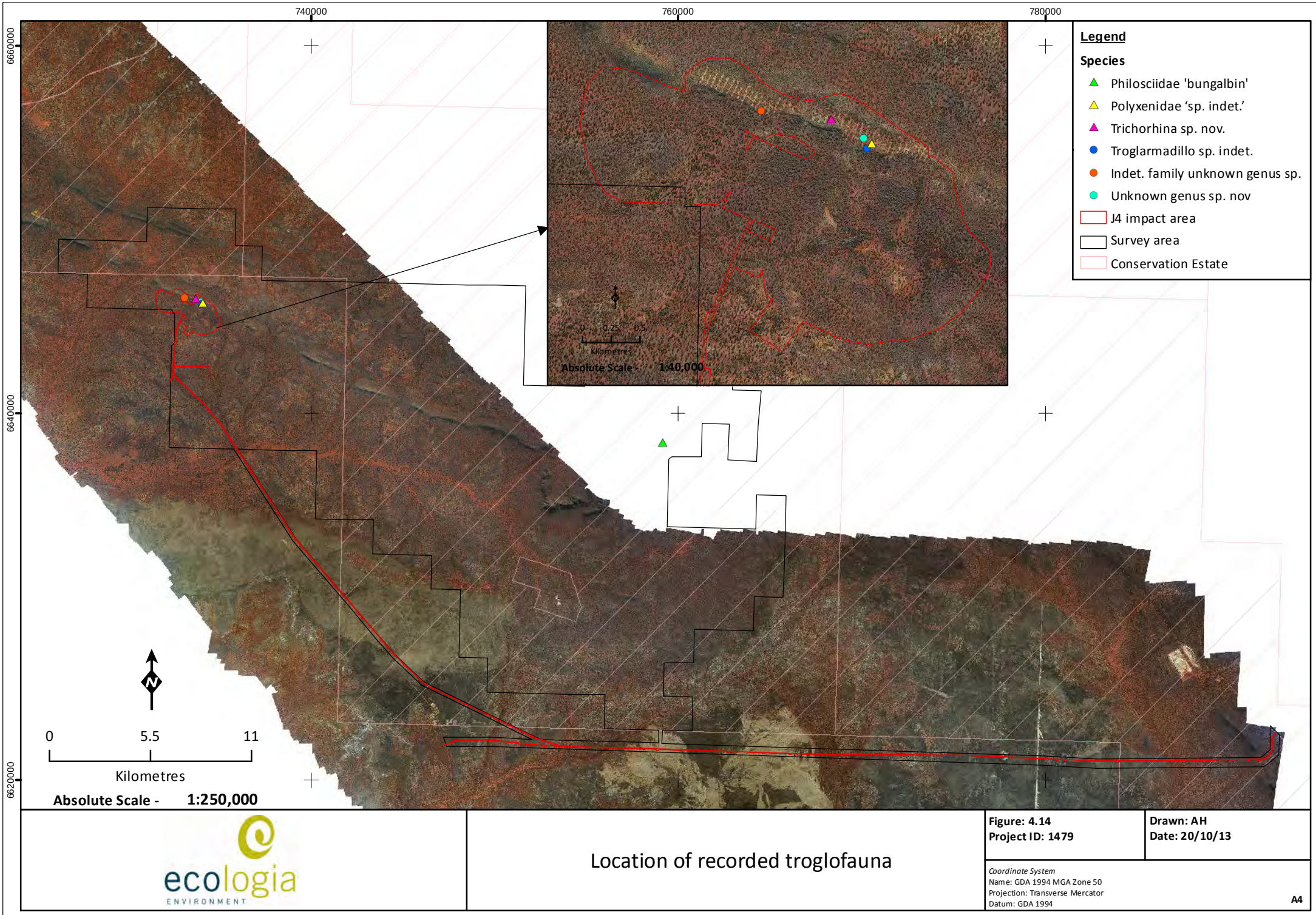
Location of collected SREs
(pseudoscorpions, isopods, snails, millipedes)

Figure: 4.13
Project ID: 1479

Drawn: AH
Date: 23/11/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

A3



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Location of recorded troglofauna

Figure: 4.14
Project ID: 1479

Drawn: AH
Date: 20/10/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

A4

4.4 SURVEY ADEQUACY

4.4.1 Vertebrate fauna

Parametric analysis of systematically obtained survey data (opportunistic records were excluded) for birds and terrestrial faunal groups revealed that survey effort was adequate.

Table 4.8 provides a summary of the theoretical maximum number of species using seven different methods of estimating richness. The Michaelis-Menton (MM) equation provides the most accurate representation of the potential species number. This is compared against the actual number of species observed, with any inconsistencies smoothed by an algorithm (Mao Tau) which simulates an infinite number of randomisations of the sample order.

SACs were generated through 1,000 randomisations of the sample sequence of the data sets for terrestrial trapped fauna (mammals and herpetofauna, Figure 4.15) and avifauna (Figure 4.16). The Sobs (Mao Tau) line reflects the actual number of species observed, with the MM means (1 run) line being the predicted total number of species that could be recorded.

Analysis of the trapped terrestrial fauna dataset produced a smooth curve that although close, has not yet reached an asymptote. Visually, the shape of the curve in this SAC displays that the number of species being recorded was still increasing slightly at the cessation of survey effort. The MM estimator, used as stopping rule, indicated that the survey was 85.3 % adequate; with the species observed (Sobs Mao Tau) value of 52 with an MM means value of 60.97. When combining the seven estimators, the trapping program was 84.7% adequate. These results indicate that, although the majority of species were recorded during the survey, additional trapping would likely detect at least nine additional species. However, a total of 59 species of trappable vertebrate fauna were recorded when all survey methods are combined (bat species and non-trappable fauna excluded).

The SAC for the bird data is nearing an asymptote. The MM estimator, used as stopping rule, indicated that the survey was 92.4% sufficient; with the species observed (Sobs Mao Tau) value of 66 with an MM means value of 71.44. When combining all seven estimators, 97.1 % of the avifauna theoretically present were detected during the systematic bird surveys. These results indicate that, although the majority of bird species were recorded during the survey, additional survey effort would likely record at least two additional species. However, a total of 90 species were recorded when including all opportunistic records.

Analysis of both fauna assemblages (birds and terrestrial fauna) indicate that at the completion of this survey, survey effort was adequate to provide an indication of the majority of the fauna assemblage present in the survey area.

Table 4.8 – Mean estimates of total species richness (Vertebrate Fauna)

Richness estimators	Total richness estimate	
	Terrestrial vertebrates	Birds
ACE	57.24	67.14
ICE	57.63	66.95
Chao-1	63.25	67
Jack-1	62.93	68.97
Jack-2	70.86	66.09
Bootstrap	56.89	68.06
Michaelis-Menten	60.97	71.44
Combined estimators (mean)	61.39	67.95
Species trapped/observed systematically	**52**	**66**
Total observed species (systematic & opportunistic)	**59**	**90**

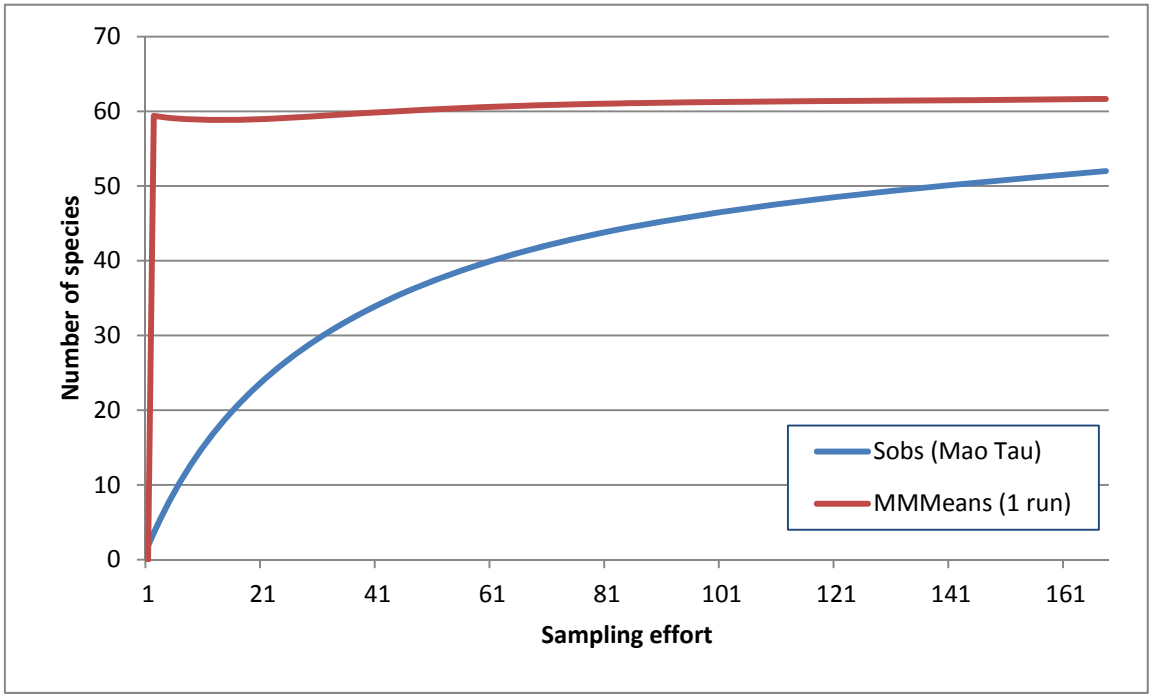

Figure 4.15 – SAC for trappable fauna

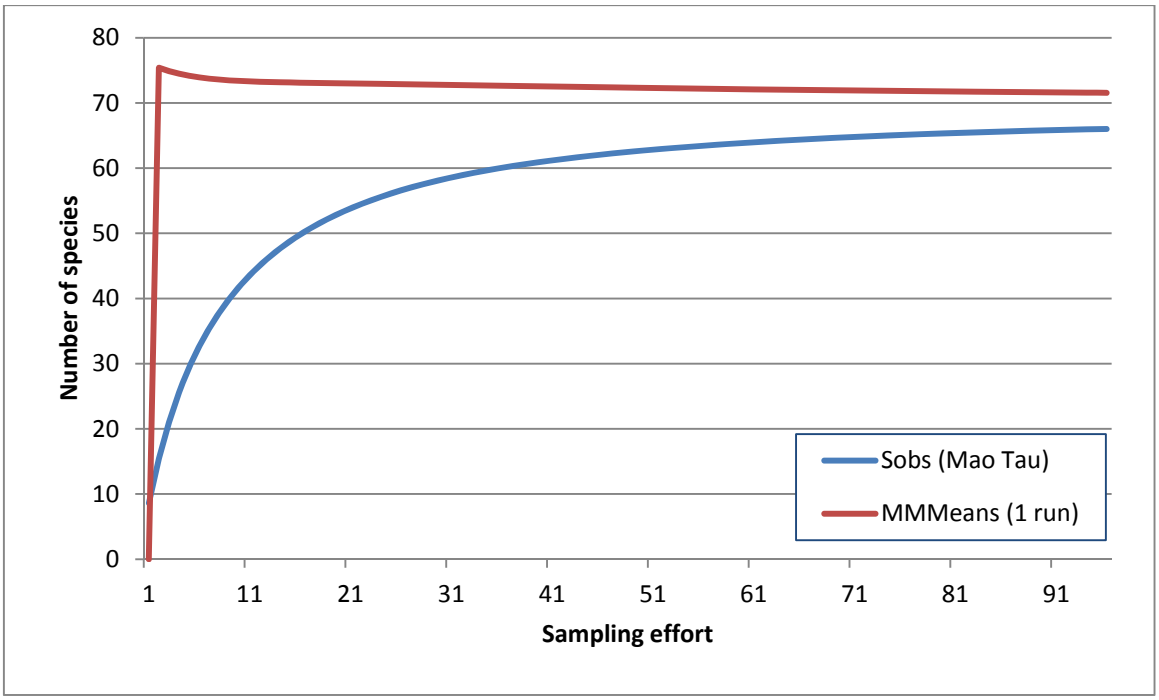

Figure 4.16 – SAC for avifauna

4.4.2 SRE Invertebrate fauna

Species Accumulation Curve (SAC) through 1,000 randomisations of the sample sequence gave a smooth curve, which has not reached a plateau even after combining wet pitfall trapping and leaf litter collections (Figure 4.17).

The Jack-2 estimator of total species richness predicted that the invertebrate assemblage in the area consisted of approximately 77 species. All other richness estimators resulted in estimate values between 54.0 and 66.87 species (Table 4.9). The Michaelis-Menten estimator used as a stopping rule detected that the survey was sufficient at 77.73%. The combined estimators indicate a survey adequacy of 78.0%. These results suggest that, while the survey was sufficient, it is likely that some species have not been captured during the survey. However, a total of 79 morphospecies were recorded during the survey when combining all systematic and opportunistic survey techniques.

Table 4.9 – Mean estimates of total species richness of systematically sampled SRE fauna

Richness Estimators	Total richness estimate
ACE	55.59
ICE	65.34
Chao-1	54.0
Jack-1	66.87
Jack-2	77.76
Bootstrap	56.89
Michaelis-Menten	63.04
Combined estimators	62.8
Recorded systematically (wet pitfalls & leaf litter)	**49**
Recorded total (systematic and foraging)	**79**

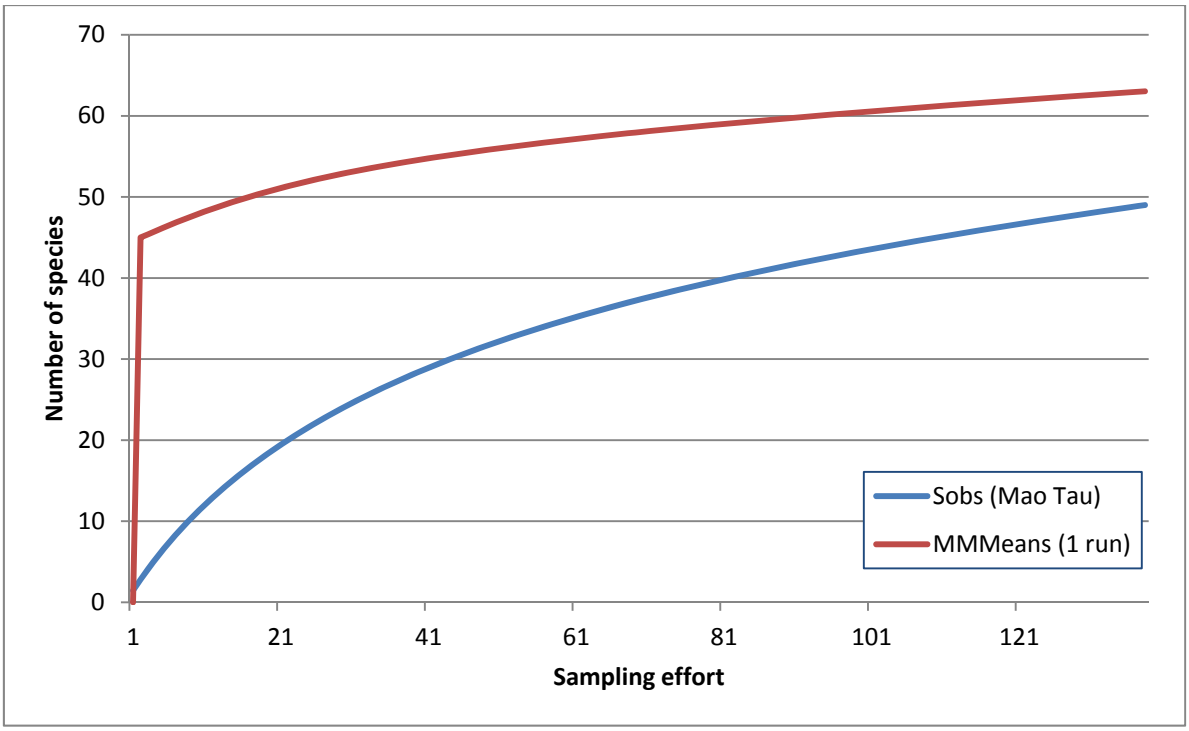

Figure 4.17 – SAC for SRE invertebrate fauna

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5 DISCUSSION

5.1 HABITATS AND ASSOCIATED FAUNA

5.1.1 Rocky ridge

The terrestrial fauna of rocky ridges is typically diverse due to the large amount of shelters and hiding spaces between rock piles and in crevices and small caves.

Mammals associated with this habitat type include small mammals such as Woolley's Pseudantechinus (*Pseudantechinus woolleyae*) and large mammals such as the conservation significant Black-footed Rock-wallaby (*Petrogale lateralis lateralis,* EPBC Vulnerable*,* WC Act Schedule 4) (not recorded), particularly where there are rocky outcrops and rock piles to provide shelter (van Dyck and Strahan 2008).

The avifauna of the rocky ridges is usually relatively sparse due to the open vegetation and the lack of flowering trees and shrubs. Bird species inhabiting this habitat type include Willie Wagtail, Chestnut-rumped Thornbill, Black-faced Cuckoo-shrike and Pied Butcherbird. The Peregrine Falcon (WC Act Schedule 4) has the potential to nest and breed on cliffs within this habitat type (Morcombe 2000) in particular along the Helena and Aurora Ranges, east of the impact area where rocky ranges are at higher elevations.

The herpetofauna associated with this habitat type include a number of species that hunt and shelter between rock piles: the geckos *Diplodactylus granariensis* and *Diplodactylus pulcher*, the skinks *Egernia depressa,* and *Egernia formosa* and the Stimson Python (*Antaresia stimsoni*) and the conservation significant South-west Carpet Python (*Morelia spilota imbricata*; WC Act Schedule 4, DPaW P4) (not recorded) (Wilson and Swan 2013).

The SRE invertebrate fauna of this habitat type can be quite sparse due to hard, rocky surface and the lack of cover. However, some scorpions may utilise patches of deeper soil for the construction of their burrows (Koch 1978, 1981) and some species of pseudoscorpions may be found under rocks (Harvey 1996; Lewis 1998). The Tree-stem Trapdoor Spider (*Aganippe castellum* - DPaW Priority 4) was recorded at a number of locations throughout this habitat type at the base of larger trees which provides suitable leaf litter and moist conditions for this species (Russell 2006).

5.1.2 Mallee woodland on rocky plain and footslopes

The rocky plains and footslopes habitat type typically harbour vertebrate fauna that can occur in a variety of habitat types. These generalists comprise mammals such as the Wongai Ningaui, the Southern Ningaui, the Stripe-faced Dunnart and the Euro (van Dyck and Strahan 2008). Western Quoll (*Dasyurus geoffroii*; EPBC Act Vulnerable, WC Act Schedule 1, DEC Vulnerable), if present within the impact area, may use the rocky plain and footslopes habitat for foraging, though they are likely to prefer the eucalypt woodland habitat as it provides more shelter options (van Dyck and Strahan 2008).

The avifauna of the rocky plains and footslopes consists of generalists that inhabit patches of denser vegetation. White-winged Triller, Black-faced Cuckoo-shrike, Rufous Whistler, Masked Woodswallow, Willie Wagtail, Pied Butcherbird, Hooded Robin and Zebra Finch are bird species typically inhabiting plains and footslopes such as those in the impact area (Simpson and Day 2010). Birds of prey utilise the open vegetation for hunting and Brown Falcons, Wedge-tailed Eagle and Whistling Kite were often seen foraging above the open vegetation cover (Johnstone and Storr 1998).

The herpetofauna assemblage of the rocky plains and footslopes lacks amphibians due to the absence of surface water and soft substrates, and is limited in suitability to reptiles that can be found in a variety of habitats that do not rely on soft substrates to construct burrows: Western netted

Dragon (*Ctenophorus reticulates*), Beaked Gecko (*Rhynchoedura ornata*), Spiny-tailed Gecko (*Strophurus wellingtonae*), Bynoe's Gecko (*Heteronotia binoei), Yellow-spotted Monitor (Varanus panoptes)* and Moon Snake (*Furina ornata*). The Pebble Dragon (*Tympanocryptis cephalus*) that was recorded in this habitat type is a specialist and is not anticipated to occur in any other habitat (*ecologia* internal database).

This habitat type includes south-facing hillslopes which can support a large range of SRE species due the presence of moist microhabitats created by shade of the tall trees and deep leaf litter beds underneath them, along small depressions and drainage lines (Black 1997; Harvey 1996; Koch 1978, 1981; Lewis 1981). The mygalomorph spiders from the family Idiopidae use leaf litter to construct the trap door at the tops of their burrows, and thus enhance their foraging area (Main 1982a, 1996), and spiders from the family Nemesiidae construct open burrows whose entries (often multiple) are hidden in the leaf litter beds (Raven 2007; Valerio 1986). This habitat type is preferred by mygalomorph spiders (Main 1982a, 1996). Microhabitats associated with the mallee found in this habitat allow scorpions from the families Urodacidae and Buthidae to construct their burrows in the softer soil (Koch 1978, 1981), and the millipedes (family Paradoxomatidae) and snails often burrow into the soil and litter around the base of shrubs to escape dessication (Black 1997; Slack-Smith 2006). Pseudoscorpions and isopods are also mainly found in litter beds under the mallee trees (Harvey 1996; Lewis 1998).

The Tree-stem Trapdoor Spider (*Aganippe castellum*) prefers *Baeckea, Melaleuca* and *Allocasuarina* shrubs which can be found in patches throughout this habitat type. As such, this species has a potential to occur on the rocky plains and footslopes, in particular along south-facing footslopes, as these provide moist microhabitats (Russell 2006). Given the spiders take several years to reach maturity and are highly reliant on their burrows, impacts to microhabitat may impact the local population (Russell 2006).

5.1.3 Mixed Eucalypt woodland

The mixed eucalypt woodland is likely to be the habitat type that supports the highest species diversity in the impact area, due to the greater structural complexity of the vegetation and the presence of tall trees that provide hollows, logs (wood debris) and habitat for arboreal species. Species recorded within this habitat included all nine species of bats, three *Lerista* species, *Varanus gouldii* and *V. tristis*, as well as an assemblage of typical woodland birds.

Mammals that are typically found within the habitats akin to the mixed eucalypt woodland of the impact area include Western Pygmy, Little Long-tailed Dunnart and several species of bats, (Bamford 2012; Ninox 2009). Some bat species, such as the Western Long-eared bat can be found roosting in tree hollows and foraging between the trees, close to the ground (Churchill 2008). Whilst not recorded, species of conservation significance that potentially occur within the eucalypt woodland include: Western Quoll (*Dasyurus geoffroii*), Numbat (*Myrmecobius fasciatus*), Western Brush Wallaby (*Macropus irma*) and Tammar Wallaby (*M. eugenii derbanius*) (van Dyck and Strahan 2008).

The avifauna of the mixed eucalypt woodland habitat type can be particularly rich. Large trees provide food, shelter and breeding habitat. Bird species commonly found within semi-arid eucalypt woodlands comprise Red-tailed Black-Cockatoo, Purple-crowned Lorikeet, Australian Ringneck, Rufous Treecreeper, Weebill, Striated Pardalote, Varied Sittella and Mistletoe Bird (Morris and Wooller 2001). The conservation significant Rainbow Bee-eater (*Merops ornatus*; EPBC Migratory, WC Act Schedule 3) was recorded from mixed eucalypt woodland in the impact area. Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris;* EPBC Endangered, WC Act Schedule 1, DEC Endangered) and Major Mitchell's Cockatoos (*Lophochroa leadbeateri*; EPBC Schedule 4, DEC Other specially protected) prefer areas of eucalypt woodland near water sources and may breed in hollows of tall eucalypt trees (Johnstone and Storr 1998). The Peregrine Falcon (WC Act Schedule 4) was recorded

from eucalypt habitat and is likely to utilise this habitat for foraging and potentially for nesting in large eucalypt trees.

The herpetofauna of the mixed eucalypt woodland habitat is similarly diverse as the avifauna, providing shelter under organic material such as logs, leaf litter and bark. The Dwarf Bearded Dragon (*Pogona minor*), Thick-tailed Gecko (*Underwoodisaurus milii*), Knob-tailed Gecko (*Nephrurus vertebralis*), Reticulated Velvet Gecko (*Oedura reticulata*), Tree Dtella (*Gehyra variegata*), a number of Leg-less Lizards and skinks, Stripe-tailed Monitor (*Varanus caudolineatus*) and Racehorse Monitor (*Varanus tristis*) can be typically found in eucalypt woodland (Wilson and Swan 2013). The conservation significant Woma (*Aspidites ramsayi;* WC Act Schedule 4, DEC Priority 1) can be found sheltering under logs or in tree hollows of eucalypt trees (Wilson and Swan 2013).

Though little is known about the Arid Bronze Azure Butterfly (*Ogyris subterrestris petrina*; EPBC Critically Endangered, WC Act Schedule 1, DEC Critically Endangered), it is likely to prefer the mixed eucalypt woodland habitat, as the species is most likely associated with sugar ant (*Camponotus terebrans*) nests at the base of smooth-barked eucalypts (e.g. *Eucalyptus salubris*) (Sands and New 2002). However, the species would be restricted to patches of suitable eucalypt trees within this habitat (Sands and New 2002). If the Arid Bronze Azure Butterfly is present within the impact area, loss of habitat could have significant impact to the species. Impacts to the species may be minimised by avoiding disturbance to these microhabitats.

The SRE invertebrate fauna of the mixed eucalypt woodland habitat can be quite rich due the presence of moist microhabitats created by shade of the tall trees and deep leaf litter beds underneath them, combined with softer top soil suitable for burrowing species. Many mygalomorph (trapdoor) spiders utilise this habitat type (Main 1982a, 1996). In particular, spiders from the family Idiopidae use leaf litter to construct the tops of their burrows with trap door (Bradley 1996), and thus enhance their foraging area, and family Nemesiidae and Barychellidae construct open burrows whose entries (often multiple) are hidden in the leaf litter beds (Raven 2007; Valerio 1986). Scorpions from the families Urodacidae and Buthidae often construct their burrows in the softer soil (Koch 1978, 1981), and the millipedes (family Paradoxomatidae) and snails often burrow into the soil and litter around the base of trees to escape dessication (Black 1997; Slack-Smith 2006). Pseudoscorpions and isopods are also mainly found in litter beds under the eucalypt trees (Harvey 1996; Lewis 1998).

5.1.4 Sandy plain with shrubland

The sandy plain with shrubland habitat provides for a number of species that require soft substrate for the construction of burrows.

Mammals typically found on sandy plains include the Hairy-footed Dunnart, Spinifex Hopping Mouse and Sandy Inland Mouse. The conservation significant Greater Bilby (*Macrotis lagotis;* EPBC Act Vulnerable, WC Act Schedule 1) is known to forage and construct its burrows within sandy plain habitats.

The avifauna of the sandy plain with shrubland is moderate and includes species that feed on grass seeds or flowering shrubs such as *Acacia*. Crested Pigeon, Common Bronzewing, Budgerigar, Little Button Quail, Brown Songlark, Rufous Songlark, Australasian Pipit and Zebra Finch are typically recorded feeding on seeds of grasses, whereas Singing Honeyeater, Crimson Chat, Brown Honeyeater and Brown-headed Honeyeater can be found searching for nectar in between the shrubs, in particular after rainfall events (Burbidge and Fuller 2007; Keast 1968).

Potential tracks of the Australian Bustard (*Ardeotis australis*; DEC Priority 4) were recorded in the sandy plain with shrubland habitat, and the species has been found regularly in this habitat type (*ecologia* internal database). Malleefowl (*Leipoa ocellata*; EPBC Vulnerable, WC Act Schedule 1, DEC Vulnerable) have a potential to occur within this habitat type given the sandy substrate is suitable for

the construction of mounds in particular in areas of mallee or other tall trees (International Malleefowl Forum 2004, ecologia internal database)

The herpetofauna of the sandy plains with shrubland habitat consist of a relatively large number of specialised amphibians and reptiles. Several frog species, such as the Desert Trilling Frog (*Neobatrachus centralis*), the Shoemaker Frog (*Neobatrachus sutor*) or the Turtle Frog (*Myobatrachus gouldii*) can aestivate in the sand throughout the dry and hot summers to then re-emerge after rainfall events (Cogger 2000). The Mallee Sand Dragon (*Ctenophorus fordi*), the Desert Skink (*Liopholis inornata*), the Bull Skink (*Liopholis multiscutata*), the Pygmy Desert Monitor (*Varanus eremius*), the Sand Monitor (*Varanus gouldii*) and Jan's Banded Snake (*Simoselaps bertholdi*) find suitable conditions to construct burrows or forage on or beneath the soft substrate (Wilson and Swan 2013). The conservation significant Woma (*Aspidites ramsayi*; WC Act Schedule 4, DEC Priority P4) may occur within the sandy plain with shrubland habitat.

Vegetation of the sandplain shrublands habitat produces an abundance of leaf litter, thus providing suitable habitat for burrowing Mygalomorph spiders, in particular from the family Idiopidae which use leaf litter to construct the tops of their burrows with a trap door (Bradley 1996). Spiders from the families Nemesiidae and Barychellidae construct open burrows whose entries (often multiple) are hidden in the leaf litter beds and therefore abundant throughout this habitat (Raven 2007; Valerio 1986). Scorpions from the family Urodacidae construct large burrows, the soft sandy soils of the sandplain shrublands provide suitable habitat for these species and other scorpions from the family Buthidae which forage and shelter amongst deep leaf litter (Koch 1981).

5.1.5 Drainage line

Although no surface water was present during the survey, the drainage line habitat may attract a high diversity of species, including some waterbirds, whenever surface water is available. However, the drainage line habitat is more likely to provide moist microhabitats, which could support amphibians and SRE invertebrates. As the drainage line habitat is located on the south-facing slopes of ridges in the survey area, there is potential for it to provide suitable microhabitat for a range of SRE species, including isopods, millipedes, pseudoscorpions and trapdoor spiders (Harvey 2002).

Mammals potentially occurring along drainage lines include generalists such as the Wongai Ningaui, the Gilbert's Dunnart and the Little Long-tailed Dunnart, but can also comprise the Pygmy possum which was recorded (trapped) within the drainage line habitat during the survey. The closed vegetation layer and the moisture of the drainage lines can attract a variety of flying insects and therefore represent a valuable food source for a number of bat species, such as the Gould's wattled bat, which may hunt in between the vegetation, and roost within hollow trees during the daytime (Churchill 2008).

The avifauna of the drainage lines can be relatively rich at times, depending on the presence of surface water. The Rufous Whistler, Weebill, Magpie-lark and White-plumed Honeyeater are typical inhabitants of drainage lines (Johnstone and Storr 2004). After rainfall, when surface water is present, a number of waterbirds are likely to occasionally visit this habitat type when travelling between the surrounding salt lakes (e.g. Lake Polaris, Lake Barlee, Lake Deborah, Lake Seabrook, Lake Giles, Hamersley Lakes, Lake Julia and Lake Koorkoordine) but are not expected to reside within the impact area. The conservation significant Rainbow Bee-eater can be frequently seen within this habitat which may provide potential nesting sites along sand banks.

Drainage lines harbour frog species after rainfall, when pools of surface water provide suitable breeding conditions: Sheep frog (*Cyclorana maini*), Spotted-thighed Frog (*Litoria cyclorhyncha*) or the Kunapalari Frog (*Neobatrachus kunapalari*) can be found along these pools (Bamford 2012; Ninox 2009). However, the drainage line within the impact area appears to have limited capacity to hold water and therefore is unlikely to support a large number of amphibians. None of the reptile species

expected to occur in this habitat are specialised and restricted to the drainage line habitat and therefore the reptiles inhabiting this habitat type are expected to occur within other habitat types.

The SRE invertebrate fauna of this habitat type are likely to reflect the wider habitat type around the drainage line, in this case the mixed eucalypt woodland and mallee woodland on rock plain and footslope. Drainage lines are suitable habitat for Idiopid mygalomorph spiders, which often build their burrows on the fringes of the channel, avoiding direct flooding but benefitting from the increased moisture in the area to keep their burrows humid. Scorpions from the families Urodacidae and Buthidae often construct their burrows in the softer soil (Koch 1978, 1981), and the millipedes (family Paradoxomatidae) and snails often burrow into the soil and litter around the base of shrubs to escape dessication (Black 1997; Slack-Smith 2006). Pseudoscorpions and isopods are mailnly found in litter beds under the trees that line this habitat (Harvey 1996; Lewis 1998). The Tree-stem Trapdoor Spider (*Aganippe castellum*; DEC Priority 4) can be found in flood-prone depressions and flats that support myrtaceous shrub communities and, as such, has a potential to occur along the drainage lines (Russell 2006).

5.1.6 Seasonal swamp

This habitat type is not discussed in detail due to the restriction of this habitat to the survey area and the lack of areas of seasonal swamp within the impact area.

5.2 FAUNA HABITAT ANALYSIS

The fauna habitat analysis (Section 4.2) for all fauna groups (trapped terrestrial vertebrates, avifauna and SRE invertebrates) indicates a significant difference between the fauna assemblage of each of the systematically surveyed habitat types. Any R-value greater than zero indicates that the difference observed between habitat types is greater than the difference observed within each habitat type.

Habitat types for trapped terrestrial vertebrate fauna shared an overall R-value of 0.1296. Pairwise comparisons of the data indicate that the greatest difference in fauna assemblage was between the rocky ridge habitat and sandy plain with shrubland habitat, which shared an R-value of 0.2605. This difference is due to the microhabitats that are unique to each of these habitat types and support a unique species composition. The lowest similarity was shared between the rocky ridge and mallee on rocky plain habitat sharing R-values of <0.05. These two habitat types share similar microhabitat features such as rocks and isolated pockets of shrubbery, leaf litter and woody debris which small ground dwelling fauna use for shelter. The microhabitat features shared between these habitat types provide habitat for generalist species such as *Gehyra variegata* and *Diplodactylus granierensis* and the presence of such species in both habtat types has resulted in a lower R-value for these two sites.

Habitat types for avifauna shared an overall R-value of 0.1666. Pairwise comparison show that the largest difference was shared between the sandy plain with shrubland and drainage line habitats with an R-value of 0.7798. As illustrated in Figure 4.9, the avifaunal assemblage of the sandy plain with shrubland is the most distinct habitat type. The dense vegetation within this habitat is often provides suitable conditions for small nectivorous and insectivorous passerines species. The density of this vegetation is unlike any other habitat type within the regional area and thus provides for a unique avifauna assemblage.

Habitat types for SRE shared an overall R-value of 0.1781. Pairwise comparisons show that the mixed eucalypt woodland was the most distinct habitat type in comparison to all other habitat types, as depicted in Figure 4.10, and is particularly dissimilar to the sandy plain with shrubland habitat. Microhabitat features within these two habitat are very distinct from one-another, particularly the soil substrate which spider and scorpions borrow into, the amount of leaf litter which is much denser

and more moist within the mixed eucalypt woodland, the type and shape of leaves which spiders use to make the top of their burrows, and the amount and abundance of woody debris which contain moist environments for isopods, millipedes, molluscs and geophilomorph centipedes.

Overall, the fauna habitat types recorded from inside the J4 impact area were also found outside the proposed impact area with good habitat connectivity between these areas and thus fauna recorded from inside the impact area is expected to occur in the local region outside the impact areas.

5.3 FAUNA ASSEMBLAGE

5.3.1 Mammals

The number of terrestrial mammals observed during this survey (20) is comparable to the number of mammals species recorded on others surveys conducted within the local region, Bamford 2012 (16), Biota 2011a (19), Dell *et al*. 1985 (23) and Ninox 2009 (21). The most diverse mammal family recorded during the survey was Vespertilionidae, with seven species recorded. This large number includes all species known to occur to within the region and indicates that there are diverse non-restricted bat populations in the impact area. The large diversity is contributed to the extensive amount of suitable roosting habitat, which is located within the survey area and represented by the mixed eucalypt woodland and mallee on rocky plain and footslopes within the impact area (Churchill 1998). Noteworthy is also the large number (42 records) of the Ash-grey Mouse recorded from the sandy plain with shrubland habitat type in the south of the survey area (Appendix G). This may indicate suitable conditions for mammals (in particular during phase 2 of the survey) and the low number of predators in the form of birds of prey and snakes at the time of surveying.

One species, Woolley's Pseudantechinus was recorded via secondary evidence during the survey. This species has been recorded during other surveys within the region (*ecologia* internal database) and is known to exist within the region (DPaW 2013), however the records from this survey represent the most southern extent of the species distribution.

The local abundance of introduced terrestrial mammals such as the House Mouse, Cat and Rabbit was also noted in particular from within the survey area (Appendix G) and may have resulted in lower mammal fauna diversity. The abundance of these introduced species could result in the exclusion of some species otherwise expected to occupy within the impact area and survey area, such as the native murids (mice and rats) that were represented by only two species which were restricted to one fauna habitat type (sandy plain with shrubland) during this survey. Competition and land degradation by rabbits is listed as a key threatening process for native flora and fauna resulting in approximately 156 threatened species that may partly affected by competition and land degradation by rabbits (Brown and Saunders 2013). In addition, feral cats are known to play a major role in the threatening process for rare fauna (e.g. Malleefowl, Bush Stone-curlew, Bilby, Western Quoll, Section 1.4.1.1) due to predation and competition for food (DEC 2011; Garnett 2012; Glen *et al.* 2009; Johnson 2008; National Parks and Wildlife Service 1999; Natural Heritage Trust 2004).

5.3.2 Birds

The avian species diversity recorded in the regional impact area (90) is typical of the region, with most of the groups being well represented. The number of species recorded is slightly higher than other surveys undertaken within the region: Bamford 2012 (68 species), Biota 2011a (51), Dell *et al*. 1985 (78) and Ninox 2009 (68) (Appendix C). The high diversity recorded during this survey is attributed to the data being collected over three separate field surveys and the ideal weather conditions (causing the vegetation to flower) that were experienced prior to the first phase of the survey (BoM 2013b)

The Major Mitchell's Cockatoo and Gilbert's Whistler records in particular are notable in that both species are uncommon, although both species have been recorded in nearby surveys (Appendix C). The Purple-gaped Honeyeater record is a slight northward range extension (~100 km northeast) for the species (DPaW 2013) and was recorded at systematic survey sites during both phases of the survey. The Brush Bronzewing and New Holland Honeyeater records represents a ~180 km northward range extension for these species (DPaW 2013). Both species were recorded opportunistically during the first phase of the survey, subsequent to a period where the region had experienced a number of extreme weather events and heavy rainfall (BoM 2013b). As a result of these conditions the vegetation was in good condition and flowering, resulting in high avifauna diversity and abundance and the presence of species which may not usually occur within the area.

The other more abundant records are typical inhabitants of the habitat types found in the impact area. The most abundant family recorded was meliphagidae, the honeyeaters, with 13 species recorded. As mentioned early this high number is attributed by the ideal conditions that were experienced within the region prior to the survey.

Six birds of conservation significance were recorded within and nearby the impact area: the Malleefowl, Rainbow Bee-eater, Peregrine Falcon, Major Mitchell's Cockatoo, Shy Heathwren, Australian Bustard/Bush Stone-curlew and Crested Bellbird.

5.3.3 Herpetofauna

The reptile assemblage of the impact area appears to be representative of the assemblage of the region (Appendix C). A total of 48 species were recorded within the regional impact area, a total higher than other surveys conducted within the region Bamford 2012 (29), Biota 2011a (26), Dell *et al*. 1985 (41) and Ninox 2009 (26). Most family groups were represented by the expected number of species (Appendix C), the most diverse family being scincidae, skinks, represented by 16 species within the regional impact area.

Delma fraseri was recorded from two locations within the impact area; these records occur within the species mapped distribution (Wilson and Swan 2013) but represent the species most northern extent across the goldfields region (DPaW 2013).

The two snake families (Boidae and Elapidae) were under-represented, possibly due to the fact that the vertebrate fauna survey was conducted in early summer, resulting in lower snake activity levels. The three gecko and one skink species that were recorded in high numbers (*Diplodactylus granariensis, Oedura reticulata, Gehyra variegata* and *Morethia butleri*) are all widespread and abundant in the arid south-west (Wilson and Swan 2013) (Appendix C). All reptile species recorded during the survey are common species within the region and typical inhabitants of the habitats within the survey area.

Only two amphibian species were recorded during the survey, *Neobatrachus pelobatoides* and *Pseudophryne occidentalis*. Both species are common and widespread throughout the region. The record of *Neobatrachus pelobatoides* represents the most northerly record of the species through the goldfields region (DPaW 2013). The lack of amphibians recorded is due to the lack of surface water and high temperatures during the first phase of surveying at the J4 impact area. Regular rainfall was recorded prior to the survey in December 2012 (Table 2.1) which softened the ground and may have brought out amphibians prior to the field assessment. However, rainfall experienced at the beginning of the survey in October 2013 (Appendix B) did not result in the appearance of any amphibian species.

5.3.4 Invertebrate Fauna

5.3.4.1 Epigean Terrestrial SREs

The database searches of species collected in the area during previous surveys set an expectation that the impact area was likely to harbour high invertebrate fauna species diversity. The taxonomic results of trapdoor spiders, scorpions, isopods and snails collected confirm this. Furthermore, of the 21 morphospecies of spiders identified, 13 represent likely or potential SRE species and one is a Priority 4 listed species (Table 4.5). Furthermore, four of the 11 scorpion species are potential SREs, eleven of the 17 pseudoscorpion species are potential SREs, nine of the 13 species of isopod are potential SREs, with an additional species, *Buddelundia* '71' a confirmed SRE, two of the nine mollusc species are potential SREs, one of the five millipedes species recorded are a potential SRE while three are confirmed SREs, and two of the three geophilomorph centipedes are potential SREs.

The terrestrial fauna assessment recorded several new invertebrate species; four arachnid species (*Yilgarnia* 'MYG272', Synothele 'MYG278', *Urodacus* 'koolyanobbing 2' and *U.* 'koolyanobbing 3'), two species of pseudoscorpion, `PSEAAD PSE076' and *Amblyolpium* `PSE077`) and five isopod species (Buddelundia '71', *Buddelundia* sp. nov. A, Unknown genus sp. nov. A, Unknown genus sp. nov. C and Armadillidae 'EE1479S'). All are currently known only from this survey. Of these new species, one species of pseudoscorpion (also representing a new genus) was recorded from only within the J4 impact area and was not recorded from the survey area. The remaining ten species were not recorded exclusively from the impact area. While species from the genera *Aganippe, Gaius, Aname, Synothele, Yilgarnia, Urodacus, Bothriembryon* and *Buddelundia* have been collected close to the impact area before (Biota 2009, 2011), the records of species belonging to *Missulena*, *Karaops, Anidiops*, *Kwonkan, Idiosoma,* and the remaining snails, isopods and geophilomorphs were previously known and represent new data for the distribution ranges of these species/genera.

Database searches and previous surveys conducted within 35 km of the impact area have revealed a total of 27 potential SRE species (Table 2.8). During this survey, a total of 40 potential SREs, four likely SREs and five confirmed SRE species were collected from the survey area and impact area. It is likely that this high level of short range endemism identified in the impact area is largely due to the low taxonomic resolution caused by the lack of mature males in the sample or lack of information on the species. DNA analysis for a species comparison with the *ecologia* and WAM DNA sequence databases, and potentially DNA of specimens collected outside the impact area, is likely to refine results and lead to a reduction in the number of SRE species, or at least clarify their distribution patterns. This is especially important for species found inside the impact area only (*Idiosoma* sp. indet., *Aname* 'MYG279', *Kwonkan* sp. indet. and `PSEAAD PSE076'). However, the isolation of habitats, in particular of the rocky ridge habitat, may result in a relatively large number of SREs present within the survey area (section 1.4.1.2).

5.3.4.2 Subterranean Fauna

Four subterranean species (all isopods) have been collected from the J4 impact area, displaying characteristics that restrict them to subterranean habitats (section 1.4.2.1), and confirm that a troglobitic assemblage exists in the impact area. One additional specimen was collected in the survey area. Information about reagional distribution of these species are not available at this stage due to the poor condition of reference specimens collected during previous surveys in the Yilgarn region which make a comparison on a morphological basis not possible (S. Judd, 2013, pers. comm.). DNA analysis for a species comparison is likely to give a conclusion on the distribution of these species.

5.3.5 Conservation Significant Fauna

Based on database searches and the results of previous biological surveys in the surrounding region, seven mammal, 33 bird and two reptile species of conservation significance could potentially occur in the impact area. An additional six species of conservation significant invertebrate species have previously been recorded in the Goldfields region. Based on habitat preferences and the representation of these in the impact area, two of these species have the potential to occur. Information regarding conservation significant species is summarised below in Table 5.1. Species of conservation significance with a high to medium likelihood of occurrence are reviewed in greater detail in the following sections.

Table 5.1 – Conservation significant fauna summary

Species	Conservation Status			Habitat	Previous Records	Likelihood of Occurrence	
	EPBC Act	WC Act	DPaW			J4 impact area	Survey area
Mammals							
Red-tailed Phascogale *Phascogale calura*	EN	S1	EN	Dense casuarina woodland with hollow-containing eucalypts.	Within field guide's distribution (Menkhorst and Knight 2011) but no records within 100km of the impact area.	LOW No previous records in the local region. No suitable habitat present within the impact area.	LOW No previous records in the local region. No suitable habitat present within the survey area
Chuditch (Western Quoll) *Dasyurus geoffroii*	VU	S1	VU	Variety of wooded habitat; eucalypt forest, dry eucalypt woodland and mallee shrublands.	Four recent and historical records (1969-2004) from the vicinity of Southern Cross and from approximately 90 km west of the impact area (DPaW 2013). Historical record (secondary evidence) from within the impact area (Dell *et al.* 1985).	MEDIUM Potential habitat present within the mixed eucalypt woodland. Few previous records from within 100 km of impact area.	MEDIUM Potential habitat present within the mixed eucalypt woodland. Few previous records from within 100 km of survey area.
Numbat *Myrmecobius fasciatus*	VU	S1	VU	Eucalypt forests and woodlands, dominated by *Eucalyptus marginata, E. calophylla* and *E. wandoo*.	One record (unknown date) from approximately 90km south of the impact area (DPaW 2013).	LOW Some potential habitat present within the mixed eucalypt woodland. One previous record in the surrounding region.	LOW Some potential habitat present within the mixed eucalypt woodland. One previous record in the surrounding region.
Greater Bilby *Macrotis lagotis*	VU	S1	VU	Variety of habitats on soft soil including spinifex hummock grassland, acacia shrubland, open woodland and cracking clays.	Closest, most recent record (2003) from approximately 100 km to the south-west of the impact area (DPaW 2013)	MEDIUM Suitable habitat exists in the sand plain with shrubland in the south of the impact area and the mixed eucalypt woodland. Very few recent records within 100 km.	MEDIUM Suitable habitat exists in the sand plain with shrubland in the south of the survey area and the mixed eucalypt woodland. Very few recent records within 100 km.
Black-flanked Rock-wallaby *Petrogale lateralis lateralis*	VU	S1	VU	Scattered locations amongst rocky outcrops.	Within field guide's distribution (Menkhorst and Knight 2011). No records within 100 km of the impact area.	LOW No previous records in the local region, very little suitable habitat present in the form of rocky ridges.	LOW No previous records in the local region, little isolated suitable habitat present in the form of rocky ridges.

Species	Conservation Status			Habitat	Previous Records	Likelihood of Occurrence	
	EPBC Act	WC Act	DPaW			J4 impact area	Survey area
Western Brush Wallaby *Macropus irma*			P4	Open forest or woodland, with low grasses and open shrubby thickets.	Within field guide's distribution (Menkhorst and Knight 2011) but no records within 100km of the impact area.	LOW No previous records in the local region, some isolated patches of suitable habitat present in the mixed eucalypt woodland habitat.	LOW No previous records in the local region, some isolated patches of suitable habitat present in the mixed eucalypt woodland habitat.
Birds							
Carnaby's Black-Cockatoo *Calyptorhynchus latirostris*	EN	S1	EN	Proteaceous woodland and scrub, eucalypt woodland and pine plantations.	One historical record from within the survey area (Dell *et al.* 1985). No recent record within 100 km of the impact area (DPaW 2013).	LOW No recent records in the local region. Some potential habitat exists in the mixed eucalypt woodland**.**	LOW One historical record within survey area. No recent records in the local region. Some potential habitat exists in mixed eucalypt woodland**.**
Malleefowl *Leipoa ocellata*	VU	S1	VU	Dry inland scrub, mallee.	Recorded from five previous surveys within 100 km of the impact area (Bamford 2012, ecologia internal database; Biota 2011a; Dell *et al.* 1985; Ninox 2009). Seventeen additional record from the region (within 100km) (DPaW 2013). Also, 41 regional records from rare fauna search return (DPaW 2013).	RECORDED Several records from the region. Species recorded via secondary evidence within sand plain with shrubland habitat of impact area. Species recorded from approximately 30 km east of impact area in November 2013. Suitable habitat present within sandy plain with shrubland habitat and dense patches of mixed eucalypt woodland of the impact area	RECORDED Several records from the region.. Species recorded approximately 4 km east of impact area in November 2012. Suitable habitat present within sandy plain with shrubland habitat and dense patches of mixed eucalypt woodland in the south of the survey area.
Slender-billed Thornbill *Acanthiza iredalei iredalei*	VU			Treeless or sparsely wooded flatlands, samphire and low melaleuca scrubs.	Three records from Lake Barlee, approximately 95 km north of the impact area (DPaW 2013). DSEWPaC suggests that some suitable habitat may exist in the vicinity of the impact area (Protected Matter Search).	LOW No suitable habitat present within impact area, no recent nearby records.	LOW No suitable habitat present within survey area, no recent nearby records.

Species	Conservation Status			Habitat	Previous Records	Likelihood of Occurrence	
	EPBC Act	WC Act	DPaW			J4 impact area	Survey area
Fork-tailed Swift *Apus pacificus*	M	S3		Nomadic, almost entirely aerial lifestyle over a variety of habitats; associated with storm fronts.	Closest record from 92 km east of survey area (DPaW 2013). Within species distribution (Simpson and Day 2010).	HIGH Species recorded closeby (within the survey area) during this survey. Species is not restricted to specific habitat types and may fly over the J4 impact area.	RECORDED Species recorded during this survey from within the survey area. Species is not restricted to specific habitat types and may occasionally fly over the survey area.
Eastern Great Egret *Ardea modesta*	M	S3		Wide range of wetland habitats, including floodwaters, rivers, shallows of wetlands, intertidal mudflats.	Impact area lies within species' distribution (Simpson and Day 2010), no previous records within 100 km of the impact area.	LOW No suitable habitat exists within impact area, no previous records.	LOW No suitable habitat exists within survey area, no previous records.
Oriental Plover *Charadrius veredus*	M	S3		Open plains, including samphire; bare rolling country; bare claypans; open ground near inland swamps.	Impact area lies within species' distribution (Simpson and Day 2010), no previous records within 100 km of the impact area.	LOW No suitable habitat exists within impact area, no previous records.	LOW No suitable habitat exists within survey area, no previous records..
Oriental Pratincole *Glareola maldivarum*	M	S3		Plains, shallow wet and dry edges in open bare wetlands, tidal mudflats, beaches.	Impact area lies within species' distribution (Simpson and Day 2010), no previous records within 100 km of the impact area.	LOW No suitable habitat exists within impact area, no previous records.	LOW No suitable habitat exists within survey area, no previous records.
Rainbow Bee-eater *Merops ornatus*	M	S3		Open country, most vegetation types, dunes, banks; prefer lightly wooded, preferably sandy, country near water.	Recorded from five previous surveys within 100 km of the impact area (Biota 2011a, ecologia internal database; Dell *et al.* 1985; Ninox 2009). Approximately 21 records within 50 km of the impact area (DPaW 2013)	RECORDED Recorded from the J4 impact area and survey area. Suitable habitat present.	RECORDED Recorded from the survey area. Suitable habitat in the form of the mixed eucalypt woodland and drainage line habitats.

Species	Conservation Status			Habitat	Previous Records	Likelihood of Occurrence	
	EPBC Act	WC Act	DPaW			J4 impact area	Survey area
Peregrine Falcon *Falco peregrinus*		S4	Other	Widespread; coastal cliffs, riverine gorges and wooded watercourses.	Recorded during three previous surveys within and surrounding the impact area (Dell *et al.* 1985, ecologia internal database). Eight records within 100 km of the impact area (DPaW 2013)	HIGH Recorded from within the survey area. Foraging habitat is present.	RECORDED Recorded from the survey area. Potential nesting habitat is present within the rocky ridge habitat.
Major Mitchell's Cockatoo *Lophochroa leadbeateri*		S4	Other	Arid to semi-arid lightly wooded country near water and tall eucalypts.	Seven records within 100 km of the impact area (DPaW 2013) and recorded from two previous surveys in the local region (Ninox 2009, ecologia internal database)	RECORDED Recorded from the Haul Road of the J4 impact area and the survey area. Previously recorded from surrounding areas. Suitable habitat present within J4 impact area in form of eucalypt woodland.	RECORDED Recorded from J4 impact area and the survey area. Previously recorded from surrounding areas. Suitable habitat present within the mixed eucalypt woodland habitat.
Masked Owl *Tyto novaehollandiae*			P3	Forest, woodland, caves, mature trees with hollows.	The impact area lies within species' distribution (Simpson and Day 2010), no previous records within 100 km of the impact area.	LOW No previous records in the local region.	LOW No previous records in the local region.
Australian Bustard *Ardeotis australis*			P4	Open grasslands, chenopod flats and low heathland.	Recorded during four previous surveys (Dell *et al.* 1985, ecologia internal database; Ninox 2009). Impact area lies within species' distribution (Simpson and Day 2010), and one very recent record from the vicinity of the impact area (DPaW 2013).	POTENTIALLY RECORDED NEARBY Potential secondary evidence (tracks) recorded from the survey area (POV S11). Suitable habitat present within J4 impact area.	POTENTIALLY RECORDED Potential secondary evidence (tracks) recorded in the sand plain with shrub land habitat of the survey area which provides suitable habitat for the species.
Bush Stone-curlew *Burhinus grallarius*			P4	Lightly wooded country next to daytime shelter of thickets or long grass.	The impact area lies within species' distribution (Simpson and Day 2010), no previous records within 100 km of the impact area.	POTENTIALLY RECORDED NEARBY Potential secondary evidence (tracks) recorded from the survey area. Suitable habitat present within J4 impact area.	POTENTIALLY RECORDED Potential secondary evidence (tracks) recorded in the sand plain with shrub land habitat of the survey area.

Species	Conservation Status			Habitat	Previous Records	Likelihood of Occurrence	
	EPBC Act	WC Act	DPaW			J4 impact area	Survey area
Shy Heathwren (western) *Hylacola cauta whitlocki*			P4	Mallee woodland that has relatively dense shrub and heath understorey.	Two recent records (2000) from the vicinity of the impact area (DPaW 2013). Recorded during two previous surveys (Dell *et al.* 1985, ecologia internal database).	RECORDED Recorded from sandplain habitat within the J4 impact area and survey area. Several records in the local region, very little suitable habitat present within impact area.	RECORDED Recorded from sandplain habitat within the survey area. Several records in the local region. Suitable habitat present in the form of sand plain with shrubland habitat.
Crested Bellbird (southern) *Oreoica gutturalis gutturalis*			P4	Variety of habitats: acacia scrubs, eucalypt, casuarina woodlands, saltbush and heath shrubland, *Triodia* grassland.	Recorded from five previous surveys within 100km of the impact area (Biota 2011a, ecologia internal database; Dell *et al.* 1985; Ninox 2009). Species recorded regularly throughout survey area and its vicinity (DPaW 2013).	RECORDED Species recorded throughout the J4 impact area and survey area.	RECORDED Species recorded throughout the survey area
Reptiles							
Woma *Aspidites ramsayi*		S4	P1	Arid regions of central Australia; shelter in hollow logs or abandoned burrows.	Six records from within 100 km of the impact area with the majority from along Great Eastern Highway (unknown date,DPaW 2013). Impact area within species' distribution (Wilson and Swan 2010).	MEDIUM Suitable habitat present in the mixed eucalypt woodland habitat and several previous records from the surrounding area.	MEDIUM Suitable habitat present in the mixed eucalypt woodland and several previous records from the surrounding area.
South-west Carpet Python *Morelia spilota imbricata*		S4	P4	Banksia woodland, eucalypt woodland, rocky outcrops.	Three records within 100 km south of the impact area (One historical record, date for remaining records unknown, DPaW 2013). Recorded from Carina North and Chamaeleon project area (Bamford 2012)	MEDIUM Suitable habitat present in the mixed eucalypt woodland habitat. Some previous records located along Great Eastern Highway.	MEDIUM Suitable habitat present in the mixed eucalypt woodland and rocky ridge habitat. Some previous records located along Great Eastern Highway.
Invertebrates							

Species	Conservation Status			Habitat	Previous Records	Likelihood of Occurrence	
	EPBC Act	WC Act	DPaW			J4 impact area	Survey area
Arid Bronze Azure Butterfly *Ogyris subterrestris petrina*	CR	S1	CR	Little known. Most likely associated with smooth barked eucalypt trees, such as Gimlet trees *Eucalyptus salubris* and the sugar ant *Camponotus terebrans.*	Species known from two locations approximately 140 km west of the impact area and 180 km east south-east of the impact area (DPaW 2013).	UNKNOWN Very little is known about the species and its habitat preference.	UNKNOWN Very little is known about the species and its habitat preference.
Tree-stem Trapdoor Spider *Aganippe castellum*			P4	Flood-prone depressions and flats which support myrtaceous shrub communities. In particular, areas supporting Broombush (*Melaleuca uncinata*) and Sheoaks (such as *Allocasuarina acutivalvis*) in sandy loam soils.	Numerous records from Mount Jackson and from the J5 impact area within the regional impact area and its surrounding (DPaW 2013).	HIGH Numerous records from within the survey area and its surrounding. One previous record within J4 impact area. Suitable habitat present.	RECORDED Recorded within the survey area during this survey. Numerous previous records from within the survey area and its surrounding. Suitable habitat present.

5.3.6 Mammals

Western Quoll (*Dasyurus geoffroii*)

Conservation Status: EPBC Act Vulnerable, WC Act Schedule 1, DPaW Vulnerable.

Distribution and Habitat: The Chuditch (or Western Quoll) formerly occurred across most of mainland Australia apart from the south-eastern coast and the top end. Following European settlement, this range contracted dramatically and it now survives only in the sclerophyll forest, drier woodland and mallee scrubland of south-west Western Australia (Serena and Soderquist 2008).

Ecology: Chuditchs occur in low densities even in high-quality habitats. Females den within a stable core area of 55-120 ha, while male dens are distributed over an area of 400 ha or more (Serena and Soderquist 2008). They are nocturnal, foraging primarily on the ground for lizards, frogs, invertebrates and mammals up to the size of rabbits. They rest in burrows or hollow logs during the day (Pavey 2006b).

Likelihood of Occurrence: Medium. The Chuditch was recorded between 1969 and 2004 from the vicinity of Southern Cross with one additional record from approximately 90 km west of the impact area (Figure 2.5, Figure 5.1)(DPaW 2013). During the current survey, a total of 2,520 hours of motion camera trapping was conducted within the J4 impact area and additional 7,560 hours were conducted within the survey area. However, no evidence of this species was recorded. Potential habitat was recorded in the form of mixed eucalypt woodland in the north of the impact area which also extends outside the impact area.

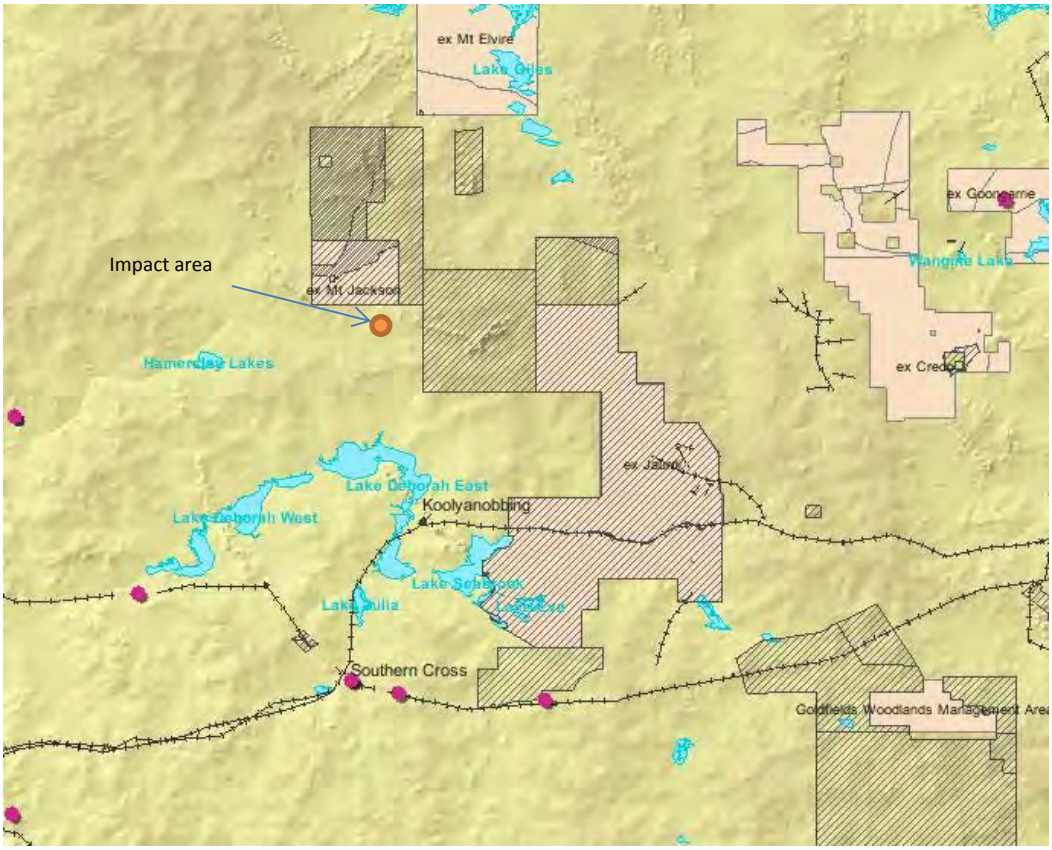

Figure 5.1 – Regional records of the Western Quoll (DPaW 2013)

Potential Impacts: Low. The Chuditch is a mobile species that can move away from disturbance. The habitat within the J4 impact area continues to surrounding areas to support a potential local poulation of the Chuditch.

Greater Bilby (*Macrotis lagotis*)

Conservation Status: EPBC Act Vulnerable, WC Act Schedule 1, DPaW Vulnerable.

Distribution and Habitat: Once common over 70% of mainland Australia's arid and semiarid regions, Greater Bilbies are currently patchily distributed through the Tanami, Great Sandy and Gibson Deserts (Maxwell *et al.* 1996). Isolated populations also occur in south-west Queensland and to the north-east of Alice Springs. Greater Bilbies occur in a variety of habitats, including spinifex grassland, acacia shrubland, open woodland and cracking clays (Johnson 2008; Maxwell *et al.* 1996). The species underwent a sudden and widespread collapse in population size in the early 1900s, and the distribution may still be contracting and fragmenting. Reasons for the decline include predation by feral predators on both young and adult bilbies, competition from rabbits and livestock, reduced food as a result of changed fire regimes, and drought (Johnson 2008; Maxwell *et al.* 1996; O'Malley 2006).

Ecology: The Greater Bilby is a nocturnal marsupial with soft, silky fur (Pavey 2006a). It uses its strong forelimbs and claws to construct an extensive tunnel system of up to 3 m long and 1.8 m deep in which it shelters during the day. Its long tongue is an adaptation to its specialised diet of seeds, insects, bulbs, fruit and fungi (Johnson 2008).

Likelihood of Occurrence: Medium. The Greater Bilby has been recorded very rarely within 100 km of the impact area (Figure 2.5,Figure 5.2) (DPaW 2013). Previous surveys did not reveal any evidence of this species, however there is a night sighting record of a Greater Bilby from 2003 near Mukinbudin, 135 km to the west of the impact area (DPaW 2013). A total of 2,520 hours of motion camera recording within the J4 impact area and an additional 7,560 hours outside the impact area did not reveale any evidence. There is some suitable habitat present in the south of the impact area which may be cleared along the proposed haul road.

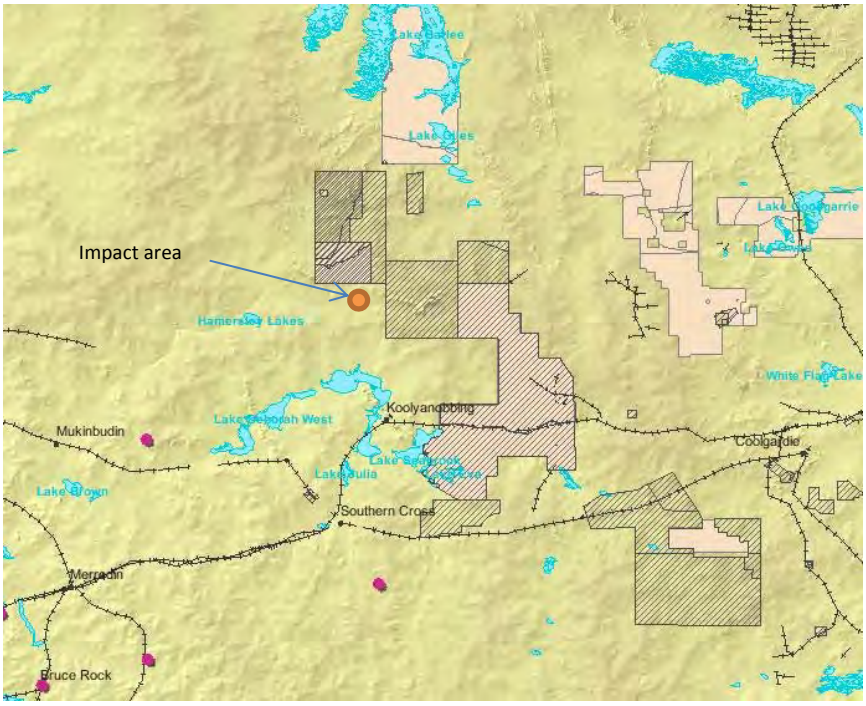

Figure 5.2 – Regional records of the Bilby (DPaW 2013)

Potential Impacts: Low. Some suitable habitat may be cleared along the proposed haul road but previous records of the Greater Bilby are very sparse in the area. The species is mobile and is able to avoid areas of disturbance.

5.3.7 Birds

Malleefowl (*Leipoa ocellata*)

Conservation Status: EPBC Act Vulnerable, WC Act Schedule 1, DPaW Vulnerable.

Distribution and Habitat: Once common and widespread across semi-arid southern Australia, Malleefowl have declined severely in the last century, with a 20% decrease in abundance and 50% decrease in area of occupancy (Benshemesh 2005; Garnett and Crowley 2000). Their current distribution is highly fragmented, increasing the risk of extinction (Benshemesh 2005). Malleefowl prefer habitat consisting of thickets of mallee, mulga or other dense litter-forming shrublands as well as dry forest dominated by other eucalypt and acacia species (Benshemesh 2005; Johnstone and Storr 1998). They require sandy substrate with leaf litter to build their nesting mounds (Frith 1976) and, hence, the highest breeding densities appear to occur in vegetation that is at least 40 years post fire (Benshemesh 1990, 1992; Woinarski 1989). They rarely breed in vegetation that has been burnt within the last 15 years (Crowley *et al.* 1969; Tarr 1965).

Ecology: Malleefowl are large, ground-dwelling birds, well known for constructing large mounds of soil and vegetation in which they incubate their eggs. Pairs occupy permanent territories (Benshemesh 2005).

The decline of Malleefowl is mainly due to loss and fragmentation of habitat due to agricultural clearing, degradation of remnant patches by grazing and predation by foxes (Garnett and Crowley 2000; Johnstone and Storr 1998; Priddel and Wheeler 1989). In the arid zone, cessation of traditional burning practices, homogenisation of the once fine-scale burning mosaic and fires on a unprecedented scale seem to be primary causes of extinctions (Benshemesh 2005).

Likelihood of Occurrence: Recorded. Suitable habitat was present in the form of sandy plain with shrubland along sections of the proposed J4 haul road. This is supported by the record of two recently active to moderately old and one old mound recorded from inside the J4 impact area (Figure 5.3, Figure 4.11). During the current survey fresh footprints of the Malleefowl were recorded from trap site POV S10 in the south of the J4 impact area (Figure 5.4). In addition, numerous records of this species exist in the surrounding region (Figure 5.5) and an adult individual Malleefowl was observed crossing the Mt Dimer road approximately 30 km east of the J4 impact area (Figure 4.11).

Potential Impacts: Low. The majority of the the impact are of this project is anticipated to be located along the rocky ridge and hillslopes north of the impact area. Suitable habitat is widespread in the area and the clearance of this habitat is anticipated to be restricted to the haul road. Any active mounds should be avoided during the clearing and construction of the proposed project.

Figure 5.3 – Malleefowl mounds recorded from the J4 impact area (recently used - moderately old)

Figure 5.4 – Tracks of the Malleefowl recorded from site POV S10

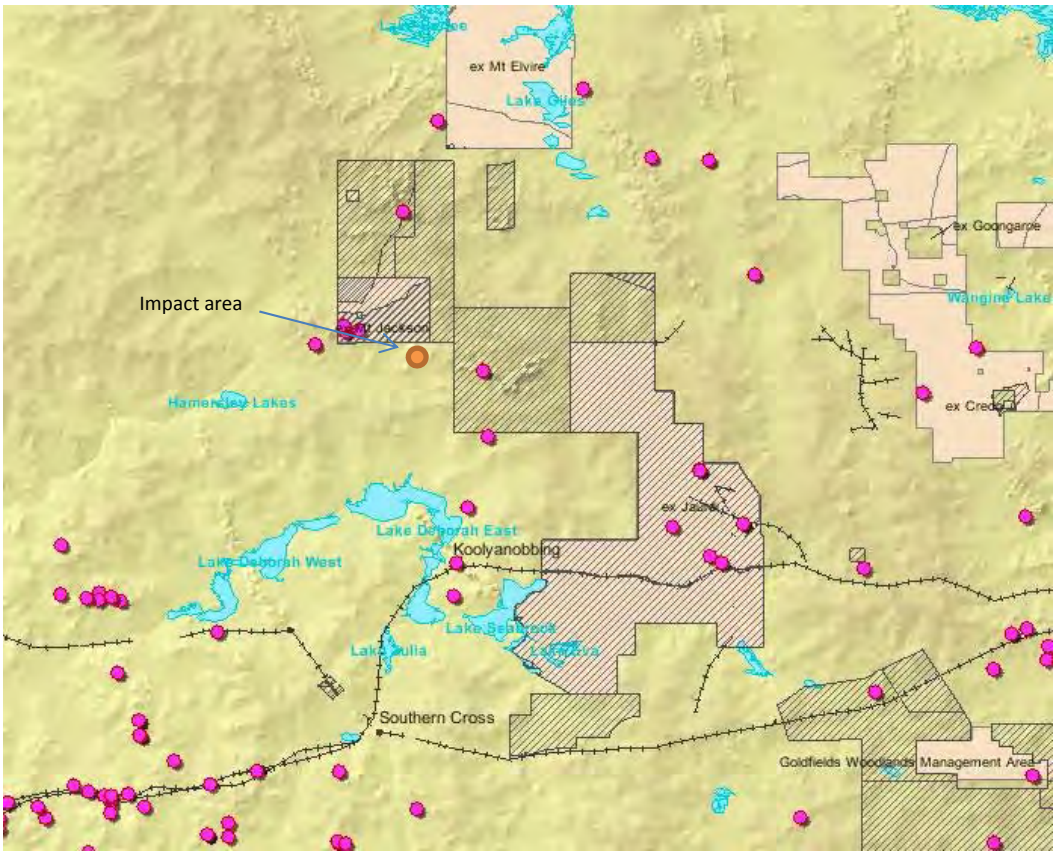

Figure 5.5 – Regional records of the Malleefowl (DPaW 2013)

Fork-tailed Swift (*Apus pacificus*)

Conservation Status: EPBC Act Migratory, WC Act Schedule 3.

Distribution and Habitat: The Fork-tailed Swift is a small, insectivorous species with a white throat and rump, and a deeply forked tail (Morcombe 2000). It is distributed from central Siberia and throughout Asia, breeding in north-east and mid-east Asia, and wintering in Australia and south New Guinea. It is a relatively common trans-equatorial migrant from October to April throughout mainland Australia (Simpson and Day 2004). In Western Australia the species begins to arrive in the Kimberley in late September, the Pilbara in November and the South-west by mid-December (Johnstone and Storr 1998). In Western Australia the Fork-tailed Swift is considered uncommon to moderately common near the north-west, west and south-east coasts, common in the Kimberley and rare or scarce elsewhere (Johnstone and Storr 1998).

Ecology: Fork-tailed swifts are nomadic in response to broad-scale weather pattern changes. They are attracted to thunderstorms where they can be seen in flocks, occasionally of up to 2,000 birds. They rarely land, living almost exclusively in the air and feeding entirely on aerial insects, especially nuptial swarms of beetles, ants, termites and native bees (Simpson and Day 2004).

Likelihood of Occurrence: High. Three individulas were recorded from the regional survey (POV S12). The J4 impact area is within the species' range but they are not anticipated to land or utlise the habitat of the impact area (DPaW 2013)

Potential Impacts: Low. The Fork-tailed Swift has an almost entirely aerial nomadic lifestyle meaning disturbance on the ground will have little impact on this species.

Rainbow Bee-eater (*Merops ornatus*)

Conservation Status: EPBC Act Migratory, WC Act Schedule 3.

Distribution and Habitat: The Rainbow Bee-eater is scarce to common throughout much of Western Australia, except for the arid interior, preferring lightly wooded, preferably sandy country near water (Johnstone and Storr 1998).

Ecology: In Western Australia the Rainbow Bee-eater can occur as a resident, breeding visitor, post-nuptial nomad, passage migrant or winter visitor. It nests in burrows usually dug at a slight angle on flat ground, sandy banks or cuttings, and often at the margins of roads or tracks (Simpson and Day 2004). Eggs are laid at the end of the metre-long tunnel from August to January (Boland 2004). Rainbow Bee-eaters are most susceptible to predation during breeding, as it spends significantly more time on the ground in this period.

Likelihood of Occurrence: Recorded. This species was recorded in the survey area surrounding the J4 impact area during the current survey (Figure 4.11) and during previous surveys (DPaW 2013). This impact area presents suitable forraging habitat. Breeding habitat was not recorded from the impact area.

Potential Impacts: Low. The Rainbow Bee-eater inhabits a variety of habitats as foraging ground and therefore can avoid areas of disturbance. No breeding habitat is expected to be impacted by the development of the proposed project.

Peregrine Falcon (*Falco peregrinus*)

Conservation Status: WC Act Schedule 4, DPaWSpecially Protected Fauna.

Distribution and Habitat: This nomadic or sedentary falcon is widespread in many parts of Australia and some of its continental islands, but absent from most deserts and the Nullarbor Plain. The species is considered to be moderately common in the Stirling Range, uncommon in the Kimberley,

Hamersley and Darling Ranges, and rare or scarce elsewhere (Johnstone and Storr 1998). The Peregrine Falcon occurs most commonly near cliffs along coasts, rivers and ranges, and around wooded watercourses and lakes.

Ecology: Peregrine Falcons feed almost entirely on birds, especially parrots and pigeons. They nest primarily on ledges on cliffs, granite outcrops and in quarries, but may also nest in tree hollows around wetlands. Eggs are predominantly laid in September (Johnstone and Storr 1998; Olsen *et al.* 2006).

Likelihood of Occurrence: High. Two records of the Peregrine Falcon were made during the survey from vertebrate trapping site POV S9 and POV S3 within the survey area (Table 4.4, Figure 4.11). The species is likely to utilise the area as foraging ground and potentially for nesting (in particular within the mixed eucalypt woodland habitat type (Morcombe 2000)).

Potential Impacts: Low. No significant impacts to Peregrine Falcons at either a local or regional scale are anticipated due to the relatively small extent of the J4 impact area. The ability of the Peregrine Falcon to move away from disturbance if present, and the presence of similar habitat in the surrounding the region decreases the likely impact on this species.

5.3.7.1 Major Mitchell's Cockatoo (*Lophochroa leadbeateri*)

Conservation Status: WC Act Schedule 4, DPaW Other Specially Protected Fauna.

Distribution and Habitat: Major Mitchell's Cockatoos are common in the Great Australian Bight, but generally rare to uncommon in Western Australia. The species is widespread, but discontinuous in the arid and semi-arid zones of the state as far north as the Edgar Ranges in the Kimberley. It also occurs in the arid and semi-arid interior of eastern Australia. Preferred habitat is lightly wooded country near water and tall eucalypts, though it also occurs on beaches and coastal dunes.

Ecology: This large cockatoo is easily recognisable by its orange-red erectile crest with a central yellow band. Major Mitchell's Cockatoos feed on split and germinating wheat seeds, the flower, roots and seeds of the doublegee (*Emex australis*), the flesh and seeds of melons, wild radish and turnip, native figs, the heads and seeds of native grasses, herbs, pinecones, Marri flowers and eucalyptus seeds, and insect larvae (Johnstone and Storr 1998; Park 1995).

Major Mitchell's Cockatoos are aggressively territorial and nest in tree hollows. They are usually found in pairs or small flocks (Morcombe 2000). To date, breeding has only been reported in the Wheatbelt, with females laying three clutches of two eggs between August and September. Both sexes incubate the eggs and brood the chicks (Johnstone and Storr 1998).

Likelihood of Occurrence: Recorded. This species was recorded during the survey from the J4 impact area and from the survey area and seven previous records exist within 100 km of the J4 impact area (Figure 5.6). The eucalypt woodland represents suitabe habitat for this species, in particular within areas near water sources. Breeding habitat consists of tall eucalypt trees which contain tree hollows. Potential foraging habitat is present within the impact area and extends to the south of the impact area from where individuals have been recorded previously.

Figure 5.6 – Major Mitchell's Cockatoo recorded during this survey

Potential Impacts: Low. Major Mitchell's Cockatoos have been recorded regularly in the region and suitable habitat extends outside the impact area. Some foraging habitat may be impacted by clearance conducted for the haul road and mining infrastructure within the J4 impact area. This species is highly mobile and can avoid most impacts.

5.3.7.2 Australian Bustard (*Ardeotis australis*)

Conservation Status: DPaW Priority 4.

Distribution and Habitat: The Australian Bustard occurs Australia-wide and utilises a number of open habitats, including open or lightly wooded grasslands, chenopod flats, plains and heathlands (Johnstone and Storr 1998).

Ecology: It is a nomadic species, ranging over very large areas, and its abundance varies locally and seasonally from scarce to common, largely dependent on rainfall and food availability. The Australian Bustard has an omnivorous diet, feeding on grasses, seeds, fruit, insects and small vertebrates.

Although the population size is still substantial, there has been a large historical decline in abundance, particularly south of the tropics, but also across northern Australia (Garnett and Crowley 2000). This is a result of hunting, degradation of its grassland habitat by sheep and rabbits, and predation by foxes and cats (Frith 1976; Garnett and Crowley 2000). Australian Bustards readily desert nests in response to disturbance by humans, sheep or cattle (Garnett and Crowley 2000).

Likelihood of Occurrence: High. Potential secondary evidence (tracks) of this species was recorded from the regional impact area (vertebrate trapping Site POV S11). The tracks were missing the rear toe as typical for the Australian Bustard and the Bush Stone-curlew. The size of the footprint and the habitat from which it was recorded suggest an Australian Bustard. The species was recorded during four previous surveys within 100 km of the impact area (Dell *et al.* 1985, *ecologia* internal database; Ninox 2009). Suitable habitat was recorded from within the J4 impact area, in particular along the haul road.

Potential Impacts: Low. Despite the high likelihood of the species occasionally occurring in the J4 impact area due to the high number of individuals in the local area and the J4 impact area supporting suitable habitat, the impact on this species will be low. This is a result of the small amount of suitable

habitat present and the ability of this nomadic species to move away from disturbance, no significant impacts to the species are anticipated at either a local or regional scale.

Figure 5.7 – Bustard or Bush Stone-curlew footprint (note lack of rear toe)

Bush Stone-curlew (*Burhinus grallarius*)

Conservation Status: DPaW Priority 4.

Distribution and Habitat: The Bush Stone-curlew occurs across much of Australia, except the arid interior and central south coast, preferring lightly wooded country near thickets or long grass that acts as daytime shelter (Johnstone and Storr 1998). Historically, this species was widely distributed throughout most of WA, but has since declined, particularly in the southern part of the State. Recent estimates indicate an Australian population of 15,000 individuals (Garnett and Crowley 2000). The Bush Stone-curlew inhabits woodlands, dry and open grasslands, and croplands with cover nearby (NSW National Parks and Wildlife Service 1999).

Ecology: The species is insectivorous, preying primarily upon beetles, although they will also eat seeds and shoots, frogs, lizards and snakes (Marchant and Higgins 1993; NSW National Parks and Wildlife Service 1999). They are usually seen in pairs, although may occasionally flock together during the breeding season (August to January) and are generally nocturnal, being especially active on moonlit nights (NSW National Parks and Wildlife Service 1999).

Since Bush Stone-curlews are a ground-dwelling and non-migratory species, they are quite susceptible to local disturbances by humans and to predation by cats and foxes (Frith 1976; Johnstone and Storr 1998). They are most common where land disturbance is minimal, and generally become rare or extinct around human settlements (Johnstone and Storr 1998).

Likelihood of Occurrence: Potentially Recorded Nearby. Despite the lack of previous records within 100 km of the J4 impact area, suitable habitat is present within the J4 impact area and this species was potentially recorded in the regional impact area. Potential tracks of the Bush Stone-curlew were recorded from the south of the impact area (Site POV S11, Figure 5.7). The tracks were missing the rear toe as typical for the Bush Stone-curlew and also for the Australian Bustard, however the size of the track is relatively small indicating that it could potentially be from a Bush Stone-curlew.

Potential Impacts: Low. The absence of regional records suggests that if this species is present, it is so in low numbers. Its infrequency and abundance of habitat outside of the J4 impact area suggests that mining activities will have very little impact on this species.

Shy Heathwren (*Hylacola cauta whitlocki*)

Conservation Status: DPaW Priority 4.

Distribution and Habitat: Shy Heathwrens are small passerines which live in shrublands and mallee woodland with a dense understorey, where they forage on the ground for insects and seeds (Garnett and Crowley 2000; Johnstone and Storr 2004). The western subspecies is found in the Wheatbelt of Western Australia but also along the coast as far as Eyre Bird Observatory (Saunders and Ingram 1995).

Ecology: Clearing for agriculture has removed most of the Shy Heathwren's habitat in the Wheatbelt, where it remains in fragmented remnants, although this subspecies also persists in continuous habitat surrounding the Wheatbelt (Saunders and Ingram 1995). Ongoing degradation of remaining wheatbelt habitat due to stock grazing and weeds is believed to continually reduce the number of fragments suitable for the Shy Heathwren (Garnett and Crowley 2000; Saunders and Ingram 1995).

Likelihood of Occurrence: Recorded. The Shy Heathwren was recorded during the survey from trap site POV S10 within the J4 impact area and from POV S11 from the survey area (Figure 4.11, Appendix G). Both locations were within the sandy plain with shrubland habita type. It was also recorded two previous surveys in the surrounding areas (Dell *et al.* 1985, *ecologia* internal database) and two more recent records (2000) listed on NatureMap (DPaW 2013) of which one record was made from Mt Jackson and one observation was made from 2 km south of the J4 impact area.

Potential Impacts: Low. Suitable habitat within the J4 impact area is only expected to be impacted on a small scale when the haul road is cleared. The species' mobility enables it to move away from any disturbance. The impact on a local and regional scale is anticipated to be low.

Crested Bellbird (southern subspecies) (*Oreoica gutturalis gutturalis*)

Conservation Status: DPaW Priority 4.

Distribution and Habitat: The southern subspecies of the Crested Bellbird occurs in the south-west of Western Australia and south to the Nullarbor Plain. This subspecies has been eliminated from much of its former range as a result of vegetation clearing, and it seems sensitive to subsequent habitat fragmentation (Garnett and Crowley 2000).

Ecology: Crested Bellbirds inhabit the shrub layer of eucalypt woodland, mallee, acacia shrubland, spinifex grassland, saltbush and heath, where they feed on a variety of insects and seeds (Blakers *et al.* 1984; Garnett and Crowley 2000).

Likelihood of Occurrence: Recorded. During the current survey, the southern subspecies of the Crested Bellbird was recorded throughout the J4 impact area and survey area with a total of 79 observations of which 16 observation were made within the J4 impact area (Figure 4.11, Appendix G). Suitable habitat is widespread in the region, within and outside the areas of impact area. The species has been recorded regularly within 100 km (Biota 2011a, ecologia internal database; Dell *et al.* 1985; Ninox 2009).

Potential Impacts: Low. Crested Bellbirds inhabit a variety of habitats of which large areas have been cleared throughout the Midwest and Wheatbelt. However, suitable habitat exists in areas surrounding the J4 impact area and therefore the impact on this species is anticipated to be low.

5.3.8 Reptiles

Woma (southwest population) (*Aspidites ramsayi*)

Conservation Status: WC Act Schedule 4, DPaW Priority 1.

Distribution and Habitat: The Woma is a large python, growing to up to 2.7 m. It occurs across Australia in the subhumid to arid interior and also in the south-west of Western Australia. Within Western Australia the Woma is found in four potentially disjunct populations: the south-west, the arid north-west, the Tanami Desert and Peron Peninsula. The south-west population extends from Yuna (near Geraldton) south to Boddington and east to the western edge of the Nullarbor Plain (Storr *et al.* 2002). Womas can be found in woodlands, heaths and shrublands, often with spinifex, in the sub-humid to arid interior.

Land clearing and predation by feral fauna have caused a decline in populations, particularly in the gorges of south-west Western Australia (Wilson and Swan 2010). Womas were formerly abundant in south-western sandplain habitat, but recent records for the species are few and come from widespread localities (Maryan 2002).

Ecology: Womas are a nocturnal species, sheltering during the day in abandoned monitor and mammal burrows and in soil cracks (Wilson and Swan 2010). They prey on lizards, snakes, birds and small mammals, which they often attract to within striking distance by wiggling their tail (Ehmann and Watson 2008).

Likelihood of Occurrence: Medium. Womas have been recorded from six locations within 100 km of the impact area of which the majority of records were made from the Great Eastern Highway (Figure 5.8). The date of these records in unknown and the proximity of the southern records to major roads suggest that these individuals were sighted or potentially killed when crossing the road. No records were made during previous surveys in the region (Appendix C). Suitable eucalypt woodland habitat is present within the J4 impact area.

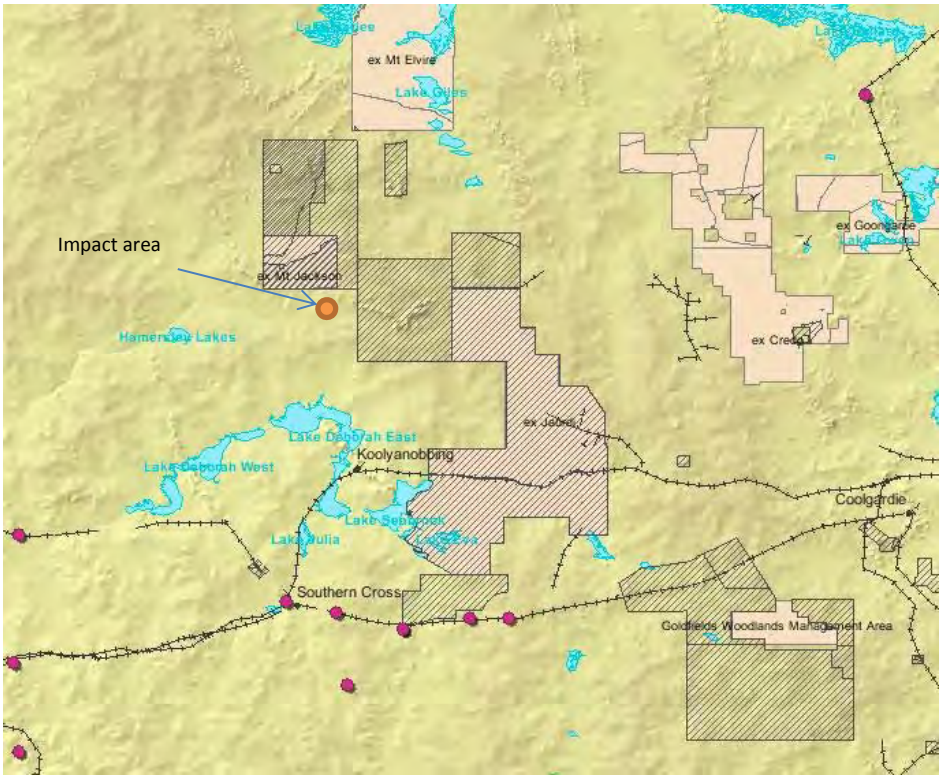

Figure 5.8 – Regional records of the Woma (DPaW 2013)

Potential Impacts: Low. The Woma potentially occurs within the J4 impact area but individuals that may be disturbed will move away into habitats outside the areas of impact. Care should be taken during clearing and construction of the haul road within the eucalypt woodland and sandy plain with shrubland habitat in the south of the impact area.

South-west Carpet Python (*Morelia spilota imbricata*)

Conservation Status: WC Act Schedule 4, DPaW Priority 4.

Description and Habitat: The South-west Carpet Python inhabits temperate climatic areas with good winter rains and dry summers. This subspecies occurs in semi-arid coastal and inland habitats, banksia woodlands, eucalypt woodlands, and grasslands of south-west Western Australia, from Northampton, south to Albany and eastwards to Kalgoorlie. It also occurs in undisturbed remnant bushland near Perth and the Darling Ranges, Yanchep National Park and Garden Island (DEC 2007b).

Ecology: South-west Carpet Pythons are arboreal, terrestrial and rock-dwelling, and can shelter in burrows made by other animals, hollow tree limbs or rock crevices. South-west Carpet Pythons have long periods of inactivity. At Dryandra in south-west Western Australia, the pythons remain inactive for several months during winter, where they may shelter in tree hollows for up to five months (DEC 2007b).

The South-west Carpet Python has declined in distribution due to the loss of bushland habitat for land development and agriculture, and changed fire regimes. Predation by introduced predators (foxes and feral cats) may have also contributed to the decline of python populations. Habitat destruction has been implicated in the decline of South-west Carpet Python populations in the Esperance area (DEC 2007b).

Likelihood of Occurrence: Medium. Three records were made within 100 km south of the impact area area (One historical record, date for remaining records unknown, DPaW 2013) (Figure 5.8). In addition, the species was also recorded from Carina North and Chamaeleon project area (Bamford 2012).

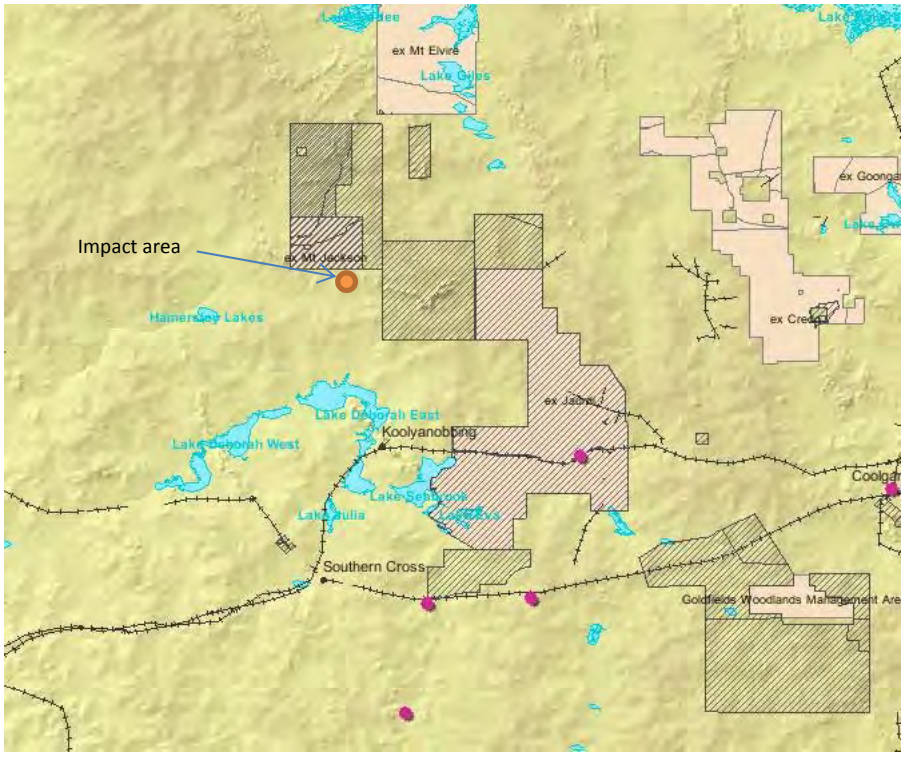

Figure 5.9 – Regional records of the South-west Carpet Python (DPaW 2013)

Potential Impacts: Low. Suitable habitat within the J4 impact area is only expected to be impacted on a small scale along the haul road. The species' mobility enables it to move away from any disturbance. The impact on a local and regional scale is anticipated to be low.

5.3.9 Invertebrate Fauna of Conservation Significance

Arid Bronze Azure Butterfly (*Ogyris subterrestris petrina)*

Conservation Status: EPBC Critically Endangered, WC Act Schedule 1, DPaW Critically Endangered.

Distribution and Habitat: Little is known about the Arid Bronze Azure Butterfly and all known records are restricted to two locations with one located in the central wheatbelt approximately 13 km north-west of Mukinbudin and the other population is located near Kalgoordie in the Goldfields region. The Arid Bronze Azure Butterfly is most likely associated with smooth barked eucalypt trees, such as Gimlet trees Eucalyptus salubris and the sugar ant Camponotus terebrans.

Ecology: The male and female adults have different upper surfaces. The male is plain dark purple with pale bronze margins. The female is similar but with a black and white bar on the costa of each forewing. Underneath, they are both pale brown, with dark brown splotches, and with a set of black and white bars on each forewing. Both sexes have black and white chequered margins to the wings. The butterflies have a wing span of about 4 cm. The eggs can be white, grey or brown. They are round with a diameter of about 1 mm. They are laid in groups about 40 on the base of a mallee gum tree that has a suitable ants nest in the roots. The pupa is cream with a length of about 1.5 cm. It is formed within the host ant nest which is suggested to be the pale form of the sugar ant *Camponotus terebrans.*

Likelihood of Occurrence: Unknown. This species is known from two locations approximately 140 km and 180 km east south-east of the J4 impact area (DPaW 2013). Little is known about the distribution and habitat preference of the Arid Bronze Azure Butterfly.However, it is suggested that the species is associated with Gimlet tree, *Eucalyptus salubris*, which is present along the proposed haul road in the J4 impact area. The likelihood of this species occuring within this impact area could not be identified adequately due to the lack of information and records regarding this species.

Figure 5.10 – Gimlet tree (*Eucalyptus salubris*) recorded from within the survey area

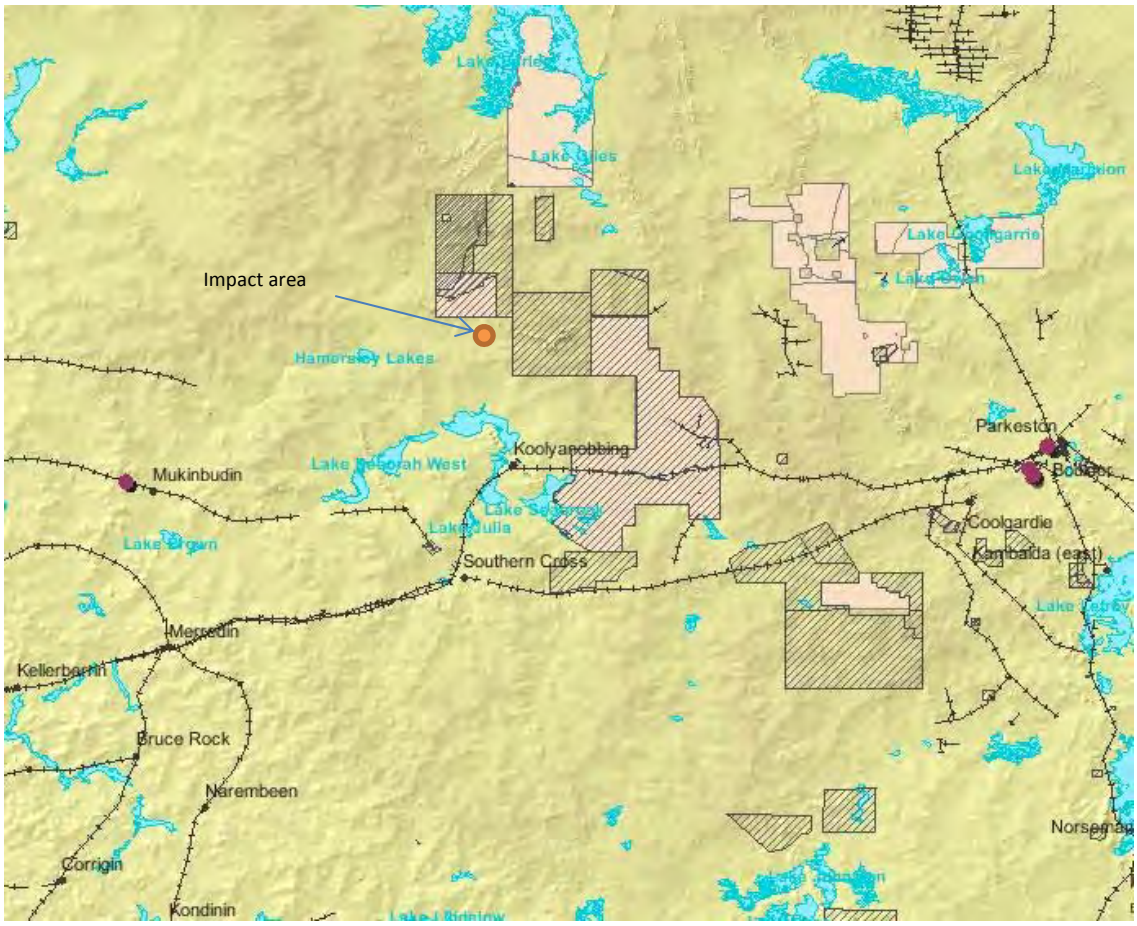

Figure 5.11 – Regional records of the Arid Bronze Azure Butterfly (DPaW 2013)

Potential Impacts: Unknown. Due to the uncertainty of this species' distribution, habitat preference and likelihood to occur within the J4 impact area, it is difficult to determine the impact the proposed project may have on this species. It can be hypothesised that clearing of the suggested associated species (the Gimlet tree, *Eucalyptus salubris*, and other smooth bark eucalypts) for the haul road may potentially have animpact on this species if it is present.

Tree-stem Trapdoor Spider (*Aganippe castellum*)

Conservation Status: DPaW Priority 4.

Distribution and Habitat: The Tree-stem Trapdoor Spider occurs in the south-west of Western Australia with the most northern extend at Pintharuka Nature Reserve (Morawa Shire), stretches south to the Merredin townsite, and east to Southern Cross. One population is located at Pintharuka and is the only known population that exists outside of the Avon Catchment Council (ACC) NRM (Natural Resource Management) Boundary. The Tree-stem Trapdoor Spider prefers habitats in flood-prone depressions and flats that support myrtaceous shrub communities. The burrows of this species are specially designed with an aboveground entrance to withstand occasional sheet flooding (DEC 2013).

Ecology: Mygalomorph spiders take several years to reach reproductive maturity. Females can live up to twenty years which they spend in their burrow. Mature males leave their burrows during moist conditions in search of females, and die shortly after mating (Main *et al.* 1985; Yen and Butcher 1997). Females lay their eggs in a silk cocoon in the burrow, and after spending several months confined to the parent burrow, spiderlings emerge approximately one year after the parental mating (Main 1982a).

The Tree-stem Trapdoor Spider is a medium-sized spider, dark brown to black in colour, and has large anterior lateral eyes that project beyond the edge of the carapace (Burbidge, 2004). The length of the carapace ranges from 6.8-8.8mm and the width ranges from 5.2-6.2mm (Main 1986).

Likelihood of Occurrence: High. Several records of the Tree-stem Trapdoor Spider exist from within the J4 impact area, survey area and the local region (Figure 2.6, Figure 5.13) with approximately 44,000 Tree-stem Trapdoor Spider individuals at Koolyanobbing Range, and approximately 200,000 individuals at Mt Jackson Range (Cliffs 2012). The species has also been recorded during this survey and previously within the regional impact area (Figure 5.12, Figure 2.6). However, the species is currently under taxonomic revision and may include a number of species; therefore the records made from the Jackson and Helena Aurora Range may belong to several different species.

Figure 5.12 – *Aganippe castellum* burrow recorded from the survey area

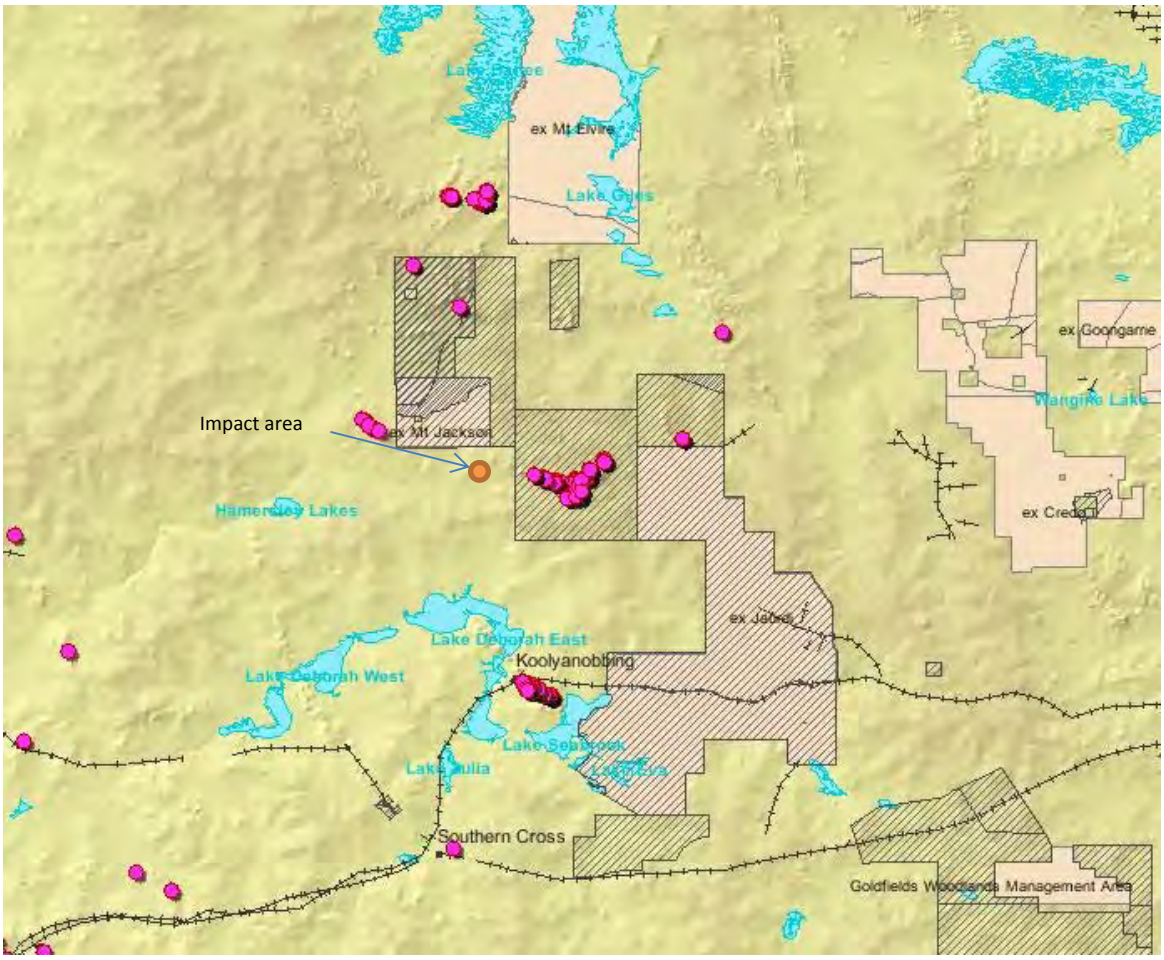

Figure 5.13 – Regional records of the Tree-stem Trapdoor Spider (DPaW 2013)

Potential Impacts: Low. Small areas of suitable habitat exist, in particular where the haul road traverses. Destruction of suitable microhabitat or burrows may impact the local population within areas of impact.

5.3.10 SRE Invertebrate Fauna

Information about higher taxa of the collected speciens is provided

Arachnids

Mygalomorphae (trapdoor spiders)

- **Family Actinopodidae (mouse spiders)**
    - **Genus *Missulena***
        - ***Missulena* sp. indet**.

Two juvenile specimens of *Missulena* was collected from the survey area (site PO OSF1 & PO OSF46) (Table 4.5, Appendix H). The specimen could not be identified to species level due to its juvenile status. The genus includes range-restricted as well as widespread species and the precautionary principal requires that the juvenile recorded during the survey is considered a potential SRE (Phoenix 2013a). Further taxonomic resolution will be possible only with the use of DNA analysis.

- **Family Barychelidae (brush-footed trapdoor spiders)**
    - **Genus *Synothele***
        - ***Synothele howi***

Two males of this species were collected from a dry pitfall trap site (POV S5) located in the survey area (Table 4.5, Appendix H). This species is not considered an SRE (WAM 2013b).

- ***Synothele* 'MYG278'**

One individual male of this species was collected at a dry pitfall site POV S2 within the survey area. The species is currently only known from the survey area and represents a new species. It is therefore considered a potential SRE (WAM 2013b).

- ***Synothele* sp. indet.**

A single juvenile specimen of *Synothele* was collected opportunistically from within the J4 impact area. The specimen could not be identified to species level. The genus includes range-restricted in addition to apparently widespread species and therefore the precautionary principal requires that this specimen is considered a potential SRE (Phoenix 2013a).

- **Genus *Idiommata***
    - ***Idiommata 'blackwalli cf'***

One adult male and one juvenile were collected from the dry pitfall sites POV S6 and POV S8 in the survey area (Table 4.5, Appendix H). This species is widespread and not considered an SRE (WAM 2013b).

- ***Idiommata* sp. indet.**

A total of 10 specimens (including mature mals) of *Idiommata* were collected from wet pitfall, dry pitfalls and foraging sites within the J4 impact area and survey area. Due to the difficulty to identify even mature males of the genus *Idiommata* charcteristics to differentiate species have not been described to date (Raven 1994), the sampled specimens could not be identified to species level (Phoenix 2013a). However, within this region, in contrast to the more arid zone representatives, the genus is not believed to contain many, if any SREs. Therefore, the *Idiommata* specimens from this survey, including the mature male, are not considered SREs (Phoenix 2013a).

- **Family Dipluridae**
    - **Genus *Cethegus***
        - ***Cethegus* 'sp. nov'**

One juveline was recorded from a dry pitfall sites (POV S5) within the survey area (Table 4.5, Appendix H). The genus includes range-restricted in addition to apparently widespread species and therefore the precautionary principal requires that this specimen is considered a potential SRE (WAM 2013b).

- **Family Idiopidae (true trapdoor spiders)**
    - **Genus *Aganippe***
        - ***Aganippe* sp. indet.**

A total of 13 specimens (female and immature) of the genus *Aganippe* were collected from the J4 impact area and from the survey area (Table 4.5, Appendix H). The specimens could not be identified in relation to the male morphospecies collection of the WA Museum. However, based on somatic and genitalic differences it is clear that at least two different species are present (Phoenix 2013a). As the genus includes range-restricted as well as apparently widespread species, all female and juvenile *Aganippe* are here considered a potential SRE (Phoenix 2013a). Further taxonomic resolution will be possible only with the use of DNA analysis.

        - ***Aganippe* sp. indet. (*A. castellum* - group)**

One female and one juvenile were collected from the survey area (Table 4.5, Appendix H) which display the typical eye pattern of *Aganippe castellum*. However, the specimens are lighter than *A. castellum* and therefore may belong to a different species. Consistent with the genus-level SRE assessment for *Aganippe* above, these are considered potential SREs (Phoenix 2013a).

    - **Genus Anidiops**
        - ***Anidiops* 'sp. juv'**

One juvenile and one female of the genus *Anidiops* were collected from a dry pitfall site and one foraging site within the survey area (POV S6, PO OSF47). The precautionary principal requires that this specimen is considered a potential SRE (Phoenix 2013a; WAM 2013b).

    - **Genus *Gaius***
        - ***Gaius* sp. indet.**

A single juvenile specimen of *Gaius* was recorded from the survey area (PO OSF1). Based on the wide distributions of species within the genus, it is not considered to represent an SRE (Phoenix 2013a).

    - **Genus *Idiosoma***
        - ***Idiosoma* sp. indet.**

A single female of *Idiosoma* was collected from within the J4 impact area (site PO S10). The species is unusually light in colour and it has not been recorded in the area previously. Based on distribution patterns of *Idiosoma* and the lack of reference material in the WA Museum, the female is currently considered to represent a likely SRE (Phoenix 2013a). Further taxonomic resolution will be possible only with the use of DNA analysis.

- **Family Nemesiidae (wishbone spiders)**
    - **Genus *Aname***
        - ***Aname* 'MYG004'**

Aname 'MYG004' was collected at Site PO OS1 (within the J4 impact area, Table 4.5, Appendix H). It is a large species with short embolus on the male pedipalp and occurs widely throughout inland WA, having been collected from the Pilbara region south into the Goldfields. It is not an SRE (Phoenix 2013a).

- **Aname 'MYG279'**

One male of this species was collected from within the J4 impact area (POV S10) during the current survey (Table 4.5, Appendix H). It is considered a potential SRE (WAM 2013b).

- **Aname 'MYG386'**

Five males of this species were colleted from four dry pitfall sites and one foraging site (Table 4.5, Appendix H). It represents an unusual species within the genus at it lacks the typical spur on the first leg of males (Phoenix 2013a).. The species is currently only known from this survey and therefore considered a potential SRE, consistent with distribution patterns within the genus (Phoenix 2013a).

- ***Aname tepperi***

Aname tepperi was collected within the survey area, outside the J4 impact area (PO S12). The species used to be placed in the genus *Chenistonia* because it also has a narrow band of cuspules along the maxillary heel (Main 1982b). The species is widespread in southern WA and occurs into South Australia. It is not an SRE (Phoenix 2013a).

- ***Aname* sp. indet.**

A female and a juvenile *Aname* were identified from the material collected at the impact area with both specimen collected from the survey area (POV S12, PO OSF1, Table 4.5, Appendix H); both are not conspecific with either *A. tepperi* or *Aname* 'MYG004'. As the genus includes range-restricted in addition to apparently widespread species, the precautionary principal requires that all females and juveniles recorded during the survey are considered potential SREs (Phoenix 2013a).

    - **Genus *Kwonkan***
        - ***Kwonkan* 'MYG175'**

Kwonkan'MYG175' is a comparatively large species within the genus, with characteristic dark carapace pattern. The specimens collected inside and outside the J4 impact area (POV S7, PO S6, Table 4.5, Appendix H), are somewhat darker than other reference material but are similar enough to assume conspecificity. The species has previously been found in the area and occurs in the east to Laverton and in the north to Lake Way and Lake Maitland. It is not an SRE (Phoenix 2013a).

- ***Kwonkan* sp. indet.**

A single juvenile of Kwonkan was collected at a dry pitfall within the J4 impact area (POV S7). It cannot be established if it is conspecific with Kwonkan 'MYG175'. As the genus includes wide-spread and range-restricted species, the precautionary principal requires that the juvenile recorded during the survey is considered a potential SRE (Phoenix 2013a).

- **Genus *Yilgarnia***
  - ***Yilgarnia* 'MYG272'**

A single male of *Yilgarnia* was collected at a wet pitfall within the survey area (site PO S5, Table 4.5, Appendix H). The species is currently not present in the morphospecies collection of the WA Museum. It has been assigned the new morphocode 'MYG272'. As the species is known currently from this survey only, the precautionary principal requires that it is considered a potential SRE (Phoenix 2013a).

- **Family Selenopidae**
  - **Genus *Karaops***
    - ***Karaops* sp. indet.**

A single juvenile of this morphospecies were collected from the survey area (Foraging site PO OSF23, Table 4.5, Appendix H). At the time of the collection, no described species were known from the vicinity of Bungalbin Hill (Crews and Harvey 2011). Another species of this genus, *Karaops jarrit* was also recorded from the survey area which was not known to occur at this location. However, the two morphospecies were collected from two different habitat types (mixed woodland and drainage line) which may indicate that they belong to two different species. Based on distribution patterns within the genus, the *Karaops* specimes collected during the current survey is considered a likely SRE (Phoenix 2013b).

    - ***Karaops jarrit***

Karaops jarrit is a widespread southern Western Australian species and not an SRE. The current record is outside the range of this species (Crews and Harvey 2011) but morphologically sufficiently similar to regard it as the same species (Phoenix 2013a).

- **Family Theraphosidae**
  - **Genus *Selenocosmia***
    - ***Selenotholus foelschei***

One male of this species was collected at dry pitfall site POV S8 outside the J4 impact area (Table 4.5, Appendix H). The burrow is typical of the group, being sinuous and long, up to 120 cm deep and has no lid. The species has also been reported feeding on small frogs and large insects (Hawkeswood 2003). It is a widespread species and is not considered an SRE (WAM 2013b).

5.3.10.1 Scorpiones (scorpions)

- **Family Buthidae**
  - **Genus *Isometroides***
    - ***Isometroides* 'goldfields 1'**

Isometroides 'goldfields1' was collected at site POV S5 and S6, within J5 impact area, and at site POV S4, S8, S9 and S11, within the survey area. This species is widespread throughout central Western Australia, and is not an SRE (Framenau 2013).

  - **Genus *Lychas***
    - ***Lychas 'adonis'***

This species was collected from the survey area (dry pitfall site POV S11, Table 4.5, Appendix H). *Lychas* 'adonis' has wide Eyrean distribution across arid Australia (Victoria, South Australia and Western Australia), where it inhabits various habitats including sparse Mallee forests on sand to Spinifex covered dunes. Itappears to prefer sandy spinifex dominated habitats. This species is not an

SRE (Framenau 2013).

- ***Lychas 'annulatus'***

Lychas 'annulatus' was collected from within the J4 impact area (site POV S10) and from the survey area (dry pitfall site POV S1, S2, S4, S5, S9 and S11 and foraging site PO OSF7, PO OSF12). The species is highly variable and is likely to represent a species complex. Similar to *L.* 'adonis', *Lychas* 'annulatus' has wide distribution across arid Australia (Victoria, South Australia and Western Australia), where it inhabits various habitats including sparse Mallee forests on sand to Spinifex covered dunes. Itappears to prefer sandy spinifex dominated habitats. This species is not an SRE (Phoenix 2013a).

- ***Lychas jonesae***

A total of 17 specimens of *Lychas jonesae* were collected at dry pitfall sites POV S1, S6, S8, S9, S11 and S12, which are located within the survey area. The species was also collected from the dry pitfall site S10 within the J4 impact area (Table 4.5, Appendix H). This species is widespread throughout Western Australia, and is not an SRE (Phoenix 2013a).

- ***Lychas 'splendens'***

Lychas 'splendens' was collected at several sites (wet pitfall, dry pitfall and foraging) inside the J4 impact area and the survey area (Table 4.5, Appendix H). This species is widespread throughout Western Australia, and is not an SRE (Phoenix 2013a).

- **Family Urodacidae**
  - **Genus *Urodacus***
    - ***Urodacus* 'koolyanobbing 2'**

Urodacus 'koolyanobbing 2' is a well-defined and clearly recognised morphospecies. This species is only known from the four specimens collected at dry pitfall site POV S7 (inside J4 impact area) and S8 (within survey area). Other similar species, such as *Urodacus* 'laverton 5', are known from the region; however, differences in the morphology of these species warrant recognition of separate morphospecies. Based on the distribution patterns within the genus that includes range-restricted as well as widespread species, *Urodacus* 'koolyanobbing 2' is considered a potential SRE (Phoenix 2013a). The species boundaries between this species and *Urodacus* 'laverton 5' can only be explored using DNA analysis.

- ***Urodacus* 'koolyanobbing 3'**

Urodacus 'koolyanobbing 3' is a well-defined and clearly recognised morphospecies. It posesses carapace features that suggest it is a lithophile, adapted for living under and amongst rocks. At least two other species of WA *Urodacus* show lithophilous characteristics, *U. koolanensis* and *U. planimanus,* both of which are SRE's. The six specimens collected at wet pitfall sites PO S1 and S2, and dry pitfall site POV S8 (within the survey area) and at dry pitfall sites POV S10 (J4 impact area) represent the first record of this species. No additional records are currently known. It is a likely SRE owing to its expected lithophilous ecology and the lack of additional records of this species (Phoenix 2013a).

- ***Urodacus* 'koolyanobbing 4'**

Urodacus 'koolyanobbing 4' is a well-defined and clearly recognised morphospecies. Two specimens were collected at sandplain habitat within the J4 impact area (dry pitfall site POV S10) and within the survey area (dry pitfall site POVS11). No additional records are known for this species in an area that is fairly well collected. It is therefore considered a likely SRE (Phoenix 2013a).

- ***Urodacus novaehollandiae***

Three individual *Urodacus novaehollandiae* were collected at the survey area (dry pitfall site POV S1, foraging site PO OSF11). This species is well-defined and clearly recogniseable. There appears to be two colour variants, one pale form on the coastal plain, and a darker form on the Darling Escarpment and on the Yilgarn plateau. Other than differing in their intensity of colouration, these forms are extremely similar and currently considered to be one species. Ongoing molecular work on this species is under-way to investigate phylogeography of this species. Urodacus novaehollandiae is not considered an SRE (Phoenix 2013a).

- ***Urodacus* sp. indet.**

Two indiviuals of *Urodacus* could not be identified to morphospecies level. Taking into account that some SREs have been found in the area, unidentified *Urodacus* are here rated potential SREs. Molecular analyses are recommended to clarify the identity of these *Urodacus* sp. indet. specimens (Phoenix 2013a).

5.3.10.2 Pseudoscorpiones (Pseudoscorpions)

- **Family Cheiridiidae**
  - **Cheiridiidae `genus indet. (juv)`**

Three juvenile members of the family Cheiridiidae were collected during this survey (Table 4.5, Appendix H). The life-stage of the specimens precluded identification to species level. Within Australia, representatives of four named genera (together with an additional unpublished genus) have a distribution extending from Southern WA (WA Goldfields) to the Pilbara, Kimberly and Northern Territory, as well as Barrow and Rottnest Islands. The precautionary principal requires that juveniles are considered a potential SRE (WAM 2013a).

- **Family Chernetidae**
  - **Genus *Chernetidae***
    - ***Chernetidae* sp. indet.**

A total of 25 juvenile specimens of chernetid were collected during this survey (Table 4.5, Appendix H). These specimens were juveniles they could not be identified to species. Based on known distribution patterns within the family, the unidentified chernetids from the sample are not considered SREs (Phoenix 2013b).

  - **Genus PSEAAD**
    - **'PSEAAD PSE076'**

Two male specimens of this novel genus and species were collected from the sandplain habitat type within the J4 impact area (foraging/leaf litter site PO OS11). Chernetidae are the most diverse of all pseudoscorpion families with 113 named genera and 652 named species worldwide. The Australian fauna is quite extensive, with 37 described species (Harvey 2011). This species has not been previously recorded by the museum and has been given the new WAM species code `PSE076`. Due to the lack of information about it distribution it is considered a potential SRE (WAM 2013a).

- **Family Chtoniidae**
    - **Genus *Austrochthonius***
        - ***Austrochthonius* 'pilbara`**

Thirty-one Juvenile individuals were collected at the survey area (wet pitfall sites PO S3, S8 and S12, Table 4.5, Appendix H). Species of *Austrochthonius* occur in leaf litter and soil environments throughout much of WA, as well as subterranean ecosystems in Cape Range and near Busselton (Harvey 1991; Harvey and Mould 2006). While this species is currently undescribed, current taxonomic work being done on this genus in WA means that the distinction of adults to species is relatively precise (WAM 2013a).

- ***Austrochthonius* `similis`**

Six specimens of A. `similis` (3 males, 3 females) were collected from two wet pitfall sites in the survey area (PO S3, S12) during this survey (Table 4.5, Appendix H). This species is currently undescribed, however, taxonomic work on this genus in WA is ongoing (WAM 2013a).

- ***Austrochthonius* `sp. indet. (female)`**

Three female specimens of Austrochthonius were collected from the survey area (wet pitfall site PO S8 & S12 Table 4.5, Appendix H) during this survey. The species level could not be determined. The precautionary principal requires that unidentified females are considered a potential SRE (Phoenix 2013a; WAM 2013a).

- **Family Garypidae**
    - **Genus Synsphyronus**
        - ***Synsphyronus mimulus***

Six specimens of *S. mimulus* were collected from the survey area during this survey (Table 4.5, Appendix H). *S. mimulus* is a widespread species that occurs in all Australian mainland states (Harvey 1987). The species is predominantly found under rocks, such as on granite outcrops and under limestone formations. It is widespread and not considered an SRE (Phoenix 2013a; WAM 2013a).

- ***Synsphyronus sp. indet.***

Three juvenile specimens of Synsphyronus were collected during this survey (Table 4.5, Appendix H). The life-stage of these specimens precluded identification to the species level. The precautionary principal requires that juveniles are considered a potential SRE (WAM 2013a).

    - **Genus *Amblyolpium***
        - ***Amblyolpium* `PSE077`**

Six specimens of this novel Amblyolpium species (3 males, 2 females, 2 juveniles) were collected at the J4 impact area and survey area during this survey (Table 4.5, Appendix H). This species has been allocated the code `PSE077`. *Amblyolpium*'s distribution is currently known to be restricted to the WA goldfields, therefore the species is a potential SRE (WAM 2013a).

- ***Geogarypus taylori***

Six specimens of *G. taylori* (3 males, 3 females) were collected from the survey area during this survey (Table 4.5, Appendix H). *Geogarypus taylori* is extremely widespread in the mallee and dry sclerophyll forest of southern Australia (Harvey 1986). It is not considered to be an SRE (WAM 2013a).

- **Family Olpiidae**
    - **Genus Austrohorus**
        - ***Austrohorus* sp.**

Eight Austrohorus specimens (4 males, 3 females, 1 juvenile) were collected from the J4 impact area and survey area (Table 4.5, Appendix H). The current knowledge of the taxonomy of this group is insufficient to accurately determine the geographic distribution of the species, therefore the species is a potential SRE (WAM 2013a).

    - **Genus Beierolpium**
        - ***Beierolpium* `sp. 8/3`**

Two specimens of *Beierolpium* `sp. 8/3` (1 female, 1 juvenile) were collected during this survey (Table 4.5, Appendix H). The 8/3 representation associated with this genus refers to the number of trichobothria (sensory hairs) on the fixed and movable fingers respectively, which is one of the characters that would coincide with species distinction in this genus. The systematic status of members of this genus has not been fully assessed. At present it is not possible to firmly establish the identity of the single male specimen collected (Table 4.5, Appendix H) until a complete systematic revision of the Western Australian members of *Beierolpium* is undertaken. The precautionary principal requires that females and juveniles are considered a potential SRE (WAM 2013a).

        - ***Beierolpium* `sp. 8/4`**

Fifty-seven of *Beierolpium* `sp. 8/4` were collected from inside and outside the J4 impact area during this survey (Table 4.5, Appendix H). The 8/4 representation associated with this genus refers to the number of trichobothria on the fixed and movable fingers respectively. *Beierolpium* '8/4' is a common form of the genus found in the arid regions of WA. It is not considered an SRE (Phoenix 2013b).

        - ***Beierolpium* sp. indet.**

Twenty-one juvenile specimens of *Beierolpium* were collected from inside and outside the J4 impact area (Table 4.5, Appendix H). These individuals could not be identified to species level. A complete systematic revision of this genus is required to determine the distribution of species within this genus in WA, therefor the species is a potential SRE (WAM 2013a).

    - ***Euryolpium***
        - ***Euryolpium* sp.**

Two male specimens of *Euryolpium* were collected at wet pitfall site PO S9 in the survey area (Table 4.5, Appendix H). Species of *Euryolpium* are commonly found under bark and under rocks throughout Australia. They can be locally abundant, and at least one species is widespread across northern Australia.

    - ***Indolpium***
        - ***Indolpium* sp. indet**

A total of 30 specimens of *Indolpium* were collected during this survey (Table 4.5, Appendix H). Until a systematic review of this genus has been conducted, a species identity to these specimens can not be assigned. The taxonomy of Indolpium is poorly resolved but the genus belongs to the most commonly collected pseudoscorpions in SRE survey in WA. Based on known distribution patterns within the genus and perceived habitat preferences, the unidentified *Indolpium* specimens from this survey are not considered SREs (Phoenix 2013a, b).

- **Unknown genus**
  - **Olpiidae genus indet. sp. indet.**

Eight juvenile olpiid pseudoscorpions were collected at the J4 impact area and survey area (Table 4.5, Appendix H). The specimens can not be identified to genus level as a consequence of their early stage of development. Molecular identification would potentially provide additional information on the specimen's identity (WAM 2013a).

5.3.10.3 Isopoda (Isopods)

- **Family Armadillidae**
  - **Genus Buddelundia**
    - ***Buddelundia* cf. *frontosa***

Forteen specimens were collected from the J4 impact area (POV S7) and the survey area (dry pitfall site POV S2, S8 & 9, S12, foraging site PO OS8, Table 4.5, Appendix H). This species is currently redescribed (Judd 2013). The type locality of this species is Coolgardie and specimens collected from the type locality match the specimens collected during this survey. Further work on the species is required and additional specimens from the remaining Goldfields region will be taken into consideration. It is most likely a relatively widespread species in the Goldfields region and therefore not considered to be an SRE (Judd 2013).

- ***Buddelundia* '39'**

Forty-three specimens were collected from inside J4, but also from the survey area (Table 4.5, Appendix H). *Buddelundia* sp. nov. 39 is a species complex found in the northern Goldfields which requires further taxonomic work as there are some differences in a few characters across this species' range. This species is very large and has a characteristically long internal lobe on the schisma of the first pereonite. This character matches the description of *B. monticola*, a described species from Kalgoorlie, for which the type specimen no longer exists. The specimens collected during the survey are typical of those found in the Coolgardie area and there is no evidence to suggest that this is an SRE species (Judd 2013).

- ***Buddelundia* '71'**

Fourteen specimens were collected from the survey area (eight survey sites) (Table 4.5, Appendix H). This species is morphologically very similar to *B.* cf *frontosa*. However, the specimens collected during this survey are much larger and display a different colouring. They are highly likely to be a different species to *B. frontosa* but require additional work including a full description and/or molecular analysis. One other record of this species (S. Judd reference collection: SJ0011) exists from the Helena and Aurora Range. It is currently only known from the Helena and Aurora Range s and believed to be confined to the range. It is therefore considered a confirmed SRE (Judd 2013; Phoenix 2013b).

- ***Buddelundia* sp. nov. A**

Two specimens were collected from a wet pitfall site (PO S3) within the survey area. This is a new species of *Buddelundia* known only from the specimens collected during this survey and further sampling is required to establish the distribution of the species. At this stage, this specimen is considered a potential SRE species (Judd 2013).

- ***Buddelundia* sp. indet.**

Three female *Buddelundia* were collected at the survey area (foraging site PO OSF20 & PO OSF45) and could not be identified based on morphological characters. As it is possible that it represents the above *Buddelundia* '71', it is here considered a potential SRE (Judd 2013).

- **Genus *Cubaris***
  - **"*Cubaris*" sp. nov.**

Three specimens were collected from wet pitfalls within the J4 impact area and survey area (PO S1, S10). Isopods of this type are currently allocated to the genus *Cubaris*; however, a review of the Australian Armadillidae is needed to resolve whether these specimens belong to another genus. The species has previously been collected at three locations near Coolgardie (along with *B. frontosa*). It is likely that this species is relatively widespread and therefore unlikely to be an SRE species; however, further work is required on this group (Judd 2013).

- **Genus unknown**
  - **unknown genus sp. nov. A,**
  - **unknown genus sp. nov. C**

Isopods of this type have previously been allocated temporarily to the genus *Spherillo*. However, a review of the Australian Armadillidae is needed and the collected specimens most likely belong to another genus.

Six specimens of the unknown genus sp. nov. A were collected within the J4 and the survey area. Three specimens of the unknown genus sp. nov. C were collected within the J4 impact area and survey area (PO S10 & S11). The collected specimens represent three distinct species. Two other species are also known from the Goldfields region which are relatively small species and the juveniles of these species can be different to the adults; consequently, they are difficult to identify. All three species collected during the survey are known only from this location and should be considered potential SRE species (Judd 2013).

- **Genus unknown**
  - **Armadillidae 'EE1479S'**

One specimen of Armdaillidae 'EE1479S' was collected from a wet pitfall and foraging site within the survey area (PO S1, PO OSF45). The species is only known from this survey and therefore is considered a likely SRE (Phoenix 2013a).

- **Family Philosciidae**
  - **Genus *Laevophiloscia***
    - ***Laevophiloscia* '1479'**

Seven specimens (females and males) were collected from within the J4 impact area and the survey area (sites PO S3 & S5, foraging sites PO OSF35, OSF40 & OSF43). First considered a potential SRE, the species is now more likely to have a widespread distribution, similar to *Buddelundia* cf. *frontosa*.

- **Family Platyarthridae**
  - **Genus *Trichorhina***
    - ***Trichorhina* sp. nov. A**
    - ***Trichorhina* sp. nov. B**

One specimen of each species was collected from wet pitfalls within the survey area (sites PO S4 & S11). There is a single species (*Trichorhina australiensis*) of the Platyarthridae family which is described from the Western Australian jarrah forest. The collected specimens do not belong to this species. *Trichorhina* are relatively widespread and cryptic isopods and numerous species are likely to be present in Western Australia. No males were collected and, based on the general external morphological characteristics of the specimens, they appear to belong to two species. Further

taxonomic work is bnecessary to determine if these species are SREs; however the precautionary principal requires that these specimens are considered a potential SRE (Judd 2013).

- ***Trichorhina* '1510'**

Two female specimens were collected from the rsurvey area during this survey and appear conspecific with specimens collected from the Chameleon project, approximately 6-38 km north-east of the impact area (*ecologia* in prep)

5.3.10.4 Molluscs (Snails)

- **Family Bothriembryontidae**
  - **Genus *Bothriembryon***
    - ***Bothriembryon* cf. *sedgwicki***

A total of 57 specimens were collected from several site within the J4 impact area (one location) and the survey area (14 locations) (Table 4.5, Figure 4.13, Appendix H). The specimens most closely resemble *Bothriembryon sedgwicki,* which was described from the Nangeenan area (Breure and Whisson 2012; Iredale 1939). Although there is considerable variation in shell shape and size within and between populations, specimens believed to be the same species (based on shell morphology) have since been found across a wide area including Marvel Loch; Lake Johnston and north of Coolgardie. All of these specimens have been found on greenstone ridges and, on many occasions, in litter at the base of eucalyptus trees. Molecular work is needed to confirm that these populations are conspecific (Whisson 2013). The species is considered a potential SRE.

- **Family Camaenidae**
  - **Genus *Sinumleon***
    - ***Sinumelon* cf. *tarcoolanum***

A total of 21 specimens were collected from the survey area (dry pitfall sites POV S4, S5, S11) and opportunistically (Table 4.5, Appendix H). *Sinumelon tarcoolanum* has a wide but disjunct distribution from Yindi Station in Western Australia east to the Gawler Ranges, South Australia and as far inland as just north of Cook, South Australia (Solem 1997). As the current survey specimens extend the known distribution of *S. tarcoolanum* approximately 270 kilometres westward, it has been tentatively identified as belonging to that species. However, as the specimens are assigned to be a close form to *S. tarcoolanum*, they may represent a different or new species. Until further taxonomic resolves the specie slevel of the collected specimens, it is possible that they represent and SRE and therefore are classified as potential SRE (Whisson 2013).

- ***Sinumelon kalgum***

One specimen was collected from the survey area (PO OS5, leaf litter collection, Table 4.5, Appendix H). *Sinumelon kalgum* was originally described from the Kalgoorlie area (Iredale 1939) but is now regarded as widespread, being found at scattered localities from south of Balladonia; Norseman; Coolgardie then north to Mount Manning (Solem 1997). It is, therefore, not an SRE. Within such geographic range, variation exists in shell size and colouration (Whisson 2013).

- **Family Punctidae**
    - o ***Genus Westralaoma***
        - ***Westralaoma aprica***

One specimen was collected from the survey area (PO S8). *Westralaoma aprica* was described by Iredale (1939) from specimens taken in the Nangeenan area, but based on a few isolated records in the collections of the WA Museum, it appears to be widely distributed across the northern wheat belt and western goldfields regions and thus is not an SRE (Whisson 2013).

- ***Westralaoma expicta***

One individual was collected from a foraging site (PO OSF5) within the J4 impact area. The species is not considered an SRE (Whisson 2013).

- **Family Pupillidae**

Subfamily Gastrocoptinae

- o **Genus *Gastrocopta***
    - ***Gastrocopta bannertonensis***

One specimen was collected from leaf litter within the survey area (PO S8). This species has a wide geographic distribution in southern Australia, having been recorded from the southern regions of Western Australia; South Australia and New South Wales. There is also an isolated record of its presence in an area to the north-west of Alice Springs in the Northern Territory (Pokryszko 1996). It is not an SRE (Whisson 2013).

Sub-family Pupillinae

- o **Genus *Pupilla***
    - ***Pupilla australis***

Seven specimens of this species were recorded from the survey area (site PO S5, Table 4.5, Appendix H). It is not considered an SRE (Whisson 2013).

- o **Genus Pupoides**
    - ***Pupoides adelaidae***

Twenty-one specimens were collected from leaf litter from the survey area (POV S8, POV S11, PO OS8). *Pupoides adelaidae* has a wide geographic distribution that appears to extend from New South Wales and north-western Victoria, across southern South Australia into the wheatbelt areas of Western Australia and as far to the north-west as Morawa (Solem 1986; Solem 1991). It may possibly also extend from Shark Bay north to North West Cape on the west coast of Western Australia (Solem 1986). It is often found to be sympatric with the more slender, sinistral coiling Pupoides myoporinae (Tate 1880), thus, it is not an SRE (Whisson 2013).

- ***Pupoides myoporinae***

Ten specimens were collected from the survey area (POV S8 and PO S5). *Pupoides myoporinae* (Tate 1880) has a wide but disjunct distribution across most of southern Australia, with a western range of apparently scattered populations from Yalata in South Australia to Hines Hill in Western Australia, and with a more restricted eastern range from the Eyre Peninsula to Bannerton in Victoria (Solem 1986; Solem 1991). It is often found to be sympatric with the larger, dextral coiling *Pupoides adelaidae* (Adams and Angas 1864). This species is not an SRE (Whisson 2013)

5.3.10.5 Diplopods (Millipedes)

- **Order Polydesmida (keeled millipedes)**
- **Family Paradoxosomatidae**
    - **Genus *Antichiropus***
        - ***Antichiropus* 'lake king'**

One individual specimen was recorded from the J4 impact area (PO S10). *Antichiropus* 'lake king' is currently known from only a single specimen from Lake King in addition to the male from this survey. Despite the low number of recordes, the distance of approximately 274 km between the two known records does not allow this species to be categorised as SRE. This species was not represented by females or immatures, but could be recognised by overall black colouration with a pale longitudinal band (Phoenix 2013b).

- ***Antichiropus* 'mt gibson 1'**

Eight specimens of this species were collected at the survey area. *Antichiropus* 'mt gibson 1' is known from the Mt Gibson Iron Ore mine and surrounds, Mt Mannig and Southern Cross in addition to the samples from this survey. Females of this species were identified based on the unique colour pattern of specimens within this sample; the species is completely black. It is a confirmed SRE (Phoenix 2013b).

- ***Antichiropus* 'mt gibson 3'**

Twenty-seven specimens were collected throughout the survey area. *Antichiropus* 'mt jackson 1' is currently known from the Mt Gibson Iron Ore mine in addition to the samples from this survey. Females of this species were identified based on the unique colour pattern of specimens within this sample; the species is uniformly pale brown. It is a confirmed SRE (Phoenix 2013b).

- ***Antichiropus* sp.**

Forty juvenile and female specimens were collected during the current survey from inside and outside the J4 impact area (Table 4.5, Appendix H). These juveniles could not be identified to species level. They have a potential to belong to either one of the *Antichiropus* species collected during the survey which results in this species to be considered as a confirmed SRE (Phoenix 2013a; WAM 2013a).

- **Order Spirostreptida**
- **Family Iulomorphidae**
    - **Genus *Atelomastix***
        - ***Atelomastix bamfordi***

Three specimens were recorded from the survey area (Table 4.5, Appendix H). This species was also recorded throughout the Chameleon impact area (ecologia 2013b). The species is fairly widely distributed throughout the area, but still within the limits of short range endemism (Edwards and Harvey 2010; Phoenix 2013b).

5.3.10.6 Chilopoda (Centipedes)

Order Scolopendromorpha (tropical centipedes)

- **Family Cryptopidae**
    - **Genus *Cryptops***
        - ***Cryptops* sp. indet.**

Molecular studies on Pilbara *Cryptops* have revealed a locally diverse fauna with many species from few localities west of Tom Price (Phoenix 2013c, d, e). As similar distribution patterns can be expected in other semi-arid and arid areas throughout the range of the genus, unidentified specimens of *Cryptops* are considered potential SREs.

Order Geophilomorpha (soil centipedes)

- **Family Geophilidae**
    - **Genus *Sepedonophilus***
        - ***Sepedonophilus* sp. indet.**

Based on their habitat preferences for deep and moist litter and currently known distribution based on molecular data (Phoenix 2013c), unidentified species of *Sepedonophilus* are currently considered potential SREs (Phoenix 2013b).

- **Family Mecistocephalidae**
    - **Genus *Mecistocephalus***
        - ***Mecistocephalus* sp. indet.**

Eleven specimens of this morpho-species were collected from the survey area. Molecular studies on Pilbara *Mecistocephalus* have revealed a locally diverse fauna with many species from few localities west of Tom Price (Phoenix 2013c, d, e). As similar distribution patterns can be expected in other arid areas throughout the range of the genus, unidentified specimens of *Mecistocephalus* are considered potential SREs (Phoenix 2013b)..

- **Family Oryidae**
    - **Genus *Orphnaeus***
        - ***Orphnaeus brevilabiatus***

Three specimen of this species were recorded from the survey area. *Orphnaeus brevilabiatus* is the only member of the family Oryidae in Australia and not being a native taxon. It is a cosmopolitan tramp species that is widespread throughout the Indo-Pacific region (Phoenix 2013b).

5.3.10.7 Troglofauna

Order Isopoda

- **Family Armadillidae**
    - **Genus unknown**
        - **Unknown genus sp. nov.**

One specimen was collected from within the J4 impact area (Table 4.7). This is an unknown genus of the Family Armadillidae and it almost certainly represents an SRE species (Judd 2013). It has a highly characteristic margin of the first pereonite, which has some affinities with *Troglarmadillo*. The single

specimen collected was tightly-rolled and would be destroyed if examined in any further detail. Similar specimens with the same distinctive characteristics are known from the Pilbara (Judd 2013).

- **Genus *Troglarmadillo***
  - ***Troglarmadillo* sp. indet.**

One individual was recorded from the J4 impact area (Table 4.7). Species delineation in *Troglarmadillo* is heavily dependent on genomic evidence since the genus is both diverse and replete with cryptic species. Troglobitic species are often highly endemic in WA. *Troglarmadillo* sp. indet. is likely to be locally endemic; however, demonstrating endemism and regional context will be dependent on genomic studies of this species with species from nearby localities. In the absence of genomic data, this species is considered a likely SRE (Judd and Volschenk 2013). This specimen is currently compared with specimens of Troglarmadillo (Troglarmadillo sp. B10) captured at Chameleon to verify its regional context as an SRE.

- **Family Platyarthridae**
  - **Genus *Trichorhina***
    - ***Trichorhina* sp. nov.**

The specimen of this morphospecies was extremely fragile during examination (Judd 2013). It was recorded from the J4 impact area and will be compared to other specimens of *Trichorhina* (*Trichorhina* sp. B1, *Trichorhina* sp. B2) collected previously from Chameleom, the J1 and J5 deposit (Bennelongia 2011). Its SRE status is currently unknown.

- **Family Philosciidae**
  - **Genus unknown**
    - ***Philosciidae 'bungalbin'***

One individual was collected from the survey area during the survey (Table 4.7). Philosciidae 'bungalbin' is considered a distinct species because it is geographically separated from all other morphologically similar isopods. They have well-developed pleonal epimera, prominent scale setae and two segments of the antennal flagellum which appear to be fused. Their placement within the Philosciidae is uncertain. The present species is only known from this project. A very similar species occurred at the vicinity of Wiluna (*ecologia* internal database) in large numbers and another species has been collected in the Kimberley. *Philosciidae 'bungalbin'* is currently considered a likely SRE. No male specimens were collected during the survey which are needed for further morphological work (Judd and Volschenk 2013). However, the specimen is currently assessed and morphologically compared with Philosciidae collected previously from the region (Bennelongia 2011).

- **Family unknown**
  - **Genus unknown**
    - **sp. indet.**

The specimen is incomplete and lacks a head and both a telson and uropods. It was collected during the troglofauna sampling in the J4 impact area. It is not from the family Armadillidae and is not any of the other species mentioned in this report (Judd 2013).

Order Polyxenida

- **Family Polyxenidae**
    - **Genus unknown**
        - **sp. indet.**

One individual was recorded from the J4 impact area. The specimen appears to belong to the family Polyxenidae based to the groupings of the setae on the terga. Further taxonomic resolution was not attained owing to dependency on genomic comparisons to make these. Without knowing the identity of this species, an exact distribution can not be determined. In the absence of genomic data, this species should be treated as a potential SRE. Morphological comparisons are currently undertaken between this species and other species from the area to verify its regional context as an SRE (Judd and Volschenk 2013).

5.4 SURVEY ADEQUACY

5.4.1 Terrestrial Vertebrate Fauna

Survey effort expended within the survey area is summarised in Table 4.2, showing that considerable systematic and opportunistic sampling effort was undertaken.

Analysis of the trappable terrestrial faunal assemblage recorded during the Level 2 vertebrate fauna assessment suggests the survey recorded between 84.7 % (seven estimates) and 85.3 % (MM estimator) of the expected terrestrial faunal assemblage. Analysis of data of the observed avifauna assemblage recorded during the Level 2 vertebrate fauna assessment suggests the survey recorded between 97.1 % (seven estimators) and 92.4 % (MM estimator) of the expected avifaunal assemblage. Based on the shape of SACs (Figure 4.15 and Figure 4.16), a plateau profile has not been achieved for the trappable fauna. This suggests that additional surveying will reveal additional species that have not been recorded yet. However, in summary, these results indicate that survey effort was adequate to provide an indication of the majority of the fauna assemblage present in the survey area. In addition, opportunistic searches revealed an additional 16 trappable vertebrate fauna species, four non-trappable fauna species (excluding bat species) and an additional 24 bird species.

5.4.2 SRE Fauna

The survey efficiency (estimated at 77.7% - 78.0%) suggests that the survey was adequate, given the context of the total number of species collected and the size of the impact area. Nevertheless, it is anticipated that additional surveying will reveal additional SRE species inhabiting the impact area and survey area.

5.5 SURVEY LIMITATIONS AND CONSTRAINTS

Limitations of the current survey are summarised in below Table 5.2. Given the few limitations encountered, it can be confirmed that if upcoming surveys do not encounter additional limitations, overall, an adequate level of survey will be undertaken.

Table 5.2 – Summary of survey limitations

Constraint	Limitation	Comment
Competency/experience of the consultant carrying out the survey.	No	All survey staff involved were experienced in fauna assessments of a variety of habitats of Western Australia, including BIF Ranges.
Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions).	No	Sampling methods were deemed adequate. Due to Polaris' commitment to not drive on wet tracks within the Helena Aurora Conservation Park, the survey of the survey area and south of the J4 impact area were delayed and conducted separately in autumn and spring 2013.
Proportion of fauna identified, recorded and/or collected.	No	All vertebrate fauna were identified in the field. Invertebrate fauna was collected and submitted to external specialists for identification.
Sources of information (previously available information as distinct from new data).	No	A relatively large number (n=17) of survey reports are available describing the fauna recorded from projects within 35 km of the impact area providing a regional context of data collected during this survey.
The proportion of the task achieved and further work which might be needed.	No/Partial	All tasks for the Level 2 fauna assessment was completed for the project. DNA analysis may be advisable for SRE species which could not be identified to species level to determine the distribution in the region.
Timing/weather/season/cycle.	No	Due to DEC's requirement to avoid driving on wet tracks within the Helena and Aurora Conservation park and the SRE, the vertebrate trapping survey at J4 was postponed and conducted in late spring/early summer after weather conditions and tracks dried up. This resulted in high temperature which limited the number of amphibians and mammals trapped. The summer season may have also resulted in a low number of elapids recorded during the first phase of surveying. However, previous regular rainfalls provided adequate moisture for SREs. The second phase of the J4 impact area and the survey of the survey area was conducted during peak season of activity of terrestrial fauna (autumn and spring 2013).
Disturbances which affected results of the survey (e.g. fire, flood, accidental human intervention).	No	No disturbance was experienced during the survey which affected the results of the survey.
Intensity (in retrospect was the intensity adequate).	No	The intensity of the Level 2 survey was deemed adequate.
Completeness (e.g. was relevant area fully surveyed).	No	The impact area and survey area was surveyed adequately.
Resources (e.g. degree of expertise available in animal identification to taxon level).	No	All vertebrate fauna was identified in the field. Invertebrate fauna was collected and identified by specialists and submitted to the WA Museum at the completion of work.
Remoteness and/or access problems.	No	The majority of the impact area and all habitats were accessible. Inaccessible areas were surveyed by helicopters and during the flora and vegetation survey.
Availability of contextual (e.g. biogeographic) information on the region).	No	The level of biogeographic information available is adequate.
Efficacy of sampling methods (i.e. any groups not sampled by survey methods).	No/Partial	Troglofauna sampling resulted in the lack of troglobitic predators during phase 1. However, the results from phase 2 of surveying contributed to the conclusion that all groups were sampled.

6 IMPACTS TO FAUNA HABITATS AND ASSEMBLAGES

6.1 THREATENING PROCESSES

Proposed activities in the impact area will involve clearing and construction followed by ongoing mining activities. Greater human activity in the area, processes/activities associated with the development of the project and processes/activities associated with the continued operation of the J4 mine will create threatening processes that could potentially impact vertebrate and invertebrate fauna and their habitats. These processes/activities are discussed in the following sections.

6.1.1 Vegetation Clearing

Impacts to native fauna arising from vegetation clearing activities will include a reduction in the amount of available fauna habitat and mortality of small or sedentary fauna that are unable to move out of the area prior to clearing, including Malleefowl (mounds), Tree-stem Trapdoor spider and *Idiosoma* sp. indet. Clearing activities which result in the fragmentation of habitats may result in the inability of individuals to move between areas of habitat and may increase predation events as individuals move across cleared areas.

6.1.2 Vegetation Degradation

Vegetation degradation is caused through the effects of dust pollution or increased weed invasion. An increase in airborne particulate matter can result from blasting, vegetation clearing and vehicle movements. Although not well documented, dust can cause damage to vegetation primarily through abrasion of leaves, reduction in photosynthesis and an intake of chemicals through the cuticle (Grantz *et al.* 2003). This can result in insect infestations and plant disease epidemics in addition to reduced growth and biomass, all of which lead to increased ecosystem stress and altered species composition (Grantz *et al.* 2003). A decline in vegetation quality impacts faunal assemblages by reducing both food and habitat resources. Vegetation degradation is expected in particular within the mixed eucalypt woodland, sandy plain with shrubland and Mallee woodland on rocky plains and footslopes, as these habitats are found within the majority of the impact area, where mining activity and the construction of the haul roads is expected to occur. Disturbance and clearing of native vegetation during construction can facilitate the spread of weed species already present in the area, whilst an increase in vehicle and equipment movement may introduce species from other areas. In a worst case scenario, this may result in weed species dominating the understorey to the exclusion of annuals and eventually larger perennial flora(Braithwaite *et al.* 1989; Griffin *et al.* 1989). This may increase the number of introduced fauna such as rabbit and house mouse which is expected to impact habitats and native fauna due to competition and land degradation (Brown and Saunders 2013).

6.1.3 Noise and Light Impacts

Light and noise impacts are likely to occur along the rocky ridge where drilling is expected to take place but also within the mixed eucalypt woodland and sandy plains with shrubland where the haul road and therefore increased traffic will occur. Noise impacts will result from blasting, transportation, crushing and other mining activities. Noise impacts may cause fauna species to move away, alter their behaviour, or change community structure due to the negative response of wildlife to new stimuli (Larkin 1996; Radle 1998).

Bat species are sensitive to both light and noise, particularly approaching and during the maternity season (Mann *et al.* 2002). The presence of light and noise may be advantageous to some species, for example those that feed on insects around lights, and disadvantageous to others, for example species in which the noise interferes with their echolocation calls (Zagorodniuk 2003). This has the potential to alter the species composition within the impact area. Mercury vapour lights in particular

have been found to affect the predator-prey relationship between bats and moths (Longcore and Rich 2004).

Noise and light can attract feral predators to areas as they associate human activity with food resources. An increase in feral predator numbers will result in a corresponding increase in predation rates on native animals. High predation rates (from both feral and native fauna) has also been found to occur in areas of high illumination, and small mammals tend to forage less in these areas (Longcore and Rich 2004).

Light can disrupt bird migrations, particularly nocturnally migrating species which travel between Lake Barlee noth of the impact area and a number of lakes south of the impact area (Lake Deborah, Lake Baladjie, Lake Seabrook, Lake Walton and Lake Julia) when environmental conditions force them to fly lower to the ground at night (Longcore and Rich 2004). Birds can become trapped in artificially lit areas as they will not move out into dark areas where they have difficulty navigating. Trapped individuals may become exhausted, collide with other individuals or suffer from increased predation (Longcore and Rich 2004).

Over time it is expected that most species will either habituate to the light and noise associated with mining operations, or move to a suitable distance away from the source so that they are no longer disturbed (Larkin 1996; Radle 1998). Due to the large areas of relatively undisturbed habitat north and south of the impact area and the mobility of most species, individuals should be able to move away from light and noise sources and thus avoid these impacts.

6.1.4 Fire

Increased human activity is often associated with an increased risk of fire or altered fire regimes, which may lead to temporary destruction of fauna habitats or more lasting degradation of natural vegetation if, for example, fire frequency is increased (Williams 2002). Movement of vehicles, machinery and human influences have the potential to increase the frequency of spot fires, particularly in the highly flammable sandy plain with shrubland due to its dense vegetation structure, including grasses that are dry for much of the year.

6.1.5 Vehicle Strike

The construction of haul roads, light vehicle roads and access tracks within the impact areas will increase the likelihood of vehicle strikes on native fauna. Small reptiles may be killed on roads while basking during the day and mammals (particularly kangaroos) are commonly killed on roads following dusk. This attracts scavenging species such as the Wedge-tailed Eagle, which are then more likely to be struck themselves.

6.1.6 Food Waste and Open Water

The presence of open water sources and accessible food wastes can cause an increase of feral fauna densities and allow these species to occur in areas that otherwise would not be possible in the arid zones of Australia. An increase in feral fauna densities will have an increased negative impact on the abundance and diversity of native fauna due to increased predation pressure and resource competition. Water resources include water sumps and any areas where excess water accumulates and water sources not often associated as such, e.g. water tanks can attract feral European honey bees which may also affect the health and safety of project personnel. Food wastes are typically concentrated around accommodation camps (such as poorly disposed kitchen scraps), however poorly disposed lunch scraps from personnel working away from the camp can also provide a food resource for feral fauna species and may increase the number of cats and House Mice recorded during the survey.

6.2 IMPACTS ON FAUNA HABITATS

Five fauna habitat types were recognised within the impact area which are not unique to the impact area: rocky ridge, Mallee woodland on rocky plain and footslope, mixed eucalypt woodland, sandy plain with shrubland and drainage line. The rocky ridge habitat type within the J4 impact area is anticipated to experience the highest impact as drilling and rock crushing operations are a destructive process and will change the composition of this habitat type on a larger scale than the remaining habitat types. The destruction of the rocky substrate is anticipated to be an additional impact to that of vegetation clearing. Within the Coolgardie Bioregion, a total of 13 BIF ranges are present of which eight are located within the Mt Manning Reserve. Of these, the Jackson Range is one of the two BIF ranges that are currently being mined. The remaining six are being explored for iron ore and are located in reserves that are not fully protect from exploration and mining activities (DEC 2007a; Helena and Aurora Range Advocates Inc 2012). BIF rages are also known to be of significant value to biodiversity which is a consequence of their unique geology, soils and relative isolation (DEC 2007a). Therefore the impacts on this habitat type are more significant than impacts on the remaining four habitat types within the impact area.

Mixed eucalypt woodland followed by sandy plain with shrubland occupied the majority of the J4 impact area (Figure 4.1, Table 4.1). Few impacts are expected as a result of vegetation clearing in these habitat types due to extensive areas of similar habitat in the surrounding region. With the exception of active Malleefowl mounds, the species of conservation significance that potentially occur in these habitat types are mobile and typically capable of moving into the surrounding areas. Therefore impacts to these fauna habitats, on a regional scale, are not anticipated to be significant.

Drainage lines and Mallee woodland on rocky plain and footslope are less common habitat types throughout the impact area but still relatively common in the surrounding region. Development of the project may result in a local impact to these habitat types; however the regional impact is anticipated to be relatively low.

6.3 IMPACTS ON FAUNAL ASSEMBLAGES

6.3.1 Biodiversity

Most terrestrial fauna are expected to be able to move temporarily to adjacent areas of suitable habitat but are not expected to establish populations outside the impact area due to intraspecific competition. Individuals of sedentary fauna, e.g. burrowing species, may be impacted. Vegetation may be also degraded from impacts, such as fire, dust and weeds, which may reduce the quality of local fauna habitats, thereby reducing local fauna diversity.

The impact area lies within the distribution of several conservation significant species which have not been recorded in the area in recent times. If suitable habitat is present within the impact area, it may be of value for future reintroductions of these species. Conservation significant species that may occur in eucalypt habitat include Numbat (*Myrmecobius fasciatus*), Western Brush Wallaby (*Macropus irma*), Tammar Wallaby (*M. eugenii derbanius*), Masked Owl (*Tyto novaehollandiae*) and Bush Stone-curlew (*Burhinus grallarius*).

6.3.2 Ecological Function

Localised reduction in ecological function such as the reduction of vegetation biomass, loss of fauna and increased predation in cleared areas can be expected as a result of habitat clearing and fragmentation, as well as other indirect impacts such as dust, traffic, noise and light. However, ecological function at a regional scale is not expected to be impacted.

Biodiversity and ecological function are expected to recover as vegetation communities regenerate in rehabilitated areas and stabilise, allowing native fauna to re-colonise from adjacent areas along the Jackson Range and plains to the south. However, adequate weed management, including regular monitoring for pest weeds, is important for rehabilitation of disturbed areas to succeed in re-creating some of the original fauna habitats present prior to the project. Those vegetation types that take the longest to fully regenerate are those containing mature eucalypts with hollows. In the impact areas these occur primarily within the haul road alignments.

6.3.3 Endemic species

The results of the fauna assessment have shown that the impact area and associated survey area host a diverse fauna assemblage with several vertebrate species endemic to the South-west of Australia: Western Pygmy Possum (*Cercartetus concinnus*), Mitchell's Hopping Mouse (*Notomys mitchelli*), Purple-gaped Honey eater (*Lichenostomus cratitius*), New Holland Honeyeater (*Lichenostomus cratitius*), Western Yellow Robin (*Eopsaltria griseogularis*), Bicycle Lizard (*Ctenophorus cristatus*), the gecko *Lucasium maini*, the legless lizards *Delma fraseri* and *Delma australis,* and the snake *Parasuta gouldii*.

In addition, new invertebrate species currently not known from any other location were recorded: four arachnid species (*Yilgarnia* 'MYG272', Synothele 'MYG278', *Urodacus* 'koolyanobbing 2' and *U.* 'koolyanobbing 3'), two species of pseudoscorpion , `PSEAAD PSE076' and *Amblyolpium* `PSE077`) and five isopod species (Buddelundia '71', *Buddelundia* sp. nov. A, Unknown genus sp. nov. A, Unknown genus sp. nov. C and Armadillidae 'EE1479S'). Of these new species, one species of pseudoscorpion (also representing a new genus) was recorded from only within the J4 impact area. In addition, three potential and likely SRE species were found inside the impact area only (*Idiosoma* sp. indet., *Aname* 'MYG279' and *Kwonkan* sp. indet.) Any impacts to their habitats such as vegetation clearing and drilling could be considered to have a significant impact to the species.

7 CONCLUSIONS

All survey methods are consistent with the relevant guidelines:

The key outcomes and results of the assessments are as follows:

- Six habitat types were recorded from within the survey area: rocky ridge, Mallee woodland on rocky plain and footslopes, mixed eucalypt woodland, sandy plain with shrubland, drainage line, and seasonal swamp. Of these, five habitat types (rocky ridge, Mallee woodland on rocky plain and footslopes, mixed eucalypt woodland, sandy plain with shrubland and drainage line) are present within the J4 impact area. These five habitat types are also present within the survey area.
- Database searches and the consultation of eight publications reporting on vertebrate fauna identified a total of 41 species of native mammal, nine species of introduced mammal, 213 species of native bird, three species of introduced bird, 111 species of reptile and 19 species of amphibian that have been recorded from surrounding areas. Of these, 41 vertebrate species of conservation significance could potentially occur within the J4 impact area and survey area: six mammals, 33 bird and two reptile species. The presumably extinct species (Lesser Stick-nest Rat) was excluded.
- Database searches and the consultation of four troglofauna assessment reports, three SRE reports and four stygofauna reports identified a total of 305 terrestrial invertebrate species from the nearby regional area, of which 29 represented potential SRE species, one stygobitic species (*Harpacticoida* sp.) and a total of 19 troglobitic species, all potentially representing short range endemics.
- During the current survey, a total of 10 native and two introduced mammal species, 46 bird and 28 reptile species were recorded from the J4 impact area. In addition, seven native and one introduced mammal species, 44 bird species, 20 reptile species and two species of frog were recorded from the survey area (outside the J4 impact area). Thus a total of 17 native and three introduced species of mammal, 90 species of bird, 48 species of reptile and two species of amphibian were recorded during the current assessment.
- Four species of conservation significance were sighted within the impact area: Crested Bellbird, Shy Heathwren, Major Mitchells' Cockatoo and Rainbow Bee-eater. In addition, the Malleeffowl was recorded through secondary evidence (fresh tracks & old mounds) within the impact area. The Fork-tailed Swift and Peregrin Falcon were recorded outside the impact area. In addition, secondary evidence of either the Australian Bustard or the Bush Stone-curlew was recorded from the survey area.
- A large number of terrestrial invertebrate species were collected during the survey. They comprised 23 morphospecies of spider (including two likely SRE, 12 potential SRE species), eleven morphospecies of scorpion (including four potential SREs), 17 morphospecies of pseudoscorpion (including 11 potential SREs), 14 morphospecies of isopod (including one confirmed SRE, seven potential SREs and two likely SRE), ten morphospecies of snail (including three potential SREs), five morphospecies of millipedes (including four confirmed SREs). One species of centipede (potential SRE) and three morphospecies of geophilomorph (including two potential SREs). Of these, one likely SRE (*Idiosoma* sp. indet) and three potential SREs (*Aname* 'MYG279', *Kwonkan* sp. indet. and `PSEAAD PSE076'), of which latter one represents a new genus and species of pseudoscorpion, were recorded from within the J4 impact area only.
- During this survey, a total of 40 potential SREs, four likely SREs and five confirmed SRE species were collected from the survey area and impact area. It is likely that the high level of

short range endemism identified in the impact area is is to a large part due to the low taxonomic resolution resulting from the lack of mature males in the sample. This is due to the fact that SRE are dominated by invertebrate species, which are historically understudied and in many cases lack formal descriptions. An extensive, reliable taxonomic evaluation of these species has begun only relatively recently and thus the availability of literature relevant to SREs is relatively scarce.

- Very few subterranean invertebrate species were collected during the survey. The stygofauna Level 1 study at J4 impact area, comprising sampling of nine bore holes, resulted in no stygofauna records. Five troglobitic morphospecies were collected from the J4 impact area during the Level 2 troglofauna sampling. Of these, three morphospecies were considered likely SRE and are currently undergoing morphological comparison with specimens collected previously in the region.

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APPENDIX A EXPLANATION OF CONSERVATION CODES

Appendix A1 Definitions of categories under the *Environment Protection and Biodiversity Conservation Act 1999*

Category	Definition
Endangered (EN)	The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction.
Vulnerable (VU)	Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate.
Migratory (M)	Species are defined as migratory if they are listed in an international agreement approved by the Commonwealth Environment Minister, including: • the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animal) for which Australia is a range state; • the agreement between the Government of Australian and the Government of the Peoples Republic of China for the Protection of Migratory Birds and their environment (CAMBA); or • the agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (JAMBA).

Appendix A2 Definition of Schedules under the *Wildlife Conservation Act 1950*

Schedule	Definition
Schedule 1 (S1)	Fauna which are rare of likely to become extinct, are declared to be fauna that is in need of special protection.
Schedule 2 (S2)	Fauna which are presumed to be extinct, are declared to be fauna that is in need of species protection.
Schedule 3 (S3)	Birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction, are declared to be fauna that is in need of species protection.
Schedule 4 (S4)	Declared to be fauna that is in need of species protection, otherwise than for the reasons mentioned above.

Appendix A3 Definition of DEC Threatened and Priority Fauna Codes

Threatened	**Definition**
Critically Endangered (CR)	Considered to be facing an extremely high risk of extinction in the wild.
Endangered (EN)	Considered to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	Considered to be facing a high risk of extinction in the wild.
Priority	**Definition**
Priority 1 (P1)	*Taxa with few, poorly known populations on threatened lands.* Taxa which are known from few specimens or sight records from one or a few localities, on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 2 (P2)	*Taxa with few, poorly known populations on conservation lands.* Taxa which are known from few specimens or sight records from one or a few localities, on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 3 (P3)	*Taxa with several, poorly known populations, some on conservation lands.* Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
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 if present circumstances change. These taxa are usually represented on conservation lands.
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.

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APPENDIX B DAILY WEATHER DATA DURING SURVEY

Date	Mean Minimum Temperature (°C)	Mean Maximum Temperature (°C)	Rainfall (mm)
SRE and Troglofauna installation survey Phase 1			
9/10/12	9.9	25.3	0
10/10/12	9.2	25.2	0
11/10/12	10.4	28.3	0
12/10/12	17.3	34.7	0
13/10/12	15.9	29.3	0
14/10/12	10.9	25.3	0
15/10/12	6.7	23.2	0
16/10/12	9.5	27.1	0
17/10/12	12.7	28.0	0.2
SRE collection and dry pitfall installation			
19/11/12	13.9	31.5	0
20/11/12	13.9	31.3	0
21/11/12	15.1	33.2	0
22/11/12	20.9	34.8	0.4
23/11/12	15.5	29.4	11.4
Spring 2012 survey (Phase 1 of vertebrate and invertebrate survey at J4 and Troglofauna collection)			
13/12/12	17.7	33.0	0
14/12/12	17.2	29.1	6.0
15/12/12	14.4	31.1	0
17/12/12	16.2	36.1	0
18/12/12	16.7	35.2	0
19/12/12	16.5	31.9	0
20/12/12	14.8	35.1	0
21/12/12	22.0	43.8	0
22/12/12	19.3	35.5	0
23/12/12	15.3	33.9	0
24/12/12	16.5	34.5	0
25/12/12	20.8	38.1	0
Troglofauna installation Ph 2			
05/02/13	18.0	37.6	0
06/02/13	19.4	33.0	0
07/02/13	15.4	32.3	0
08/02/13	15.7	35.1	0
Autumn survey 2013 (Phase 2 of J4 fauna survey, Phase 1 of J5 and BE survey and Troglofauna collection)			
3/04/13	16.6	31.8	0
4/04/13	16.1	33.2	0
5/04/13	16.0	36.2	0
6/04/13	17.1	32.0	0
7/04/13	16.5	32.0	0
8/04/13	16.8	35.9	0
9/04/13	20.0	36.3	0

Date	Mean Minimum Temperature (°C)	Mean Maximum Temperature (°C)	Rainfall (mm)
SRE and Troglofauna installation survey Phase 1			
10/04/13	15.0	36.4	0
11/04/13	16.1	37.0	0
Autumn spring 2013 (Phase 2 of survey area)			
9/10/13	11.0	15.0	1.2
10//10/13	5.3	22.0	8.4
11/10/13	6.4	25.7	0
12/10/13	8.3	19.8	0
13/10/13	55.5	22.1	0
14/10/13	6.9	25.9	0
15/10/13	5.2	29.8	0
16/10/13	13.1	25.6	0
17/10/13	10.0	28.7	0

Note: climate data recorded from Southern Cross weather station (BoM 2013a)

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APPENDIX C REGIONAL FAUNA DATA

Mammals

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	DPaW/DEC rare fauna search	Menkhorst & Knight 2001	This survey
		EPBC Act	WC Act	DPaW											
TACHYGLOSSIDAE															
Tachyglossus aculeatus	Echidna				✓		✓	✓						✓	
DASYURIDAE															
Antechinomys laniger	Kultarr													✓	
Dasyurus geoffroii	Western Quoll	VU	S1	VU		S							✓	✓	
Ningaui ridei	Wongai Ningaui					✓						✓		✓	✓
Ningaui yvonneae	Southern Ningaui				✓	✓			✓		✓	✓		✓	
Phascogale calura	Red-tailed Phascogale	EN	S1	EN										✓	
Pseudantechinus woolleyae	Woolley's Pseudantechinus				✓							✓		✓	S
Sminthopsis crassicaudata	Fat-tailed Dunnart						✓		✓			✓		✓	
Sminthopsis dolichura	Little Long-tailed Dunnart				✓	✓	✓	✓	✓		✓	✓		✓	✓
Sminthopsis gilberti	Gilbert's Dunnart													✓	
Sminthopsis granulipes	White-tailed Dunnart													✓	
Sminthopsis hirtipes	Hairy-footed Dunnart					✓						✓		✓	✓
Sminthopsis macroura	Stripe-faced Dunnart										✓				
MYRMECOBIIDAE															
Myrmecobius fasciatus	Numbat	VU	S1	VU									✓	✓	
PERAMELIDAE															
Perameles bougainville	Western Barred Bandicoot													✓	
THYLACOMYIDAE															
Macrotis lagotis	Bilby	VU	S1	VU									✓	✓	
MACROPODIDAE															
Macropus fuliginosus	Western Grey Kangaroo				✓	✓	✓				✓			✓	

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	DPaW/DEC rare fauna search	Menkhorst & Knight 2001	This survey
		EPBC Act	WC Act	DPaW											
Macropus irma	Western Brush Wallaby			P4										✓	
Macropus robustus	Euro				✓	✓	✓	✓			✓			✓	S
Macropus rufus	Red Kangaroo				✓		✓		✓			✓		✓	
Petrogale lateralis lateralis	Black-footed Rock-wallaby	VU	S1	VU										✓	
PHALANGERIDAE															
Trichosurus vulpecula vulpecula	Common Brushtail Possum													✓	
BURRAMYIDAE															
Cercartetus concinnus	Western Pygmy-possum				✓	✓	✓	✓	✓			✓		✓	✓
TARSIPEDIDAE															
Tarsipes rostratus	Honey Possum													✓	
VESPERTILIONIDAE															
Chalinolobus gouldii	Gould's Wattled Bat				✓	✓	✓	✓	✓		✓	✓		✓	✓
Chalinolobus morio	Chocolate Wattled Bat					✓		✓	✓		✓	✓		✓	✓
Nyctophilus geoffroyi	Lesser Long-eared Bat				✓	✓	✓		✓			✓		✓	✓
Nyctophilus major	Western Long-eared Bat					✓	✓							✓	✓
Scotorepens balstoni	Inland Broad-nosed Bat					✓	✓		✓		✓	✓		✓	✓
Vespadelus baverstocki	Inland Forest Bat				✓				✓			✓		✓	✓
Vespadelus regulus	Southern Forest Bat				✓	✓	✓		✓			✓		✓	✓
MOLOSSIDAE															
Mormopterus planiceps	Southern Freetail Bat						✓		✓			✓		✓	
Mormopterus sp. 4	South-western Freetail Bat										✓				✓
Tadarida australis	White-striped Freetail Bat				✓	✓	✓	✓	✓		✓	✓		✓	✓
MURIDAE															
Leporillus apicalis	Lesser Stick-nest Rat	EX	S2	EX					S				✓	✓	
Notomys alexis	Spinifex Hopping-mouse					✓					✓	✓		✓	

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	DPaW/DEC rare fauna search	Menkhorst & Knight 2001	This survey
		EPBC Act	WC Act	DPaW											
Notomys mitchellii	Mitchell's Hopping-mouse					✓	✓	✓	✓			✓			✓
Pseudomys albocinereus	Ash-grey Mouse				✓	✓		✓	✓			✓		✓	✓
Pseudomys bolami	Bolam's Mouse										✓			✓	
Pseudomys hermannsburgensis	Sandy Inland Mouse				✓	✓	✓	✓				✓		✓	
CANIDAE															
Canis lupus dingo	Dingo				✓						✓	✓		✓	
INTRODUCED MAMMALS															
Mus musculus	House Mouse				✓	✓	✓	✓	✓		✓	✓		✓	✓
Rattus rattus	Black Rat													✓	
Canis lupus familiaris	Dog				✓	✓	✓	✓	✓		✓				
Vulpes vulpes	Red Fox				✓	✓	✓	✓	✓					✓	
Felis catus	Cat				✓		✓	✓			S			✓	✓
Oryctolagus cuniculus	Rabbit				✓	✓	✓	✓	✓		✓			✓	✓
Camelus dromedarius	Camel							✓	✓						
Bos taurus	Cow				✓						✓				
Capra hircus	Goat				✓		S				S			✓	

S Species recorded from secondary signs only

Birds

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	Birdata	Simpson & Day 2004	DSEWPaC protected matters	DPaW/DEC rare fauna search	This survey
		EPBC Act	WC Act	DPaW													
CASUARIIDAE																	
Dromaius novaehollandiae	Emu				✓		✓	✓	✓	✓		✓	✓	✓			✓
MEGAPODIIDAE																	
Leipoa ocellata	Malleefowl	VU	S1	VU	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	☒
PHASIANIDAE																	
Coturnix pectoralis	Stubble Quail													✓			
ANATIDAE																	
Biziura lobata	Musk Duck													✓			
Stictonetta naevosa	Freckled Duck													✓			
Cygnus atratus	Black Swan													✓			
Tadorna tadornoides	Australian Shelduck												✓	✓			
Chenonetta jubata	Australian Wood Duck												✓	✓			
Malacorhynchus membranaceus	Pink-eared Duck													✓			
Anas rhynchotis	Australasian Shoveler													✓			
Anas gracilis	Grey Teal												✓	✓			
Anas superciliosa	Pacific Black Duck							✓					✓	✓			
Aythya australis	Hardhead													✓			
Oxyura australis	Blue-billed Duck													✓			
PODICIPEDIDAE																	
Tachybaptus novaehollandiae	Australasian Grebe												✓	✓			
Poliocephalus poliocephalus	Hoary-headed Grebe												✓	✓			
Podiceps cristatus	Great Crested Grebe													✓			
COLUMBIDAE																	

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	Birdata	Simpson & Day 2004	DSEWPaC protected matters	DPaW/DEC rare fauna search	This survey
		EPBC Act	WC Act	DPaW													
**Columba livia*	Rock Dove													✓			
**Streptopelia senegalensis*	Laughing Dove													✓			
Phaps chalcoptera	Common Bronzewing				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Phaps elegans	Brush Bronzewing													✓			✓
Ocyphaps lophotes	Crested Pigeon				✓				✓				✓	✓			✓
Geopelia cuneata	Diamond Dove													✓			
PODARGIDAE																	
Podargus strigoides	Tawny Frogmouth				✓	✓	✓	✓		✓	✓	✓	✓	✓			✓
EUROSTOPODIDAE																	
Eurostopodus argus	Spotted Nightjar				✓	✓	✓	✓			✓	✓	✓	✓			✓
AEGOTHELIDAE																	
Aegotheles cristatus	Australian Owlet-nightjar				✓	✓	✓	✓				✓	✓	✓			✓
APODIDAE																	
Apus pacificus	Fork-tailed Swift	M	S3											✓	✓		✓
PHALACROCORACIDAE																	
Microcarbo melanoleucos	Little Pied Cormorant													✓			
Phalacrocorax carbo	Great Cormorant													✓			
Phalacrocorax sulcirostris	Little Black Cormorant													✓			
ARDEIDAE																	
Ardea pacifica	White-necked Heron						✓							✓			
Ardea modesta	Eastern Great Egret	M	S3											✓	✓		
Ardea ibis	Cattle Egret	M	S3												✓		
Egretta novaehollandiae	White-faced Heron												✓	✓			
THRESKIORNITHIDAE																	

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	Birdata	Simpson & Day 2004	DSEWPaC protected matters	DPaW/DEC rare fauna search	This survey
		EPBC Act	WC Act	DPaW													
Plegadis falcinellus	Glossy Ibis	M	S3											✓			
Threskiornis molucca	Australian White Ibis													✓			
Threskiornis spinicollis	Straw-necked Ibis													✓			
Platalea flavipes	Yellow-billed Spoonbill													✓			
ACCIPITRIDAE																	
Elanus axillaris	Black-shouldered Kite												✓	✓			
Elanus scriptus	Letter-winged Kite													✓			
Lophoictinia isura	Square-tailed Kite				✓		✓		✓	✓			✓	✓			✓
Hamirostra melanosternon	Black-breasted Buzzard											✓	✓	✓			
Haliastur sphenurus	Whistling Kite							✓						✓			✓
Milvus migrans	Black Kite													✓			
Accipiter fasciatus	Brown Goshawk				✓				✓	✓		✓	✓	✓			✓
Accipiter cirrocephalus	Collared Sparrowhawk				✓		✓	✓	✓	✓		✓	✓	✓			✓
Circus assimilis	Spotted Harrier									✓				✓			
Circus approximans	Swamp Harrier													✓			
Aquila audax	Wedge-tailed Eagle				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Hieraaetus morphnoides	Little Eagle				✓	✓	✓			✓			✓	✓			✓
FALCONIDAE																	
Falco cenchroides	Nankeen Kestrel				✓	✓	✓	✓			✓	✓	✓	✓			✓
Falco berigora	Brown Falcon				✓	✓	✓	✓	✓	✓		✓	✓	✓			✓
Falco longipennis	Australian Hobby				✓		✓		✓	✓		✓	✓	✓			✓
Falco subniger	Black Falcon													✓			
Falco peregrinus	Peregrine Falcon		S4		✓	✓	✓			✓		✓	✓	✓		✓	✓
RALLIDAE																	
Porphyrio porphyrio	Purple Swamphen													✓			

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	Birdata	Simpson & Day 2004	DSEWPaC protected matters	DPaW/DEC rare fauna search	This survey
		EPBC Act	WC Act	DPaW													
Gallirallus philippensis	Buff-banded Rail													✓			
Porzana pusilla	Baillon's Crake													✓			
Porzana fluminea	Australian Spotted Crake													✓			
Porzana tabuensis	Spotless Crake													✓			
Tribonyx ventralis	Black-tailed Native-hen													✓			
Gallinula tenebrosa	Dusky Moorhen													✓			
Fulica atra	Eurasian Coot													✓			
OTIDIDAE																	
Ardeotis australis	Australian Bustard			P4	✓		✓		✓	✓				✓		✓	Δ
BURHINIDAE																	
Burhinus grallarius	Bush Stone-curlew			P4										✓			Δ
RECURVIROSTRIDAE																	
Himantopus himantopus	Black-winged Stilt												✓	✓			
Recurvirostra novaehollandiae	Red-necked Avocet													✓			
Cladorhynchus leucocephalus	Banded Stilt												✓	✓			
CHARADRIIDAE																	
Charadrius ruficapillus	Red-capped Plover												✓	✓			
Charadrius veredus	Oriental Plover	M	S3											✓			
Charadrius australis	Inland Dotterel													✓			
Elseyornis melanops	Black-fronted Dotterel						✓						✓	✓			
Thinornis rubricollis	Hooded Plover			P4									✓	✓		✓	
Erythrogonys cinctus	Red-kneed Dotterel													✓			
Vanellus tricolor	Banded Lapwing												✓	✓			

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	Birdata	Simpson & Day 2004	DSEWPaC protected matters	DPaW/DEC rare fauna search	This survey
		EPBC Act	WC Act	DPaW													
SCOLOPACIDAE																	
Limosa limosa	Black-tailed Godwit	M	S3											✓			
Numenius minutus	Little Curlew	M	S3											✓			
Xenus cinereus	Terek Sandpiper	M	S3											✓			
Actitis hypoleucos	Common Sandpiper	M	S3											✓		✓	
Tringa nebularia	Common Greenshank	M	S3											✓		✓	
Tringa stagnatilis	Marsh Sandpiper	M	S3											✓			
Tringa glareola	Wood Sandpiper	M	S3											✓			
Arenaria interpres	Ruddy Turnstone	M	S3											✓			
Calidris ruficollis	Red-necked Stint	M	S3										✓	✓		✓	
Calidris subminuta	Long-toed Stint	M	S3											✓			
Calidris melanotos	Pectoral Sandpiper	M	S3											✓			
Calidris acuminata	Sharp-tailed Sandpiper	M	S3											✓			
Calidris ferruginea	Curlew Sandpiper	M	S3										✓	✓		✓	
TURNICIDAE																	
Turnix varius	Painted Button-quail							✓						✓			
Turnix velox	Little Button-quail				✓		✓	✓		✓			✓	✓			
GLAREOLIDAE																	
Glareola maldivarum	Oriental Pratincole	M	S3											✓			
Stiltia isabella	Australian Pratincole													✓			
LARIDAE																	
Gelochelidon nilotica	Gull-billed Tern													✓			
Hydroprogne caspia	Caspian Tern	M	S3											✓			
Chlidonias hybrida	Whiskered Tern													✓			
Chlidonias leucopterus	White-winged Black Tern	M	S3											✓			

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	Birdata	Simpson & Day 2004	DSEWPaC protected matters	DPaW/DEC rare fauna search	This survey
		EPBC Act	WC Act	DPaW													
Chroicocephalus novaehollandiae	Silver Gull													✓			
CACATUIDAE																	
Calyptorhynchus banksii	Red-tailed Black-Cockatoo				✓		✓			✓	✓	✓	✓	✓			
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	EN	S1	EN		✓								✓			
Lophochroa leadbeateri	Major Mitchell's Cockatoo		S4		✓				✓	✓			✓	✓		✓	✓
Eolophus roseicapillus	Galah				✓	✓	✓	✓	✓	✓	✓		✓	✓			✓
Cacatua pastinator	Western Corella													✓			
Cacatua sanguinea	Little Corella												✓				
Nymphicus hollandicus	Cockatiel													✓			
PSITTACIDAE																	
Glossopsitta porphyrocephala	Purple-crowned Lorikeet				✓	✓	✓	✓	✓	✓		✓	✓	✓			✓
Polytelis anthopeplus	Regent Parrot				✓		✓	✓	✓			✓	✓	✓			
Platycercus icterotis	Western Rosella						✓							✓			
Barnardius zonarius	Australian Ringneck				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Purpureicephalus spurius	Red-capped Parrot													✓			
Psephotus varius	Mulga Parrot				✓					✓	✓		✓	✓			
Melopsittacus undulatus	Budgerigar							✓		✓			✓	✓			✓
Neophema elegans	Elegant Parrot													✓			
Neophema splendida	Scarlet-chested Parrot													✓			◊
CUCULIDAE																	
Chalcites basalis	Horsfield's Bronze-Cuckoo							✓	✓	✓	✓		✓	✓			✓
Chalcites osculans	Black-eared Cuckoo				✓		✓	✓	✓	✓	✓		✓	✓			✓
Chalcites lucidus	Shining Bronze-Cuckoo													✓			

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		EPBC Act	WC Act	DPaW													
Cacomantis pallidus	Pallid Cuckoo				✓				✓				✓	✓			✓
Cacomantis flabelliformis	Fan-tailed Cuckoo				✓									✓			
STRIGIDAE																	
Ninox connivens	Barking Owl													✓			
Ninox novaeseelandiae	Southern Boobook				✓	✓	✓	✓				✓	✓	✓			✓
TYTONIDAE																	
Tyto novaehollandiae	Masked Owl			P3										✓			
Tyto javanica	Eastern Barn Owl				✓					✓			✓	✓			
HALCYONIDAE																	
**Dacelo novaeguineae*	Laughing Kookaburra													✓			
Todiramphus pyrrhopygius	Red-backed Kingfisher				✓			✓	✓				✓	✓			✓
Todiramphus sanctus	Sacred Kingfisher							✓				✓	✓	✓			
MEROPIDAE																	
Merops ornatus	Rainbow Bee-eater	M	S3		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
CLIMACTERIDAE																	
Climacteris affinis	White-browed Treecreeper				✓						✓	✓	✓	✓			
Climacteris rufa	Rufous Treecreeper				✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
MALURIDAE																	
Malurus splendens	Splendid Fairy-wren				✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
Malurus leucopterus	White-winged Fairy-wren				✓		✓						✓	✓			
Malurus lamberti	Variegated Fairy-wren							✓	✓	✓	✓	✓		✓			
Malurus pulcherrimus	Blue-breasted Fairy-wren				✓	✓						✓	✓	✓			✓
ACANTHIZIDAE																	

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		EPBC Act	WC Act	DPaW													
Sericornis frontalis	White-browed Scrubwren												✓	✓			
Hylacola cauta whitlocki	Shy Heathwren (western)			P4	✓	✓		✓				✓	✓	✓		✓	✓
Calamanthus campestrismontanellus	Rufous Fieldwren				✓	✓							✓	✓			
Pyrrholaemus brunneus	Redthroat				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Smicrornis brevirostris	Weebill				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Gerygone fusca	Western Gerygone				✓	✓	✓						✓	✓			
Acanthiza robustirostris	Slaty-backed Thornbill				✓						✓			✓			
Acanthiza chrysorrhoa	Yellow-rumped Thornbill				✓	✓	✓		✓		✓	✓	✓	✓			✓
Acanthiza uropygialis	Chestnut-rumped Thornbill				✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
Acanthiza inornata	Western Thornbill													✓			
Acanthiza iredalei iredalei	Slender-billed Thornbill	VU													✓		
Acanthiza apicalis	Inland Thornbill				✓	✓	✓	✓	✓	✓		✓	✓	✓			✓
Aphelocephala leucopsis	Southern Whiteface				✓	✓	✓		✓		✓	✓	✓	✓			
PARDALOTIDAE																	
Pardalotus punctatus	Spotted Pardalote				✓									✓			✓
Pardalotus striatus	Striated Pardalote				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
MELIPHAGIDAE																	
Acanthorhynchus superciliosus	Western Spinebill													✓			
Certhionyx variegatus	Pied Honeyeater								✓				✓	✓			
Lichenostomus virescens	Singing Honeyeater				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Lichenostomus leucotis	White-eared Honeyeater				✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
Lichenostomus cratitius	Purple-gaped Honeyeater													✓			✓
Lichenostomus ornatus	Yellow-plumed Honeyeater				✓	✓	✓	✓	✓	✓		✓	✓	✓			✓

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		EPBC Act	WC Act	DPaW													
Lichenostomus plumulus	Grey-fronted Honeyeater				✓				✓					✓			
Manorina flavigula	Yellow-throated Miner				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Acanthagenys rufogularis	Spiny-cheeked Honeyeater				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Anthochaera lunulata	Western Wattlebird													✓			
Anthochaera carunculata	Red Wattlebird				✓	✓	✓	✓	✓			✓	✓	✓			✓
Epthianura tricolor	Crimson Chat				✓		✓		✓			✓	✓	✓			
Epthianura aurifrons	Orange Chat													✓			
Epthianura albifrons	White-fronted Chat													✓			
Sugomel niger	Black Honeyeater												✓	✓			✓
Glyciphila melanops	Tawny-crowned Honeyeater													✓			
Lichmera indistincta	Brown Honeyeater				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Phylidonyris albifrons	White-fronted Honeyeater				✓	✓	✓	✓	✓	✓			✓	✓			✓
Phylidonyris novaehollandiae	New Holland Honeyeater													✓			✓
Phylidonyris niger	White-cheeked Honeyeater													✓			
Melithreptus brevirostris	Brown-headed Honeyeater				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Melithreptus lunatus	White-naped Honeyeater													✓			
POMATOSTOMIDAE																	
Pomatostomus superciliosus	White-browed Babbler				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
PSOPHODIDAE																	
Cinclosoma castanotum	Chestnut Quail-thrush				✓	✓	✓	✓		✓	✓	✓	✓	✓			✓
Cinclosoma castaneothorax	Chestnut-breasted Quail-thrush								✓								

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		EPBC Act	WC Act	DPaW													
Psophodes occidentalis	Chiming Wedgebill												✓				
NEOSITTIDAE																	
Daphoenositta chrysoptera	Varied Sittella				✓	✓	✓	✓			✓	✓	✓	✓			✓
CAMPEPHAGIDAE																	
Coracina maxima	Ground Cuckoo-shrike				✓				✓				✓	✓			
Coracina novaehollandiae	Black-faced Cuckoo-shrike				✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
Lalage sueurii	White-winged Triller						✓	✓	✓				✓	✓			✓
PACHYCEPHALIDAE																	
Pachycephala inornata	Gilbert's Whistler						✓	✓	✓			✓	✓	✓			✓
Pachycephala pectoralis	Golden Whistler					✓	✓	✓		✓		✓	✓	✓			✓
Pachycephala rufiventris	Rufous Whistler				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Colluricincla harmonica	Grey Shrike-thrush				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Oreoica gutturalis gutturalis	Crested Bellbird (southern)			P4	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓
ARTAMIDAE																	
Artamus personatus	Masked Woodswallow							✓	✓			✓	✓	✓			✓
Artamus superciliosus	White-browed Woodswallow													✓			
Artamus cinereus	Black-faced Woodswallow				✓	✓		✓				✓	✓	✓			✓
Artamus cyanopterus	Dusky Woodswallow				✓	✓	✓	✓	✓			✓	✓	✓			✓
Artamus minor	Little Woodswallow				✓	✓	✓		✓			✓	✓	✓			✓
Cracticus torquatus	Grey Butcherbird				✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
Cracticus nigrogularis	Pied Butcherbird				✓	✓	✓		✓		✓	✓	✓	✓			✓
Cracticus tibicen	Australian Magpie				✓	✓	✓		✓		✓	✓	✓	✓			✓

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		EPBC Act	WC Act	DPaW													
Strepera versicolor	Grey Currawong				✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
RHIPIDURIDAE																	
Rhipidura albiscapa	Grey Fantail				✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
Rhipidura leucophrys	Willie Wagtail				✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
CORVIDAE																	
Corvus coronoides	Australian Raven				✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
Corvus bennetti	Little Crow				✓	✓	✓				✓	✓	✓	✓			✓
Corvus orru	Torresian Crow							✓	✓			✓	✓	✓			
MONARCHIDAE																	
Myiagra inquieta	Restless Flycatcher													✓			
Grallina cyanoleuca	Magpie-lark				✓		✓						✓	✓			✓
PETROICIDAE																	
Microeca fascinans	Jacky Winter				✓	✓	✓	✓	✓	✓		✓	✓	✓			✓
Petroica boodang	Scarlet Robin													✓			
Petroica goodenovii	Red-capped Robin				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Melanodryas cucullata	Hooded Robin				✓	✓	✓				✓		✓	✓			✓
Eopsaltria griseogularis	Western Yellow Robin				✓	✓		✓			✓	✓	✓	✓			✓
Drymodes brunneopygia	Southern Scrub-robin				✓		✓	✓				✓	✓	✓			✓
ACROCEPHALIDAE																	
Acrocephalus australis	Australian Reed-Warbler													✓			
MEGALURIDAE																	
Megalurus gramineus	Little Grassbird													✓			
Cincloramphus mathewsi	Rufous Songlark						✓						✓	✓			✓
Cincloramphus cruralis	Brown Songlark												✓	✓			

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		EPBC Act	WC Act	DPaW													
TIMALIIDAE																	
Zosterops lateralis	Silvereye													✓			
HIRUNDINIDAE																	
Cheramoeca leucosterna	White-backed Swallow				✓			✓					✓	✓			✓
Hirundo neoxena	Welcome Swallow				✓							✓	✓	✓			✓
Petrochelidon ariel	Fairy Martin				✓								✓	✓			
Petrochelidon nigricans	Tree Martin				✓	✓	✓		✓		✓		✓	✓			✓
NECTARINIIDAE																	
Dicaeum hirundinaceum	Mistletoebird				✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
ESTRILDIDAE																	
Taeniopygia guttata	Zebra Finch				✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
Stagonopleura oculata	Red-eared Firetail													✓			
MOTACILLIDAE																	
Anthus novaeseelandiae	Australasian Pipit				✓	✓	✓						✓	✓			

* Introduced species
◊ recorded outside the impact area
Δ Secondary evidence of either species (Australian Bustard or Bush Stone-curlew)

Reptiles

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	Wilson & Swan 2010	DPaW/DEC rare fauna search	This survey
		EPBC Act	WC Act	DPaW											
AGAMIDAE															
Caimanops amphiboluroides													✓		
Ctenophorus cristatus	Bicycle Lizard				✓	✓	✓	✓	✓			✓	✓		✓
Ctenophorus fordi	Mallee Sand Dragon					✓						✓	✓		
Ctenophorus isolepis	Central Military Dragon					✓						✓	✓		
Ctenophorus maculatus	Spotted Military Dragon											✓	✓		
Ctenophorus ornatus	Ornate Crevice Dragon												✓		
Ctenophorus reticulatus	Western Netted Dragon				✓	✓	✓	✓			✓	✓	✓		✓
Ctenophorus salinarum	Salt Pan Dragon												✓		
Ctenophorus scutulatus					✓	✓	✓	✓				✓	✓		✓
Moloch horridus	Thorny Devil				✓	✓	✓	✓	✓		✓	✓	✓		✓
Pogona minor	Dwarf Bearded Dragon				✓	✓	✓	✓	✓			✓	✓		✓
Tympanocryptis cephalus	Pebble Dragon				✓	✓	✓					✓	✓		✓
DIPLODACTYLIDAE															
Crenadactylus ocellatus	Clawless Gecko				✓	✓		✓	✓			✓	✓		✓
Diplodactylus calcicolus	South Coast Gecko												✓		
Diplodactylus granariensis					✓	✓	✓	✓	✓		✓	✓	✓		✓
Diplodactylus ornatus											✓				
Diplodactylus pulcher					✓	✓	✓	✓	✓		✓	✓	✓		✓
Lucasium maini					✓	✓	✓	✓	✓		✓	✓	✓		✓
Lucasium squarrosum													✓		
Oedura reticulata	Reticulated Velvet Gecko				✓	✓	✓	✓	✓			✓	✓		✓
Rhynchoedura ornata	Beaked Gecko				✓	✓	✓					✓	✓		✓

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		EPBC Act	WC Act	DPaW											
Strophurus assimilis	Goldfields Spiny-tailed Gecko				✓	✓	✓					✓	✓		
Strophurus elderi						✓						✓	✓		
Strophurus spinigerus													✓		
Strophurus wellingtonae													✓		
CARPHODACTYLIDAE															
Underwoodisaurus milii	Thick-tailed Gecko, Barking Gecko				✓	✓	✓	✓	✓			✓	✓		✓
Nephrurus stellatus	Starred Knob-tailed Gecko					✓						✓	✓		
Nephrurus vertebralis							✓						✓		
GEKKONIDAE															
Christinus marmoratus	Marbled Gecko												✓		
Gehyra purpurascens												✓			
Gehyra variegata	Tree Dtella				✓	✓	✓	✓	✓		✓	✓	✓		✓
Heteronotia binoei	Bynoe's Gecko				✓	✓	✓	✓			✓	✓	✓		✓
PYGOPODIDAE															
Aprasia inaurita													✓		
Aprasia repens												✓	✓		
Aprasia striolata													✓		
Delma australis					✓	✓	✓	✓	✓		✓	✓	✓		✓
Delma butleri					✓							✓	✓		✓
Delma fraseri													✓		✓
Delma grayii													✓		
Lialis burtonis							✓					✓	✓		✓
Pygopus lepidopodus	Common Scaly Foot				✓							✓	✓		✓
Pygopus nigriceps							✓				✓	✓	✓		

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		EPBC Act	WC Act	DPaW											
SCINCIDAE															
Acritoscincus trilineatus													✓		
Cryptoblepharus buchananii					✓	✓		✓				✓	✓		✓
Cryptoblepharus plagiocephalus					✓	✓	✓	✓		✓		✓	✓		
Ctenotus ariadnae													✓		
Ctenotus atlas					✓	✓	✓				✓	✓	✓		✓
Ctenotus brooksi													✓		
Ctenotus impar													✓		
Ctenotus leonhardii						✓						✓	✓		✓
Ctenotus mimetes					✓		✓					✓	✓		
Ctenotus pantherinus	Leopard Ctenotus											✓	✓		
Ctenotus schomburgkii					✓	✓	✓				✓	✓	✓		✓
Ctenotus severus													✓		
Ctenotus uber					✓	✓	✓	✓	✓		✓	✓	✓		✓
Ctenotus xenopleura						✓						✓	✓		
Cyclodomorphus melanops	Slender Blue-tongue				✓	✓	✓		✓			✓	✓		✓
Egernia depressa	Pygmy Spiny-tailed Skink				✓		✓			✓	✓	✓	✓		
Egernia formosa					✓				✓			✓	✓		
Egernia kingii	King's Skink												✓		
Egernia napoleonis													✓		
Eremiascincus richardsonii	Broad-banded Sand Swimmer				✓			✓				✓	✓		✓
Hemiergis initialis					✓	✓	✓	✓	✓		✓	✓	✓		✓
Hemiergis peronii													✓		
Lerista distinguenda													✓		

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	Wilson & Swan 2010	DPaW/DEC rare fauna search	This survey
		EPBC Act	WC Act	DPaW											
Lerista gerrardii					✓		✓	✓				✓	✓		✓
Lerista kingi	(L. muelleri group)											✓	✓		✓
Lerista macropisthopus					✓	✓	✓				✓	✓	✓		✓
Lerista muelleri					✓	✓	✓			✓		✓			
Lerista timida					✓			✓	✓		✓		✓		✓
Liopholis inornata	Desert Skink				✓	✓	✓				✓		✓		✓
Liopholis multiscutata	Bull Skink												✓		
Menetia greyii					✓	✓	✓	✓	✓		✓	✓	✓		✓
Morethia butleri					✓	✓	✓		✓			✓	✓		✓
Morethia obscura										✓		✓	✓		
Tiliqua occipitalis	Western Blue-tongue					✓						✓	✓		✓
Tiliqua rugosa	Bobtail				✓								✓		
VARANIDAE															
Varanus brevicauda	Short-tailed Pygmy Monitor												✓		
Varanus caudolineatus	Stripe-tailed Monitor				✓								✓		
Varanus eremius	Pygmy Desert Monitor												✓		
Varanus giganteus	Perentie				✓	✓	✓						✓		✓
Varanus gouldii	Sand Monitor				✓	✓	✓	✓				✓	✓		✓
Varanus panoptes	Yellow-spotted Monitor										✓		✓		
Varanus rosenbergi	Heath Monitor												✓		
Varanus tristis	Racehorse Monitor				✓		✓	✓	✓	✓		✓	✓		✓
TYPHLOPIDAE															
Ramphotyphlops australis					✓	✓		✓	✓			✓	✓		✓
Ramphotyphlops bicolor									✓		✓		✓		

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	Wilson & Swan 2010	DPaW/DEC rare fauna search	This survey
		EPBC Act	WC Act	DPaW											
Ramphotyphlops bituberculatus					✓			✓			✓	✓	✓		
Ramphotyphlops hamatus					✓	✓						✓	✓		
Ramphotyphlops pinguis													✓		
Ramphotyphlops waitii													✓		
BOIDAE															
Antaresia stimsoni	Stimson's Python						✓				✓		✓		
Aspidites ramsayi	Woma		S4	P4									✓	✓	
Morelia spilota imbricata	South-west Carpet Python		S4	P4				✓					✓	✓	
ELAPIDAE															
Acanthophis pyrrhus	Desert Death Adder												✓		
Brachyurophis fasciolatus												✓	✓		
Brachyurophis semifasciatus					✓	✓		✓	✓		✓	✓	✓		✓
Demansia psammophis	Yellow-faced Whipsnake								✓		✓		✓		✓
Echiopsis curta	Bardick												✓		
Furina ornata	Moon Snake				✓							✓	✓		
Neelaps bimaculatus	Black-naped Snake								✓				✓		
Parasuta gouldii									✓				✓		✓
Parasuta monachus	Hooded Snake				✓		✓		✓		✓	✓	✓		✓
Parasuta nigriceps	Mitchell's Short-tailed Snake												✓		
Paroplocephalus atriceps	Lake Cronin Snake												✓		
Pseudechis australis	Mulga Snake				✓		✓					✓	✓		
Pseudonaja affinis	Dugite				✓								✓		
Pseudonaja mengdeni	Western Brown Snake												✓		✓
Pseudonaja modesta	Ringed Brown Snake											✓	✓		✓

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	Wilson & Swan 2010	DPaW/DEC rare fauna search	This survey
		EPBC Act	WC Act	DPaW											
Simoselaps bertholdi	Jan's Banded Snake				✓	✓	✓	✓				✓	✓		✓
Suta fasciata	Rosen's Snake				✓		✓					✓	✓		✓

Amphibians

Family and Species	Common name	Conservation Status			*ecologia* internal database	Dell *et al* 1985 (Bungalbin)	Dell *et al* 1985 (Mt Jackson)	Bamford 2012 (Carina Ext, Carina North, Chamaeleon)	Ninox 2009 Carina	Bamford 2010 (Windarling Range)	Biota 2011 Deception Deposit	NatureMap	Tyler & Doughty 2009	DPaW/DEC rare fauna search	This survey
		EPBC Act	WC Act	DPaW											
HYLIDAE															
Cyclorana maini	Sheep Frog												✓		
Cyclorana platycephala	Water-holding Frog												✓		
Litoria cyclorhyncha	Spotted-thighed Frog												✓		
LIMNODYNASTIDAE															
Heleioporus albopunctatus	Western Spotted Frog										✓		✓		
Heleioporus psammophilus	Sand Frog												✓		
Limnodynastes dorsalis	Western Banjo Frog												✓		
Neobatrachus albipes	White-footed Trilling Frog												✓		
Neobatrachus centralis	Desert Trilling Frog												✓		
Neobatrachus kunapalari	Kunapalari Frog				✓			✓				✓	✓		
Neobatrachus pelobatoides	Humming Frog												✓		✓
Neobatrachus sutor	Shoemaker Frog					✓				✓			✓		
Neobatrachus wilsmorei	Plonking Frog												✓		
Platyplectrum spenceri	Centralian Burrowing Frog												✓		
MYOBATRACHIDAE															
Crinia georgiana	Quacking Frog												✓		
Crinia glauerti	Clicking Frog												✓		
Crinia pseudinsignifera	Bleating Froglet												✓		
Myobatrachus gouldii	Turtle Frog												✓		
Pseudophryne guentheri	Crawling Toadlet												✓		
Pseudophryne occidentalis	Western Toadlet				✓		✓	✓			✓	✓	✓		✓

APPENDIX D SURVEY SITE INFORMATION

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Appendix D1 Terrestrial vertebrate and invertebrate fauna survey site information

Site	Location		Sampling Date	Inside/Outside Impact area
	Easting	Northing		
Vertebrate fauna trapping & SRE dry pitfall site				
POV S1	758949	6638266	3-10/04/13 10-17/10/13	Survey area
POV S2	759856	6638579	3-10/04/13 10-17/10/13	Survey area
POV S3	753073	6637905	20-21/11/12 10-17/10/13	Survey area
POV S4	751493	6631953	20-21/11/12 10-17/10/13	Survey area
POV S5	757434	6635812	20-21/11/12 9-16/10/13	Survey area
POV S6	752138	6637844	20-21/11/12 10-17/10/13	Survey area
POV S7	732991	6646350	16-23/12/12 3-10/04/13	J4 impact area
POV S8	732633	6647827	16-23/12/12 3-10/04/13	Survey area
POV S9	741820	6642117	14-21/12/12 3-10/04/13	Survey area
POV S10	749381	6623700	20-21/11/12 9-16/10/13	J4 impact area
POV S11	750498	6629226	20-21/11/12 9-16/10/13	Survey area
POV S12	737536	6643114	15-22/12/12 3-10/04/13	Survey area
SRE wet pitfall sites				
PO S1	759038	6638247	11 Oct – 22 Nov 2012	Survey area
PO S2	759868	6638765	11 Oct – 22 Nov 2012	Survey area
PO S3	752986	6637871	11 Oct – 22 Nov 2012	Survey area
PO S4	751370	6631902	11 Oct – 22 Nov 2012	Survey area
PO S5	757275	6635771	11 Oct – 22 Nov 2012	Survey area
PO S6	752201	6637934	11 Oct – 22 Nov 2012	Survey area
PO S7	732862	6646392	11 Oct – 22 Nov 2012	J4 impact area
PO S8	732718	6647915	11 Oct – 22 Nov 2012	Survey area
PO S9	741808	6641600	11 Oct – 22 Nov 2012	Survey area
PO S10	749432	6623586	11 Oct – 22 Nov 2012	J4 impact area
PO S11	750413	6629100	11 Oct – 22 Nov 2012	Survey area

Site	Location		Sampling Date	Inside/Outside Impact area
	Easting	Northing		
PO S12	737669	6643094	11 Oct – 22 Nov 2012	Survey area
Foraging site				
PO OSF1	750735	6630607	11/10/12	Survey area
PO OSF2	733575	6646150	12/10/12	J4 impact area
PO OSF3	751743	6638180	13/10/12	Survey area
PO OSF4	759292	6638149	14/10/12	Survey area
PO OSF5	733068	6647308	05/04/13	J4
PO OSF6	733881	6646524	06/04/13	J4
PO OSF7	751822	6638190	06/04/13	Survey area
PO OSF8	751705	6638230	06/04/13	Survey area
PO OSF9	751799	6632520	06/04/13	Survey area
PO OSF10	751431	6638509	06/04/13	Survey area
PO OSF11	757367	6638099	06/04/13	Survey area
PO OSF12	759374	6636181	07/04/13	Survey area
PO OSF13	760720	6639436	07/04/13	Survey area
PO OSF14	752674	6634816	07/04/13	Survey area
PO OSF15	756021	6636300	07/04/13	Survey area
PO OSF16	763871	6633044	07/04/13	Survey area
PO OSF17	751960	6638138	07/04/13	Survey area
PO OSF18	751730	6638248	07/04/13	Survey area
PO OSF19	751806	6632416	07/04/13	Survey area
PO OSF20	755099	6634343	08/04/13	Survey area
PO OSF21	759261	6631484	08/04/13	Survey area
PO OSF22	755165	6630430	08/04/13	Survey area
PO OSF23	759340	6638170	08/04/13	Survey area
PO OSF24	750458	6627363	08/04/13	Survey area
PO OSF24	750583	6629624	08/04/13	Survey area
PO OSF25	749338	6622723	08/04/13	Survey area
PO OSF26	748475	6623123	08/04/13	Survey area
PO OSF27	749538	6624499	08/04/13	Survey area
PO OSF28	748932	6621164	08/04/13	Survey area
PO OSF29	747242	6623048	08/04/13	Survey area

Site	Location		Sampling Date	Inside/Outside Impact area
	Easting	Northing		
PO OSF30	749445	6636917	09/04/13	Survey area
PO OSF31	751667	6638222	09/04/13	Survey area
PO OSF32	751760	6638215	09/04/13	Survey area
PO OSF33	749368	6623054	11/010/13	Survey area
PO OSF34	751316	6639476	11/010/13	Survey area
PO OSF35	750280	6639530	11/010/13	Survey area
PO OSF36	752741	6630296	11/010/13	Survey area
PO OSF37	749361	6623523	11/010/13	J4 impact area
PO OSF38	752703	6638164	11/010/13	Survey area
PO OSF39	751649	6635788	11/010/13	Survey area
PO OSF40	759333	6638580	11/010/13	Survey area
PO OSF41	757557	6636355	12/10/13	Survey area
PO OSF42	760385	6638979	12/10/13	Survey area
PO OSF43	759447	6638485	12/10/13	Survey area
PO OSF44	760947	6639785	12/10/13	Survey area
PO OSF47	759100	6625498	13/10/13	Survey area
PO OSF48	747675	6639051	13/10/13	Survey area
PO OSF49	748802	6623102	13/10/13	Survey area
PO OSF50	749647	6624859	13/10/13	Survey area
PO OSF51	749862	662547	13/10/13	Survey area
PO OSF52	751766	6632462	13/10/13	Survey area
PO OSF53	751886	6638138	13/10/13	Survey area
Foraging site and leaf litter collection				
PO OS1	733250	6646147	19/12/12	J4 impact area
PO OS2	734108	6645948	19/12/12	J4 impact area
PO OS3	734461	6645214	20/12/12	Survey area
PO OS4	736316	6645544	20/12/12	Survey area
PO OS5	742082	6643511	21/12/12	Survey area
PO OS6	747099	6641930	22/12/12	Survey area
PO OS7	754136	6638557	23/12/12	Survey area
PO OS8	752657	6633686	23/12/12	Survey area
PO OS9	740401	6631559	24/12/12	J4 impact area

Site	Location		Sampling Date	Inside/Outside Impact area
	Easting	Northing		
PO OS10	749180	6622051	24/12/12	J4 impact area
PO OS11	749383	6623669	24/12/12	J4 impact area
PO OS12	751760	6638215	05/04/13	Survey area
PO OS13	752135	6638108	05/04/13	Survey area
PO OS14	751770	6638272	05/04/13	Survey area
PO OS45	759672	6638457	12/10/13	Survey area
PO OS46	760700	6639515	12/10/13	Survey area
Targeted Malleefowl transect				
Malleefowl transect 1 north	from 739804 to 732846	From 6632147 to 6645296	09/04/13	J4 impact area
Malleefowl transect 1 south	From 739804 to 752350	From 6632147 to 6622012	09/04/13	J4 impact area
Malleefowl transect 2	From 749180 to 747298	From 6622038 to 6622010	14/10/13	J4 impact area
Malleefowl transect 3	From 748359 to 749386	From 6624139 to 6623640	14/10/13	J4 impact area
Malleefowl transect 4	From 749386 to 750395	From 6623640 to 6623126	15/10/13	J4 impact area
SM2 Bat recorder				
Bat rec 1	751492	6631953	20-22/11/12	Survey area
Bat rec 2	757433	6635812	20-22/11/12	Survey area
Bat rec 3	741820	6642117	15-17/12/12	Survey area
Bat rec 4	732633	6647827	17-19/12/12	Survey area
Bat rec 5	734112	6645943	19-21/12/12	J4 impact area
Bat rec 6	752430	6633509	21-23/12/12	Survey area
Bat rec 7	732990	6646350	16-18/12/12	J4 impact area
Bat rec 8	751559	6638077	19-21/12/12	Survey area
Bat rec 9	751868	6638178	21-23/12/12	Survey area
Bat rec 10	737535	6643114	16-18/12/12	Survey area
Bat rec 11	733658	6646182	18-20/12/12	J4 impact area
Bat rec 12	745319	6639444	20-22/12/12	Survey area
Bat rec 13	758949	6638266	4-5/4/13	Survey area
Bat rec 15	753073	6637905	5-6/4/13	Survey area
Bat rec 16	752138	6637844	6-7/04/2013	Survey area
Bat rec 17	737536	6643114	8-9/04/2013	Survey area

Site	Location		Sampling Date	Inside/Outside Impact area
	Easting	Northing		
Bat rec 18	750498	6629226	9-10/04/2013	Survey area
Bat rec 19	759856	6638579	4-5/04/2013	Survey area
Bat rec 20	753262	6629790	5-6/04/2013	Survey area
Bat rec 21	749381	6623700	6-7/04/2013	J4 impact area
Bat rec 22	741820	6642117	8-9/04/2013	Survey area
Bat rec 23	732991	6646350	9-10/04/2013	J4 impact area
Bat rec 24	753073	6637905	10-11/10/2013	Survey area
Bat rec 25	757434	6635812	11-12/10/2013	Survey area
Bat rec 26	749381	6623700	12-13/10/2013	J4 impact area
Bat rec 27	759856	6638579	14-15/10/20113	Survey area
Bat rec 28	751493	6631953	10-11/10/2013	Survey area
Bat rec 29	752138	6637844	11-12/10/2013	Survey area
Bat rec 30	750498	6629226	12-13/10/2013	Survey area
Bat rec 31	758949	6638266	14-15/10/2013	Survey area
Motion Camera				
MC 1	734205	6645420	24/12/12 – 9/04/13	J4 impact area
MC 2	748088	6637902	24/12/12 – 9/04/13	Survey area
MC 3	737960	6642541	24/12/12 – 9/04/13	Survey area
MC 4	742721	6639400	24/12/12 – 9/04/13	Survey area
MC 5	733645	6646180	19-21/12/12	J4 impact area
MC 6	732567	6646546	19-21/12/12	J4 impact area
MC 7	751600	6638085	19-21/12/12	Survey area
MC 8	734112	6645921	19-21/12/12	J4 impact area
MC9	733640	6646186	06-10/04/13	J4 impact area
MC10	751797	6638208	06-10/04/13	Survey area
MC11	751797	6638172	06-10/04/13	Survey area
MC12	733685	6646734	07-10/04/13	Survey area
MC13	759266	6638283	12-16/10/13	Survey area
MC14	760388	6639054	13-16/10/13	Survey area

Datum: GDA 94
Zone: 50J

Appendix D2 Troglofauna survey site information

Phase	Method	Drill Hole ID	Depth (m)	Coordinates	
				Easting	Northing
J4 impact area					
1	Baited Single Trap/Scraping	J4RC043	30	734122	6645932
1	Baited Single Trap/Scraping	J4RC03	20 (Obstruction at 25m)	734042	6646017
1	Baited Single Trap/Scraping	J4RC028	40	733860	6646047
1	Baited Single Trap/Scraping	J4RC018	10	733685	6646226
1	Baited Single Trap/Scraping	J4RC021	10 (obstruction at 11m)	733075	6646304
1	Baited Single Trap/Scraping	J4RC013	10	732729	6646473
1	Baited Single Trap/Scraping	J4RC23	40	732904	6646376
1	Baited Single Trap/Scraping	J4RC15	10	732913	6646396
1	Baited Single Trap/Scraping	J4RC30	45 (obstruction at 50m)	733884	6645996
1	Baited Single Trap/Scraping	J4RC32	10	733972	6646062
2	Baited Double Trap	J4RC043	20 & 30	734122	6645932
2	Baited Double Trap	J4RC03	15 & 20	734042	6646017
2	Baited Double Trap	J4RC028	20 & 30	733860	6646047
2	Baited Double Trap	J4RC013	9 & 14	732729	6646473
2	Baited Double Trap	J4RC23	20 & 30	732904	6646376
2	Baited Double Trap	J4RC30	20 & 30	733884	6645996
2	Baited Double Trap	J4RC32	10 & 15	733972	6646062
2	Baited Double Trap	J4RC39	20 & 30	734066	6645985
2	Baited Double Trap	J4RC31	20 & 40	733912	6646036
2	Baited Double Trap	J4RC19	20 & 30	734003	6645976
Survey area					
1	Baited Single Trap/Scraping	BG09	20	759129	6638386
1	Baited Single Trap/Scraping	BG10	110	759170	6638345
1	Baited Single	BG11	10	759208	6638303

Phase	Method	Drill Hole ID	Depth (m)	Coordinates	
				Easting	Northing
	Trap/Scraping				
1	Baited Single Trap/Scraping	BG17	70	759482	6638394
1	Baited Single Trap/Scraping	BG15	80	759555	6638295
1	Baited Single Trap/Scraping	BG16	60	759506	6638342
1	Baited Single Trap/Scraping	BG24	100	759606	6638612
1	Baited Single Trap/Scraping	BG19	60	759777	6638765
1	Baited Single Trap/Scraping	BG25	10	759819	6639096
1	Baited Single Trap/Scraping	BG30	60	759081	6638072
2	Baited Double Trap	BG09	20 & 30	759129	6638386
2	Baited Double Trap	BG10	20 & 30	759170	6638345
2	Baited Double Trap	BG11	10 & 15	759208	6638303
2	Baited Double Trap	BG17	20 & 30	759482	6638394
2	Baited Double Trap	BG15	20 & 40	759555	6638295
2	Baited Double Trap	BG16	20 & 30	759506	6638342
2	Baited Double Trap	BG24	20 & 30	759606	6638612
2	Baited Double Trap	BG25	10 & 15	759819	6639096
2	Baited Double Trap	BG30	20 & 40	759081	6638072

Datum: GDA 94
Zone: 50K

Appendix D3 stygofauna sampling site information

Drill Hole ID	Water table (m)	Sample depth	Coordinates	
			Easting	Northing
J4RC052	73	84	733890	6646203
J4RC063	92	104	734069	6646017
J4RC140	84	100	733843	6646201
J4RC113	78	95	733809	6646260
J4RC094	75	100	733108	6646381
J4RC093	74	100	733022	6646422
J4RC085	81	100	732761	6646540
J4RC136	70	100	732997	6646458
J4RC100	80	100	733407	6646306

APPENDIX E SITE DESCRIPTIONS

Vegetation and fauna habitat description	Site photo
POV S1 / PO S1 South-facing hillslope on top of ridge with shrubland (mixed *Acacia* spp.) and very few trees over sparse grass. Some wood litter and a moderate amount of leaf litter present. Substrate is moderately soft loamy clay with continuous rocky outcrops and stones. Habitat type: Rocky ridge. Vegetation unit: EcEeeOmNa	
POV S2/ PO S2 South-facing hillslope with Mallee woodland over open shrubland over dense grass (*Neurachne annularis*), with a moderate amount of wood and leaf litter in patches. Substrate is firm loam with continuous rocky outcrops and stones. Habitat type: Malee wood land on rocky plain and footslope. Vegetation unit: EcEeeOmNa	

Vegetation and fauna habitat description	Site photo
POV S3/ PO S3 Drainage line on a plain with scattered trees and large shrubs (*Eucalyptus loxophleba* subsp. *lissophloia*, *Santalum acuminatum, Pimelea microcephala* subsp. *microcephala* and *Pittosporum angustifolium*) over patches of moderately dense shrubland (*Acacia* sp. narrow phyllode (B.R. Maslin 7831), *A. tetragonophylla, Senna artemisioides* subsp. *filifolia, Enchylaena tomentose, Atriplex vesicaria, Eremophila decipiens* subsp. *decipiens*) over lower shrubs, mixed grasses and herbs (*Solanum nummularium, Ptilotus nobilis, Ptilotus obovatus, Centaurea melitensis, Dianella revoluta* var. *divaricate, Austrostipa elegantissima, Austrostipa trichophylla, Austrostipa ?elegantissima* and *Rytidosperma caespitosum*). Plentiful wood litter and moderate leaf litter. Substrate is loose loam-clay with a few rocky outcrops. Rabbits inhabit the area and have caused some degradation. Habitat type: Drainage line. Vegetation unit: EllSsAe	
POV S4 / PO S4 Plain with open woodland (*E. salubris*) and shrubland (mixed *Acacia* spp.), with plentiful wood and leaf litter in patches. Substrate is loose sand-loam with a few pebbles. Habitat type: Mixed eucalypt woodland. Vegetation unit: N/A	

Vegetation and fauna habitat description	Site photo
POV S5 / PO S5 Plain with moderately dense eucalypt woodland (Eucalyptus longissima, Eucalyptus salubris and Eucalyptus salmonophloia) over open shrubs and perennial herbs (*Atriplex nummularia, Eremophila ionantha, Olearia muelleri, Atriplex vesicaria, Solanum nummularium, Maireana triptera, Sclerolaena diacantha, Sida spodochroma, Ptilotus nobilis*) with moderate wood and leaf litter. Substrate is loose sand-loam with a few pebbles. Habitat type: Mixed eucalypt woodland. Vegetation unit: EeeEtEaEoaAeSs & ElEsEvAnAvAe	
POV S6 / PO S6 Gentle hillslope with open eucalypt woodland (*Eucalyptus ebbanoensis* subsp*. ebbanoensis* and *Eucalyptus corrugata*) over open mixed shrubs (*Zygophyllum ovatum, Maireana georgei, Olearia muelleri, O. exiguifolia, Ptilotus obovatus, Eremophila decipiens* subsp. *decipiens, Solanum nummularium, Senna artemisioides* subsp. *filifolia, Atriplex nummularia* and *Rhagodia drummondii*) and open grass (*Neurachne annularis* and *Austrostipa elegantissima*), with plentiful wood litter and moderate leaf litter in patches. Substrate is firm loam-clay with continuous stones throughout. Habitat type: Mallee woodland on rocky plain and footslopes. Vegetation unit: EeeCpEgMnNa & EcEeeMgPoAeNa	

Vegetation and fauna habitat description	Site photo
POV S7 / PO S7 South-facing hillslope with eucalypt woodland (*Eucalyptus ?oleosa* and *Eucalyptus ?corrugata*) over moderately dense shrubland (*Allocasuarina eriochlamys* subsp. *eriochlamys* , *Melaleuca nematophylla, Santalum spicatum, Acacia ramulosa, A. quadrimarginea, Grevillea zygoloba, Eremophila latrobei* subsp. *latrobei, Keraudrenia velutina, Solanum nummularium, Leucopogon* sp. Clyde Hill (M.A. Burgman 1207) over moderately dense grass (*Neurachne annularis* and scattered *Amphipogon caricinus* var. *caricinus*) over scattered herbs (*Waitzia acuminata* var. *acuminate*) and *Philotheca brucei* subsp. *brucei*), with plentiful wood litter and moderate leaf litter. Substrate is weak loam-clay with continuous rocky outcrops and loose stones. Habitat type: Rocky ridge. Vegetation unit: RMR1 (BgEgPbbAe) & RMR2 (AiEllNa)	
POV S8 / PO S8 Plain with open eucalypt woodland (*E. salmonophloia*) over open shrubs (*Eremophila scoparia, Santalum acuminatum, Exocarpos aphyllus, Atriplex nummularia, A. nummularia, A. vesicari, Acacia colletioides* and *A. hemiteles*) over some grasses (*Austrostipa elegantissima* and *A. trichophylla*) with moderate wood litter and plentiful leaf litter in patches. Substrate is weak loam-clay without rocks. Habitat type: Mixed eucalypt woodland. Vegetation unit: SF5 (EsEsSafAe)	

Vegetation and fauna habitat description	Site photo
POV S9 / PO S9 Plain with open eucalypt woodland (Eucalyptus ?horistes and Eucalyptus loxophleba subsp. lissophloia) over open layer of mixed shrubs (*Acacia* sp. narrow *phyllode* (B.R. Maslin 7831), *Acacia colletioides, Olearia exiguifolia, O. pimeleoides, Ptilotus obovatus* and *Eremophila granitica*) over moderately open grasses (*Neurachne annularis, Austrostipa ?elegantissima* and *Aristida contorta*) on firm sandy clay with patches of wood litter and leaf litter. Habitat type: Mixed eucalypt woodland. Vegetation unit: EsEsAvAe	
POV S10 / PO S10 Plain with occasional *Eucalyptus ewartiana* tree over moderate to very dense shrubland (*Allocasuarina acutivalvis, Callitris preissii, Phebalium canaliculatum* s. lat.*, Thryptomene urceolaris, Grevillea ?juncifolia, Malleostemon roseus, Acacia resinimarginea, A. yorkrakinensis* subsp. *acrita, Westringia cephalantha* var. *cephalantha* and *Homalocalyx thryptomenoides*) with plentiful wood litter and moderate leaf litter. Substrate is firm yellow sand with no rocks. Habitat type: Sandy plain with shrubland. Vegetation unit: RMR5 (AePcTuAcc)	

Vegetation and fauna habitat description	Site photo
POV S11 / PO S11 Plain with scattered *Eucalyptus rigidula trees* over open to dense shrubland of *Allocasuarina acutivalvis* subsp. *acutivalvis, Homalocalyx thryptomenoides, Thryptomene urceolaris, Acacia effusifolia*, *Phebalium canaliculatum*, *Grevillea paradoxa*, *Prostanthera semiteres* subsp. *semiteres* over some occasional *Dianella revoluta* var. *divaricata* and *Comesperma integerrimum*. Some patches of *Amphipogon caricinus* var. *caricinus* and *Triodia ?rigidissima* grasses. Moderate wood and leaf litter. Substrate is weak yellow sand with no rocks. Habitat type: Sandy plain with shrubland. Vegetation unit: N/A	
POV S12 / PO S12 Plain with open eucalypt woodland (*Eucalyptus ravida* and *Eucalyptus salmonophloia*) over mixed shrubs (*Eremophila scoparia, Acacia erinacea, Atriplex vesicaria, Olearia muelleri, Ptilotus nobilis* subsp. *nobilis, Ptilotus obovatus, Maireana trichoptera, Maireana georgei* and *Sclerolaena drummondii*) on sandy clay. Some Small depression through trap site which did not contain water at time of trapping. Loose rocks and pebbles. Some patches of *Austrostipa scabra* present. Wood litter and leaf litter present under trees and shrubs. Habitat type: Mixed eucalypt woodland. Vegetation unit: EsEsAvAe	

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APPENDIX F PREVIOUS SUBTERRANEAN FAUNA SAMPLE SITES

Inside/Outside Impact area	Bore hole ID	Coordinate	
		Easting	Northing
Bennelongia (2011)			
Survey area	VE0004	759080	6636081
Survey area	VE0007	758845	6635679
Survey area	VE0013	758567	6634796
Survey area	VE0015	758319	6634480
Survey area	VE0017	758324	6634238
Survey area	VE0009	758889	6635367
Survey area	VE0011	758598	6635125
Bennelongia (2008)			
J4 impact area	J4RC013	732734	6646478
J4 impact area	J4RC015	732915	6646396
J4 impact area	J4RC018	733682	6646236
J4 impact area	J4RC021	733077	6646304
J4 impact area	J4RC023	732905	6646385
J4 impact area	J4RC025	733898	6646009
J4 impact area	J4RC027	733851	6646033
J4 impact area	J4RC029	733879	6645988
J4 impact area	J4RC030	733888	6645987
J4 impact area	J4RC032	733977	6646063
J4 impact area	J4RC033	734023	6645996
J4 impact area	J4RC038	734004	6645974
J4 impact area	J4RC039	734071	6645983
J4 impact area	J4RC040	734072	6646028
J4 impact area	J4RC041	734052	6645984
J4 impact area	J4RC043	734128	6645927
J4 impact area	J4RC044	734138	6645949
J4 impact area	J4RC046	734148	6645971
J4 impact area	PH01	733918	6646031
J4 impact area	PH03	733861	6646043
Survey area	J5DD001	751470	6638297
Survey area	J5RC031	751727	6638169
Survey area	J5RC032	751698	6638181
Survey area	J5RC039	751882	6638232
Survey area	J5RC040	751787	6638279
Survey area	J5RC045	751352	6638600

Inside/Outside Impact area	Bore hole ID	Coordinate	
		Easting	Northing
Survey area	J5RC046	751332	6638556
Survey area	J5RC051	751397	6638477
Survey area	J5RC052	751415	6638398
Survey area	J5RC054	751357	6638411
Survey area	J5RC057	751465	6638486
Survey area	J5RC061	751500	6638341
Survey area	J5RC065	751566	6638273
Survey area	J5RC066	751498	6638263
Survey area	J5RC067	751586	6638306
Survey area	J5RC068	751614	6638272
Survey area	J5RC069	751616	6638372
Survey area	J5RC073	751681	6638270
Survey area	J5RC074	751769	6638324
Survey area	J5RC078	751312	6638512
Survey area	J5RC080	751777	6638246
Survey area	J5RC081	751871	6638177
Survey area	J5RC091	751414	6638354
Survey area	J5RC093	752043	6638096
Survey area	J5RC094	752100	6638094
Survey area	J5RC098	752215	6638080
Survey area	J5RC101	752253	6638035
Survey area	J5RC106	752293	6638123
Survey area	J5RC113	752349	6638033
Survey area	J5RC116	751370	6638522
Survey area	J5RCUNK01	751900	6638143
Survey area	PHJ5066	751671	6638226
Rockwater (2009)			
Survey area	VE0004	759080	6636081
Survey area	VE0007	758845	6635679
Survey area	VE00013	758567	6634796
Survey area	VE00015	758319	6634480
Survey area	VE00017	758324	6634238

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APPENDIX G VERTEBRATE FAUNA SITE BY SPECIES MATRIX

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Mammals

Family and Species	Common name	Conservation Status			J4 impact area						Survey area																					
					POV S7		POV S10		Opportunistic		POV S1		POV S2		POV S3		POV S4		POV S5		POV S6		POV S8		POV S9		POV S11		POV S12		Opportunistic	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
DASYURIDAE																																
Ningaui ridei	Wongai Ningaui											1		1							2											
Pseudantechinus wolleyae	Wolley's Pseudantechinus																															S
Sminthopsis dolichura	Little Long-tailed Dunnart												1				1		2						3		2		2			
Sminthopsis hirtipes	Hairy-footed Dunnart																											1				
BURRAMYIDAE																																
Cercartetus concinnus	Western Pygmy-possum											1		3	2	1				1					1				1			
MACROPODIDAE																																
Macropus robustus	Euro																															S
VESPERTILIONIDAE																																
Chalinolobus gouldii	Gould's Wattled Bat				R	R	R	R	R		R	R	R		R		R	R	R	R	R	R	R		R	R	R	R	R	R	R	
Chalinolobus morio	Chocolate Wattled Bat				R	R	R		R		R	R	R		R		R				R		R		R	R	R		R	R	R	
Nyctophilus geoffroyi	Lesser Long-eared Bat				R	R	R		R			R	R		R		R	R	R		R	R	R		R	R	R		R	R	R	
Nyctophilus major tor	Western Long-eared Bat				R	R					R			R				R	R			R	R		R	R		R			R	
Scotorepens balstoni	Inland Broad-nosed Bat				R		R		R						R		R		R				R		R	R	R	R	R		R	
Vespadelus baverstocki	Inland Forest Bat				R				R			R		R	R			R		R			R								R	
Vespadelus regulus	Southern Forest Bat											R		R	R		R	R	R	R	R	R	R		R				R		R	
MOLOSSIDAE																																
Mormopterus sp. 3/sp. 4	South-western Freetail Bat				R	R	R	R	R		R	R		R	R	R	R	R	R	R	R	R	R		R	R		R	R	R	R	
Tadarida australis	White-striped Freetail Bat				R	R	R	R	R		R	R	R		R				R	R	R	R	R		R	R	R	R		R	R	
MURIDAE																																
Pseudomys albocinereus	Ash-grey Mouse																										11	31				
Notomys mitchelli	Mitchell's Hopping Mouse						5	8																			2	1				
INTRODUCED MAMMALS																																
Mus musculus	House Mouse				4	12	8		1			1				1			1				2	1								
Felis catus	Feral Cat																														1	S
Oryctolagus cuniculus	Rabbit						S		5	1					S	S															11	S

R call recorded

S Secondary evidence

Birds

Family and Species	Common name	Conservation Status			J4 impact area						Survey area																			
					POV S7		POV S10		Opportunistic		POV S1		POV S2		POV S3		POV S4		POV S5		POV S6		POV S8		POV S9		POV S11		POV S12		Opportunistic	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
CASUARIIDAE																														
Dromaius novaehollandiae	Emu																												2	
MEGAPODIIDAE																														
Leipoa ocellata	Malleefowl	VU	S1	VU				S		S																				
COLUMBIDAE																														
Phaps chalcoptera	Common Bronzewing																	2											4	
Phaps elegans	Brush Bronzewing																												1	
Ocyphaps lophotes	Crested Pigeon																												2	
PODARGIDAE																														
Podargus strigoides	Tawny Frogmouth								2																				4	
EUROSTOPODIDAE																														
Eurostopodus argus	Spotted Nightjar															1													1	1
AEGOTHELIDAE																														
Aegotheles cristatus	Australian Owlet-nightjar																				2	1							1	1
APODIDAE																														
Apus pacificus	Fork-tailed Swift	M	S3																										3	
ACCIPITRIDAE																														
Lophoictinia isura	Square-tailed Kite																					1							1	
Haliastur sphenurus	Whistling Kite																												1	
Accipiter fasciatus	Brown Goshawk																												2	2
Accipiter cirrocephalus	Collared Sparrowhawk																												1	
Aquila audax	Wedge-tailed Eagle																												1	1
Hieraaetus morphnoides	Little Eagle									1																				
FALCONIDAE																														
Falco cenchroides	Nankeen Kestrel																												2	
Falco berigora	Brown Falcon																				1								3	2
Falco longipennis	Australian Hobby																						1							
Falco peregrinus	Peregrine Falcon		S4													1								1						
OTIDIDAE																														
Ardeotis australis	Australian Bustard			P4																					S					
BURHINIDAE																														
Burhinus grallarius	Bush Stone-curlew			P4																					S					
CACATUIDAE																														
Lophochroa leadbeateri	Major Mitchell's Cockatoo		S4							2																			2	
Eolophus roseicapillus	Galah										1										6			1	8				4	
PSITTACIDAE																														

Family and Species	Common name	Conservation Status			J4 impact area						Survey area																			
					POV S7		POV S10		Opportunistic		POV S1		POV S2		POV S3		POV S4		POV S5		POV S6		POV S8		POV S9		POV S11		POV S12		Opportunistic	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
Glossopsitta porphyrocephala	Purple-crowned Lorikeet						4										12						7		3		3		5	2	17	
Barnardius zonarius	Australian Ringneck					3	10				5	3			2	1		4		2	5		3	3				2	24	5	10	
Melopsittacus undulatus	Budgerigar																														15	
CUCULIDAE																																
Chalcites basalis	Horsfield's Bronze-cuckoo																											1				
Chalcites osculans	Black-eared Cuckoo															1															
Cacomantis pallidus	Pallid Cuckoo																														1	
STRIGIDAE																																
Ninox novaeseelandiae	Southern Boobook																														1	1
HALCYONIDAE																																
Todiramphus pyrrhopygius	Red-backed Kingfisher							1										2	1						1							1
MEROPIDAE																																
Merops ornatus	Rainbow Bee-eater	M	S3					1				3		4		3		2					1		3				1			2
CLIMACTERIDAE																																
Climacteris rufa	Rufous Treecreeper						2								1	11	7	11	7	21			13	2	15	4			27	5	33	
MALURIDAE																																
Malurus splendens	Splendid Fairy-wren				4										8	5																
Malurus pulcherrimus	Blue-breasted Fairy-wren										3																9	5			2	
ACANTHIZIDAE																																
Hylacola cauta whitlocki	Shy Heathwren (western)			P4			1																				1	2				
Pyrrholaemus brunneus	Redthroat							2		2		1			5	3												1				
Smicrornis brevirostris	Weebill				5	5	1	2		2	14	7	45	21	14	27	24		12	20	33	19	13	8	5	9	3	2			26	8
Acanthiza chrysorrhoa	Yellow-rumped Thornbill																				12											
Acanthiza uropygialis	Chestnut-rumped Thornbill				10			3							11	6						3				5	4			1	14	
Acanthiza apicalis	Inland Thornbill						3	4		6		1	2		2								4				20	8			6	3
PARDALOTIDAE																																
Pardalotus punctatus	Spotted Pardalote							5		1																	1					
Pardalotus striatus	Striated Pardalote				2	3				1	4	2	4	5	1	10	16	1	5	22	4	9	4	7	14	10			3	1	13	5
MELIPHAGIDAE																																
Lichenostomus virescens	Singing Honeyeater							6		1	5	8	2	5		3					2	4						8	1		2	1
Lichenostomus leucotis	White-eared Honeyeater						6	10		1	10	5	11	10	6	5			1		7	1	1	1		1	1	1			5	3
Lichenostomus cratitius	Purple-gaped Honeyeater																														2	
Lichenostomus ornatus	Yellow-plumed Honeyeater				2	13	10						4			2	4	53	10	14	1		21	10	14	11					16	9
Purnella albifrons	White-fronted Honeyeater					4	19	39		10	8		3		1				5		2		1			1		11			4	5
Manorina flavigula	Yellow-throated Miner												18	5	1		1	2	4				1	5		1			6		5	
Acanthagenys rufogularis	Spiny-cheeked Honeyeater				1	16	8	8		6			2	1		2		1	5	2		3	8	11	3	3			22	16	8	7
Anthochaera carunculata	Red Wattlebird					11	8				1			1	1	1	8	5	4	17	4	3		4				1		14	8	
Sugomel niger	Black Honeyeater				1			2		1		1													1						1	1
Lichmera indistincta	Brown Honeyeater					1	2	21			8	18	14	9	5	2	1				6	3	1	1				3	4	1	3	6

Family and Species	Common name	Conservation Status			J4 impact area						Survey area																			
					POV S7		POV S10		Opportunistic		POV S1		POV S2		POV S3		POV S4		POV S5		POV S6		POV S8		POV S9		POV S11		POV S12		Opportunistic	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
Phylidonyris novaehollandiae	New Holland Honeyeater																													1	
Melithreptus brevirostris	Brown-headed Honeyeater							2			4		6	10		3				4	2	11								2	7
POMATOSTOMIDAE																															
Pomatostomus superciliosus	White-browed Babbler						1	2					3				1				1									1	4
PSOPHODIDAE																															
Cinclosoma castanotum	Chestnut Quail-thrush																	2						1	1					4	2
NEOSITTIDAE																															
Daphoenositta chrysoptera	Varied Sittella																													4	1
CAMPEPHAGIDAE																															
Coracina novaehollandiae	Black-faced Cuckoo-shrike				1			1			9			2			1	2		6	9	1			13	1				4	1
Lalage sueurii	White-winged Triller																								20	2			3			
PACHYCEPHALIDAE																															
Pachycephala inornata	Gilbert's Whistler					3	1								8		3	7					3	3		2			5	1	2	
Pachycephala pectoralis	Golden Whistler									1																					2	
Pachycephala rufiventris	Rufous Whistler				7	2		4		2					2	2					3	1	2	6	2			1	2	1	12	2
Colluricincla harmonica	Grey Shrike-thrush				1		2	3		4	2	3	2	3	1	3	2	6	1	2	5	3	6	4	13			4	15	4	12	3
Oreoica gutturalis gutturalis	Crested Bellbird (southern)			P4	5	1	3	4		1	2				1	1	2	4	1		2	3	9	6	6	3	1	2	5	2	9	6
ARTAMIDAE																															
Artamus personatus	Masked Woodswallow						4																	3			2			4	1	
Artamus cinereus	Black-faced Woodswallow																														2	1
Artamus cyanopterus	Dusky Woodswallow					1												13					2		2	3			15	3	9	
Artamus minor	Little Woodswallow													1																		
Cracticus torquatus	Grey Butcherbird						4				1						2	2		1	1	2		2					1	3	1	3	2
Cracticus nigrogularis	Pied Butcherbird							3								2	1	1		7		2		1	1						6	
Cracticus tibicen	Australian Magpie												1			1	1			9	1		3	1							7	
Strepera versicolor	Grey Currawong						3				4		2	3	4	1	2	1			3	3				1				2	7	1
RHIPIDURIDAE																															
Rhipidura albiscapa	Grey Fantail																														1	2
Rhipidura leucophrys	Willie Wagtail					1						1	1	1									2	3	3	3					5	2
CORVIDAE																															
Corvus coronoides	Australian Raven														1		1				13	1		2							20	
Corvus bennetti	Little Crow				11																											
MONARCHIDAE																															
Grallina cyanoleuca	Magpie-lark																						1								2	
PETROICIDAE																															
Microeca fascinans	Jacky Winter																				2	1		1	19	4						
Petroica goodenovii	Red-capped Robin							1														2		1		3						1
Melanodryas cucullata	Hooded Robin				3	2					2																2					
Eopsaltria griseogularis	Western Yellow Robin						1				3		1																		1	

Family and Species	Common name	Conservation Status			J4 impact area						Survey area																					
					POV S7		POV S10		Opportunistic		POV S1		POV S2		POV S3		POV S4		POV S5		POV S6		POV S8		POV S9		POV S11		POV S12		Opportunistic	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
Drymodes brunneopygia	Southern Scrub-robin																														2	
MEGALURIDAE																																
Cincloramphus mathewsi	Rufous Songlark																						1								1	
HIRUNDINIDAE																																
Cheramoeca leucosterna	White-backed Swallow																															9
Hirundo neoxena	Welcome Swallow																														5	
Petrochelidon nigricans	Tree Martin				2					1											2		3	10						2	5	7
NECTARINIIDAE																																
Dicaeum hirundinaceum	Mistletoebird											1		3		3						5									13	2
ESTRILDIDAE																																
Taeniopygia guttata	Zebra Finch																														4	

S secondary evidence

Reptiles

Family and Species	Common name	Conservation Status			J4 impact area						Survey area																					
					POV S7		POV S10		Opportunistic		POV S1		POV S2		POV S3		POV S4		POV S5		POV S6		POV S8		POV S9		POV S11		POV S12		Opportunistic	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
AGAMIDAE																																
Ctenophorus cristatus	Bicycle Lizard								2	1						2	2						2					1		7	6
Ctenophorus reticulatus	Western Netted Dragon				1																	2										
Ctenophorus scutulatus	Lozenge Dragon							1		1																						
Moloch horridus	Thorny Devil																													2		
Pogona minor	Dwarf Bearded Dragon					1				1				1										1				1			1	
Tympanocryptis cephalus	Pebble Dragon																														1	
DIPLODACTYLIDAE																																
Crenadactylus ocellatus	Clawless Gecko													1										1				5				
Diplodactylus granariensis					4			1	7					1	2	2	2				2	1	3		1	1			7	1	2	1
Diplodactylus pulcher					6	2	1		1		2				1						5				2						3	
Lucasium maini							1		3								1		2	2			3						1	1	3	1
Oedura reticulata					1				2							1	1						3		2				12		1	7
Rhynchoedura ornata	Beaked Gecko				4	1																										
CARPHODACTYLIDAE																																
Underwoodisaurus milii	Barking Gecko								1		1	1								1				1		1					5	3
GEKKONIDAE																																
Gehyra variegata					1		2	2	2		1	1				1					3	1	9		7	2	9		6		6	9
Heteronotia binoei	Bynoe's Gecko							1	1	2	2					2							1		1		1			3	1
PYGOPODIDAE																																
Delma australis															2										1			1	2		1	
Delma butleri					3																		2									
Delma fraseri																1							1									
Lialis burtonis	Burton's Legless Lizard											1	1								2											
Pygopus lepidopodus	Common Scaly Foot																	1	1		2									1	1	
SCINCIDAE																																
Cryptoblepharus buchananii									1		1			3			1						5								5	
Ctenotus atlas							1	15																				2			1	
Ctenotus leonhardii					5																				2			1				
Ctenotus schomburgkii							2	8																2							2	
Ctenotus uber						6			2	2	2	2	2								9	4				1					1	
Cyclodomorphus melanops	Slender Blue-tongue											4																			3	
Eremiascincus richardsonii	Broad-banded Sand Swimmer																						1		1							
Hemiergis initialis									2			1																	1		8	13
Lerista gerrardii																			1						4				2		2	
Lerista kingi								1			1		2					1	1				1	1	2						3	
Lerista macropisthopus																							3									
Lerista timida																															3	

Family and Species	Common name	Conservation Status			J4 impact area						Survey area																			
					POV S7		POV S10		Opportunistic		POV S1		POV S2		POV S3		POV S4		POV S5		POV S6		POV S8		POV S9		POV S11		POV S12		Opportunistic	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
Liopholis inornata							4	8																			3	3				1
Menetia greyii					2	1												1	1		1	2							1		6	
Morethia butleri													1	2				2					9	2	8					3	1	
Tiliqua occipitalis	Western Blue-tongue							1																				1			1	
VARANIDAE																																
Varanus giganteus	Perentie							1		S		1																			3	
Varanus gouldii	Sand Monitor																														9	2
Varanus tristis	Racehorse Monitor					1				1	1											1		1					1		3	
TYPHLOPIDAE																																
Ramphotyphlops australis												1																				
ELAPIDAE																																
Brachyurophis semifasciatus					1																											
Demansia psammophis	Yellow-faced Whipsnake										1		2	1																		
Parasuta gouldii																2									1							
Parasuta monachus	Hooded Snake					1	1				1										1				1	2						
Pseudonaja mengdeni	Western Brown Snake																															1
Pseudonaja modesta	Ringed Brown Snake					1		1													1											
Simoselaps bertholdi	Jan's Banded Snake												2								1											
Suta fasciata	Rosen's Snake																									1						

Amphibians

Family and Species	Common name	Conservation Status			J4 impact area						Survey area																			
					POV S7		POV S10		Opportunistic		POV S1		POV S2		POV S3		POV S4		POV S5		POV S6		POV S8		POV S9		POV S11		POV S12			
		EPBC Act	WC Act	DPaW	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2		
LIMNODYNASTIDAE																														
Neobatrachus pelobatoides	Humming Frog																												1	
MYOBATRACHIDAE																														
Pseudophryne occidentalis	Western Toadlet														4															

APPENDIX H SRE INVERTEBRATE FAUNA RECORDED

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		Wet pitfall sites (incl. leaf litter collection)												Dry pitfall sites (dry pitfall traps only)											
	Species	PO S1	PO S2	PO S3	PO S4	PO S5	PO S6	PO S7	PO S8	PO S9	PO S10	PO S11	PO S12	POV S1	POV S2	POV S3	POV S4	POV S5	POV S6	POV S7	POV S8	POV S9	POV S10	POV S11	POV S12
Araneae	Actinopodidae																								
	Missulena sp. indet. (juv.)																								
	Barychelidae																								
	Synothele howi																	2							
	Synothele `MYG278`														1										
	Synothele sp. indet.													1									1		
	Idiommata 'blackwalli cf'																		1		1				
	Idiommata sp. indet.				1												1			1			1		
	Dipluridae																								
	Cethagus 'sp. nov'																	1							
	Idiopidae																								
	Aganippe sp. indet.														1	1			1	3					
	Aganippe castellum																								
	Anidiops 'sp juv'																		1						
	Gaius sp. indet. (juv.)																								
	Idiosoma sp. indet.										1														
	Nemesiidae																								
	Aname 'MYG279'																						1		
	Aname 'MYG004'																								
	Aname 'MYG386'													1	1	1			1						
	Aname sp. indet																								1
	Aname tepperi												1												
	Kwonkan 'MYG175'						1													1					
	Kwonkan sp. indet.																			1					
	Yilgarnia 'MYG272'					1																			
	Selenopidae																								
	Karaops sp. indet.																								
	Karaops jarrit															2									
	Theraphosidae																								
	Selenotholus foelschei																				1				
Scorpiones	Buthidae																								
	Isometroides 'goldfields1'																1	2	1		2	2		1	
	Lychas adonis																							1	
	Lychas annulatus													2	2		1	3				1	2	3	
	Lychas jonesae													3					1		5	5	1	1	1
	Lychas splendens						2	1		2						1					1	1			1
	Urodacidae																								
	Urodacus 'gibson 2'																1	2							
	Urodacus 'koolyanobbing 2'																			3	1				
	Urodacus 'koolyanobbing 3'	2	1																		1		2		
	Urodacus 'koolyanobbing 4'																						1	1	
	Urodacus novaehollandiae													2											
	Urodacus sp. indet.													2											
Pseudoscorpiones	Cheiridiidae																								
	Cheiridiidae `genus indet. (juv)`	2		1	2				2											1	2				4
	Chernetidae																								
	Chernetidae sp. indet.				1	1					3	1													
	`PSEAAD PSE076'																								
	Chtoniidae																								
	Austrochthonius 'pilbara'			26					1				4												
	Austrochthonius 'similis'			3									3												
	Austrochthonius sp. indet (female)								2				1												
	Garypidae																								
	Synsphyronus mimulus			1			1																		
	Synsphyronus sp. indet	1			1																				
	Amblyolpium 'PSE077'	1			1				3																
	Geogarypus taylori																								

	Leaf litter Collection/Foraging Sites												Foraging Sites																											Opp
Species	PO OS1	PO OS2	PO OS3	PO OS4	PO OS5	PO OS6	PO OS7	PO OS8	PO OS11	PO OS12	PO OS13	PO OS14	PO OSF1	PO OSF5	PO OSF7	PO OSF8	PO OSF10	PO OSF11	PO OSF12	PO OSF13	PO OSF14	PO OSF17	PO OSF20	PO OSF23	PO OSF27	PO OSF32	PO OSF34	PO OSF35	PO OSF37	PO OSF40	PO OSF41	PO OSF43	PO OSF44	PO OSF45	PO OSF46	PO OSF47	PO OSF50	PO OSF51	
Actinopodidae																																							
Missulena sp. indet. (juv.)													1																						1				
Barychelidae																																							
Synothele howi																																							
Synothele `MYG278`																																							
Synothele sp. indet.																					1	1																	1
Idiommata 'blackwalli cf'																																							
Idiommata sp. indet.																	1							1						1		1		1	1				
Dipluridae																																							
Cethagus 'sp. nov'																																							
Idiopidae																																							
Aganippe sp. indet.					1	1							2												1				1									1	
Aganippe castellum																						1																	
Anidiops 'sp juv'																																				1			
Gaius sp. indet. (juv.)													1																										
Idiosoma sp. indet.																																							
Nemesiidae																																							
Aname 'MYG279'																																							
Aname 'MYG004'													1																										
Aname 'MYG386'																																		1					
Aname sp. indet													1																										
Aname tepperi																																							
Kwonkan 'MYG175'																																							
Kwonkan sp. indet.																																							
Yilgarnia 'MYG272'																																							
Selenopidae																																							
Karaops sp. indet.																								1															
Karaops jarrit																																							
Theraphosidae																																							
Selenotholus foelschei																																							
Buthidae																																							
Isometroides 'goldfields1'																																							
Lychas adonis																																							
Lychas annulatus															1				1		1																		
Lychas jonesae																																							
Lychas splendens		1																												1		1							1
Urodacidae																																							
Urodacus 'gibson 2'																							1																
Urodacus 'koolyanobbing 2'																																							
Urodacus 'koolyanobbing 3'																																							
Urodacus 'koolyanobbing 4'																																							
Urodacus novaehollandiae																		1																					
Urodacus sp. indet.																																							
Cheiridiidae																																							
Cheiridiidae `genus indet. (juv)`				2	1		4		4																														
Chernetidae																																							
Chernetidae sp. indet.																																							
`PSEAAD PSE076'									2																														
Chtoniidae																																							
Austrochthonius 'pilbara'																																							
Austrochthonius 'similis'																																							
Austrochthonius sp. indet (female)																																							
Garypidae																																							
Synsphyronus mimulus							1					1																						2					
Synsphyronus sp. indet				1																																			
Amblyolpium 'PSE077'			1																																				
Geogarypus taylori					6																																		

		Wet pitfall sites (incl. leaf litter collection)												Dry pitfall sites (dry pitfall traps only)												Leaf litter Collection/Foraging Sites												Foraging Sites																									Opp	
	Species	PO S1	PO S2	PO S3	PO S4	PO S5	PO S6	PO S7	PO S8	PO S9	PO S10	PO S11	PO S12	POV S1	POV S2	POV S3	POV S4	POV S5	POV S6	POV S7	POV S8	POV S9	POV S10	POV S11	POV S12	PO OS1	PO OS2	PO OS3	PO OS4	PO OS5	PO OS6	PO OS7	PO OS8	PO OS11	PO OS12	PO OS13	PO OS14	PO OSF1	PO OSF5	PO OSF7	PO OSF8	PO OSF10	PO OSF11	PO OSF12	PO OSF13	PO OSF14	PO OSF17	PO OSF20	PO OSF23	PO OSF27	PO OSF32	PO OSF34	PO OSF35	PO OSF37	PO OSF40	PO OSF41	PO OSF43	PO OSF44	PO OSF45	PO OSF46	PO OSF47	PO OSF50	PO OSF51	
Pseudoscorpiones	Olpiidae																																																															
Pseudoscorpiones	*Austrohorus* sp.	2				1	1		1		2															1																																1		2				
Pseudoscorpiones	*Beierolpium* sp. 8/3	2																																																														
Pseudoscorpiones	*Beierolpium* sp. 8/4						3	6	6		4	3	2							1	3					1	3	1	4		1	4	7		2	2	2																							2				
Pseudoscorpiones	*Beierolpium* sp. indet		1	1	2			1		1			6								2	2			1	1					1	1	1																															
Pseudoscorpiones	*Euryolpium* sp.									2																																																						
Pseudoscorpiones	*Indolpium* sp. indet.	4	10				1					1																													1																		4	7				
Pseudoscorpiones	Olpiidae genus indet. sp. indet							3	2				3																																													1						
Isopoda	Armadillidae																																																															
Isopoda	*Buddelundia* cf. *frontosa*		1										10												1			1																														4						
Isopoda	*Buddelundia* '39'	2					1			22							1			1	3												1							2							3				7													
Isopoda	*Buddelundia* '71'		4																																								1		1										1		1	3	2					1
Isopoda	*Buddelundia* sp. nov. A			2																																																												
Isopoda	*Buddelundia* sp. indet																																															1											2					
Isopoda	*"Cubaris"* sp. nov.	2									1																																																					
Isopoda	Armadillidae unknown genus sp. nov. A						1	1	7				1																																																			
Isopoda	Armadillidae unknown genus sp. nov. C										1	3																																																				
Isopoda	Armadillidae 'EE1479S'	1																																																							1							
Isopoda	Armadillidae unknown indet.				1	4																																																										
Isopoda	Philosciidae																																																															
Isopoda	*Laevophiloscia* sp. nov			1				1																																													1		1		3							
Isopoda	Platyarthridae																																																															
Isopoda	*Trichorhina* sp. nov. A											1																																																				
Isopoda	*Trichorhina* sp. nov. B				2																																																											
Isopoda	*Trichorhina* '1510'																																																									2						
Molluscs	Bothriembryontidae																																																															
Molluscs	*Bothriembryon* cf. *sedgwicki*		1	14	2	12	1										4	2						1	5			4			1						1							2	2																			5
Molluscs	*Bothriembryon* sp. nov. 'Marda'																	4				3																														12				10		10	3					
Molluscs	Camaenidae																																																															
Molluscs	*Sinumelon* cf. *tarcoolanum*																12	6						3																												1			2									3
Molluscs	*Sinumelon kalgum*																													1																																		
Molluscs	Punctidae																																																															
Molluscs	*Westralaoma aprica*								1																																																		7					
Molluscs	*Westralaoma expicta*																																						1																									
Molluscs	Pupilidae																																																															
Molluscs	*Gastrocopta bannertonensis*								1																																																							
Molluscs	*Pupilla australis*					7																																																										
Molluscs	*Pupoides adelaidae*			10		6												1			3			1									1																										1					
Molluscs	*Pupoides myoporinae*					5															5																																											
Polydesmida	Paradoxosomatidae																																																															
Polydesmida	*Antichiropus* 'lake king'										1																																																					
Polydesmida	*Antichiropus* 'mt gibson 1'																																													5		2	1															
Polydesmida	*Antichiropus* 'mt gibson 3'		1	3			4																														3			4				2	1	1	5				3													
Polydesmida	*Antichiropus* sp.						1		1	3			1	1		3					3	1		2								2	1	2																			6		1			7	3	2				
Spirostrepida	Iulomorphidae																																																															
Spirostrepida	*Atelomastix bamfordi*			2																																												1																
Scolopendromorphae	*Cryptopidae*																																																															
Scolopendromorphae	*Cryptops* sp. indet.													1																																																		
Geophilomorpha	Geophilidae																																																															
Geophilomorpha	*Sepedonophilus* sp. indet.																																														1																	
Geophilomorpha	Mecistocephalidae																																																															
Geophilomorpha	*Mecistocephalus* sp. indet.															1		1																									1		1							1	2					2	1	1				
Geophilomorpha	Oryidae																																																															
Geophilomorpha	*Orphnaeus brevilabiatus*																						1																							1	1																	

J4 impact area

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APPENDIX I INVERTEBRATE TAXA FAMILY AND GENUS DESCRIPTIONS

Mygalomorphae (trapdoor spiders)

Mygalomorphae are burrowing spiders, often displaying low dispersal abilities, low fecundity and high life expectancy (Main 1985c; Main 1992). The order represents one of the groups primarily targeted during surveys of short range endemic taxa (Harvey 2002). A number of mygalomorph spiders, e.g. *Idiosoma nigrum* Main, 1952, *Kwonkan eboracum Main,* 1983 and *Moggridgea tingle* are listed on Schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2012 (2) (Western Australian Government 2012). The Western Australian mygalomorph fauna is vast and, taxonomically, many families and genera remain poorly known (e.g. Barychelidae: *Idiommata;* Idiopidae: *Aganippe;* Nemesiidae: *Aname, Chenistonia, Kwonkan).*

Family Actinopodidae (mouse spiders)

In Australia, the trapdoor spider family Actinopodidae is represented only by the genus *Missulena.* Spiders within this family are medium-sized to large with an extremely raised head region and widely spaced eyes (in contrast to most other trapdoor spider families in which the eyes are grouped closely together). Actinopodidae can be found in a variety of habitats from open-forest to semi-arid.

Genus *Missulena*

Western Australia is the centre of diversity for the genus, with nine named species but many more undescribed species, in particular from the arid northern and central parts of the State. The WAM/DEC Carnarvon survey recovered four undescribed species within the genus (Main *et al.* 2000b). Similarly, DPaW's Pilbara survey discovered four species (Durrant *et al.* 2010), however, the diversity in the genus is probably much higher. The entrance of the burrow of *Missulena* is ovoid in shape and equipped with two neighbouring doors (Main 1956a). Emergent juveniles of some *Missulena* species have been reported to disperse via ballooning (Faulder 1995); however, this may only happen over a few metres thus limiting long-distance dispersal (R. J. Raven, *pers. comm.*).

Family Barychelidae (brush-footed trapdoor spiders)

Barychelid spiders, commonly called brush-footed trapdoor spiders, are small to fairly large in size with well-developed claw tufts and short terminal segments of the posterior lateral spinnerets (Raven 1994). In Western Australia, the genera *Aurecocrypta, Idiommata, Mandjelia* and *Synothele* are known to occur from the Southwest region into the Pilbara and *Moruga* has been found in the Kimberley region (Raven 1994). Of all trapdoor spiders, few are as cryptic as the Barychelidae. Their burrows tend to be less than 60 cm deep and often lack the firm thick door of the Ctenizidae or the extensive webs of Dipluridae.

Genus *Synothele*

The genus *Synothele* can be identified by the low number of maxillary cuspules in combination with the lack of lyra on the maxillae, and the often mottled abdomen (uniformly dark in the similar *Aurecocrypta*). The genus is widespread throughout Western Australia (21 species) and South Australia (three species) with most species known only from very limited ranges (Raven 1994).

Genus *Idiommata*

The genus *Idiommata* includes the largest species in the family Barychelidae. The genus can be identified by the low number of maxillary cuspules in combination with the presence of a maxillary lyra (row of specialised clubbed setae) (Raven 1994). The taxonomy of the genus is poorly resolved. A single, presumably widespread species, *I. blackwalli,* is currently known from south-west WA but a number of different morphospecies are known from the reference collection of the WA Museum.

Family Dipluridae

The Dipluridae are one of the better known families of mygalomorph spider. The majority of the species are uncommon and live in remote areas and are rarely encountered by the general public. They are mostly large, hairy, dark brown to black spiders, living in silken burrows in the ground or occasionally holes in trees above ground. Their burrows are rarely attached with doors but are sometimes adorned with an expansive silken sheet or curtain-like sheet threads over the entrance (Hawkeswood 2003).

Genus *Cethegus*

The species of the genus *Cethegus* are typical burrow builders but they all construct a distinctive sheet-like web or curtain-like threads over the entrance in order to capture prey that may be wandering nearby. Some of the species also construct dense silken tubes from the outside curtain webs and sheets to the entrance holes below.

Family Idiopidae

The family Idiopidae comprises several genera in Western Australia, including *Aganippe*, *Anidiops, Gaius* (currently listed as junior synonym of *Anidiops*), *Euoplos, Blakistonia, Cataxia, Eucyrtops, Idiosoma* and *Misgolas* (Main 1985b; Raven and Wishart 2005). These spiders represent the 'typical' trap door spiders, i.e. those that usually close the burrow with a hinged door. Spiders of this family are abundant in Australia, particularly in relatively stable habitats of temperate to tropical regions (Main 1985a).

Genus *Aganippe*

The genus *Aganippe* is common throughout Western Australia. Fourteen species are described from Australia and many new species await description (Main 1985a). The genus has close morphological affinities to *Idiosoma,* as representatives of both genera have abdominal sigillae. However, *Idiosoma* differs from *Aganippe* by the larger size of the posterior sigillae, a generally more rugose abdomen that is posteriorly flattened in females and short tubercles on the finger-like process of the male pedipalp (Main 1985a).

Genus Anidiops

The genus Anidiops contains two known species from Western Australia, with one species also extending into South Australia. They are found mostly in the arid and semi-arid areas where they dig deep burrows often sealed with silk and plaster (Hawkeswood 2003).

Genus *Gaius*

The genus *Gaius* is well represented throughout WA and into the Pilbara region, based on WA Museum records. Most recognised species have a fairly wide distribution (Main 1957; Main 1978; WAM 2008)

Genus *Idiosoma*

Spiders in the genus *Idiosoma* are morphologically similar to *Aganippe,* but the abdomen is very thick, rugose and hard and is used by the spiders to plug their burrow against invaders. Three species are currently known from Western Australia, *I. sigillatum* from the Swan Coastal Plain, *I. hirsutum* from a small area around South Perth and *I. nigrum* from the Avon Wheatbelt, the Geraldton Sandplain and into the Murchison (Main 1952, 2003). *Idiosoma nigrum* is listed on Schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2012 (2) (Western Australian Government 2012)

Family Nemesiidae (wishbone spiders)

Members of the family Nemesiidae are represented in Western Australia by several genera, including

Aname, Chenistonia, Yilgarnia, Stanwellia, Teyl, Swolnpes and *Kwonkan*. They usually dig burrows in the soil, and do not cover their burrow entrances with a lid.

Genus *Aname*

This genus of the wishbone spiders currently represents a highly diverse array of species of very small to large spiders. Males generally have a spur and spine on the first tibia opposing an often incrassate metatarsus. The genus currently includes 33 named species in Australia and is well represented by four named and numerous unnamed species from many different regions in Western Australia. Members of the genus *Aname* are believed to be most common in dry sclerophyll forest, but are also known from rainforests and deserts (Raven 1981). *Aname* regularly belongs to the most diverse mygalomorph genera in biological spider surveys in Western Australia. Many *Aname* species appear to have restricted distributions, particularly the species from northern Australia (Harvey *et al.* 2012; Raven 1985).

Genus *Kwonkan*

Kwonkan includes those nemesiid spiders that have spines on their pedal tarsi. The genus is restricted to Western Australia and currently includes six named species (Main 1983; Majer 1977). All of these are currently known from their type specimens only. *Kwonkan eboracum* from the York region is listed on Schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2012 (2) (Western Australian Government 2012).

Genus *Yilgarnia*

The genus *Yilgarnia* is characterised by the presence of patches of cuspules on the ventral side of the third and fourth coxa. The genus is currently known from two described species in Western Australia (Main 2008), but many more undescribed species are known from collections. Generic boundaries between *Yilgarnia* and *Kwonkan* remain uncertain as some species have the characteristics of both genera, i.e. cuspules on coxae III and IV (Yilgarnia) and tarsal spines (*Kwonkan*). This intermittent group was listed as "*Kwonkan/Yilgarnia*" in the WAM/DEC Carnarvon survey, where three species were recovered at a variety of sites (Main *et al.* 2000a). Species of *Yilgarnia* have been found throughout WA and occur as far north as the Kimberley. Some are currently known from very small ranges.

Family Selenopidae

Spiders of the family *Selenopidae* are distributed in the tropical and subtropical regions worldwide. Also known as wall crab spiders or flatties, they are exceptional in running and striking, and they are also extremely flattened dorsoventrally(Crews and Harvey 2011).

Genus *Karaops*

The genus *Karaops* differs from other genera in the family Selenopidae by the spination of the two first pairs of legs and by the absence of scopulae (brushes of dense setae) from their tarsi (Crews and Harvey 2011). Sixteen species are described from the Pilbara region and its vicinity of which one, *K. martamarta* is fairly widespread. This supports a high diversity of the genus in the region and suggests restricted ranges for most of the species. Unidentifiable members of the genus are therefore categorised as likely SREs (Phoenix 2013b).

Family Theraphosidae

This is a small family of usually very large, hairy spiders, which in Australia, occurs mainly in northern and south-western Australia. They are commonly called Bird-eating Spiders because they have been known to kill and eat small birds. Other small vertebrates such as lizards and frogs are also preyed upon. They are very distinctive spiders; large (up to 6 or 7 cm body length) and covered with dense

greybrown to dark brown hairs all over their bodies and legs. Their legs are also clothed with spines and each leg has two claws with dense tufts of hairs. Unlike other spiders which live in holes in the ground (e.g. trap-door spiders), they do not construct a lid of silk at the entrance of their burrows. Their burrows may be concealed under rocks, and beneath roots of trees and fallen logs, and may also have a sheet-web surrounding the entrance. The abdomen of theraphosid spiders possesses four spinnerets, the last segment of the lateral pair is long and tapered and sometimes turned upwards (Hawkeswood 2003).

Genus *Selenocosmia*

Selenocosmia are large spiders with dense, long hairs on the legs and tarsi and have stridulatory organs on the chelicerae. These consist of a cluster of short, hard spines on the anterior margins of the maxillae and a series of short hairs on the outer portion of the chelicerae (Hawkeswood 2003).

Scorpiones (scorpions)

Scorpiones is a relatively small order of arachnids, with approximately 1,700 described species (Fet *et al.* 2000). Scorpions are instantly recognisable by the presence of chelate pedipalps, pectenes and an elongate metasoma with a terminal sting. Scorpions are infamous for their venomous sting, which they use to subdue prey and for defence. In most species, the venom is relatively benign for humans, resulting in varying degrees of discomfort. The venom from 25 species only (all members of the family Buthidae) is known to be fatal to humans (Fet *et al.* 2000). Scorpions are important predators and in some ecosystems their diversity and abundance contribute significantly to the biomass of animal assemblages (Polis 1993).

Family Buthidae

The family Buthidae is the most diverse and widespread of all scorpion families (Fet *et al.* 2000). In Australia, Buthidae are represented by five genera; *Australobuthus, Isometrus, Isometroides, Lychas,* and *Hemilychas.* In Western Australia, only the latter three genera have been recorded. The taxonomy of the constituent species of *Isometrus, Isometroides* and *Lychas* is very problematic and each genus contains numerous undescribed species, most notably in the genus *Lychas* (E. S. Volschenk, unpublished data). Most authors refer to Koch (1977) for keys and identification. This revision represents an important study of the Australian scorpions; however, several taxonomic decisions made by Koch (1977) have been rejected by subsequent authors and the taxonomy in the publication is not current. Most Australian buthid species appear to have wide distributions; however, a few taxa have confirmed SRE distributions (E. S. Volschenk, unpublished data).

Genus *Isometroides*

The taxonomy of the species in this genus is known extremely poorly. Only two species, *I. vescus* and *I. angusticaudus,* are presently recognised; however, many undescribed species are known from collections. Most morphospecies appear to have fairly wide distributions, but this perception may change with further systematic work on the genus. *Isometroides* are ground dwelling scorpions and are the only scorpion species known to be a predatory specialist. Main (1956b) described the association of the genus with burrowing spiders and numerous records have since shown species in the genus to prey on spiders, being found in trapdoor (Mygalomorphae) and wolf spider (Lycosidae) burrows (E.S. Volschenk unpublished data). Species in this genus usually do not appear to be abundant in pitfall-trapped samples; the ground disturbance surrounding the pitfall trap is thought to possibly deter them.

Genus Lychas

The genus *Lychas* is widespread across the Australian mainland. The taxonomy of this genus is problematic, with numerous undescribed species known in Australia (Volschenk *et al.* 2010). The

situation is further complicated with the genus being also represented in Africa, India and eastern Asia (Fet *et al.* 2000). All of the Australian species are endemic to the country and are currently under revision by E.S. Volschenk. Most species of *Lychas* appear to have wide distributions; however, a small number of undescribed species are known to be SREs.

Family Urodacidae

The family Urodacidae is endemic to Australia (Fet *et al.* 2000; Prendini and Wheeler 2005; Volschenk *et al.* 2000) where it is represented by the genera *Urodacus* and *Aops*.

Genus *Urodacus*

Urodacus was considered a member of the family Scorpionoidea for many years, but in a revision of the superfamily Scorpionoidea, Prendini (2000) placed *Urodacus* in its own family, Urodacidae. Unlike the species designations for Buthidae, Koch's (1977) species of *Urodacus* have been mostly supported by subsequent authors (Harvey and Volschenk 2002; Volschenk and Prendini 2008; Volschenk *et al.* 2000). The biggest issue confronting *Urodacus* taxonomy is the number of undescribed species being uncovered through current revisionary work (E. S. Volschenk unpublished data). Currently, 23 species of *Urodacus* are described; however, this may represent as little as 20% of the real diversity of this genus in Australia. *Urodacus* appears to be most diverse in Western Australia and few species are recorded east of the Great Dividing Range in eastern Australia. *Urodacus* contains both widespread and SRE species.

Pseudoscorpiones (Pseudoscorpions)

Pseudoscorpions resemble scorpions in that they possess a pair of long pedipalps with pincers which are directed anteriorly of the body; however, they do not possess the tail or a sting of scorpions. Most species are small to very small in size (most species are less than 1cm long). The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families (Harvey 2011). They are found in a variety of biotopes, but can be most commonly collected from the bark of trees, from the underside of rocks, or from leaf litter microhabitats (Harvey 1992).

Family Chernetidae

Chernetidae are the most diverse of all pseudoscorpion families with 113 named genera and 652 named species worldwide. The Australian fauna is quite extensive, with 37 described species (Harvey 2011). Chernetid pseudoscorpions are generally found under bark of trees and unlikely to include many, if any, short-range endemic species (M.S. Harvey personal communication).

Genus 'PSEAAD'

This genus has not been previously recorded by the museum and has been given the new WAM genus code `PSEAAD`(WAM 2013a).

Family Chtoniidae

The family has a global distribution and is represented by 27 genera; five indigenous genera have been reported from Australia, and each is widespread (Edward and Harvey 2008; Harvey 1992). Chthoniidae are especially common in leaf litter and under rocks in high rainfall areas of eastern and south-western Australia.

Genus *Austrochthonius*

Austrochthonius are found Australia-wide, and in WA species of *Austrochthonius* occur in leaf litter and soil environments throughout much of south-western Australia, in the Kimberleys, as well as subterranean ecosystems in Cape Range and near Busselton (Harvey 1991; Harvey and Mould 2006).

Recent molecular analyses showed deep genetic divergences within the genus, but this is not reflected in their morphology and species identification is extremely difficult.

Family Garypidae

The described Australian fauna consists of a single species of *Solinus* (*S. australianus* from New South Wales and Victoria), two species of *Protogarypinus* (*P. dissimilis* from South Australia and *P. giganteus* from WA) and a single species in Oreolpium (*O. semotum* from Tasmania), but numerous undescribed species are represented in museum collections (M.S Harvey, unpublished data).

Isopoda (Isopods)

Isopods (or slaters) are one of two groups of Crustacea that have become terrestrial. They range in size but are usually less than 15 millimetres in length. Their characteristics include one pair of prominent antennae and one pair of inconspicuous antennae, seven pairs of legs, simple or compound eyes composed of either single ocellus or many closely associated ocelli, and obvious uropods. Slaters are omnivores or scavengers, presenting an important link in the food chain by recycling dead and decaying matter. They inhabit moist areas and are commonly found under rocks and logs and in leaf litter in forested areas. Some species are found in the semiarid regions of inland Australia.

Family Armadillidae

Unlike other isopods, the members of the family Armadillidae are able to form their bodies into a ball shape, in a process known as conglobation (shared with pill millipedes, armadillos and cuckoo wasps). This behaviour may be triggered by stimuli such as vibrations or pressure, and is a key defence against predation and, possibly, against respiratory water losses (Smigel and Gibbs 2008). In Australia, the family includes many undescribed species.

Family Platyarthridae

The members of the family Platyarthridae are relatively small (usually less than 6 mm long). They have no lungs on the pleopods, and have very small compound eyes, with fewer than 10 ommatidia. The family comprises nine genera and potentially few undescribed species.

Molluscs (Snails)

Family Bothriembryontidae

Bothriembryontidae is a family of air-breathing land snails in the superfamily Orthalicoidea. The family has Gondwanaland distribution and comprises 12 genera. The genus *Bothriembryon* is endemic to Australia and includes over 40 described species.

Family Camaenidae

Camaenidae is a very diverse family of air-breathing land snails in the superfamily Helicoidea. In Australia, the Camaenidae comprise 131 currently recognised genera, most of which are endemic to the continent.

Family Punctidae

The Punctidae are a cosmopolitan (with the exception of South America) family of minute to small snails and comprise a number of undescribed species.

Family Pupillidae

Pupillidae is a family of mostly minute, air-breathing, land snails in the superfamily Pupilloidea. The family comprises 12 genera and harbours both wide-spread and range-restricted species.

Diplopods (Millipedes)

The Australian millipedes are poorly studied and biogeographic patterns remain largely unresolved (Black 1997). Millipedes belong to one of the main target groups of SRE surveys. SREs are particularly expected within the orders Sphaerotheriida (rolling millipedes), Polydesmida, and Chordeumatida (not known from WA) (EPA 2009, Harvey 2002). A recent review of Australian *Atelomastix* (order Spirostreptida) found all of 29 species treated were SREs (Edwards and Harvey 2010).

Order Polydesmida (keeled millipedes)

Polydesmida are the largest of all millipede orders. In Australia, the order is represented by four families, the Dalodesmidae, Haplodesmidae, Paradoxosomatidae and Pyrgodesmidae (Mesibov 2012).

Polydesmida are poor dispersers under natural conditions and appear to be very good at evolving new species. As a result, many polydesmidan species have small geographical ranges (100–1000 sqkm). Polydesmidan genera are also good at forming distribution mosaics, in which each species occupies its own patch on the map and overlaps very little (or not at all) with other species in the same genus (Mesibov 2006).

Family Paradoxosomatidae

Members of the family Paradoxosomatidae are abundant and occur widely within Australia. They differ from the other two Australian families within the Polydesmida, Dalodesmidae, Haplodesmidae and Pyrgodesmidae, by the separated bases of the male gonopods. Many paradoxosomatids are relatively large with adults that range from 20 to 40 mm in length (Mesibov 2006). Although there are hundreds of undescribed species, many from diverse habitats, most appear to have small ranges.

Many genera contain SRE taxa although they may be locally abundant. For example, the genus *Boreohesperus* is only known from six species in the Pilbara and Carnarvon bioregions and all three are known from very small ranges (Car and Harvey 2013). In addition, almost all 140+ recognised morphospecies of *Antichiropus* are believed to be SREs and many are known from only a few hundred square kilometres (Wojcieszek *et al.* 2011). Unidentified keeled millipedes are therefore considered confirmed SREs.

Genus *Antichiropus*

The genus *Antichiropus* is the most abundant and diverse millipede genus in WA and occurs throughout most of the state. *Antichiropus* was initially named in 1911 for seven species (Attems 1911). Two additional species were added by Jeekel (1982) and Shear (1992). Scientific field surveys, collections from environmental assessment studies and taxonomic work at the Western Australian Museum have led to the genus now being known to consist of over 140 species, ranging as far north as the Kimberley, and extending into the Nullarbor Plain and the Eyre Peninsula in South Australia. Accurate species identification requires the examination of adult males. Almost all species of *Antichiropus* are believed to be SREs and many are known from only a few hundred square kilometres (Wojcieszek *et al.* 2011).

Order Spirostreptida

Spirostreptidan millipedes do not have legs on the fourth body segment. They are typically round in cross-section and may reach up to 100 mm body length. The Australian described fauna includes two families, the Cambalidae (currently only known from New South Wales) and the Iulomorphidae which have been found throughout Australia except the Northern Territory and South Australia (Mesibov 2006)

Family Iulomorphidae

Australia. Four of these, *Atelomastix*, *Podykipus*, *Samichus* and *Dinocambala* were established by Attems (Attems 1911) in his monograph on the millipedes of the Michaelsen & Hartmeyer expedition

of the Hamburg University to south-west Western Australia in 1905. The family is taxonomically poorly known with the exception of the genus *Atelomastix* which was recently revised for Australia endemism (Edwards and Harvey 2010; Phoenix 2013b).

Genus *Atelomastix*

Males of the genus *Atelomastix* differ from other iulomorphid genera mainly by male genital morphology. The gonopods which are laterally compressed, terminally split into three sclerites and possess a pseudoflagellum with a chitinous duct. The genus is currently only known from Victoria (one species) and Western Australia (28 species). All species have very small distribution ranges and are considered SREs endemism (Edwards and Harvey 2010; Phoenix 2013b).

Chilopoda (Centipedes)

The centipedes represent a diverse group of predatory arthropods. Each pair of legs is attached to a separate body segment which distinguishes this class from the millipedes (Diplopoda; two pairs of legs per segment) (Colloff *et al.* 2005).

Scolopendromorpha (tropical centipedes) and Scutigeromorpha (house centipedes) are the most commonly encountered centipedes in WA. Most species are very fast runners and are highly mobile and therefore, widespread (Edgecombe and Barrow 2007; Edgecombe and Giribet 2007). Therefore, they are not considered target groups for SRE surveys.

In contrast, Geophilomorpha (soil centipedes), Lithobiomorpha (stone centipedes) and the Cryptopidae (within the Scolopendromorpha) may include Gondwanan refugial SREs based on the habitat preference for moist and deep leaf litter. Geophilomorpha and Cryptopidae have been found in subterranean environments in the Pilbara where they are limited to very small ranges (Edgecombe 2005).

Geophilomorpha (soil centipedes)

Geophilomorpha translates into 'soil-lover' and as this name suggests, their behaviour is characterised by burrowing into soil, leaf litter and under rocks. With more than 1,200 described species world-wide, the Geophilomorpha are the most diverse centipede order (Bonato 2011).

Thirteen families of geophilomorphan centipedes are known world-wide, of which five families occur in Australia, the Ballophilidae with a single described species, the Geophilidae (incl. traditional Chilenophilidae) with 34 described species, the Mecistocephalidae with six described species, and the Oryidae and Schendylidae with a single described species (DSEWPaC 2010). Most recent taxonomic additions to the WA fauna included the description of the genus *Australoschendyla* (family Schendylidae) (Jones 1996) and a new species in the genus *Tuoba* (family Geophilidae) (Jones 1998).

Family Geophilidae

Thirty-four species in 19 genera are currently listed for the Geophilidae (incl. the traditional Chilenophilidae) in Australia, of which five genera occur in Western Australia: *Eurytion* (one species), *Geophila* (one species), *Ribautia* (five species), *Sepedonophilus* (one species) and *Tuoba* (three species) (DSEWPaC 2010).

Genus *Sepedonophilus*

Centipedes in the genus *Sepedonophilus* have 49–79 pairs of legs and no sternal pores. Four species are described from Australia, of which one, *S. antipodus*, is known from WA (Bonato 2011; DSEWPaC 2010).

Family Mecistocephalidae

Mecistocephalidae are small, generally 50–90 mm in length, with an elongate body, filiform antennae and a rectangular head (DSEWPaC 2010). The Mecistocephalidae are characterised by a cephalic shield and forcipular segment that are often heavier sclerotised and darker than the rest of

the body (Bonato 2011). Sternal pore fields are missing, and leg numbers are fixed within species (they are variable in other geophilomorphan centipedes) (DSEWPaC 2010).

Genus *Mecistocephalus*

Ten species and one subspecies of *Mecistocephalus*, the only genus within the Mecistocephalidae in Australia, are currently described from the country, including three species and one subspecies from WA: *Mecistocephalus collinus*, *M. gracilis*, *M. tahitiensis* and *M. tahitiensis major*. The latter two are also found in Queensland (DSEWPaC 2010).

Troglofauna

Order Isopoda

The troglobitic isopods from this area of WA are virtually unknown (Judd 2013). Therefore, it is not possible to provide any distributional information about the following species.

Genus *Troglarmadillo*

The genus Troglarmadillo is very poorly defined and is characterised by being mostly blind, some species posess reduced eyes, pale and small (usually less than 5 mm long with a distinctive groove on the ventral surface of the first pereonite. Taiti *et al.* (1998) considered *Troglarmadillo* as a name of doubtful validity since the cepahalon and pereon of the type specimen are damaged and its identitity cannot be proven. The species collected in WA are all morphologically very similar. The morphological similarity of these species makes genomic comparisons the only way to reliably define species boundaries at this time (Judd and Volschenk 2013)..

Family Philosciidae

In contrast to the Armadillidae, members of the family Philosciidae cannot conglobate (roll into a ball). Five of ten genera described from Australia are endemic (*Abebaioscia*, *Ashtonia*, *Eurygastor*, *Huntonia* and *Metriogaster*) and *Laevophiloscia*. Philosciids are primitive isopods and they lack pleopodal lungs present in the Aramadillidae. Consequently, they rely on relatively humid conditions for respiration and are rarely recorded in dry environments (Judd and Volschenk 2013).

Order Polyxenida

Members of the order Polyxenida are commonly referred to as pincushion millipedes. Like all millipedes (Diplopoda), they possess numerous body segments with two pairs of legs per segment. Polyxenids differ from all other millipede orders by their soft bodies and characteristic tufts or rows of setae (Shelley 2003). Polyxenida of the Pilbara have been relatively well studied in unpublished studies by Helix Molecular Solutions. These studies indicate that one species of subterranean polyxenid is very widespread throughout the Pilbara; however, there are also several locally endemic species. For this reason polyxenids should be treated as potential SREs (Judd and Volschenk 2013)

APPENDIX J CAMERA TRAP RECORDINGS

Appendix J *Varanus tristis* recorded on Motion Camera

Appendix J European Rabbit recorded on Motion Camera

Appendix J *Varanus gouldii* recorded on Motion Camera

Appendix J *Ctenophorus cristatus* recorded on Motion Camera

Appendix J Cat recorded on Motion Camera

Appendix J *Varanus giganteus* recorded on Motion Camera