Bennelongia Environmental Consultants

Short-Range Endemic Fauna at the Mulga Rock Uranium Project

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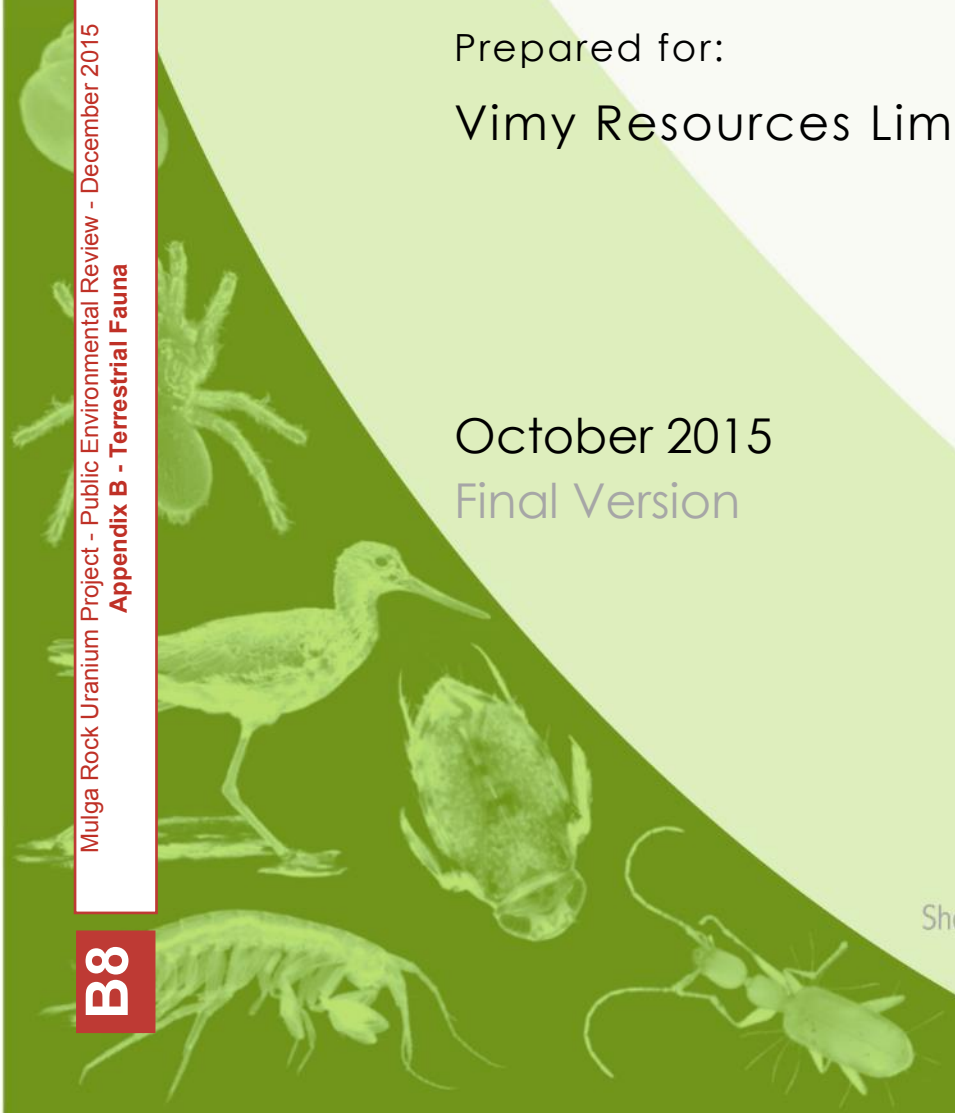

Short-Range Endemics I Subterranean Fauna

Waterbirds I Wetlands

Short-Range Endemic Fauna at Mulga Rock Uranium Project

Bennelongia Pty Ltd
5 Bishop Street
Jolimont WA 6913

P: (08) 9285 8722
F: (08) 9285 8811
E: info@bennelongia.com.au

ACN: 124 110 167

Report Number: 229

Report Version	Prepared by	Reviewed by	Submitted to Client	
			Method	Date
Draft 1	Danilo Harms	Stuart Halse	email	17 November 2014
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EXECUTIVE SUMMARY

Introduction. Vimy Resources is aiming to develop a uranium mine at the Mulga Rock Uranium Rock Project (MRUP). The proposed project aims to produce a uranium oxide concentrate, as well as concentrates of other base metals and rare earth metals that occur in the palaeochannel, mostly below the water-table. Open pit mining is first planned at Ambassador and Princess in the south-eastern part of MRUP. Two additional areas, Emperor and Shogun in the north-western part of the MRUP, will be mined at a later stage. Construction is expected to start in 2017 and the estimated project duration is up to 16 years.

Study area. The MRUP is situated on the western flank of the Great Victoria Desert in Western Australia, approximately 240 km north east of Kalgoorlie. The Development Envelope covers an area of 9,998 ha and includes four areas of resource: Ambassador, Princess, Shogun and Emperor.

Methods. A desktop review was undertaken to collate existing data on the short-range endemic invertebrate species (SREs) occurring in the vicinity of MRUP, as well as the extent of potential habitats of these species. Selected invertebrate groups that contain a high proportion of SRE species (called SRE Groups) were sampled and detailed habitat descriptions were made during a reconnaissance survey between the 9 and 14 October 2014. A total of 21 sites were sampled by foraging, with 18 sites in proposed impact areas and three sites in areas expected to remain undisturbed. Foraging methods included searching for spider burrows, the excavation of mygalomorph spiders, peeling dry tree bark, turning tree logs and large bark pieces, sifting leaf litter with a soil sieve, and sorting deep soil and bark detritus at the base of large trees. Scorpions were collected at night at three sites using ultraviolet light torches, and by fixing 35 cup traps to the entrance of burrows. Species in SRE Groups were identified using the available taxonomic literature/data sources. SRE status was assessed using a simple three-tier system, and the threat of mining to the species was assessed on the basis of likely distributions of each species.

Results. The desktop review showed that no listed invertebrate species are likely to occur at MRUP. However, there were records of at least 87 species belonging to SRE Groups within a 250 km by 250 km search area surrounding MRUP. A total of 20 species (23% of SRE Group species) were potential SREs: 12 mygalomorph spiders, three millipedes, two centipedes, one araneomorph spider, one pseudoscorpions and one slater. Seven species in the search area were confirmed SREs. The review also showed that some of the potential and confirmed SRE species in the search area have been recorded in habitats similar to those at MRUP.

The reconnaissance survey, undertaken to provide additional information to that of the desktop review, collected at least 32 species belonging to seven SRE Groups. Mygalomorph spiders were the most diverse group (15 species), followed by pseudoscorpions (5), scorpions (4), slaters (3), centipedes (2), millipedes (2) and snails (1). Based on available knowledge, 20 (62%) of the 32 species were considered not to be SREs. The other 12 species (38%) had a moderate or high probability of being SREs. Of these, five species were found outside the Development Envelope and are not of conservation concern. Seven species were collected only within the Development Envelope: eight mygalomorph spiders, one centipede, and one slater. However, these putative SREs occurred in habitats that are common both within and outside the Development Envelope. In addition, the species collected that are closely related to the putative SREs were mostly more widespread in the GVD.

Conclusion. In accordance with the relative uniformity of the landscape and the limited availability of potential SRE habitats, most species belonging to SRE Groups were widespread in the survey area. The proportion of potential SRE species (38%) was similar to the results of nearby regional survey. Although seven potential SRE species are known only from the Development Envelope, the habitats in which these species were collected are common outside this area. It is considered likely that all seven species have wider distributions than the Development Envelope and are unlikely to be threatened by the proposed mine development.

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1. INTRODUCTION

Vimy Resources Limited is proposing to develop the Mulga Rock Uranium Project (MRUP), located about 240 km north east of Kalgoorlie on the western flank of the Great Victoria Desert (Figure 1). The Development Envelope at MRUP covers an area of approximately 9,998 ha on tenure held by Vimy. It includes four areas of resource: Ambassador, Princess, Shogun and Emperor. The MRUP will involve mining uranium ore from open pits, as well as recovering other base and rare earth metals occurring at the base of complete oxidation in the palaeochannel close to or below the water-table. This report assesses whether project development is likely to adversely affect the conservation status of any short-range endemic (SRE) or listed invertebrate species.

SRE invertebrates are species with distributions of less than 10,000 km^2 and their occurrence within their distribution is usually patchy because they are confined to discontinuous habitats. The small ranges of SRE invertebrates, combined with poor dispersal capacities, slow growth and low fecundity, make them particularly vulnerable to habitat loss or disturbance (Harvey 2002; Ponder and Colgan 2002). Guidance Statement 20 (EPA 2009) requires that impacts on SRE invertebrates are considered during environmental impact assessments. In practice, assessment of risk to SRE invertebrates in arid Western Australia is focused on seven taxonomic groups (the *SRE Groups*) that are known to contain high proportions of SRE species: centipedes (Chilopoda), land snails (Pulmonata), millipedes (Diplopoda), pseudoscorpions (Pseudoscorpiones), slaters (Isopoda), scorpions (Scorpiones) and spiders (Araneae).

Listed invertebrate species are those listed under the Western Australian *Wildlife Conservation Act 1950* or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). They may belong to any invertebrate group and are listed because they potentially face severe population reduction, have lost much of their habitat, or are collected intensively.

Information on SRE and listed invertebrate species at MRUP was compiled in a Level 1 survey consisting of two components: a desktop review and a reconnaissance fauna survey. The desktop review aimed to collate existing information on SREs and listed invertebrates in the vicinity of MRUP, as well as information on likely SRE habitats within the Development Envelope. The reconnaissance survey was undertaken to validate the results of the desktop review through limited sampling of the Development Envelope and the immediate vicinity for the seven SRE Groups mentioned above, and to provide detailed information about habitats suitable for SRE species.

The specific objectives of this report were:

1) To characterise habitats and classify landforms according to their suitability for listed or SRE invertebrate species;
2) To identify any listed and SRE invertebrate species that may occur in the vicinity of MRUP, and to identify the species actually occurring within the Development Envelope; and
3) To evaluate the likelihood of threat to listed or SRE species arising from mining at MRUP.

2. FRAMEWORK

2.1 Project Description

The MRUP lies approximately 240km east-north-east of Kalgoorlie-Boulder in the Shire of Menzies (Figure 1). The area is remote, located on the western flank of the Great Victoria Desert, comprising series of large, generally parallel sand dunes, with inter-dunal swales and broad flat plains.

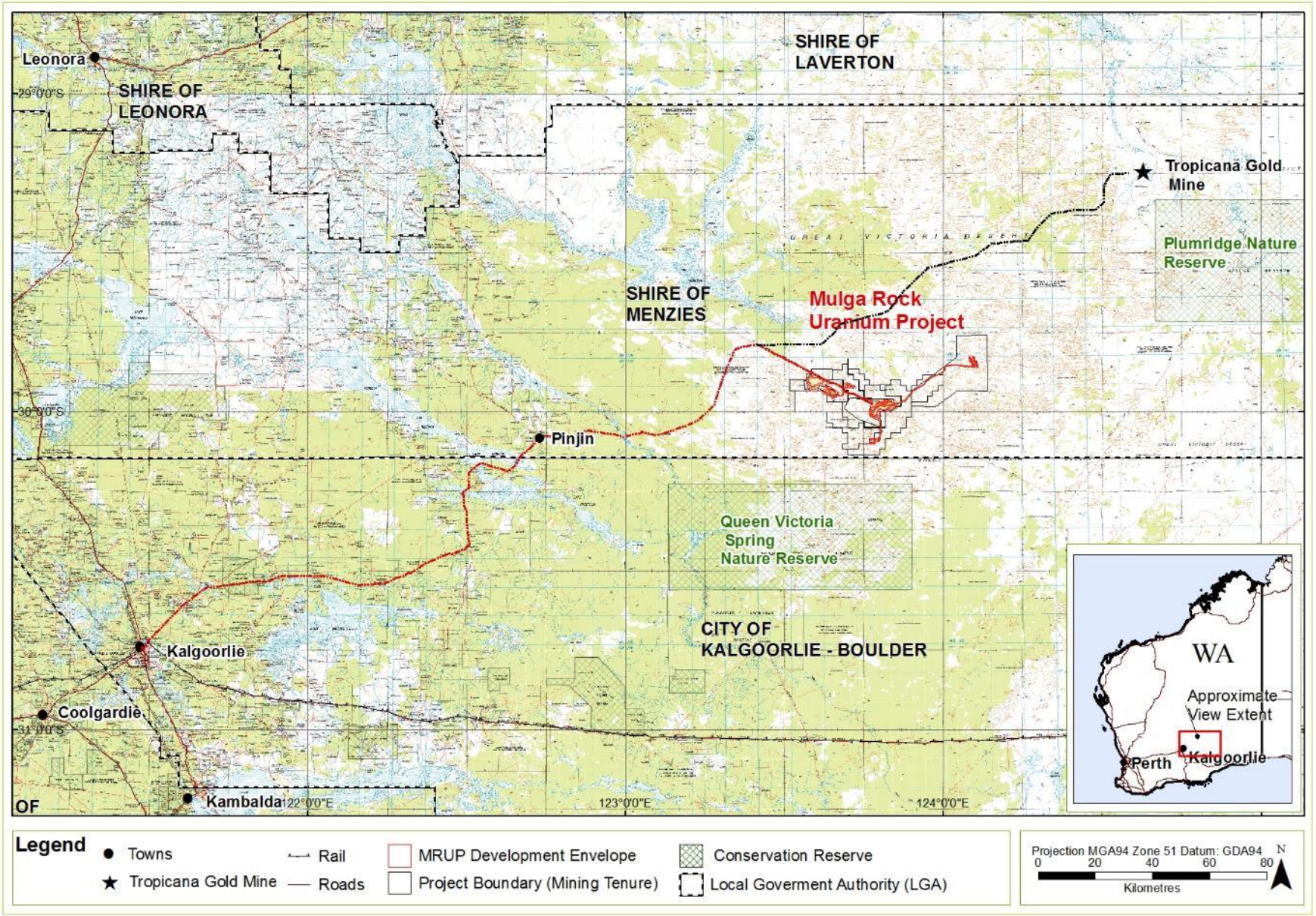

Figure 1. Location of the Mulga Rock Uranium Project.
The MRUP is located between the Queen Victoria Spring-and Plumridge Nature Reserves in the Great Victoria Desert. The Development Envelope covers an area of ca. 9,872 ha on tenure held by Vimy.

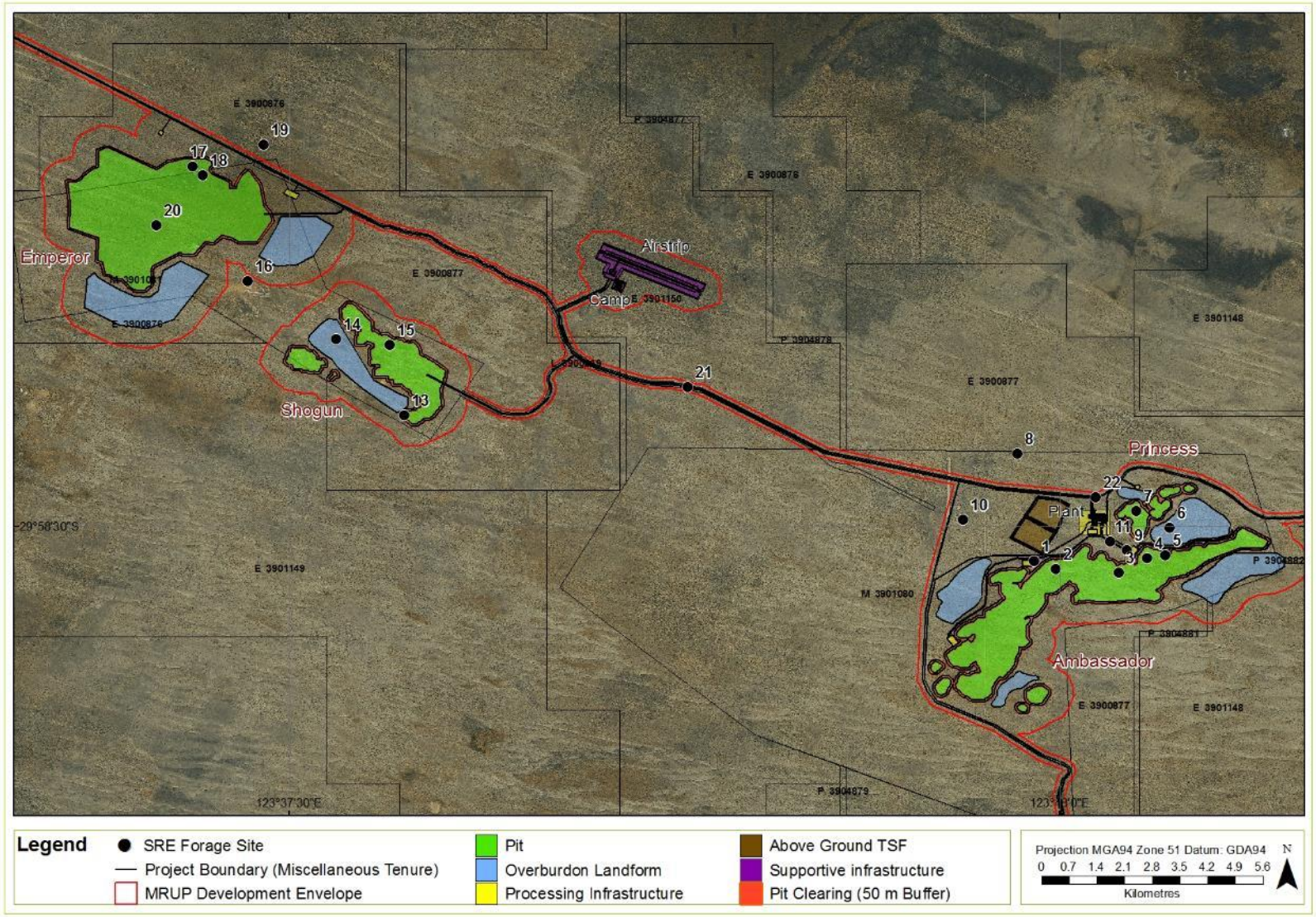

Figure 2. Detailed view of the Mulga Rock Uranium Project.
The MRUP consists of four resource areas: Ambassador, Princess, Emperor and Shogun, and associated infrastructure. The 21 foraging sites in the reconnaissance survey are indicated as black circles (there is no site 12). Tenement boundaries are given as black lines and numbered (e.g. E 39/1149). Proposed mining infrastructure (open pits, waste rock landform, plant, ponds etc.) are shaded rusty red and buffer zones are delineated by dark red lines.

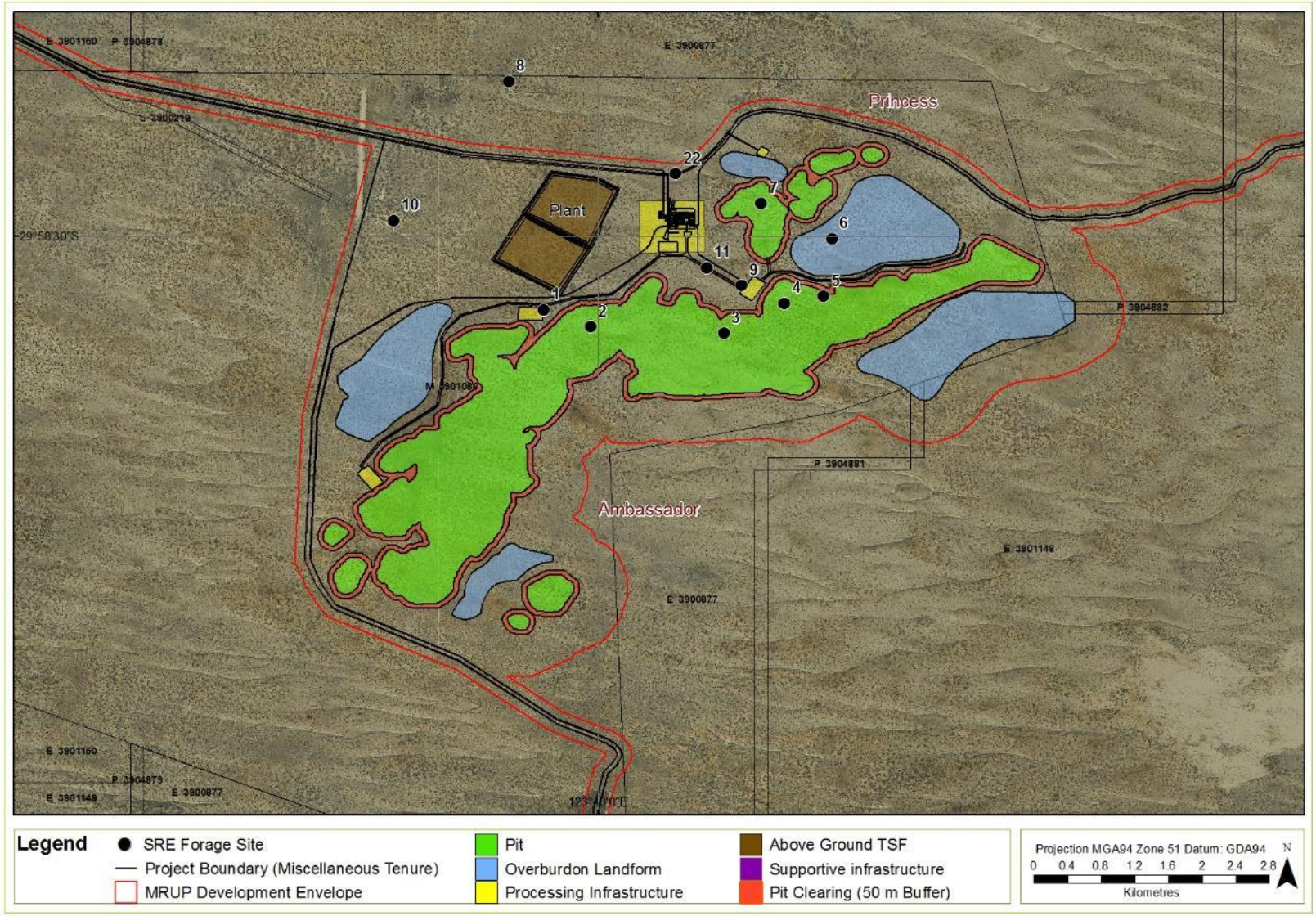

Figure 3. Expanded view of SRE foraging sites at Princess and Ambassador.

Access to MRUP is limited and is possible only using four-wheel-drive vehicles. The nearest residential town to MRUP is Laverton, which lies approximately 200km to the north-west. Other regional residential communities include Pinjin Station homestead located approximately 100km to the west, Coonana Aboriginal community situated approximately 130km to the south-south-west, Kanandah Station homestead positioned approximately 150km to the south-east and the Tropicana Gold Mine lying approximately 110km to the north-east.

The MRUP covers approximately 102,000 hectares on granted mining tenure (primarily M39/1080 and M39/1081) within Unallocated Crown Land. It includes two distinct mining centres: an eastern centre comprising the Princess and Ambassador resources and western centre comprising the Emperor and Shogun resources, which are approximately 20km apart (Figures 2, 3). Princess and Ambassador contain over 65% of the total recoverable uranium, which is of a higher grade than at Emperor and Shogun. Mining will commence at the eastern centre, where the processing plant will be located. Up to 4.5 Million tonnes per annum (Mtpa) of ore will be mined using traditional open cut techniques, crushed, beneficiated and then processed at an acid leach and precipitation treatment plant to produce, on average, 1,360 tonnes of uranium oxide concentrate (UOC) per year over the life of the Project. The anticipated Life-of-Mine (LOM) is up to 16 years, based on the currently identified resource.

Other metal concentrates will be extracted using sulphide precipitation after the uranium has been removed and then sold separately. These metal concentrates will not be classified as radioactive. The UOC product will be sealed in drums and transported by road from the mine site in sealed sea-containers to a suitable port (expected to be Port Adelaide) which is approved to receive and ship Class 7 materials for export.

The MRUP will require the clearing of vegetation, borefield abstraction, mine dewatering and reinjection of groundwater, the creation of above-ground and in-pit overburden (non-mineralised) and tailings landforms and the construction of on-site processing facilities and associated infrastructure. Key infrastructure will include mine administration and workshop facilities, fuel and chemical storage depots, a diesel-fired power plant of up to 20 megawatt (MW) capacity and distribution network, a saline groundwater abstraction borefield and a saline mine water reinjection borefield with associated pipelines and power supply units, an accommodation village servicing a fly-in / fly-out workforce, an airstrip, laydown areas and other supporting ancillary infrastructure including communications systems, roads, a waste water treatment plant and solid waste landfill facilities. Transport to site for consumables, bulk materials and general supply items will be via existing public road systems linked to dedicated Project site roads, branching off the Tropicana Gold Mine access road.

At the completion of operations, the Project site will be decommissioned and rehabilitated in accordance with an approved Mine Closure Plan.

2.2 Conservation framework

Protection of native flora and fauna in Western Australia is provided at both state and federal levels. At the federal level, a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places is provided via the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

At the state level, native flora and fauna are protected under the *Wildlife Conservation Act 1950* (in particular Section 14, pp. 8-9). The highest level of protection is given to Schedule 1 species that are considered rare, likely to become extinct, or otherwise in need of special protection. The current list of threatened species is the Wildlife Conservation (Specifically Protected Fauna) Notice 2014.

The Department of Parks and Wildlife (DPaW) also maintains a list of priority fauna species that are of conservation importance but, for various reasons, do not meet the criteria for listing as threatened. The current list from December 2014 includes 112 terrestrial invertebrate species: seven insects, 26 arachnids, 22 crustaceans, 22 millipedes and 35 molluscs (DPaW, 2014).

Sampling methods for SRE invertebrates are outlined in the Guidance Statement 20 (EPA 2009), which also provides a theoretical framework for SRE assessments and sampling protocols.

3. DESKTOP REVIEW

A desktop review process was used to assess whether any listed invertebrate species or a significant SRE community was likely to occur at MRUP. The assessment of the SRE community focussed on the seven SRE Groups that are usually targeted during environmental surveys in arid areas: centipedes (Chilopoda), land snails (Pulmonata), millipedes (Diplopoda), pseudoscorpions (Pseudoscorpiones), slaters (Isopoda), scorpions (Scorpiones) and spiders (Araneae).

Records of species belonging to the SRE Groups or listed species were compiled for a 250 by 250 km search area surrounding the MRUP (29°59'S; 123°47'E) from the Western Australian Museum (WAM) database, published research papers, available environmental reports, and online sources such as the Atlas of Living Australia (ALA) and DPaW's NatureMap web page. This was done to assess the wider occurrence of SRE species in the vicinity of MRUP and to identify any SRE or listed species that have been recorded in this area previously. The search area spanned the western section of the Great Victoria Desert and Eastern Goldfields and included many environments that are geologically and climatically similar to that at MRUP. A relatively wide search area, 250 km by 250 km, was used here because the invertebrate fauna of the Great Victoria Desert is generally not well documented whereas more data are available for the adjacent Goldfields.

Published research papers and publicly available environmental reports for the Great Victoria Desert and Eastern Goldfields (Murchison and Coolgardie bioregions; Figure 1) were used to identify habitats potentially suitable for SRE species. Using high-resolution satellite imagery provided by Vimy, the Project area was split into distinct habitat types which were evaluated further according to four criteria: the likely availability of moisture, soil structure, vegetation type and extent of shading or shelter. The emphasis was on identifying 'relict' habitats (sheltered, moist) and those that may contain specialist species (e.g. rocky outcrops).

3.1 Determining SRE status

It can be difficult to determine whether or not a species belonging to a SRE Group is actually a SRE species with a range <10,000 km^2 (many species in SRE Groups have ranges >10,000km^2). For desktop review, SRE status was determined by staff at WAM when they provided results of the search of WAM database, unless explicit information was available from other sources.

The SRE status of species collected during reconnaissance survey was determined by Bennelongia using a three-rank SRE classification:

Rank 1: The species has a high probability of being a SRE based on expert opinion, literature or reference databases. Usually, the species will belong to a group that is well studied taxonomically and contains a high proportion of regionally endemic species.

Rank 2: The species has a moderate probability of being a SRE, given that the species belongs to a group with a high proportion of SRE species and has been collected from a single microhabitat, or has an ecology or morphology that suggests habitat specialisation and range restriction.

Rank 3: This species has a low probability of being a SRE, given the species belongs to a group that has a low or moderate proportion of SRE species, has been collected from diverse microhabitats across its known range or is locally common.

It should be recognised, however, that identifying SRE species is just part of the process used to determine whether species may be threatened by development (or other natural processes such as bushfires). While SRE species have the potential to be threatened because their ranges may fall entirely within an area of disturbance, the actual level of threat to species depends on the extent to which their ranges are confined to the Development Envelope and the actual Disturbance Footprint within the Development Envelope. Most SRE species found inside MRUP are likely to also occur outside the Development Envelope and, thus, will not be threatened.

3.2 Great Victoria Desert

The Great Victoria Desert is the largest desert in Australia and dominated by extensive dune fields of Quaternary aeolian sands that overlay Permian and Mesozoic strata of several palaeobasins (Barton and Cowan 2002a). The Great Victoria Desert can be broken down into subregions (Barton and Cowan 2002a; Barton and Cowan 2002b) of which the Great Victoria Desert Shield subregion (GVD1) borders on the Eastern Goldfields. The GVD1 has a higher proportion of sandplains than other subregions of the Great Victoria Desert but also includes landforms such as salt lakes and major valley floors with lake-derived dunes (Barton and Cowan 2002a). The topography is mostly flat but there are areas of moderate relief with out-cropping and silicate-capped plateaus. Hummock grasslands and open low tree steppe (mulga over *Triodia scariosa*) are the predominant vegetation forms.

Owing to its arid climate, lack of topographic diversity and the predominance of open vegetation types, the Great Victoria Desert may appear to be unsuitable for SRE species with high moisture dependence. However, habitat specialist species may occur, as well as groups that have radiated extensively in the arid regions since the Miocene, such as mygalomorph spiders (trapdoor spiders and allies).

3.3 Previous Fauna Surveys

There has been no systematic fauna survey in the Great Victoria Desert to date and the few scientific studies conducted have focussed entirely on vertebrate diversity, ecology and taxonomy (e.g. Burbidge *et al.* 1976, Burbidge and Fuller, 1979; Pianka 1994; Brennan *et al.* 2012). There are few reports dealing with SREs in the Great Victoria Desert and Eastern Goldfields, although there have been surveys at Mt Henry (Bennelongia 2013b), Ularring (Bennelongia 2011b), and the Aphrodite and Majestic Gold Prospect (Bennelongia 2011a; Bennelongia 2013a; Terrestrial Ecosystems 2010). Other fauna surveys have focussed on the vertebrate fauna only (Martinick *et al.* 1986; Ninox Wildlife Consulting 2010).

The most important SRE invertebrate survey to date was conducted at the Tropicana Gold Project, located ca. 110 km north east of the Project area (ecologia Environment 2009a,b). This survey reported an "unexpectedly rich" invertebrate biodiversity consisting of 46 species from SRE Groups, of which 19 species (41%) were of conservation significance. The high number of conservation significant species may have geological causes. The Tropicana Gold Project is located at the junction of the Yilgarn Craton and the Fraser Range Mobile Belt and is unusual in having a high proportion of near-surface weathered bedrock and ferruginous and siliceous duricrusts (360 Environmental 2009; Lawrance 2009). Lateritic weathering profiles are also present and the interdunal areas are often windswept and expose the red-brown earth, colluvium or the ferruginous hard cap (360 Environmental, 2009). These features have a relatively high moisture-holding capacity and greater potential for SRE fauna.

There is less diversity of landforms and soil types at MRUP than Tropicana. MRUP is dominated by alluvial sand dunes, yellow sand plains and open *Eucalyptus* woodlands on mixed red/yellow sands (Figure 4). Unlike Tropicana, there are no rocky outcrops, laterite breakaways and deep ferruginous

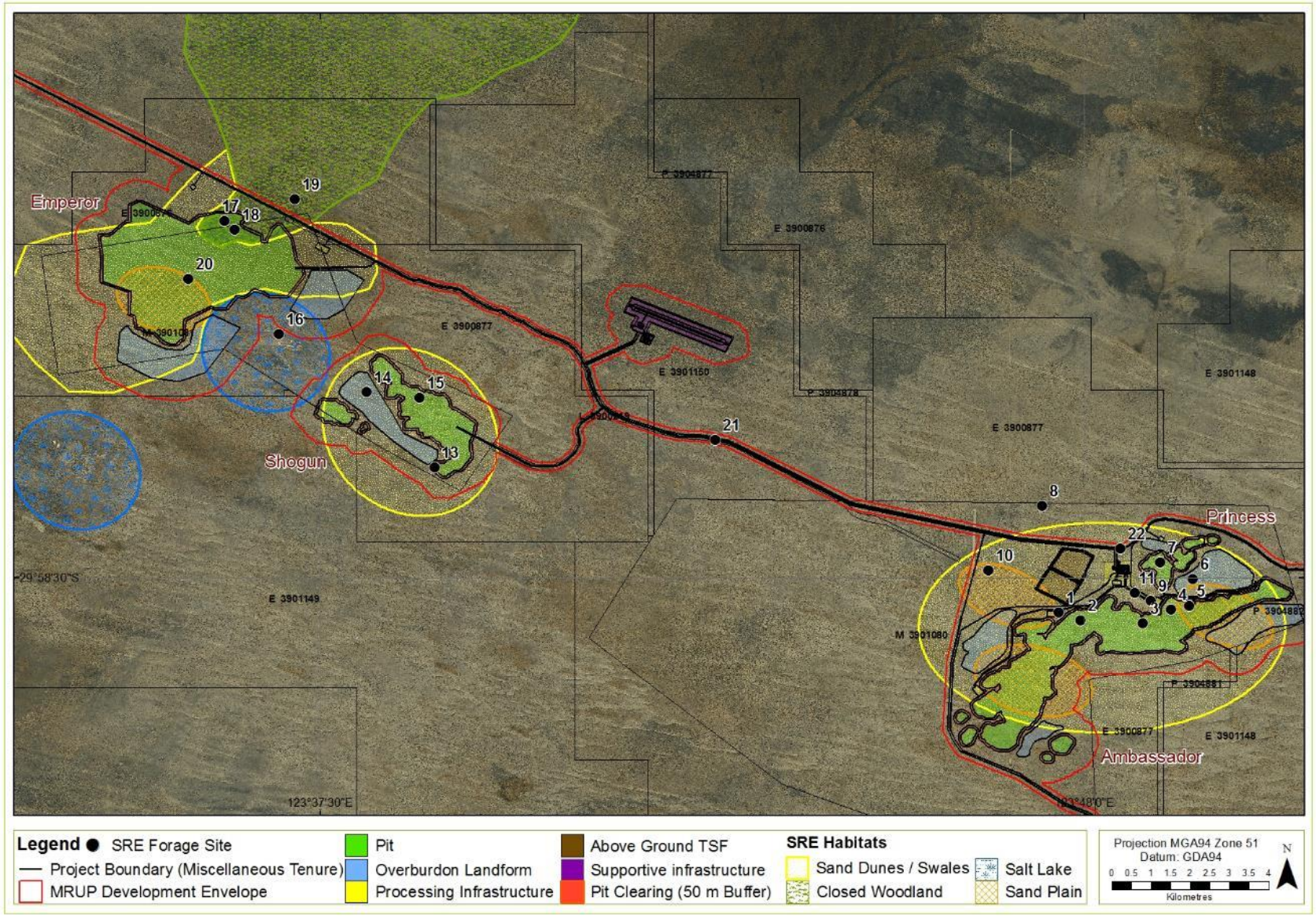

Figure 4. Potential SRE habitats at the Project.
Four habitats are likely to be important to SRE communities: i) sand dunes and associated swales; ii) open sandplains; iii) dry salt lakes and associated claybanks; and iv) closed *Eucalyptus* woodlands.

hard caps that may have a higher moisture-holding capacity and often provide local refugia for SRE fauna (e.g. Nistelberger *et al.* 2014; Slatyer *et al.* 2007).

The most diverse group at Tropicana was mygalomorph spiders with 26 putative SRE species in five families. Other groups were much less diverse (e.g. scorpions, six species; pseudoscorpions, five species) and had a much lower proportion of threatened species. A new genus of Wishbone Spider, *Swolnpes* Main and Framenau 2009, was described from material collected at Tropicana and the two species in this genus are considered to be SREs (Main and Framenau 2009).

3.4 Habitat Characterisation

Preliminary habitat characterisation at MRUP was undertaken using satellite imagery, contours and vegetation mapping (Figure 4). Emphasis was given to the identification of habitats likely to support a suitable microclimate for SREs, e.g. long unburnt sites with high vegetation cover, south-facing slopes, breakaways and tributaries. The main focus was on the Ambassador and Princess deposits because they will be developed first.

3.4.1 SRE Habitats

There are four potential SRE habitats at MRUP: i) flat and exposed sandplains; ii) aeolian sand dunes and associated swales; iii) dry salt lakes and adjacent lunettes; and iv) closed *Eucalyptus/Callitris* woodlands on red sands (Figure 4). The sandplains and aeolian sand dunes are by far the most common and widespread habitats at MRUP, especially at Ambassador, Princess and Shogun. Closed woodlands on red sands were less common and restricted to the northern section of Emperor. Dry salt lakes and lunettes were the least common habitats and found only in a small area between the Shogun and Emperor.

The two most common SRE habitats, aeolian sand dunes and sandplains, are a characteristic feature of the GVD1 and more or less uniformly spread across this region. The associated vegetation features, hummock grasslands and open low tree steppe (Barton and Cowan 2002a) are also widespread. It appears unlikely that the ranges of invertebrate species in these habitats are restricted by landscape features and wide distributions are expected. The two remaining habitats, closed *Eucalyptus* woodlands and dry salt lakes, are also common in the GVD1 but distributed patchily across the landscape. Their localised nature may lead to some invertebrate species have relatively small ranges.

Vegetation mapping for all four resource areas was based on the results of flora and vegetation survey by Mattiske Consulting (2013) and five major habitats were identified, ranging from tall *Eucalyptus* woodlands, through open mallee woodland, to low spinifex shrubland without trees (Figures 5, 6). These vegetation features provide different levels of ground cover and shade. The tall woodlands may have greater moisture retention capacity than other habitats, and may foster species belonging to SRE Groups (although the Great Victoria Desert is expected to be unsuitable for species with high moisture dependence).

Overall, MRUP appeared to be depauperate in landforms suitable for SRE communities because of:

1) Uniform surface geology predominated by aeolian sands that have a low moisture-holding capacity;
2) Lack of topographic diversity other than the change between seif dunes and associated swales/flats;
3) Absence of features retaining moisture, such as river tributaries, gullies or lakes; and
4) Predominantly open vegetation that does not provide shade and ground cover (e.g. leaf litter), and a long-lived natural bushfire cycle that exhibits episodic major denudation of the understorey. Climate

Figure 5. Habitats at Ambassador and Princess.

Six vegetation types of potential relevance to SRE fauna can be distinguished: i) tall woodlands; ii) low open woodlands; iii) open mallee; iv) open shrublands; v) low shrublands; and vi) disturbed areas. Mapping is based on the vegetation communities identified by Mattiske Consulting (2013).

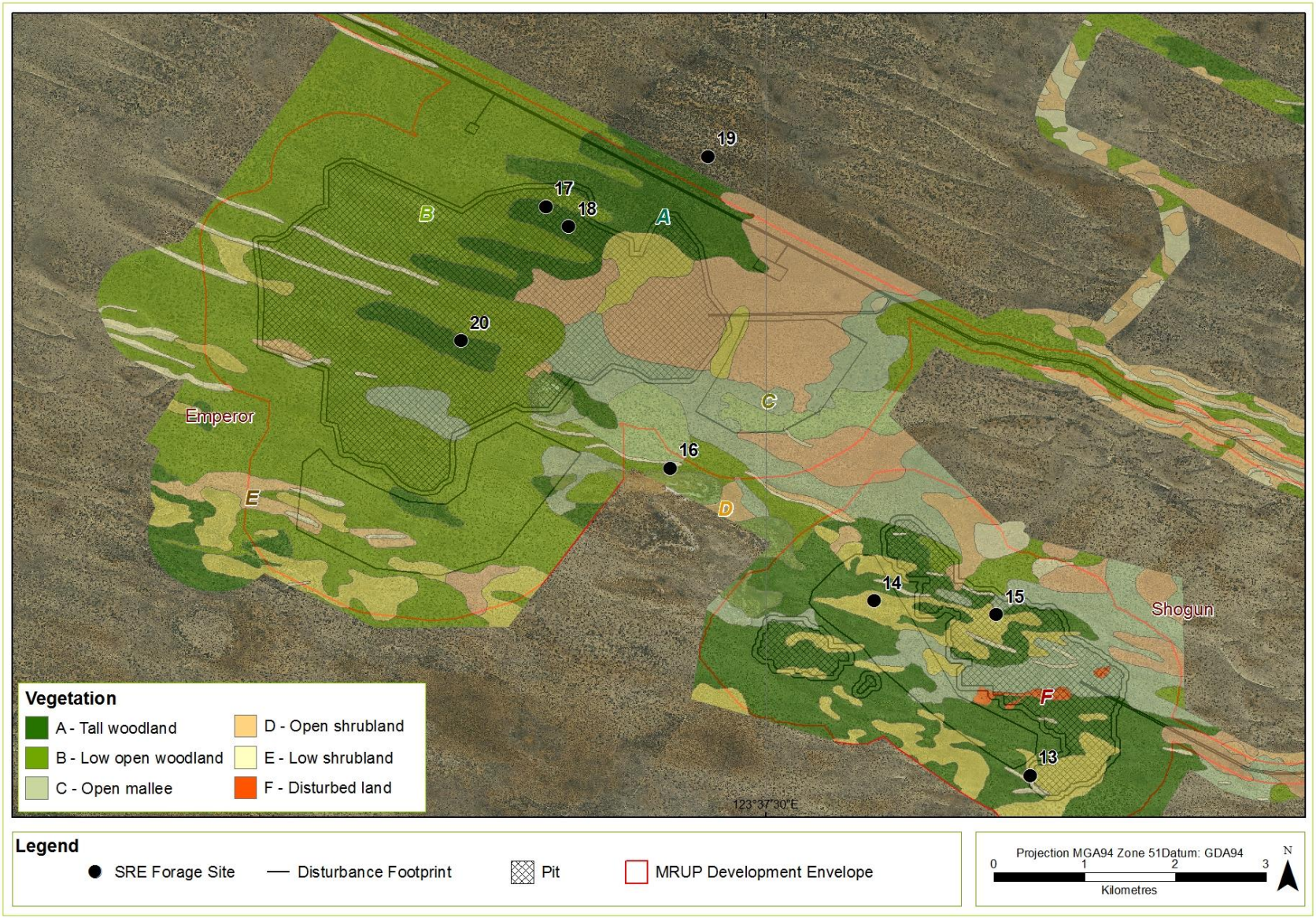

Figure 6. Habitats at Emperor and Shogun.
Six vegetation types of potential relevance to SRE fauna can be distinguished: i) tall woodlands; ii) low open woodlands; iii) open mallee; iv) open shrublands; v) low shrublands; and vi) disturbed areas. Mapping is based on the vegetation communities identified by Mattiske Consulting (2013).

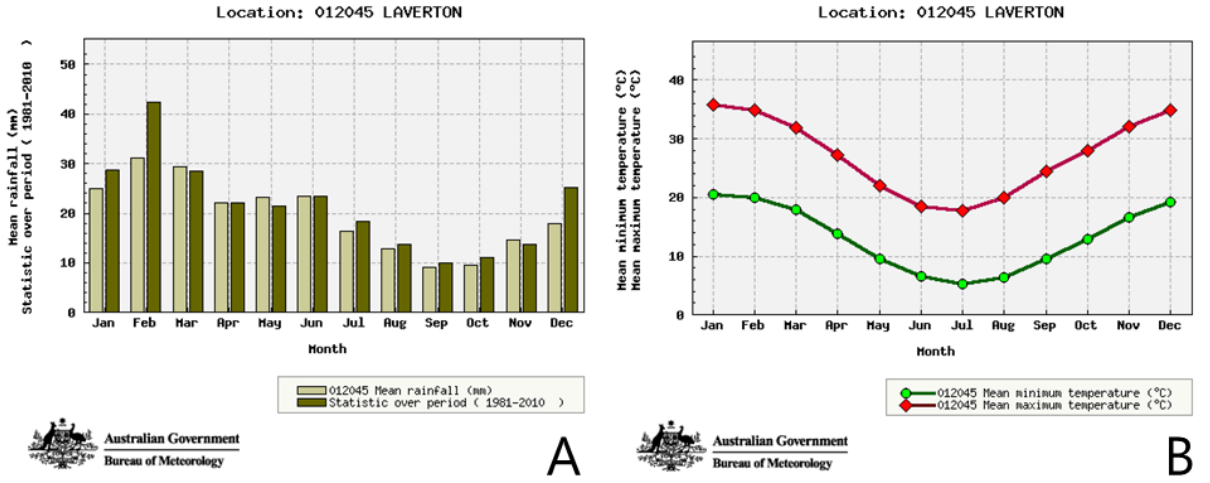

Figure 7. Mean rainfall and mean temperatures for Laverton 1981 – 2010.

The GVD1 has an arid climate, with summer and winter rain approximately 190mm per year (Barton and Cowan 2002a). The weather stations with comprehensive records closest to MRUP are Laverton ca. 200 km north-west (Table 1) and, to a lesser extent, Balgair for which only limited data are available (1983-2012). Rainfall data from Edjudina, ca. 140 km west of MRUP, is not markedly different from Laverton. Local weather data collected at MRUP since 2009 suggest that under typical conditions rainfall averages about 200mm, with greater than 600mm rainfall recorded in an exceptionally wet year (2011).

The majority of rainfall occurs in summer between January and June and is usually associated with cyclonic rainfall extending inland (Figure 7). Dry periods are frequent and years with almost no rainfall have been recorded (e.g. 65.6mm at Laverton in 1928). The winter and spring months (August-November) are very dry and rainfall is uncommon. Temperatures can vary greatly but are usually highest in spring and summer (October-March). Daily maxima can exceed 40 °C at Laverton and Balgair but night frosts may occur. Over the period 2009-2014, maxima and minima of 44.3 °C and -5.8 °C were recorded at the Project, in January and August 2014 respectively.

The 12 months preceding the survey were reasonably wet by local standards, with rainfall of 290 mm averaged across three weather stations within MRUP.

Table 1. Climatic data for Laverton (Weather Station 012027) since 1899.

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum temperature (°C)	35.8	34.8	31.9	27.2	22.1	18.5	17.8	20.0	24.5	28.0	32.1	34.9	27.3
Mean minimum temperature (°C)	20.5	20.0	18.0	13.9	9.5	6.6	5.2	6.4	9.5	12.8	16.6	19.3	13.2
Mean rainfall (mm)	25.0	31.1	29.4	22.1	23.2	23.4	16.3	12.9	9.0	9.6	14.6	17.9	234.5
Solar exposure	27.6	24.4	21.2	16.9	13.5	11.5	12.8	16.6	20.9	24.7	27.4	28.2	20.5

Data courtesy of the Australian Bureau of Meteorology website (2012).

4. LISTED SPECIES

No species listed in the Threatened and Priority Fauna Rankings have been recorded from the Great Victoria Desert but three threatened species are known to occur in the Eastern Goldfields: namely the Arid Bronze Azure Butterfly (*Ogynes subterrestris petrina,* critically endangered), the Inland Hairstreak Butterfly (*Jalmenus aridus*, priority 1: poorly-known species on threatened lands) and the trapdoor spider *Kwonkan moriartii* (priority 2: poorly-known species on conservation lands). The latter species was described from a single male at Kathleen Valley Station (Main 1983), more than 400 km north-

west of the Project area, and has not been collected since. It is unlikely to occur at MRUP. Nothing is known about its preferred habitat and an assessment of its ecology, based on the very imprecise locality data available, is not possible.

The Arid Bronze Azure Butterfly has been recorded only from a small area between Coolgardie and Kalgoorlie (ALA data, 2015) and has a low probability of occurrence at MRUP. Similarly, the Inland Hairstreak Butterfly is known mostly from multiple sites in Kalgoorlie although there is an isolated record of the latter species from Ngaanyatijarraku in the Gibson Desert (ALA data, 2015), perhaps indicating that this species is widespread but rarely collected.

5. SRE SPECIES

The desktop review identified the presence of at least 96 species belonging to SRE Groups in the search area (Table 2): comprising mygalomorph spiders (46 species), araneomorph spiders (1), centipedes (12), scorpions (11), pseudoscorpions (8), land snails (10), millipedes (5) and isopods (3). The list contained 38 described species but the remaining 60% of species were undescribed.

Of the 85 species for which SRE status could be assessed, 62 species (73%) were considered unlikely to be SREs. Based on current information, seven species are regarded as SREs and a further 16 species are potentially SREs. They comprise 16 species of mygalomorph spiders, three millipedes, two centipedes, one pseudoscorpion and one isopod.

Mygalomorph Spiders: Mygalomorph spiders were by far the most frequently documented SRE Group in the search area and the families Nemesiidae (Wishbone spiders; 19 species), Idiopidae (True Trapdoor spiders; 14 species) and Barychelidae (Brushed Trapdoor spiders, 8 species) were diverse. Mygalomorph spiders had a relatively high proportion of SRE or potential SRE species (16 species; 35%) compared with other arachnids. Given that mygalomorph spiders are increasingly recognised for their high proportion of SRE species (Castalanelli *et al.* 2014; Harms and Framenau 2013) and that a taxonomic revision of the Brushed Trapdoor spiders in the Eastern Goldfields/Great Victoria Desert clearly illustrates regional endemism (Raven 1994), the presence of range restricted mygalomorph species at MRUP appears likely.

Araneomorph Spiders: The WAM database lists one species of Lynx Spider, *Oxyopes gratus*, as a potential SRE species that is known in Western Australia only from Yundamindra. ALA data, however, clearly demonstrate a wider distribution that includes several records from the Northern Territory, Queensland, and Victoria. *Oxyopes gratus* is not a SRE species.

Pseudoscorpions: There was a moderately diverse fauna of eight species in three families. As expected in desert habitats, the arid-adapted family Olpiidae was most diverse with at least five genera. Olpiid species are usually widespread (ecologia Environment 2009a; Phoenix 2011). Therefore, none of the olpiid species in the search area was classified as a SRE.

Scorpions: The fauna within the search area consists primarily of arid-adapted species that are widespread across the sandy deserts of Western Australia (Volschenk *et al.* 2010; Volschenk *et al.* 2012). ALA data also illustrates that all described species in the Eastern Goldfields and Great Victoria Desert have wide distributions.

Slaters: The isopod fauna of the Great Victoria Desert is virtually unknown but three species in the family Armadillidae were recorded from the Tropicana Gold Project north east of MRUP (ecologia Environment 2009a). Short-range endemism in the slater fauna of south-western Australia is pronounced (Judd and Horwitz 2003) and the presence of range-restricted armadillid isopods at MRUP is possible, with one of the species collected from the Tropicana Gold Project being a potential SRE species.

Table 2. SRE Groups recorded previously from the search area.
Records collated from the WAM database, published information, online databases and publically available environmental reports. Species 'sp. indet' are records based on juvenile or female specimens that cannot be identified based on morphology. 1= WAM database and WAM staff interpretation of SRE status.

Taxonomic Groups	Species	SRE Status	No. of Records	Source/Reference
Arachnida				
Araneae (Mygalomorphae)				
Actinopodidae	*Missulena occatoria*	No	2	1, Harms and Framenau 2013
	Missulena sp. indet.	NA	3	1
Barychelidae	*Aurecocrypta lugubris*	No	1	1; Raven 1994
	Idiommata sp. indet.	NA	2	1
	Mandjelia humphreysi	No	NA	ecologia 2009a
	Mandjelia sp. 'Wanjarri'	Potential	2	1
	Synothele arrakis	No	2	2, Raven 1994
	Synothele meadhunteri	No		ecologia 2009a
	Synothele yundamindra	Yes	1	1, Raven 1994
	Synothele 'megaspiral'	Potential	1	ecologia 2009a
Dipluridae	*Cethegus ischnotheloides*	No	1	1, Raven 1983
Idiopidae	*Aganippe* 'Tropicana sp. 1'	Potential	1	ecologia 2009a
	Aganippe 'Tropicana sp. 2'	No	6	ecologia 2009a
	Aganippe 'Tropicana sp. 3'	Potential	2	ecologia 2009a
	Aganippe 'Tropicana sp. 4'	Potential	1	ecologia 2009a
	Aganippe 'Tropicana sp. 5'	Potential	2	ecologia 2009a
	Aganippe 'Tropicana sp. 6'	Potential	1	ecologia 2009a
	Aganippe 'Tropicana sp. 7'	No	4	ecologia 2009a
	Aganippe 'Tropicana sp. 8'	Potential	2	ecologia 2009a
	Aganippe 'occidentalis group'	No	3	1
	Aganippe 'MYG017'	No	1	1
	Anidiops manstridgei	No	6	ecologia 2009a ; ALA data
	Anidiops villosus	No	4	1
	Eucyrtops eremaea	Yes	2	1, Main 1957
	Euoplos sp. indet.	NA	9	1
Nemesiidae	*Aname mellosa*	No	11	1, Raven 2000
	Aname tepperi	No	3	1; ecologia 2009a; Raven 2000
	Aname 'Tropicana sp. 1'	No	1	ecologia 2009a
	Aname 'Tropicana sp. 2'	Potential	6	ecologia 2009a
	Aname 'Tropicana sp. 3'	No	3	ecologia 2009a
	Aname 'Tropicana sp. 4'	No	1	ecologia 2009a
	Kwonkan goongarriensis	Yes	3	1, Main 1983
	Kwonkan 'Tropicana sp. 1'	Potential	1	1, Castalanelli *et al.* 2014
	Kwonkan 'Tropicana sp. 2'	Potential	7	1
	Swolnpes darwini	Yes	4	Main and Framenau 2009
	Nemesiidae n. gen. n. sp. 1	Potential	2	ecologia 2009a
	Nemesiidae sp. 'A' (Laverton)	No	76	1
	Nemesiidae sp. 'B' (Laverton)	No	12	1
	Nemesiidae sp. 'C' (Laverton)	No	2	1
	Nemesiidae sp. 'D' (Laverton)	No	1	1
	Nemesiidae sp. 'E' (Laverton)	No	1	1
	Teyl 'Tropicana sp. 1'	No	4	ecologia 2009a
	Teyl 'Yundamindra'	No	10	1
	Teyl 'Lake Carey'	NA	4	1
Theraphosidae	*Selenocosmia* sp. indet	NA	3	1
	Selenotholus foelschei	No	1	1
Araneae (Araneomorphae)				
Oxyopidae	*Oxyopes gratus*	No	1	1, ALA 2015

Taxonomic Groups	Species	SRE Status	No. of Records	Source/Reference
Pseudoscorpiones				
Chernetidae	Chernetidae sp. indet	NA	1	1, ecologia 2009a
Chthoniidae	*Tyrannochthonius* sp. indet.	Potential	13	1
Olpiidae	*Austrohorus* sp. indet	No	1	1, ALA 2015
	Beierolpium sp. 8/3	No	2	1, ecologia 2009a
	Euryolpium sp.	No	1	ecologia 2009a
	Indolpium sp. indet	No	1	1, ALA 2015
	Xenolpium sp.	No	1	1, ALA 2015
	Olpiidae indet.	NA	4	1
Scorpiones				
Buthidae	*Isometroides vescus*	No	2	1, ALA 2015
	Isometroides sp. indet.	No	2	1
	Lychas annulatus	No	16	1
	Lychas jonesae	No	7	1
	Lychas marmoreus splendens	No	1	1
	Lychas sp. *'adonis'*	No	20	ecologia 2009a
	Lychas sp. indet.	NA	2	1
Urodacidae	*Urodacus armatus*	No	125	1, ALA 2015, Koch 1977
	Urodacus hoplurus	No	37	1, ALA 2015, Koch 1977
	Urodacus similis	No	4	1, ALA 2015, Koch 1977
	Urodacus yaschenkoi	No	5	1, ALA 2015, Koch 1977
Crustacea				
Isopoda				
Armadillidae	*Buddelundia* sp. nov.	No	8	ecologia 2009a
	Platyarthridae sp. nov.	No	5	ecologia 2009a
	Pseudolaureola sp. nov.	Potential	10	ecologia 2009a
Chilopoda				
Geophilomorpha				
Chilenophilidae	'Genus indet, Sp. Indet.'	Potential	1	1
Oryidae	*Orphnaeus brevilabiatus*	Potential	3	1, Bennelongia 2011b
Scolopendromorpha				
Cryptopidae	'Genus indet, Sp. Indet.'	NA	1	1
Scolopendridae	*Arthrorhabdus paucispinus*	No	2	1, ALA 2015
	Cormocephalus aurantiipes	No	1	1, ALA 2015
	Cormocephalus michaelseni	No	1	1, ALA 2015
	Cormocephalus turneri	No	15	1, ALA 2015
	Ethmostigmus curtipes	No	19	1, ALA 2015
	Scolopenedra laeta	No	40	1, ALA 2015
	Scolopendra morsitans	No	30	1, ALA 2015
Scutigeromorpha				
Scutigeridae	*Pilbarascutigera* sp.	Unlikely	1	1
	Thereuopoda 'lesueurii'	Unlikely	2	1, ALA 2015
Diplopoda				
Polydesmida				
Paradoxosomatidae	*Antichiropus* sp. 'Butterfly'	Yes	1	1, Car and Harvey 2014
	Antichiropus sp. Tropicana 1'	Yes	5	1, Car and Harvey 2014
	Antichiropus sp. Tropicana 2'	Yes	2	1, Car and Harvey 2014
Polyzoniida				
Family indet.	'Genus indet, Sp. indet.'	Unlikely	1	ecologia 2009a
Polyxenida				
Synxenidae	'Genus indet, Sp. indet.'	Unlikely	1	ecologia 2009a
Gastropoda				
Helicoideaea				
Camaenidae	*Sinumelon kalgum*	No	3	1; ALA 2015
	Sinumelon tarcoolanum	No	4	1; ALA 2015

Taxonomic Groups	Species	SRE Status	No. of Records	Source/Reference
	Sinumelon vagente	No	1	1; ALA 2015
	Sinumelon sp. indet.	NA	1	1
Orthalicoidea				
Bothriembryontidae	*Bothriembryon distinctus*	No	1	1; ALA 2015
	Bothriembryon sp.	NA	2	1
Pupilloidea				
Pupillidae	*Gastrocopta bannertonensis*	No	2	ecologia 2009a, ALA 2015
	Pupoides adelaidae	No	3	1, ALA 2015
	Pupoides cf. *myoporinae*	Unlikely	2	1
	Pupilla australis	No	1	1, ALA 2015

Centipedes: There was a moderately diverse centipede fauna in the search area with ten species in three families. The family Scolopendridae contains widespread species of the arid regions, as does the family Scutigeridae (Helix Molecular Solutions 2009; Waldock and Edgecombe 2012). The scolopendromorph family Cryptopidae may contain SRE species and the SRE status of the species of an unknown genus recorded in the search area could not be determined. The two species collected of geophilomorph families Chilenophilidae and Oryidae were considered to be potential SRE species by WAM staff.

Millipedes: Most millipedes are moisture-dependent and common in habitats with permanent moisture. Such habitats are rare in the search area and, as a consequence, the millipede fauna is poor. Three SRE species of *Antichiropus*, a genus consisting almost exclusively of SRE species (Car and Harvey 2014; Car *et al.* 2013b) have been recorded in the search area, two of which are from the Tropicana Gold Prospect.

Land snails: Three families have been recorded in the search area but the more frequently collected genera, *Sinumelon* (Camaenidae) and *Pupoides* (Pupillidae), contain few SRE species (Whisson and Kirkendale 2014).

6. DESKTOP FINDINGS

The desktop study identified the occurrence of three Schedule 1 species (under the WC Act) in the Eastern Goldfields but showed all three species are unlikely to occur at MRUP.

Only a few invertebrate surveys have been conducted in the vicinity of MRUP. The extensive Level 2 survey at the Tropicana Gold Project (ecologia Environment 2009a) and the subsequent targeted survey for mygalomorph spiders (ecologia Environment 2009b) have revealed unexpectedly speciose assemblages within some SRE Groups, with up to 19 species of conservation significance found (ecologia Environment 2009a). Results from the WAM database and literature for a wider search area around MRUP also showed the occurrence of a rich fauna within SRE Groups, with 96 species recorded. About 30% of these species are likely to be SRE or potential SRE species.

Two land systems occurring in MRUP may support SRE communities. These are closed and/or tall *Eucalyptus* woodlands, and dry salt lakes and their associated lunettes. Vimy staff had reported anecdotal evidence of potential SRE species in the area since 2008, prior to the survey, namely mouse spiders of the genus *Missulena*, and photographic records had been taken of these.

7. RECONAISSANCE SURVEY

Given the occurrence of a large number of species in SRE Groups in the search area, a reconnaissance survey of SRE invertebrates was conducted at MRUP from 9 to 15 October 2014. The aims of the reconnaissance survey were:

- To collect information on the occurrence of SRE Groups in MRUP;
- To assess the SRE status of species in the SRE Groups and the likelihood of them being restricted to the Development Envelope; and
- To ground-truth habitat mapping undertaken in the desktop review.

The survey approach and methods used were based on Position Statement 3 and Guidance Statement 20 (EPA 2002, 2009). In accordance with best practice in arid areas, the survey was designed to target seven invertebrate groups: centipedes (Chilopoda), land snails (Pulmonata), millipedes (Diplopoda), pseudoscorpions (Pseudoscorpiones), slaters (Isopoda), scorpions (Scorpiones) and spiders (Araneae). SRE Groups not targeted were earthworms (Oligochaeta) and velvet worms (Onychophora) because they are restricted to high-rainfall areas (Blakemore 2000; Reid 2002).

7.1 Field and Laboratory Methods

A total of 21 sites were sampled within or near MRUP, with 18 sites located within the Development Envelope and three nearby reference sites outside the proposed Development Envelope (Figures 2, 3; Table 3). Site coordinates and a summary of collecting methods used are provided in Appendix 1. Site descriptions were compiled and information on landform, vegetation type, dominant substrate, indicative plant species, amount of leaf litter, history of burning and site condition were collected.

Most sampling was by foraging, as described below, although some cup traps were set as well. Much of the time was spent searching for burrows of mygalomorph spiders. At 13 sites a leaf blower was used to clear litter and facilitate the search for burrows. Scorpions were collected at night at three sites using ultraviolet ("black") light torches. At five sites where scorpions were abundant, a total of 35 cup traps were fixed to the entrance of burrows and checked every morning.

Small species, such as pseudoscorpions, were extracted from dry and wet leaf litter using a soil sieve (16 sites), or were found by turning over tree logs (10 sites). Mallee and dry *Eucalyptus* tree bark was peeled at 13 sites to collect habitat specialists such as chernetid pseudoscorpions. Centipedes and slaters were collected by excavating deeper soil layers and bark detritus at the base of *Eucalyptus* trees.

Sampling occurred in all prospective microhabitats at each site, such as moist and dry leaf litter accumulations, around tree logs, under tree bark and in spinifex clumps. All sites were sampled once, except for the five sites with cup traps that were re-visited every morning.

A photograph was taken of each site to capture the diversity of habitats available. These photographs are compiled as Appendix 4.

Table 3. Foraging sites and sampling methods.
Comprehensive foraging is the search for scorpion and mygalomorph spider burrows, the excavation of representative spider specimens, peeling bark, turning dead tree logs, sifting leaf litter with a soil sieve, and sorting bark debris and deep soil at the base of large trees. See Appendix 1 for detailed collecting methods per site.

Area	No of Sites	Site Codes
Ambassador/Princess	11	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 22
Shogun	3	13, 14, 15
Emperor	3	17, 18, 20
Haul roads	1	21
Reference sites	3	8, 16, 19

Animals collected in the field were preserved directly in 100% ethanol and identified morphologically using dissecting and compound microscopes, as necessary, and the available taxonomic literature and unpublished keys. Molecular species identifications were not attempted because morphology provided sufficient resolution for species identification.

7.1.1 Personnel

The field survey was conducted by Danilo Harms and Michael Curran. Centipedes, isopods, millipedes and snails were identified by Jane McRae, scorpions by Michael Curran, and mygalomorph spiders and pseudoscorpions by Danilo Harms.

7.1.2 Specimen Lodgement

Representative specimens of all species have been lodged at the Department of Terrestrial Zoology, WAM.

7.2 Conditions for Collecting

Many SRE species are most active following periods of rain (Harvey 2002). It did not rain during the survey period and no surface water was present at MRUP but an average of 14mm of rainfall was recorded across three calibrated weather stations within MRUP on 20 September, approximately 2 weeks prior to the start of the survey. The behaviour of some of the species found also indicated moisture levels were relatively high: mygalomorph spider burrows were not sealed, scorpion burrows showed traces of recent digging, and isopods were active at the base of tree trunks. Daily temperatures during the survey period were moderate and did not exceed 30°C. Night temperatures varied and three cool nights (ca. 10°C minimum) were followed by a warm period (ca. 16-18°C minimum). There were no signs of recent burning (<6 months) anywhere in the survey area.

A compilation of bushfire ages by Vimy personnel showed that that majority of the sampling sites had not burnt for over 20 years (Appendix 3). Sites 20 and 13 were sited on the edges of a major fire scar about 7 years old. Site 10 (Mulga Rock camp) was affected by annual preventive back-burning between 2010 and 2012 (carried out in August-September of each year). Shortly after the survey was carried out, a major bushfire (~75,000 ha) of low to medium intensity burnt over 70% of the Development Envelope (and around 90-95% of the Disturbance Footprint

8. RECONNAISSANCE RESULTS

8.1 Listed Invertebrates

No butterfly species were seen during the reconnaissance survey. This suggests that neither of the two listed butterfly species *Jalmenus aridus* and *Ogynes subterrestris petrina* occur at MRUP. No species in the mygalomorph spider genus *Kwonkan* were collected and this suggests the listed *Kwonkan moriartii* does not occur at MRUP.

The survey results match the conclusion drawn from desktop review that these three listed species are unlikely to occur at MRUP.

8.2 SRE Invertebrates

A total of 223 specimens belonging to at least 32 species within the seven SRE Groups were collected (Table 4; Appendix 5). Mygalomorph spiders were most diverse (15 species), followed by pseudoscorpions (5), scorpions (4), slaters (3), centipedes (2), millipedes (2) and land snails (1). Based on available knowledge, 20 species (62%) were considered not to be SREs. A total of 11 species (34%) had a moderate (Rank 2) probability of being SREs and only one species, *Antichiropus* sp. indet., was treated as having a high (Rank 1) probability of being a SRE species. Of the 12 species with a moderate or high probability of being SREs, five were collected outside, or both inside and outside, the proposed impact areas. Seven species with moderate probability of being SRE species were found only in impact areas: three at the Ambassador/Princess deposits, one at Shogun, two at a dry salt lake next to a proposed haul road, and one near the camp area at the time field work was undertaken.

Table 4. SRE Groups recorded from MRUP.
SRE status based on framework in section 3.1. Species belonging to non-SRE Groups are excluded from this list. 1= WAM database.

Taxonomic Groups	Species	Total No. of Sites	Reference/ Impact	SRE Status	Source/Reference
Arachnida					
Araneae					
Actinopodidae	*Missulena ?occatoria*	1	0 / 1	No	1, Harms and Framenau 2013
Barychelidae	*Aurecocrypta* sp. B05	1	0 / 1	R2	1, Raven 1994
	Synothele sp. B10	1	0 / 1	R2	1, Raven 1994
	Synothele sp. B11	2	0 / 2	R2	1, Raven 1994
	Synothele sp. B12	2	0 / 2	R2	1, Raven 1994
Dipluridae	*Cethegus cf. fugax* (B06)	7	2 / 5	No	1, Raven 1983
	Cethegus ischnotheloides	1	1 / 0	No	1, Raven 1983
Idiopidae	*Anidiops* sp. B07	1	1 / 0	R2	1, Raven and Wishart 2005
	Anidiops sp. B08	1	1 / 0	R2	1, Raven and Wishart 2005
	Anidiops sp. B09	4	1 / 3	No	1, Raven and Wishart 2005
Nemesiidae	*Aname* sp. B15	6	1 / 5	No	1, Raven 2000, ALA 2015
	Aname sp. B16	10	3 / 7	No	1, Raven 2000, ALA 2015
	Aname sp. B17	1	1 / 0	R2	1, Raven 2000, ALA 2015
	Aname sp. B18	5	1 / 4	No	1, Raven 2000, ALA 2015
	Yilgarnia sp. B02	1	0 / 1	R2	1, Main 2008, ALA 2015
Pseudoscorpiones					
Atemnidae	*Oratemnus* sp. B09	2	1 / 1	No	1, Harvey 1985, Harvey 2009
Chernetidae	Chernetidae sp. B09	4	0 / 4	No	1,
	Chernetidae sp. B10	1	0 / 1	No	1, Harvey 1985; Harvey 2009
Olpiidae	*Beierolpium* sp. 8/4 large	3	0 / 3	No	1, ecologia 2009a
	Indolpium sp. B18	1	1 / 0	No	1, ecologia 2009a
Scorpiones					
Buthidae	*Lychas annulatus*	3	0 / 3	No	1, Koch 1977, ALA 2015
	Lychas marmoreus splendens	7	0 / 7	No	1, Koch 1977, ALA 2015
Urodacidae	*Urodacus* cf. *armatus* (B10)	3	0 / 3	No	1, Koch 1977, ALA 2015
	Urodacus yaschenkoi	2	0 / 2	No	1, Koch 1977, ALA 2015
Crustacea					
Isopoda					
Armadillidae	*Acanthodillo* sp. B15	2	0 / 2	R2	1, ecologia 2009a
	Buddelundia sp. B56	4	0 / 4	No	1, Dalens 1992; Dalens 1993
	Buddelundia sp. indet*	1	1 / 0		
Platyarthridae	*Trichorhina* sp. B20	2	1 / 1	R2	1
Chilopoda					
Geophilomorpha					
Chilenophilidae	'Genus indet, Sp. indet.'	1	0 / 1	R2	1, ALA 2015
Geophilidae	*Ribautia sp. B03*	6	1 / 5	No	1, ALA 2015
Diplopoda					
Polydesmida					
Paradoxosomatidae	*Antichiropus* sp. indet.	1	1 / 0	R1	1, Car and Harvey 2014; ALA 2015
Polyxenida					
Polyxenidae	Polyxenidae sp. B13	5	1 / 4	No	1, Car *et al.* 2013a
Gastropoda					
Pupilloidea					
Pupillidae	*Pupoides adelaidae*	2	0 / 2	No	1, Whisson and Kirkendale 2014

*Specimens which could not be identified to species level may belong to another species already listed (shaded grey).

Isopods, mygalomorph spiders and centipedes had the highest proportion of potential SRE species (66, 53 and 50%, respectively). However, because there were more species of mygalomorph spiders than other groups, the eight potential SRE mygalomorph species constituted 67% of all species with

high or moderate likelihood of being SREs. The pseudoscorpion, scorpion and land snail faunas did not contain any potential SRE species.

Some species in SRE groups were found only at Princess/Ambassador in the south-east (e.g. *Synothele* sp. B10 and 11, *Acanthodillo* sp. B15), whereas *Anidiops* sp. B08) was collected only from Shogun in the north-west. This may reflect natural differences in landforms and habitats between these areas rather than sampling bias. The Princess/Ambassador resource areas are dominated by sandplains and aeolian dunes whereas Shogun also supports salt lakes and closed *Eucalyptus* woodlands on red sands. Some other species in the SRE Groups were clearly widespread across MRUP and beyond (e.g. *Aname* sp. B16).

Information about potential SRE species is summarised below. Detailed collecting information about each species is given in Appendix 5.

8.2.1 Trapdoor spiders and allies

A total of 14 mygalomorph spider species (57 specimens), representing our families, were collected at MRUP (Figure 8). An additional species of mygalomorph was photographed by Vimy staff prior to the survey but no specimen could be collected. It was tentatively identified as *Missulena occatoria* (Table 4), so that in total 15 species of five families of mygalomorph have been recorded. Mygalomorph spiders represent a lineage that has a high proportion of SRE species (Castalanelli *et al.* 2014; Harms and Framenau 2013) and we discuss the status of the species collected in proposed impact areas below.

Missulena occatoria

Species of this genus have very cryptic burrows and are difficult to collect but the males of many species are also easy to recognise because they have a red cephalic region (e.g. Harms and Framenau 2013) A single male belonging to the mouse spider genus *Missulena* (family Actinopodidae) was photographed by Vimy staff at Site 3 at the Ambassador. However, no live specimens were obtained in the reconnaissance survey. The identification of this specimen to species level is difficult because *Missulena* species are morphologically cryptic and DNA data are often required to delineate species (Harms and Framenau 2013). However, the red carapace and the relatively large body size (> 6.0 cm) resemble *Missulena occatoria*, which is a very widespread species in Australia (Miglio *et al.* 2014; ALA data 2015). Given the absence of additional specimens, we tentatively treat this species as *Missulena occatoria*, which is not **a SRE species**.

Aurecocrypta sp. B05

A single juvenile was collected at Site 10 in the proposed impact area. *Aurecocrypta lugubris* has been collected in the search area (Table 2) but assignment of the juvenile specimen collected at MRUP to species is difficult and, to be precautionary, *Aurecocrypta* sp. B05 is treated here as a **Rank 2 SRE species** . However, based on the habitat type in which *Aurecocrypta* sp. B05 was collected (an exposed sandplain with open *Eucalyptus* woodlands over *Triodia*, which is extremely common in the area), the species is likely to be locally widespread and unlikely to be threatened by mine development.

Synothele sp. B10

MRUP appeared to have a rich *Synothele* fauna and inactive burrows were detected at many sites across the open *Eucalyptus* woodlands, although only five specimens could be collected. A single female specimen of *Synothele* sp. B10 was collected from Site 14 at Shogun. This specimen does not belong to any of the three named *Synothele* species in the eastern Goldfields (*S. arrakis*, *S. meadhunteri* and *S. yundamindra*; Raven 1994) and may represent a new species. Although Site 14 was dominated by a fairly widespread vegetation type (open mallee woodland over *Acacia* shrubs and *Triodia*) the soil type differed from the surrounding sandy plains in that the red sands contained a high proportion of clay. Inactive burrows were common at Site 14 and were also detected at Site 15, indicating that this species may be more widespread in the Project area. Given the short ranges of at

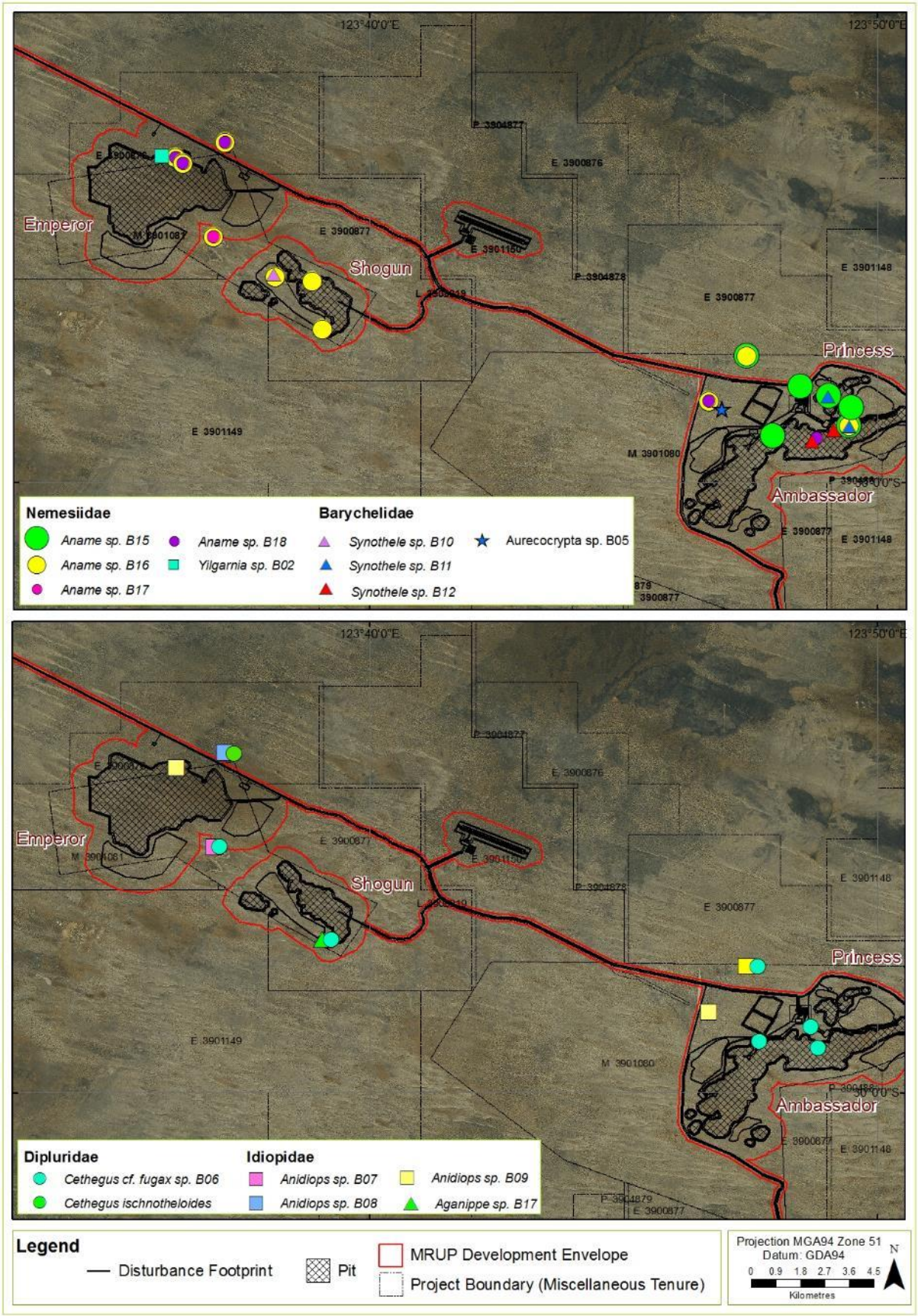

Figure 8. Distribution of mygalomorph spiders collected at the Project.
All species are colour coded and ordered according to family level (Nemesiidae, Barychelidae, Dipluridae and Idiopidae).

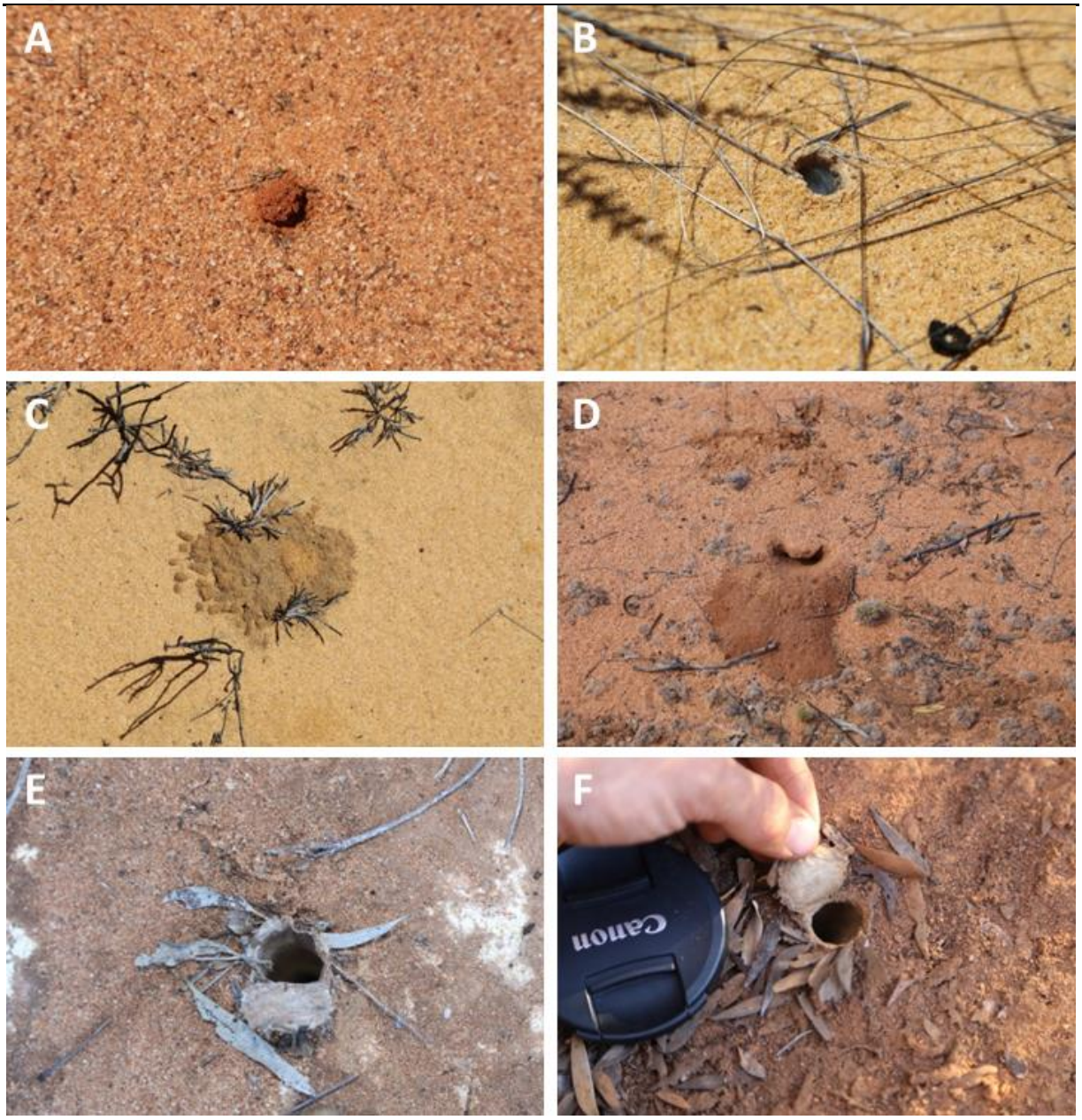

Figure 9. Examples of animal burrow entrances in the field.
A = *Aname* sp. B18; B = adult specimen of *Aname* sp. B16; C = juvenile specimen of *Aname* sp. B16 (note the recent digging activities); D = *Urodacus armatus*; E = *Anidiops* sp. B07; and F = *Anidiops* sp. B09.

least some *Synothele* species (Raven 1994; Castalanelli *et al.* 2014), we treat this as a **Rank 2 SRE species** that is likely to be moderately widespread locally and unlikely to be threatened by mine development.

Synothele sp. B11

This species is presently known only from two juvenile specimens that were collected at Ambassador (Sites 5 and 7). These juveniles cannot be assigned to any described species (Raven 1994) and may represent a new species. Site 5 is located between tall woodland and an exposed alluvial sand dune whereas Site 7 is open mallee woodland on a flat sandplain, illustrating that this species occurs in at least two microhabitat types. Both habitat types are common in the vicinity of the resource areas and regionally. Considering that inactive *Synothele* burrows were also detected at Sites 8, 9 and 10, this **Rank 2 SRE species** is likely to be widespread in the vicinity of the Ambassador/Princess and, therefore, is unlikely to be threatened by mine development.

Synothele sp. B12

Known only from two juvenile specimens collected at Sites 3 and 4 at the Ambassador, this **Rank 2 SRE species** differs from *Synothele* sp. B11 by the abdominal colour pattern and the dark bands on the carapace (the carapace of the former species is uniformly yellow). Both habitats are tall *Eucalyptus* woodlands with mallee and shrubby understorey on yellow sandplains. This is a common habitat type at MRUP and extends outside the Deveopment Envelope, suggesting that *Synothele* sp. B12 is likely to be locally more widespread and, therefore, unlikely threatened by mine development.

Anidiops sp. B07

This large idiopid species (5-6 cm in body length) was collected only outside the Development Envelope. It was found in the lunette of a dry salt lake between Shogun and Emperor (Site 16) where it constructs deep burrows (Figure 9A). This species may be a specialist that prefers the moist clay banks of salt lakes and we treat it as a **Rank 2 SRE species**. *Anidiops* sp. B07 is not threatened by the mine development.

Anidiops sp. B08

This species is currently only known from a single record outside the Development Envelope, located North of Emperor (Figure 8). It is not threatened by mine development and does not require conservation assessment.

Anidiops sp. B09

This is the second largest idiopid species at MRUP (Figure 10D) and known from four sites across MRUP and its immediate vicinity, including Site 8 which is outside the Development Envelope. This is **not a SRE species.**

Cethegus cf. *fugax*

This was the most common mygalomorph spider species at MRUP and present at almost every sample site (Figure 8). The species constructs its curtain webs at the base of spinifex clumps and can be extremely abundant in the open *Triodia* steppe of the exposed sand plains and swales. The species has been collected at seven sites, including sites outside the Development Envelope, and is **not a SRE species**.

Cethegus ischnotheloides

Most *Cethegus* species are currently considered to be widespread and *Cethegus ischnotheloides* is no exception. The species is common in south-eastern Western Australia and South Australia (ALA data), has been recorded in the Great Victoria Desert previously (ecologia Environment 2009a) and is **not a SRE species**.

Aname sp. B15

There are multiple records of this large, black species at Ambassador and Princess. The species is locally common and has been collected from open *Eucalyptus* woodlands between the seif dunes, as well as from the exposed sandy areas on top of these dunes. It is notably absent from the Shogun and Emperor, despite the availability of seemingly suitable microhabitats. Given that this species has been collected at six sites across two microhabitat types, including sites outside the Development Envelope, it is considered to be **not a SRE species**.

Aname sp. B16

This large species (Figure 10C) is the most common Wishbone Spider in the Project area and has been collected from 10 sites in all four resource areas, including sites outside the Development Envelope. It is very common in the sandplains and swales between alluvial sand dunes and clearly is **not a SRE species**.

Aname sp. B17

This species is known only from a single juvenile specimen collected from a clay bank outside the Development Envelope at Site 16 between the Shogun and Emperor. Its placement in *Aname* is tentative because it is too small to be properly identified. The data suggest that this species may be restricted to salt lakes and associated lunettes. Given the short-range endemism in many species of *Aname* (Harvey *et al.* 2012, Castalanelli *et al.* 2014), this species is treated as a **Rank 2 SRE species** but it is not be threatened by mine development.

Aname sp. B18

This very small species is notable for its dome-shaped burrow-entrances, which consist of sand particles finely held together by silk (Figure 8A). Its placement in *Aname* is tentative because its burrow structure differs from other species in this genus (usually a simple open entrance lined with silk); however, it also does not fit into any other nemesiid genus recorded in the Eastern Goldfields and Great Victoria Desert. The species is **not a SRE** and has been collected from five sites, both within and outside the Development Envelope.

Yilgarnia sp. B02

This genus is easily recognisable by the presence of short conical spines on the third and fourth leg coxae (Main 2008). This is the first record of *Yilgarnia* from the Great Victoria Desert and is likely to be a new species because the closest record is from Kambalda ca. 300 southwest of the Project area (ALA data 2015). Many more putative species of this genus are known from Western Australia, in particular from the adjacent eastern Goldfields (ALA data 2015), but only two species are currently described: *Yilgarnia linnaei* from Durokoppin Nature Reserve and *Yilgarnia currycomboides* from Peak Charles National Park (Main 1986, 2008). The single record of *Yilgarnia* sp. B02 is from Site 17 at Emperor, in a landform dominated by closed *Eucalyptus* woodland with complex understory. This woodland is widespread north of MRUP. This **Rank 2 SRE species** is likely to be more widespread in this northern woodland and, therefore, not threatened by mine development.

8.2.2 Pseudoscorpions

A total of five pseudoscorpion species, representing three families, were collected at MRUP (Table 4). The Atemnidae and Chernetidae are usually widely dispersed and live under bark. They use other, more mobile invertebrates to carry them to new microhabitats (i.e. phoresy). Chernetids have been recorded phoretic on a variety of insects, including flies and beetles (Weygoldt 1969). The Olpiidae is a family of arid-adapted pseudoscorpions that are extremely common in low rainfall areas, including the Eastern Goldfields and Great Victoria Desert (ALA data 2015).

Oratemnus sp. B09

This species has been collected from under *Eucalyptus* bark at Emperor and may prefer closed *Eucalyptus* woodlands. It is known from both the south-eastern and north-western resource areas and is considered to be **not a SRE species**.

Chernetidae sp. B09

This cosmopolitan family is poorly defined taxonomically and it is not possible at this stage to assign this species to a particular genus. Despite the taxonomic uncertainty, Chernetidae sp. B09 is widespread in the Project area and has been collected from four sites at the Ambassador, Princess and Emperor. This is considered to be **not a SRE species**.

Chernetidae sp. B10

This species is currently known only from Site 15 in the Shogun deposit but is likely to be more widespread, given the phoretic nature of chernetids in general and that the species was collected from under tree bark. Therefore, Chernetidae sp. B10 is considered to be **not a SRE species**.

Beierolpium 8/4 large

These dorso-ventrally compressed pseudoscorpions were collected from under dry mallee ('stringy') bark where they co-occur with ants. The species was collected at Sites 3, 5 and 18 at the Ambassador and Emperor and was seen at additional sites. Considering the ubiquitous nature of its macrohabitat (extensive woodlands of mallee are common in the sand dunes and plains), the ephemeral nature of its microhabitat (dry bark), and the ecology of olpiids in general, this is considered to be **not a SRE species**.

Indolpium sp. B18

This is the most common olpiid genus in Western Australia and species in this genus are regularly collected as part of environmental surveys. *Indolpium* sp. B18 is currently known only from Site 08 outside the Development Envelope and is considered to be **not a SRE species**.

8.2.3 Scorpions

Scorpions were very abundant and scorpion burrows were recorded from all sample sites across the four deposits. Despite their relative abundance, the 53 collected specimens represented only four species in two families (Table 4; Figure 10A, B). All four species are clearly widespread across the arid regions of the Australian continent and have ranges that exceed the Western Australian border, with *Urodacus yaschenkoi*, *Lychas annulatus* and *L. marmoreus splendens* known also from the Northern Territory, South Australia, and Queensland (ALA data 2015). These species are **not SREs** and do not require detailed conservation assessment as part of the current proposal.

8.2.4 Slaters

A total of 54 specimens of three slater species in the families Armadillidae and Platyarthridae were collected (Table 4), demonstrating that slaters can be quite common in arid desert habitats. The sample includes the first record of *Trichorhina* isopods (family Platyarthridae) in the Great Victoria Desert.

Acanthodillo sp. B15

This small species was collected from sites 3 and 4 at Ambassador. It was not found at Shogun and Emperor, despite similar habitats being available. The three specimens were excavated from deep soil and bark debris at the base of large *Eucalyptus* tree where water runs off the tee trunk and moisture is available. Given the widespread presence of similar trees (and vegetation types) at Ambassador and Princess and considering also the difficulties of sampling such microhabitats (hand excavation of deep soil), we treat *Acanthodillo* sp. B15 as a **Rank 2 species** that is likely to be more widespread at Ambassador and Princess than records suggest. The species is unlikely to be threatened by mine development.

Buddelundia sp. B56

Species belonging to this genus are common across the arid regions of Western Australia and there are clearly many undescribed species. *Buddelundia* species often have short ranges because they are confined to microhabitats with high moisture retention (Dalens 1992). However, *Buddelundia* sp. B56 appears widespread at MRUP and was collected at Princess and Ambassador, including at Site 19 outside the Development Envelope. The species was abundant and 43 specimens were collected in total. This is **not a SRE species**.

Additional fragments of *Buddelundia* isopods were collected under dry tree bark at Site 8 outside the Development Footprint. It is not possible to identify these fragments to species level but they may belong to *Buddelundia* sp. B56.

Trichorhina sp. B20

This is the first record of the genus in the Great Victoria Desert (Figure 10E) and the five specimens were collected from moist soil and bark debris at the base of large *Eucalyptus* trees. This species is

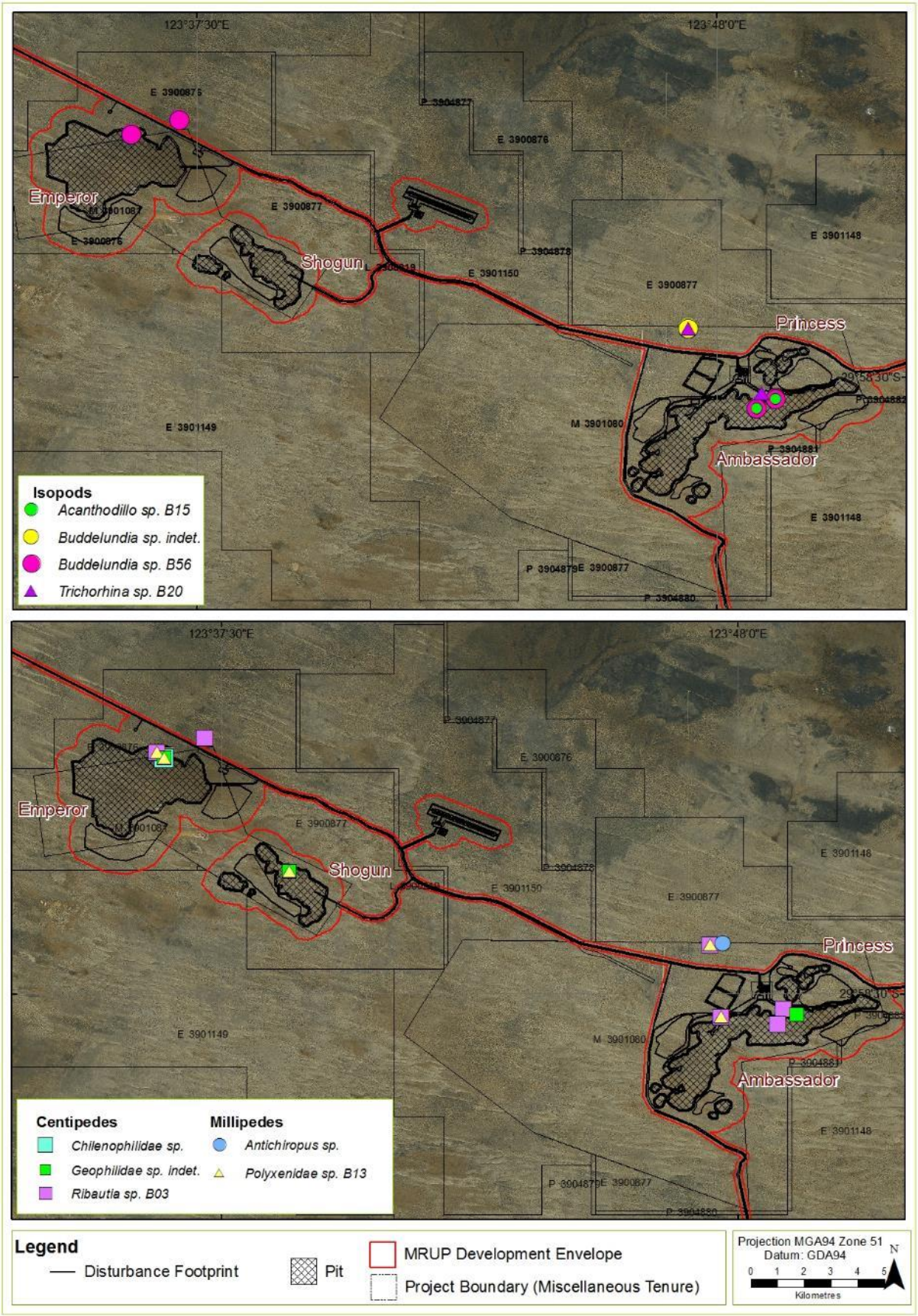

Figure 10. Distribution of slaters, centipedes and millipedes at the Project.
All species are colour coded and ordered according to the taxonomic groups (Isopoda, Chilopoda and Diplopoda).

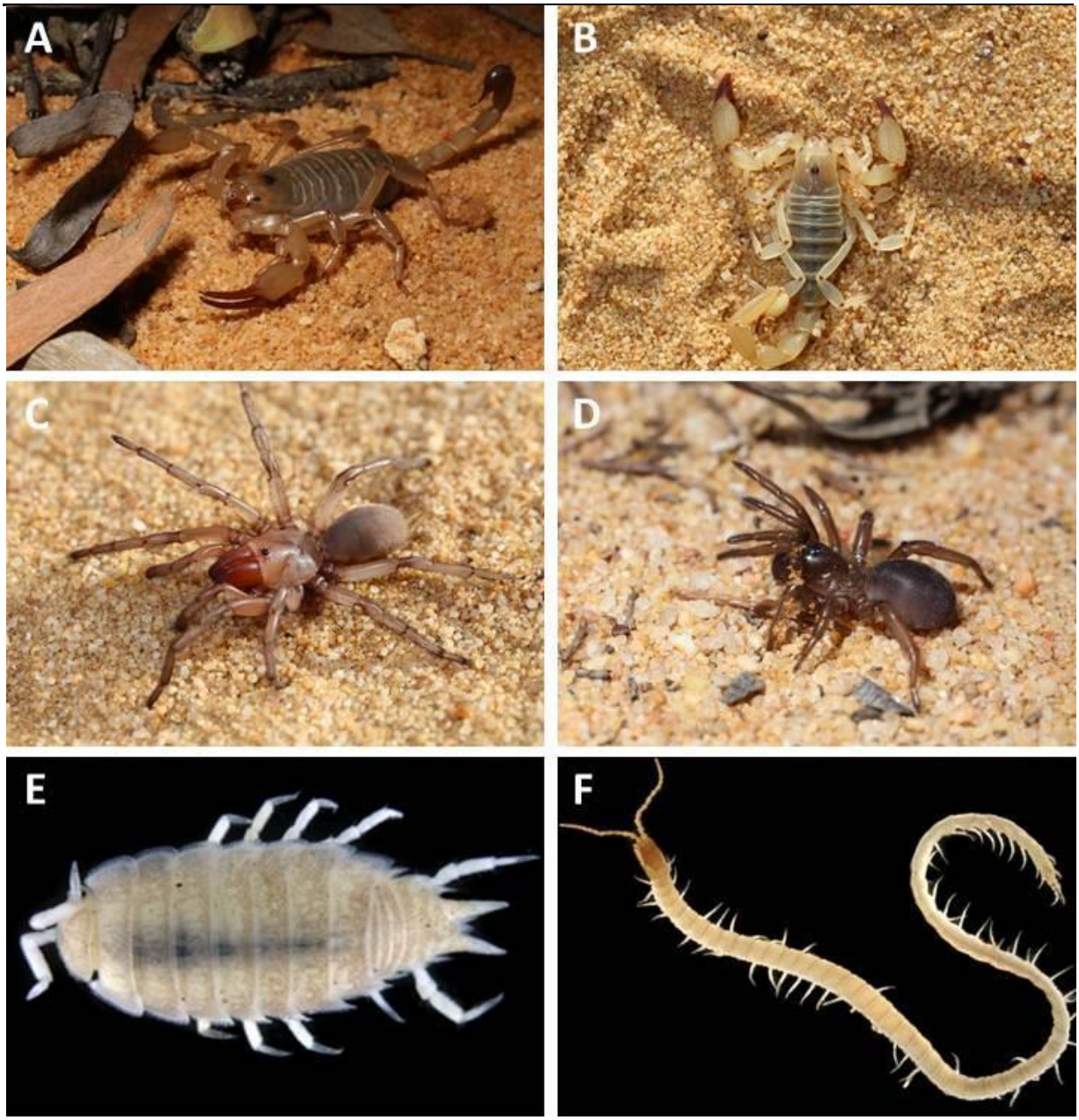

Figure 11. Examples of species collected at Mulga Rock Uranium Project.
The scorpions *Urodacus yaschenkoi* (A) and *Urodacus armatus* (B); the mygalomorph spiders *Aname* sp. B16 (C) and *Anidiops* sp. B09 (D); the slater *Trichorhina* sp. B20 (E) and the centipede *Ribautia* sp. B20 (F).

known only from Sites 8 and 9 at Ambassador/Princess and, based on ecological attributes such as moisture-dependence, the species is considered to be a **Rank 2 SRE**. One record of the species was froom Site 8 outside the Development Envelope and the species is unlikely to be threatened by mining.

8.2.5 Centipedes

At least two species and 24 specimens in the families Chilenophilidae and Geophilidae were collected from the Project area (Table 4; Figure 11).

Chilenophilidae 'Genus indet, sp. indet'

There is no taxonomic framework for chilenophilid genera in Australia and species identification is very difficult. A single specimen of the family Chilenophilidae was collected from Site 18, closed *Eucalyptus* woodland in the Emperor deposit, which will be impacted by the proposed development. The specimen was found in deep soil at the base of a large *Eucalyptus* tree; a microhabitat that is usually difficult to sample. The closed *Eucalyptus* woodland extends beyond the tenement boundaries. Based

on ecological attributes (moisture-dependence, poor dispersal capacities) this is a **Rank 2 SRE species** but it is almost certainly more widespread in the vicinity of the Project area and, therefore, unlikely to be threatened by mining.

Ribautia sp. B03

This species is known from six sites at Emperor and Ambassador. It is clearly widespread at MRUP and is **not a SRE species**. Additional specimens that may belong to this species have been collected from Ambassador (Site 4), Shogun (Site 15) and Emperor (Site 18). These specimens represent fragments that cannot be identified further, and are listed here as Geophilidae sp. indet.

8.2.6 Millipedes

Two millipede species (10 specimens) in two families were recorded at MRUP. The pincushion millipedes in the family Polyxenidae are widespread in arid Australia and considered not to contain SRE species (Car *et al.* 2013b) Conversely, the paradoxosomatid genus *Antichiropus* is very diverse at a species level and consists almost exclusively of SRE species (Car and Harvey 2014; Car *et al.* 2013b). The genus is known at MRUP from two cuticle fragments that were collected at Site 8 at the base of a *Eucalyptus* tree. The identification of these fragments cannot be advanced further but the only other records of *Antichiropus* millipedes in the Great Victoria Desert are from the Tropicana Gold Project (ecologia Environment 2009a) and, considering the short distribution ranges, the fragments likely represent a new species. However, the single site where the fragments were collected (Site 8) is outside the Development Envelope and this species is unlikely to be threatened by mining.

8.2.7 Land Snails

The snail fauna of MRUP is depauperate and only a single species, *Pupoides adelaidae*, was collected as dry shells (Table 4). Pupillid snails are considered widespread (Whisson and Kirkendale 2014) and *P. adelaidae* has a wide range that includes south-eastern Western Australia, South Australia, and western Victoria (ALA data 2015).

8.3 Completeness of survey

Species accumulation curves were calculated for the species belonging to SRE groups to determine the degree of sampling completeness across the survey area. Calculations were made using the software package EstimateS 9 (Colwell 2013) for all 21 sample sites and the 32 species in SRE groups, with 100 randomisation runs and a bias-corrected formula for the Chao 1 index. Sobs (Mao Tao) showed the number of species observed and the Michaelis-Menten (MMMeans) and Chao 1 richness estimators were used for extrapolating species richness because they are most appropriate in this case (Foggo *et al.* 2003).

While 32 species in SRE Groups were collected, the mean Chao 1 estimate suggests that 40 species (95% confidence interval = 35-65) occur in the area, while the MMMeans estimator suggests 48 species occur (Figure 12). Thus, it is likely that about 70-80% of species belonging to SRE Groups at MRUP and its immediate surrounds were collected. Comparisons of sampling completeness at MRUP and Tropicana cannot be made because species accumulation curves at Tropicana were based only on the potential SRE species collected and no estimate of richness of SRE Groups was made (ecologia Environment 2009a). However, the actual number of species at MRUP is probably similar to the number of species in SRE Groups collected at Tropicana (ecologia Environment 2009a).

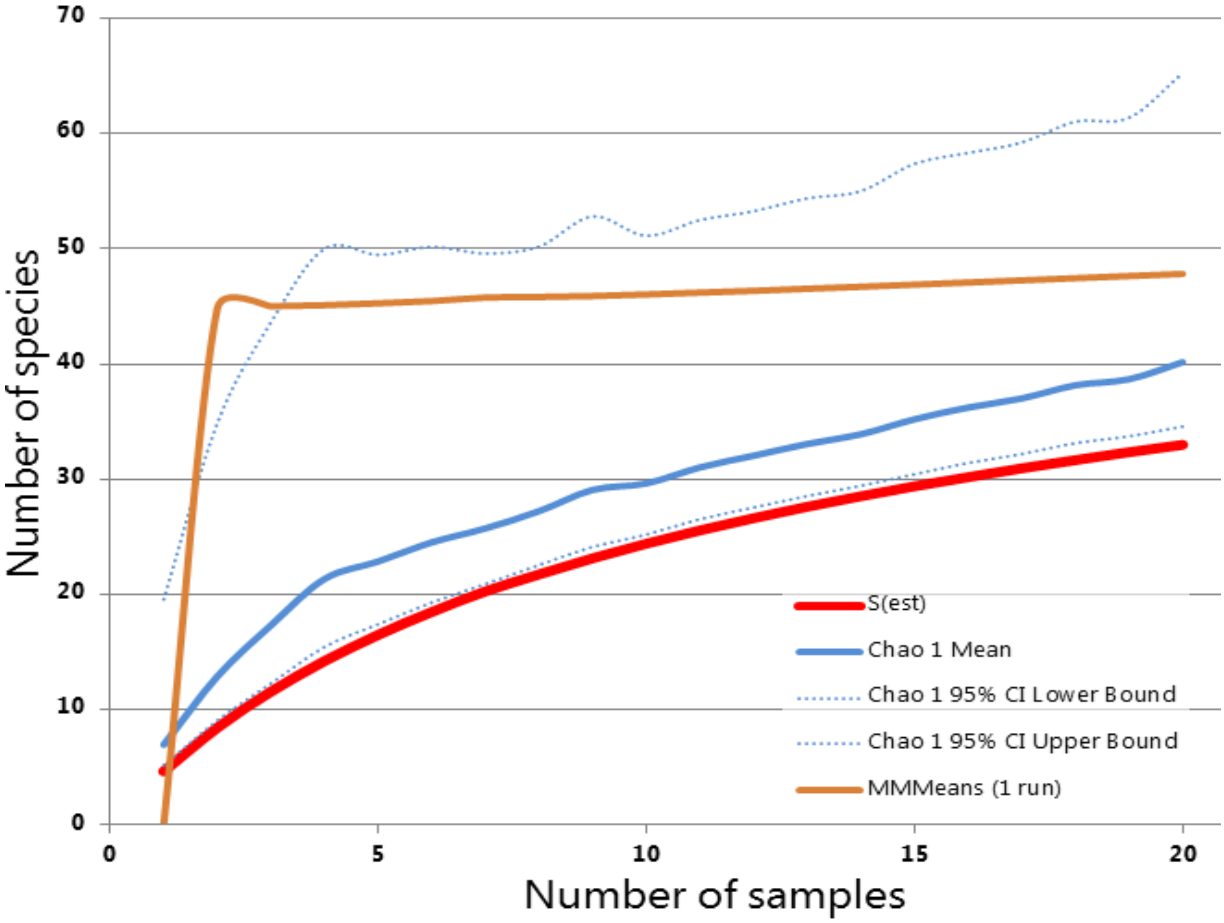

Figure 12. Species accumulation curves for the Mulga Rock Project area.
S(est) = Sobs, a metric for the samples actually collected; Chao 1 = richness estimator incl. 95% confidence interval (CI Lower/Higher bounds) and corrected for sampling bias; and MMMeans = Michaelis-Menten estimator.

8.3.1 Alluvial sand dunes

This very common landform had no SRE species which, given its widespread and interconnected nature in the GVD1, was expected. Microhabitats associated with the sand dunes and swales also appeared unsuitable for SRE species because they were generally exposed, dry and without ground cover or litter. The lack of spatial barriers separating the sand dunes probably fosters widespread and generalist species that utilise a variety of microhabitats, including *Triodia* steppe and open mallee woodland on yellow sands. The mygalomorph spiders *Aname* sp. B16 and *Cethegus* cf. *fugax* are such a species and are widespread and very common at MRUP, although they belong to SRE Groups with many range-restricted species.

8.3.2 Sandplains

This landform had a higher proportion of SRE species, especially when tall *Eucalyptus* woodlands on yellow and red sands provided shade and sufficient ground cover at a microhabitat level. The trapdoor spiders *Synothele* sp. B11 and 12, and the slater *Acanthodillo* sp. B15 from Ambassador and Princess were collected only in tall *Eucalyptus* woodlands on these plains and may be restricted to such habitats. Given that such woodlands are common outside the proposed impact areas and the Project area, there is a high likelihood that these Rank 2 SRE species are more widespread in the GVD1. This is the case for *Synothele arrakis* and *S. meadhunteri*, which were initially described from only a few localities and a single habitat type (Raven 1994) but are now known to be more widespread. A wider distribution is also likely for *Aurecocrypta* sp. B05 which was collected from open woodland on these sandplains, a vegetation type that is even more widespread at MRUP.

8.3.3 Dry salt lakes

Salt lakes and salty valley floors are a characteristic feature of the GVD1 and may promote a unique invertebrate community that is dependent on the muddy lunettes, salinity of soils, and halophilic vegetation. Two mygalomorph spider species were collected only from the clay banks of a dry salt lake between Shogun and Emperor (Site 16). Given the distinct soil structure of the site (the specimens were excavated from gypsum), these species may be habitat specialists and potentially endemic to the salty clay banks. However, this site is outside the Development Envelope and additional dry salt lakes occur ca. 4.0 km south of the impact area and are common in the GVD1.

8.3.4 Closed Eucalyptus woodlands

This landform was associated with diverse microhabitats, and provided shade and ground (e.g. leaf litter) cover for SRE communities. The level of moisture retention should also be higher than elsewhere because the tall *Eucalyptus* forests prevent quick desiccation of the red sandy soils after rainfall. Two invertebrate species, the Wishbone Spider *Yilgarnia* sp. B02 and the chilenophilid millipede 'Genus indet, sp. indet' have only been collected from such woodlands at Emperor. Both species are currently known from single specimens and are obviously undersampled. The closed woodlands at Emperor are a relatively small southern extension of much larger woodlands ca. 2.5 km north west and 5.5 km north-east of MRUP. Given the size and extent of these vegetation features (at least 10 km^2 of the same habitat is available to the north-east) it is highly likely that the two species in question are much more widespread in the vicinity of MRUP.

9. RISK ASSESSMENT FOR SRE SPECIES

The SRE survey at MRUP provided evidence for the occurrence of 11 possible and one confirmed SRE species. In this fauna, four species were recorded exclusively from outside the proposed mining development, including the Rank 1 SRE species *Antichiropus* sp. indet. An additional species was collected from both outside and inside the impact areas. These species are unlikely to be threatened by mine development and unlikely to be of conservation significance.

Table 5. SREs known only from the Development Envelope.
Seven species are presently known only from impact areas but are found in landforms and microhabitats that are wide-spread in the vicinity of MRUP. Six species are represented by single records and obviously under-sampled.

Taxonomic Groups	Species	Deposit	Site(s)	Habitat Type	Habitat Surrogates
Arachnida					
Barychelidae	*Aurecocrypta* sp. B05	Camp	10	Low open woodland on exposed sandplain	Available
	Synothele sp. B10	Shogun	14	Open woodland on clay soils	Available
	Synothele sp. B11	Ambassador	5 & 7	Tall and open woodlands on sandplains	Available
	Synothele sp. B12	Ambassador	3 & 4	Tall woodland on sandplains	Available
Nemesiidae	*Yilgarnia* sp. B02	Emperor	17	Closed *Eucalyptus* woodland with *Callitris*	Available
Crustacea					
Armadillidae	*Acanthodillo* sp. B15	Ambassador	3 & 4	Tall woodland on sandplains	
Chilopoda					
Chilenophilidae	'Genus indet, Sp. indet.'	Emperor	18	Closed, tall woodland on red sands	Available

Only seven potential SRE species were collected solely from within proposed impact areas, comprising five mygalomorph spider species, one slater and one centipede (Table 5). The analysis of landforms and microhabitats for these species has shown that they are primarily found in tall or closed *Eucalyptus* woodlands and salt lakes that are more widespread in the vicinity of the Project.

In reality, all seven species are likely to be more widespread than currently documented, with ranges both within and outside the Development Footprint, because the habitats they occupy have wide occurrence. There are no landforms or microhabitats unique to the Project area and the two

landforms that may contain specialist species, salt lakes and closed/tall *Eucalyptus* woodlands, are more widespread outside the Development Footprint.

10. CONCLUSIONS

A total of 223 specimens belonging to at least 32 species of seven SRE Groups were recorded in the survey. The mygalomorph spiders had the highest number of potential SRE species (8 species), followed by the slater (2), centipede (1) and millipede (1) faunas.

The key results of the assessment are as follows:

- 20 species (62%) in SRE Groups were considered not, or unlikely, to be short-range endemic species under the framework of determining SRE status;
- 12 species (38%) in MRUP or its near vicinity had a moderate or high probability of being SRE species;
- Of these potential SREs, five species were collected outside the Development Envelope and are not of conservation concern;
- Seven SRE species were collected only from the Development Envelope but have been sampled from landforms and microhabitats that are widespread outside the Development Envelope;

Given the relative habitat uniformity in the MRUP area and the paucity of landforms suitable for SRE communities, there is unlikely to be a much more diversified SRE fauna than currently documented and the SRE species present are likely to be locally widespread. This is also the case for the sevenpotential SRE species presently known only from the Development Footprint, especially those species collected in tall *Eucalyptus* woodlands that are common in the wider GVD1 area.

It is difficult to make comparisons between surveys unless standardised sampling protocols have been used but about 30% fewer species in SRE Groups were collected from MRUP than the Tropicana Gold Project (32 v. 46 species). However, sampling effort was greater at Tropicana and the true difference in richness of the two areas is unclear. Approximately 40% of the species collected in both areas were potential SRE species (moderate or high likelihood of being a SRE).

The main difference between MRUP and Tropicana relates to faunal composition, with the mygalomorph spider genera *Kwonkan*, *Mandjelia*, *Swolnpes* and *Teyl*, millipedes belonging to the order Polyzoniida, *Cercophonius* scorpions and *Pseudolaureola* slaters being collected at Tropicana but not MRUP. Conversely, the mygalomorph spider genus *Yilgarnia* and *Trichorhina* isopods occur at MRUP but were not collected at Tropicana.

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Appendix 1. Coordinates, type of sampling, and date of most sampling at sampling sites.

Coordinate information based on WGS94 datum.

Site	Principal Date	LatDec	LonDec	Foraging	Burrow digging	Litter Sieve	Bark peeling	Log turning	Leaf blow	UV	No. of Cup traps
01	09/10/2014	29.9829197	123.7941756	✓	✓	✓	✓	✓	✓	×	0
02	09/10/2014	29.98475151	123.799143	✓	✓	×	✓	×	×	×	2
03	09/10/2014	29.98544042	123.8134079	✓	✓	✓	✓	✓	✓	×	10
04	09/10/2014	29.98223065	123.819848	✓	✓	✓	✓	✓	✓	×	0
05	09/10/2014	29.98148769	123.824038	✓	✓	✓	✓	✓	✓	×	0
06	09/10/2014	29.97534104	123.824931	✓	✓	✓	✓	✓	×	×	6
07	10/10/2014	29.97157038	123.8174079	✓	✓	✓	×	×	×	×	0
08	10/10/2014	29.95851658	123.7903945	✓	✓	✓	×	×	✓	×	0
09	10/10/2014	29.98031237	123.8152671	✓	✓	✓	✓	✓	✓	×	0
10	10/10/2014	29.97340111	123.7780858	✓	✓	✓	✓	×	×	×	11
11	10/10/2014	29.97843469	123.8115361	✓	✓	✓	✓	✓	✓	×	0
13	11/10/2014	29.94976047	123.6511529	✓	✓	✓	✓	✓	×	×	6
14	11/10/2014	29.93243902	123.6356858	✓	✓	✓	×	✓	✓	×	0
15	11/10/2014	29.9338238	123.6478234	✓	✓	✓	×	✓	✓	✓	0
16	11/10/2014	29.91931074	123.6154861	✓	✓	×	×	×	✓	×	0
17	11/10/2014	29.89355759	123.6031079	✓	✓	✓	✓	×	✓	✓	0
18	12/10/2014	29.91201365	123.6053935	✓	✓	✓	✓	×	✓	×	0
19	12/10/2014	29.88839369	123.6192382	✓	✓	✓	✓	×	✓	×	0
20	12/10/2014	29.90667705	123.5947392	✓	✓	×	×	×	×	✓	0
21	12/10/2014	29.94341254	123.7155259	✓	✓	×	×	×	×	×	0
22	13/10/2014	29.96841825	123.8082439	✓	✓	×	×	×	×	×	0

Appendix 2. Vegetation, soil and litter characteristics of the sampling sites.

Site	Litter Depth			Vegetation	Soil
	< 1	1 to 5	5 +		
01	89.9	10	0.1	Open *Eucalyptus* woodland over shrubland/grassland	Yellow silicate
02	96.4	3.5	0.1	Open *Eucalyptus* woodland over shrubland/grassland	Yellow silicate
03	89.9	10	0.1	Open *Eucalyptus* and *Callitris* woodland over herbland and spinifex	Lateritic alluvial sand dune
04	92.4	7.5	0.1	Open *Eucalyptus* woodland over mallee, open shrubland and hummock grassland	Lateritic alluvial sand dune
05	89.9	10	0.1	Open *Eucalyptus* woodland over closed low shrubland	Yellow silicate alluvial sand dune
06	94.9	5	0.1	Very open *Eucalyptus* woodland over low shrubland	Yellow silicate alluvial sand dune
07	74.9	25	0.1	Open *Eucalyptus* woodland over mallee, low shrubland and hummock	Orange/brown lateritic sand
08	84.9	15	0.1	Open *Eucalyptus* woodland over *Callitris* and mixed shrubs and hummock grassland	White/yellow sand
09	95.9	4	0.1	Open *Eucalyptus* and mallee woodland over low shrubland and hummock grassland	Yellow silicate
10	94.1	5	0.9	Open *Eucalyptus* woodland, sparse shrubland over hummock	Yellow silicate
11	95.9	4	0.1	Open *Eucalyptus* woodland over mallee, low shrubland and hummock	Yellow/red sand-loam
13	89.9	10	0.1	Open *Eucalyptus* woodland over mallee, shrubland and hummock	Yellow/red sand dune
14	89.9	10	0.1	Open mallee woodland over shrubland and hummock	Lateritic sands with clay
15	95	5	0	Open mallee woodland with scattered wandoo	Slightly lateritic sand
16	83	15	2	Open Eucalyptus woodland over mallee and shrubland	Shallow lateritic sand over dry clay
17	79	20	1	Closed Eucalyptus woodland with *Callitris*, fringing shrubs and hummock grassland	Red/yellow-red sand with clay
18	84.9	15	0.1	Tall mallee and *Callitris* woodland with patches of hummock grassland	Red/yellow-red sand on dune
19	84	15	1	Closed *Eucalyptus* woodland with *Callitris*, shrubs and patches of hummock grassland	Red to slightly yellow sand with clay
20	89.9	10	0.1	Open *Eucalyptus* woodland over mixed shrubs and hummock grassland	Yellow-red to yellow sand
21	89.9	10	0.1	Open *Eucalyptus* woodland over mixed shrubs and patches of hummock grassland	White/yellow sand
22	100	-	-	Open *Eucalyptus* and *Callitris* woodland over hummock grassland	Yellow silicate

Appendix 3. Characterisation of Field sites.

Litter index calculated by summing weighted percentage cover scores of litter <1 cm depth (including bare soil), 1 – 5 cm depth, and >5 cm depth. Weighting factors are 0.1, 3 and 8, respectively (i.e. a site with 50% <1 cm, 45% 1-5 cm and 5 % > 5cm has an index of 180).

Site	SRE Habitat	Litter Index^	Recent Fire	Stock	Sun exposure	% Shade Cover
01	Flat sandplain	39.79	No	No	Medium	25
02	Elevated sand dune	20.94	No	No	High (full day)	4
03	Flat sandplain	39.79	Parts of site	No	Medium	33
04	Flat sandplain	32.54	No	No	Medium	25
05	Alluvial dune (south facing)	39.79	No	No	Medium/high	16
06	Alluvial dune (east facing)	25.29	No	No	High	8.3
07	Flat sandplain	83.29	No	No	Medium	25
08	Flat sandplain	54.29	No	No	Medium	20
09	Swale between two dunes	22.39	No	No	Medium/high	7.5
10	Flat san plain	31.61	c. 5 y ago	No	High/medium	5
11	Base of sand dune	22.39	No	No	Medium	5
13	Plain associated with sand dune	39.79	No	No	High (full day)	3.5
14	Lateritic plain with clay	39.79	No	No	Medium	7.5
15	Swale/rise between three dunes	24.5	No	No	Medium	15
16	Dry salt lake with sandy clay banks	69.3	No	No	Medium	5
17	Flat woodland	75.9	No	No	Medium	30
18	Slight rise towards dune	54.29	No	No	Medium/high	25
19	Flat san plain	61.4	No	No	Medium	15
20	Flat sandplain	39.79	No	No	Medium	5
21	Sandplain and associated slope	39.79	No	No	Medium	15
22	Sand dune	10			High	0

Appendix 4. Photographic documentation of field sites.

Forage 01

Forage 01

Forage 02

Forage 02

Forage 03

Forage 03

Forage 04

Forage 04

Forage 05

Forage 05

Forage 06

Forage 06

Forage 07

Forage 07

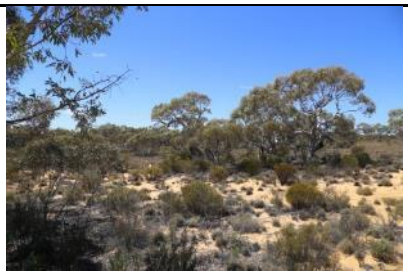
Forage 08

Forage 08

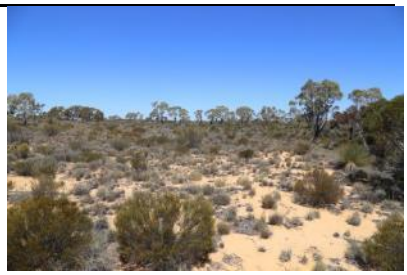
Forage 09

Forage 09

Forage 10



Forage 10



Forage 11

Forage 11

Forage 13

Forage 13

Forage 14

Forage 14

Forage 15

Forage 15

Forage 16

Forage 16

Forage 17

Forage 17

Forage 18

Forage 18

Forage 19

Forage 21



Appendix 5. Collection records for all species and number of specimens.

Group		Impact		Non-Impact		Specimens
	Species	Site	Deposit	Site	Deposit/location	
Gastropoda						
Stylommatophora	*Pupoides adelaidae*	15, 18	Shogun, Emperor			3
Arachnida						
Araneae	*Aname* sp. B15	02, 05, 06, 07, 22	Ambassador	08	West of Ambassador	8
	Aname sp. B16	05, 10, 13, 14, 15, 17, 18		08, 16, 19	North of Emperor, Ambassador	18
	Aname sp. B17		Damp Area	16	Ambassador	1
	Aname sp. B18	10, 17, 18	Camp and Surrounds, Emperor	19	North of Emperor	6
	Anidiops sp. B07		Damp Area	16	Ambassador	2
	Anidiops sp. B08			19	North of Emperor	3
	Anidiops sp. B09	10, 17	Camp Area and Surrounds, Emperor	08	Ambassador	3
	Aurecocrypta sp. B05	10	Camp Area and Surrounds			1
	Cethegus cf. *fugax*	01, 11, 13, 21, 03	Ambassador, Shogun	08, 16	Ambassador	8
	Cethegus ischnotheloides			19	North of Emperor	1
	Synothele sp. B10	14	Shogun			1
	Synothele sp. B11	05, 07	Ambassador			2
	Synothele sp. B12	04, 03	Ambassador			2
	Yilgarnia sp. B02	17	Emperor			1
Pseudoscorpiones	Chernetidae sp. B09	04, 05, 18, 03	Ambassador, Emperor			8
	Chernetidae sp. B10	15	Shogun			1
	Beierolpium 8/4 large	05, 18, 03	Ambassador, Emperor			3
	Indolpium sp. B18			08	Ambassador	2

Group		Impact		Non-Impact		Specimens
	Species	Site	Deposit	Site	Deposit/location	
	Oratemnus sp. B09	17	Emperor	19	North of Emperor	8
Scorpiones	*Lychas annulatus*	05, 13, 17	Ambassador, Shogun, Emperor			10
	Lychas splendens	10, 13, 15, 17, 20, 21, 03	Camp Area, Shogun, Emperor, Ambassador			29
	Urodacus cf. *armatus*	06, 15, 20	Ambassador, Shogun, Emperor			12
	Urodacus yaschenkoi	13, 03	Shogun, Ambassador			2
Malacostraca						
Isopoda	*Acanthodillo* sp. B15	03, 04	Ambassador			3
	Buddelundia sp. indet.			08	Ambassador	3
	Buddelundia sp. B56	04, 17, 03	Ambassador, Emperor	19	North of Emperor	43
	Trichorhina sp. B20	09		08	Ambassador	5
Chilopoda						
Geophilida	Chilenophilidae 'Sp. indet.'	18	Emperor			1
	Geophilidae sp. indet.	04, 15, 18	Ambassador, Shogun, Emperor			3
	Ribautia sp. B03	01, 09, 17, 03	Ambassador, Emperor	08, 19	Ambassador, North of Emperor	20
Diplopoda						
Polydesmida	*Antichiropus* sp. indet.			08	Ambassador	1
Polyxenida	*Polyxenidae* sp. B13	01, 15, 17, 18	Ambassador, Shogun, Emperor	08	Ambassador	9