Northern Minerals Limited

Browns Range Project

Terrestrial Short-range Endemic Invertebrate Fauna Impact Assessment

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Browns Range Project: Terrestrial Short-range Endemic Invertebrate Fauna Impact Assessment

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Executive Summary

Northern Minerals Limited (Northern Minerals) commissioned Outback Ecology to undertake a terrestrial short-ranged endemic (SRE) invertebrate fauna impact assessment of the proposed Browns Range Project (the Project). The Project is located approximately 150 kilometres southeast of Halls Creek in the Tanami bioregion of Western Australia. It is understood that this document will be used to support future environmental impact assessment documentation for the Project. This Assessment is based on information compiled in the standalone reports prepared for Northern Minerals by Outback Ecology (2013c)– *Browns Range Project: Terrestrial Short-range Endemic Invertebrate Fauna Baseline Survey*; and Outback Ecology (2013b) – Browns Range Project: Targeted Mygalomorph Spider Survey.

The Study Area considered by this Assessment consisted of approximately 16,294 ha containing a Development Envelope of approximately 2,590 ha. Northern Minerals have committed to locating the Project within the Development Envelope and the indicative footprint provided to Outback Ecology ('Development Footprint') has a total area of approximately 711 ha. Calculations of impacts to habitat have been made using this proposed footprint to provide scale and context to the impact assessment.

The objective of this Assessment was to assess the potential impacts of the Project on terrestrial SRE invertebrate fauna and invertebrate fauna habitats. This Assessment was conducted in accordance with Environmental Protection Authority (EPA) guidelines and policy statements for terrestrial invertebrate fauna surveys and impact assessment (EPA 2004, 2006, 2009).

A total of five invertebrate habitat types were identified in the Study Area; these habitats were categorised as having a high, medium or low potential to support SRE species based on the presence of sheltered micro-habitats or their propensity to form habitat isolates. Internal Drainage and Seasonal Drainage Surface habitats were considered to be restricted within the Study Area. Habitat types that are restricted are more likely to support species with restricted distributions, and therefore support true SRE species. Habitat types that are not restricted are less likely to support species with restricted distributions. The 'potential SRE' status given by taxonomists to species collected from these unrestricted habitat types may reflect a lack of regional collection records and/or taxonomic knowledge, rather than being an accurate reflection of the SRE status of these species.

Internal Drainage was considered to have a high potential of supporting SRE species although there is not perceived to be any impact to this habitat as it does not occur within the Development Envelope. Seasonal Drainage Surface, which is considered as having a medium potential to supporting SRE species, occurs inside the Development Envelope (42.1 ha) and may be impacted by the Project. The remaining three habitats; Sand Plain, Flood Plain and Rocky Rise, were not considered to be restricted within the Study Area, and although they may be impacted on a local scale via land clearing, impacts to these habitats on a regional scale are likely to be negligible.

Based on current scientific knowledge, none of the species collected were confirmed to be SRE species, however, 19 species recorded during this assessment were considered potential SRE species as defined by criteria used by the Western Australian Museum (2013) comprising:

- the mygalomorph spider *Aganippe* 'MYG260', *Aname* 'MYG258', *Aname* 'MYG287', *Aname* 'MYG288', *Idiommata* 'MYG259'. and *Kwonkan* 'MYG257';
- the selenopid spider *Karaops* 'sp. browns range';
- the scorpions *Isometroides* 'kimb1', *Lychas* 'annulatus2', *Urodacus* 'kimb2' and *Urodacus* 'yaschenkoi kimb1';
- the pseudoscorpions *Beierolpium* 'sp. 8/4' and *Xenolpium* 'PSE070';
- the millipedes 'DIPAAB' 'DIP043' and *Helicopodosoma* 'DIP044'; and
- the slaters *Acanthodillo* 'sp. browns range', *Buddelundia* sp.nov. 59, *Cubaris* 'sp. browns range' *and Spherillo* 'sp. browns range'.

Two potential SRE species; *Aname* 'MYG287' and *Karaops* 'sp. browns range' have only been collected from inside the Development Envelope and may be impacted upon as a result of the Project. For situations where SRE species have only been recorded inside potential impact areas, the EPA (2009) accepts that a risk based approach may be adopted in cases which meet the following criteria:

- a potential SRE taxon is represented by one or few specimens from only within proposed impact area;
- contextual data on the wider distribution and status of the taxon is unavailable from the WA Museum or the DEC; and
- additional targeted surveys appear unlikely to yield results in a reasonable timeframe.

The two potential SRE species fulfil all of the above criteria: each species is represented by between one and three specimens; contextual data on the distributions of these species is unavailable with the WAM, probably due to a lack of invertebrate surveys in the Tanami bioregion and an additional targeted survey completed one year after the baseline survey was unsuccessful in gaining a better understanding of the distribution of these species. In these situations, the EPA (2009) acknowledges that habitat can be used as a surrogate for inferring the distributional boundaries of the species.

Aname 'MYG287' was collected from Sand Plain and *Karaops* 'sp. browns range' was collected from Sand Plain and Rocky Rise habitat. All of these habitat types have a low potential of supporting SRE species as they were widespread within the Study Area and surrounding region. If habitat is used as a surrogate for inferring distributional boundaries of these species, it is assumed that they have distributions that extend outside of the Development Envelope and therefore the Project is unlikely to affect the long-term persistence of the species. The remaining 17 species were collected from at least one location outside of the Development Envelope and consequently the development of the Project is unlikely to affect the long-term persistence of these species.

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1. INTRODUCTION

Northern Minerals Limited (Northern Minerals) commissioned Outback Ecology to undertake a terrestrial short-ranged endemic (SRE) invertebrate fauna impact assessment of the proposed Browns Range Project (the Project). It is understood that this document will be used to inform future approvals and permitting documentation for the Project. This Assessment is based on data obtained during a terrestrial SRE invertebrate baseline survey conducted in January 2012 (**Appendix A**), a targeted mygalomorph spider survey conducted in January/February 2013 (**Appendix B**) and a vegetation and flora survey conducted in May 2012 and May 2013 (Outback Ecology 2013a).

1.1 Project Location And Description

The Project is located approximately 150 kilometres (km) south-east of Halls Creek in the Tanami region of Western Australia (WA), adjacent to the Western Australia/Northern Territory border (**Figure 1**). The area considered during this Assessment (the Study Area) consists of approximately 16,294 hectares (ha) of land, containing a Development Envelope of approximately 2,589 ha (**Figure 2**). Northern Minerals have committed to locating the Project entirely within the Development Envelope and the indicative footprint provided to Outback Ecology ('Development Footprint') has a total area of approximately 711 ha. Calculations of impacts to habitat have been made using this footprint to provide scale and context to the impact assessment.

The Development Footprint will consist of two components: the mining infrastructure and the access road. The mining infrastructure will likely include pits, waste rock landforms, an ore processing facility, tailings storage facility, roads, borefield, pipelines, parking and laydown areas, a workshop, fuel and water storage, accommodation village and administration buildings (**Figure 3**). Mining activities will consist of open pit mining, with crushing, grinding and separation being conducted on site. The construction of the access road will require a combination of new road construction and upgrades to existing roads. It is intended that borrow pits will be placed along the access road for the purpose of sourcing earth materials required for the upgrades. Concentrate will be transported from the Project to the public road via the access road (included in this Assessment) and public roads.

1.2 Report Scope and Objectives

The objective of this Assessment was to assess the potential impacts of the Project on terrestrial SRE invertebrate fauna and invertebrate fauna habitats. This Assessment is based on data obtained during the terrestrial SRE invertebrate fauna baseline survey conducted in January 2012 (**Appendix A**), a targeted mygalomorph spider survey conducted in January/February 2013 (**Appendix B**) and a vegetation and flora survey conducted in May 2012 and May 2013 (Outback Ecology 2013a). Details of the methods applied and the areas surveyed are provided within the relevant reports and summarised in **Section 2.1**.

This Assessment, and the supporting surveys were conducted in accordance with Environmental Protection Authority (EPA) guidelines and policy statements for terrestrial invertebrate fauna surveys and impact assessment (EPA 2004, 2006, 2009). There were no limitations to this assessment arising from the requirements of Northern Minerals.

1.3 Legislative Framework

Key legislation contributing to the protection of the biological diversity of native fauna in WA includes the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act (Cwlth)), Western Australian *Wildlife Conservation Act 1950* (WC Act), *Land Management Act 1984* and the *Environmental Protection Act 1986*. The Environmental Protection Authority (EPA) adopts the definition of biological diversity and the principles as defined in the National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth of Australia 1996). The EPA (2004) intends to ensure that, as far as possible, development proposals in WA are consistent with these principles, objectives and targets.

Additionally Section 4a of the Environmental Protection Act 1986 states that developments in WA must take into consideration to the following principles:

- The precautionary principle – where there are threats of serious and irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- The principle of intergeneration 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; and
- The principle of the conservation of biological diversity and ecological integrity – conservation of biological diversity and ecological integrity should be a fundamental consideration.

Comprehensive systematic reviews of different faunal groups often reveal the presence of SRE species (Harvey 2002). These species generally exist in relictual habitats formed as a result of widespread aridification and forest contraction since the Miocene and Pleistocene, which has resulted in population fragmentation and the evolution of new species. Particular attention should be given to these types of species in an environmental impact assessments (EIA) because habitat loss and degradation will further decrease their prospects for long-term survival (EPA 2004).

Some better known SRE species have been listed as threatened or endangered under State or Commonwealth legislation, but the majority have not (EPA 2009). Often the lack of knowledge about these species precludes their consideration for listing as threatened or endangered (EPA 2009). Listing under legislation should, therefore, not be the only conservation consideration in an EIA (EPA 2009). The EPA expects that an EIA will consider the potential impacts on the conservation status of SRE species (EPA 2004). The information provided in this document meets the standards, requirements and protocols as determined by the EPA.

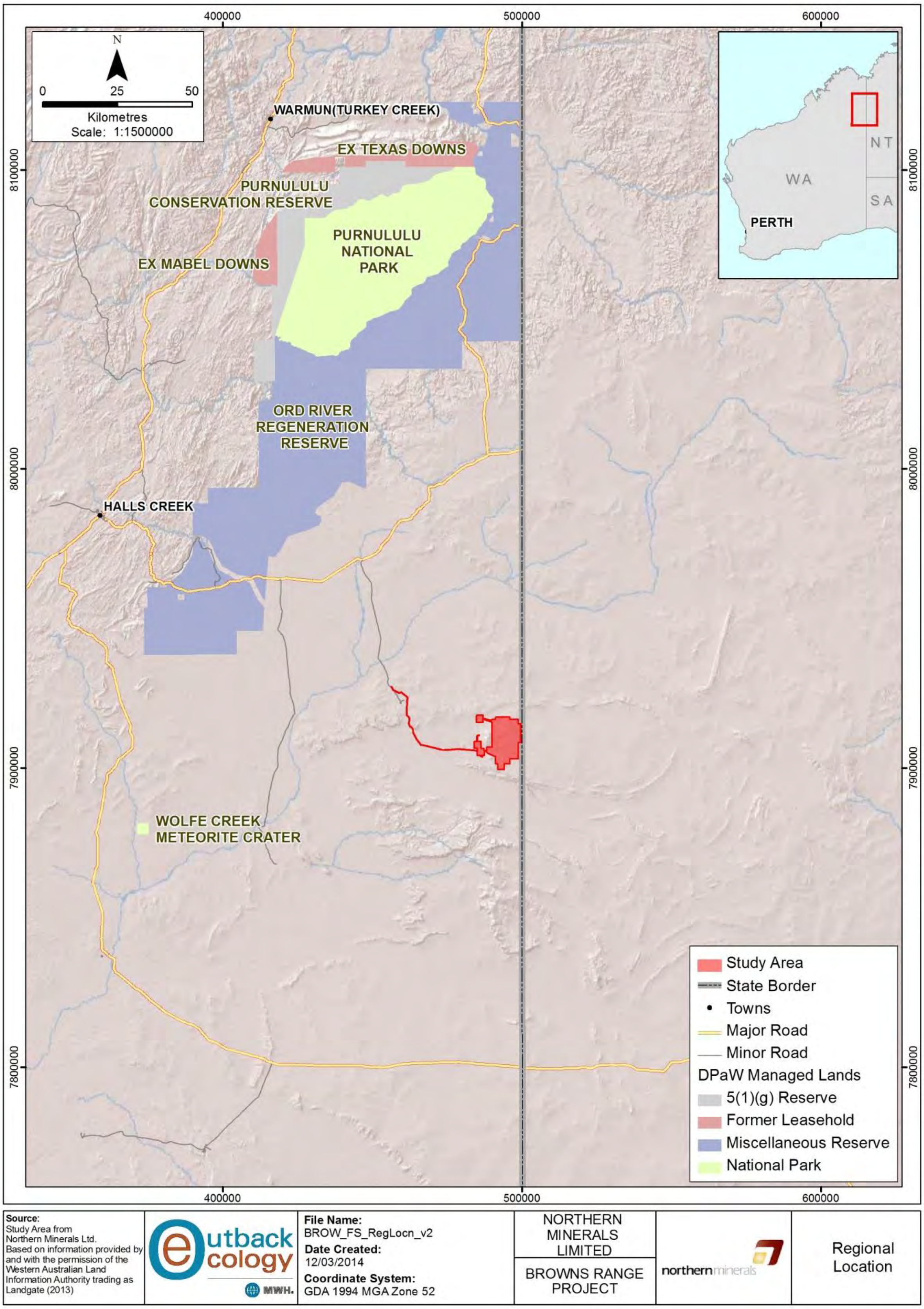


Figure 1: Regional location of the Project

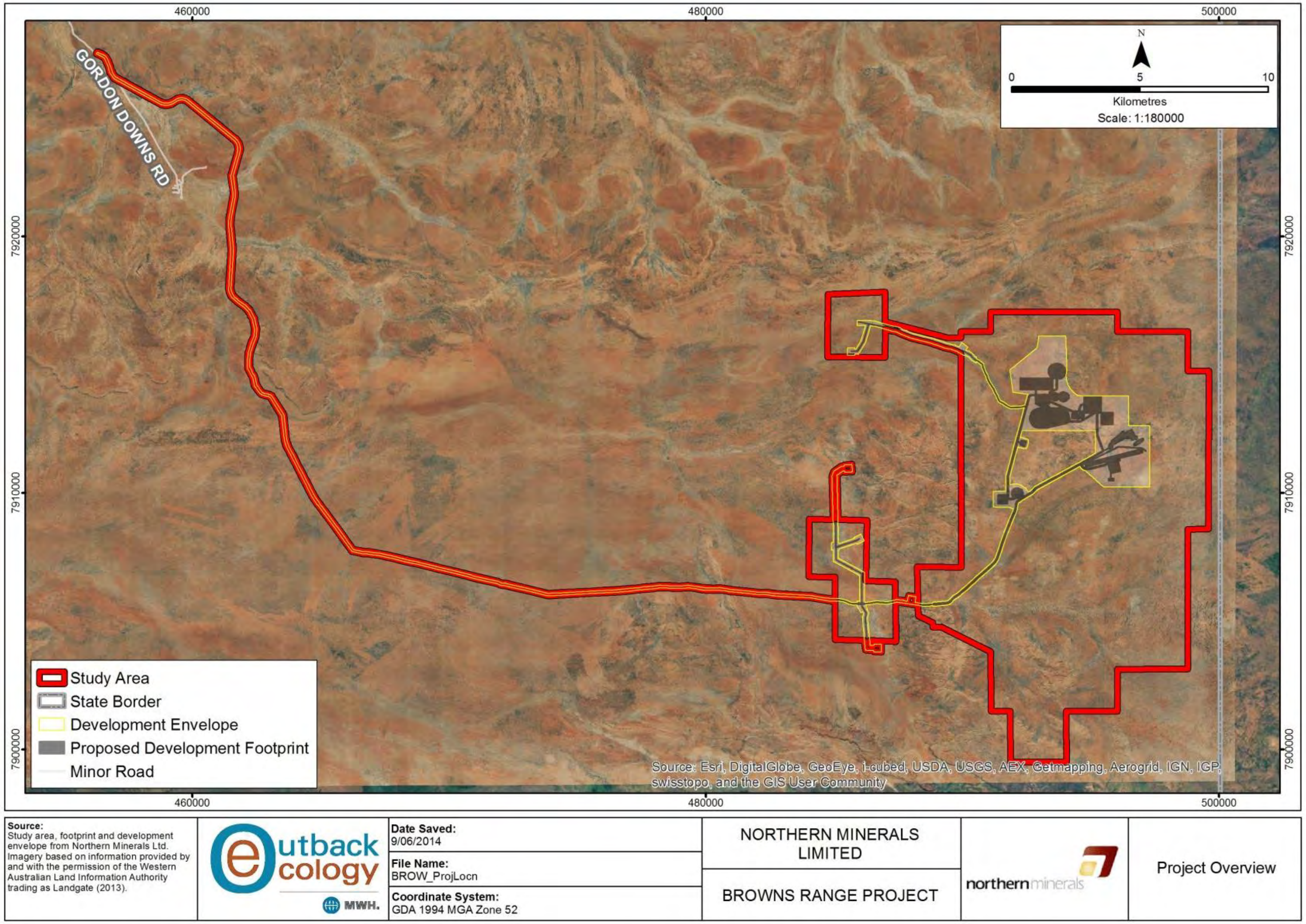


Figure 2: Study Area, Development Envelope and Development Footprint

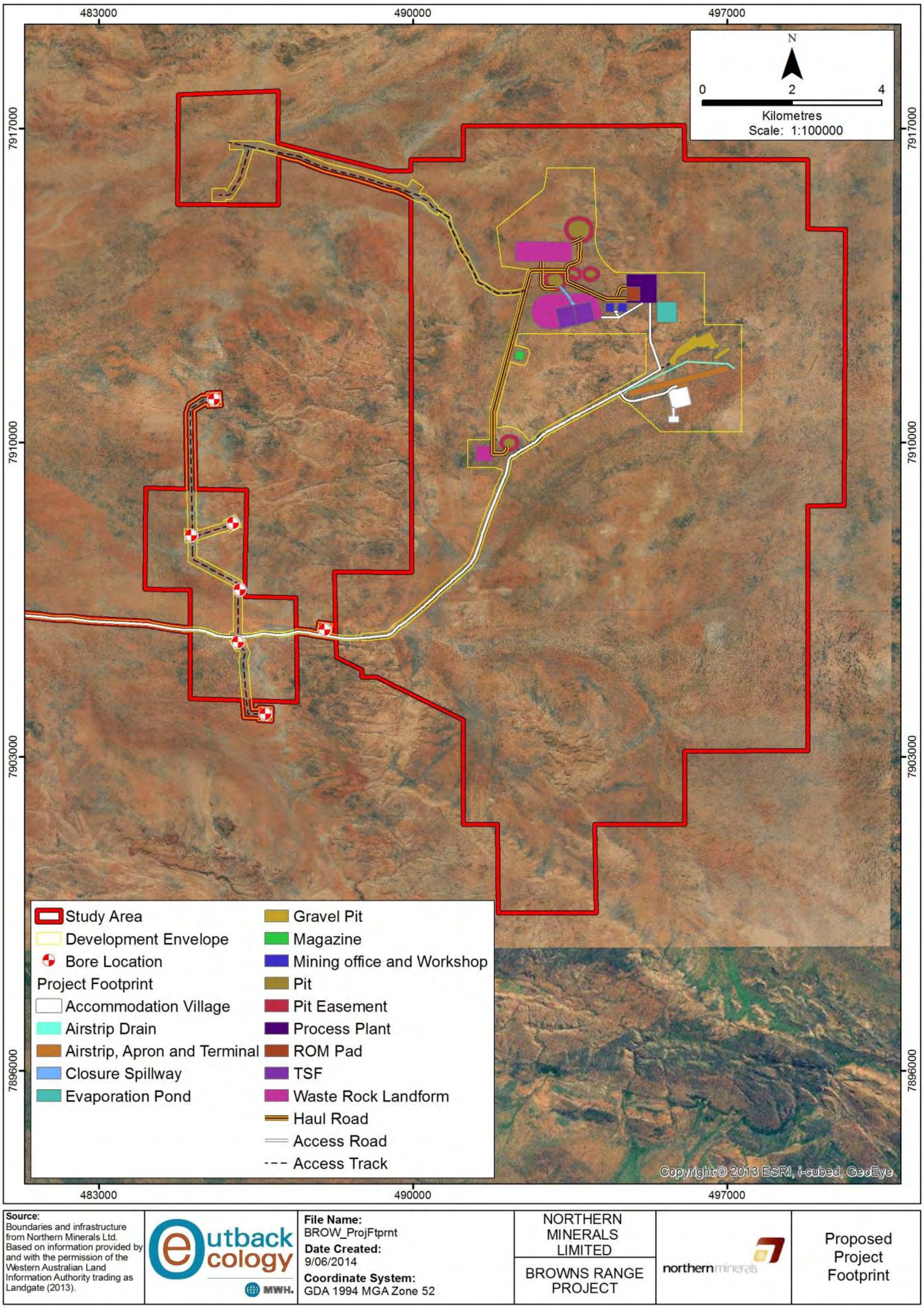


Figure 3: Conceptual Layout of the Project Infrastructure and Development Footprint

2. ADDENDUM TO THE BASELINE SURVEY

2.1 Revision of the Extent of the Study Area

This Assessment is based on data obtained during a terrestrial invertebrate fauna baseline survey (**Appendix A**), a targeted mygalomorph spider survey (**Appendix B**) and a vegetation and flora survey (Outback Ecology 2013a). Subsequent to the completion of the fauna survey (May 2012), the Development Envelope for the Project was extended beyond the original baseline survey area. Consequently, it was necessary for the Study Area to be extended (by 8,622 ha; **Figure 4**) to include the expanded Development Envelope. The Study Area was extended to incorporate mining infrastructure comprising an accommodation village, airstrip, clay deposit (in parentheses), gravel deposit and borefield locations. Additionally, the Study Area was extended to the northwest for approximately 50 km to incorporate the proposed access road between the Project and Gordon Downs Road.

Detailed habitat mapping was completed over the extensions of the Study Area to inform this Assessment of the likelihood for fauna species to occur. This habitat mapping was based upon detailed vegetation mapping of the extended areas completed in May 2013 (**Appendix A**) (**Figure 4**). No new habitats or land systems were found to occur in the extended areas and consequently, information from the baseline fauna survey was considered adequate to predict species occurrence in the extended areas and was therefore appropriate for informing this Assessment.

2.2 Implications of the Study Area Revisions

The enlargement of the Study Area subsequent to the completion of the baseline survey and targeted mygalomorph spider survey necessitated revision of the extent of land systems (**Section 2.3**) and fauna habitats occurring within it (**Section 2.4**). This new information, when reviewed with the other baseline survey data and the targeted mygalomorph spider survey data, provides an adequate baseline for this Assessment. Of the 8,622 ha of additions to the Study Area, 159 ha in five small sections have not been verified through ground surveys and have been characterised through remote sensing methods (**Figure 4**).

2.3 Land Systems in the Study Area

The 8,622 ha portion of land added to create the Study Area extends into the Coolindie and Winnecke Land Systems, which were identified as occurring in the area originally surveyed during the baseline survey. While the types of land systems occurring in the Study Area have not changed as a result of the addition, their extents are now different from those presented in the baseline survey report (**Table 1**, **Figure 5**). The Coolindie land system remains the dominant land system in the Study Area.

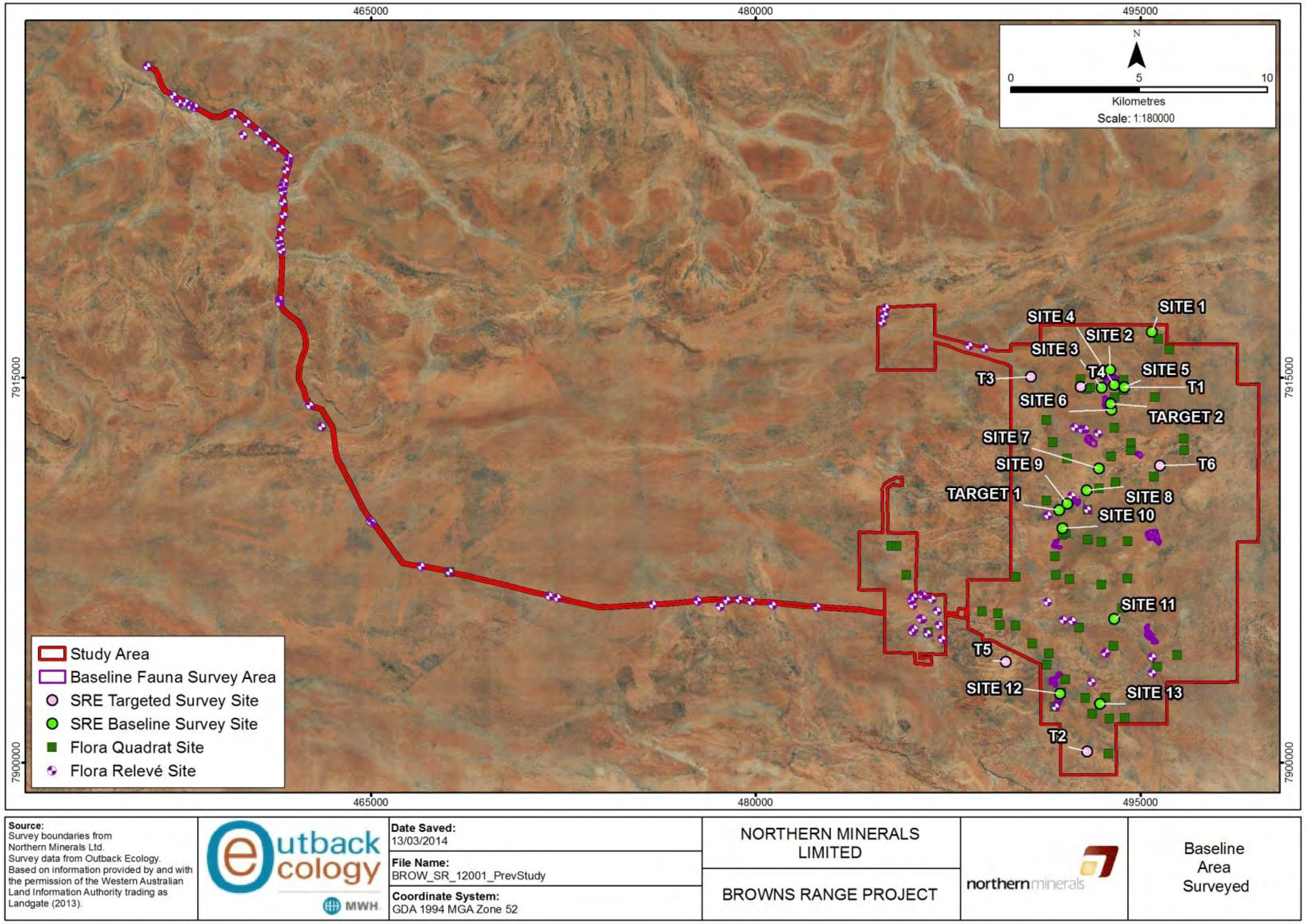


Figure 4: Flora and SRE survey effort within the boundaries of the Study Area relative to those of the SRE baseline survey area and the SRE targeted mygalomorph spider survey

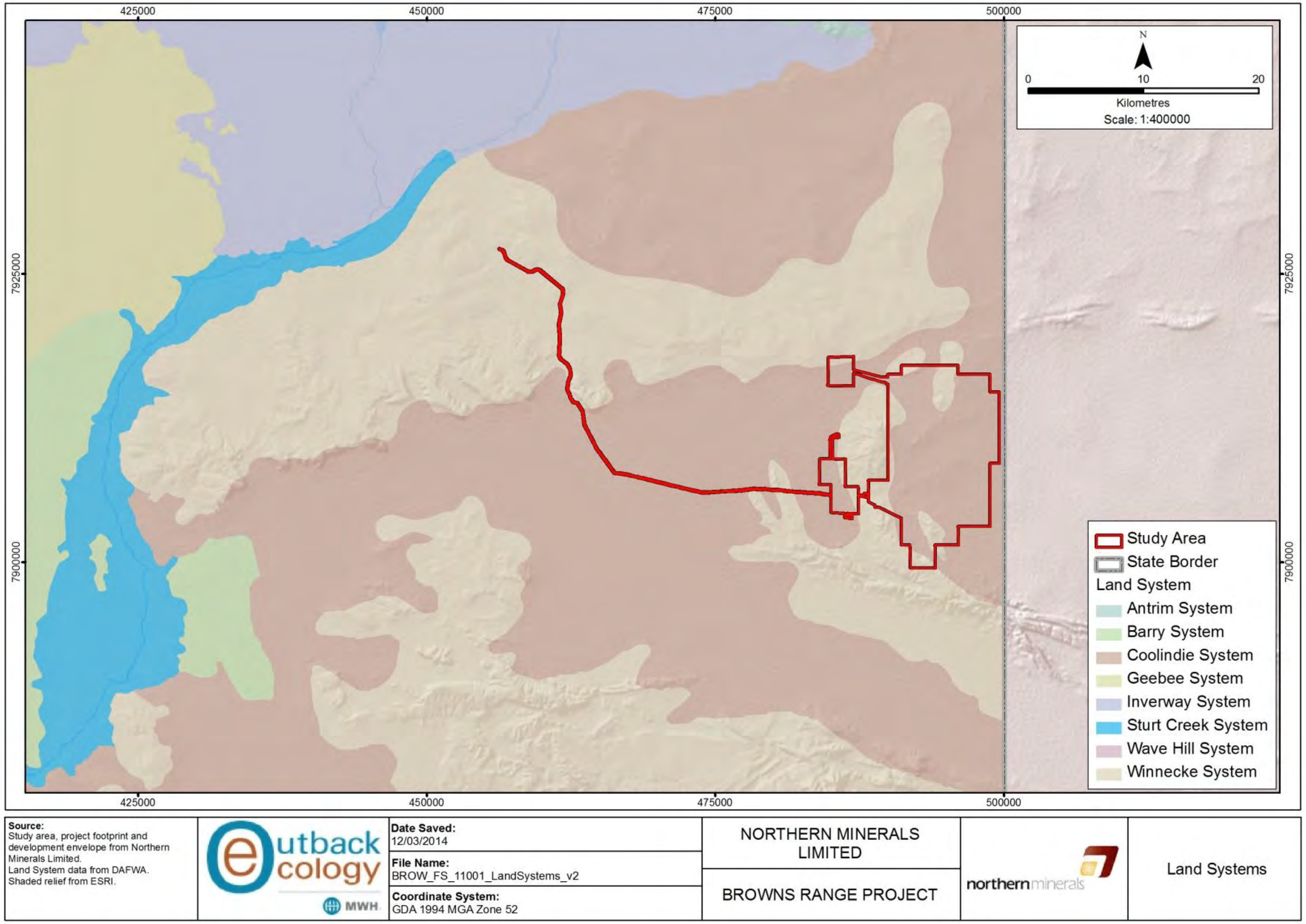


Figure 5: Land systems within and surrounding the Study Area

Table 1: Land systems within and surrounding the Study Area

Land System	Description	Extent in Study Area[1]
Coolindie	Consists of gently undulating red desert Sand Plains and dunes supporting *Acacia* shrublands, *Eucalyptus* woodlands and soft spinifex (*Triodia pungens*) grasslands. These grasslands are subject to frequent fires that cause short-term changes in floristic composition and abundance. Drainage lines are shallow, widely spaced and infrequent, and erosion is minimal.	13,276 ha 81.48%
Winnecke	Consists of stony hills and lowlands associated with red desert sands that support *Acacia* and *Eucalyptus* woodlands and soft spinifex (*Triodia pungens*) grasslands. These grasslands are subject to frequent fires that cause short-term changes in floristic composition and abundance. Intensive parallel drainage lines occur on upper slopes, while widely spaced angular drainage lines occur on lower slopes and terminate at the base of hills. Erosion is generally minimal, though some drainage floors are moderately susceptible.	3,018 ha 18.52%
	Total	16,294 ha

[1]Size (ha) and proportion of Study Area (%); Source: Payne and Schoknecht (2011)

2.4 Habitats in the Study Area

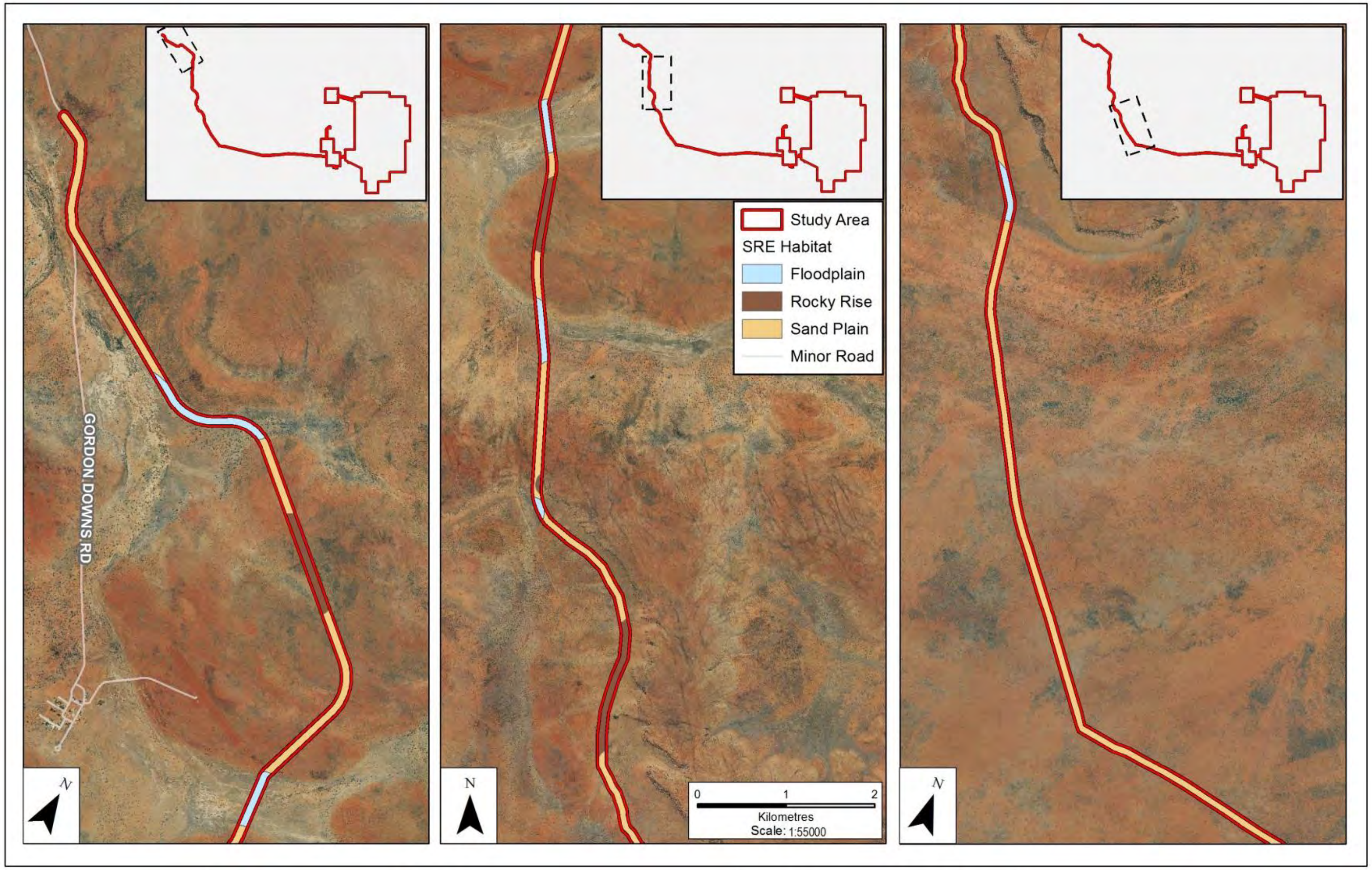
The 8,622 ha portion of land added to create the Study Area contains extensions of three invertebrate habitats previously defined by Outback Ecology (**Appendix A**):

- Sand Plain;
- Flood Plain; and
- Rocky Rise.

The total extents of all habitats of the Study Area are presented in **Table 2** and **Figure 6** - **Figure 8**.

Table 2: Assessment of habitats within the Study Area

Habitat	Regional Extent	Potential to support SRE species	Habitat Description	Area of habitat in the Study Area (ha)	Composition of the Study Area (%)
Sand Plain	Not restricted	Low	Sand Plain habitat was characterised by sparse to very sparse mixed *Acacia* shrubland over a mixed open grassland. The habitat type is widespread in the Study Area and surrounding region. Sand Plain habitats are exposed for much of the day and provided limited sheltered areas for relictual species	12,838 ha	78.79%
Flood Plain	Not restricted	Low	Flood plain habitat was characterised by large, shallow drainage areas and basins. The habitat type generally occurred in association with Sand Plain habitat, however a greater abundance of Acacia shrubs was present. Flood Plain habitats are sheltered environments that tend to have elevated soil moisture content.	1.937 ha	11.89%
Rocky Rise	Not restricted	Low	Rocky rise habitat was characterised by lateritic protrusions, with vegetation comprising very sparse *Eucalyptus* spp. over an open mixed grassland. The habitat type is relatively common in the Study Area and surrounding region. Rocky Rise habitats are exposed for much of the day and provided limited sheltered areas for relictual species	1,392 ha	8.54%
Seasonal Drainage Surface	Restricted	Medium	Seasonal Drainage Surface habitat was characterised by a mixed *Acacia* shrubland over a closed mix grassland. The habitat type occurs at the base of Rocky Rise habitat. Rainfall generally inundated in this habitat after draining from the surrounding Rocky Rise habitat. Seasonal Drainage Surfaces are generally isolated and have elevated levels of soil moisture, however are exposed for much of the day.	121 ha	0.74%
Internal Drainage	Restricted	High	Internal Drainage habitat was characterised by sparse *Eucalyptus* spp. over a closed mixed *Acacia* shrubland over a closed mix grassland, predominately comprising Spear grass. The habitat type featured a basin feature surrounded by Rocky Rise habitat. Rainfall generally pooled in this habitat after draining from the surrounding Rocky Rise habitat. Internal Drainage habitats are isolated, sheltered environments that tend to have elevated soil moisture content.	6 ha	0.04%
			Total	16,294 ha	100%



Source: Boundary data from Northern Minerals Limited. Habitat data from Outback Ecology. Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2013).	outback ecology MWH.	**Date Saved:** 13/03/2014 **File Name:** BROW_SR_12001_Habitat_1of3 **Coordinate System:** GDA 1994 MGA Zone 52	NORTHERN MINERALS LIMITED BROWNS RANGE PROJECT	northern minerals	SRE Habitat (1 of 3)

Figure 6: Invertebrate habitat occurring within the Study Area (1 of 3)

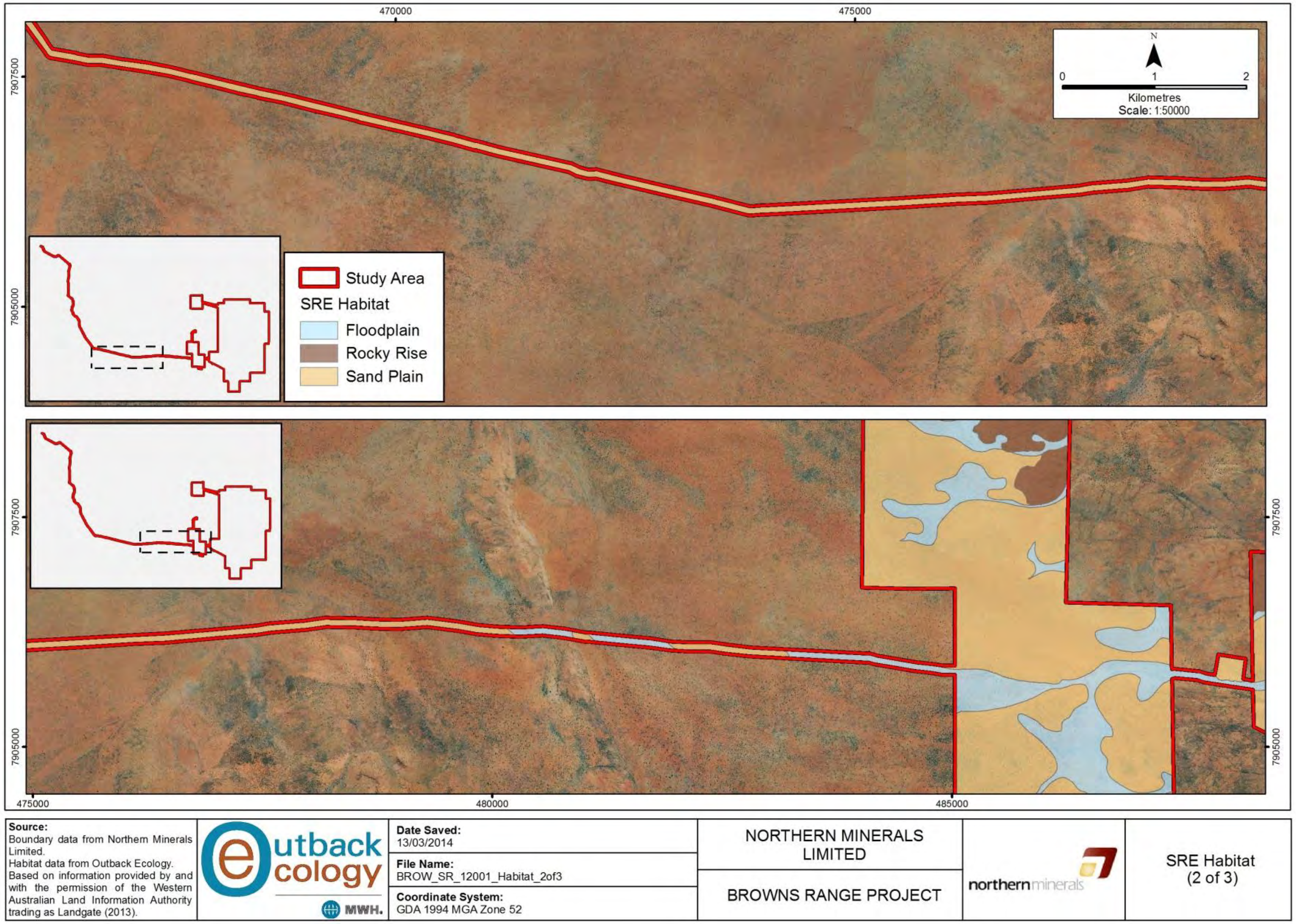


Figure 7: Invertebrate habitat occurring within the Study Area (2 of 3)

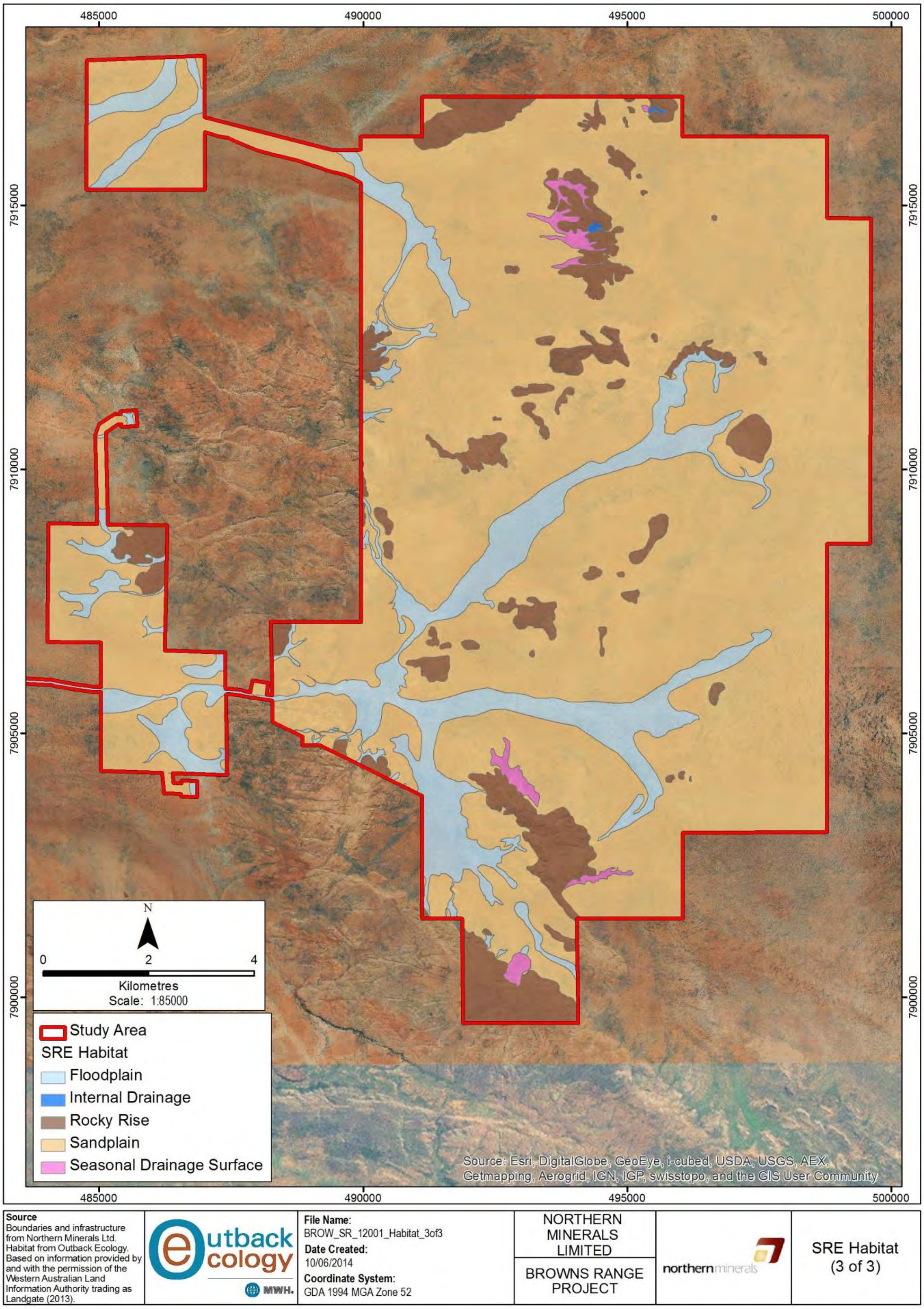


Figure 8: Invertebrate habitat occurring within the Study Area (3 of 3)

3. POTENTIAL IMPACTS

This section presents an assessment of aspects of the Project with the potential to impact on terrestrial SRE invertebrate fauna habitat and terrestrial invertebrate species identified during the surveys and from the desktop study. The primary objectives of this section are to describe the relevant threatening processes associated with the Project (**Section 3.1**) and to examine the likely impact of these threatening processes on invertebrate fauna habitat (**Section 3.2**) and potential SRE species present in the Study Area (**Section 3.3**).

3.1 Threatening Processes

Aspects of the Project that constitute threatening processes with potential to impact upon SRE invertebrate fauna or SRE habitats include land clearing, inappropriate fire regimes, introduced flora and changes to surface hydrology (EPA 2009), increased noise, vibration, artificial light and impacts of dust.

The aspect of the Project with greatest potential to impact upon fauna or fauna habitat is the removal and modification of habitat through land clearing. The other aspects of the Project listed above have potential to impact on fauna, however the extent of the impacts are likely to be localised and have negligible to no effect at a regional scale.

3.1.1 Habitat Removal and Modification

Habitat removal and modification is an aspect of the Project with the greatest potential to impact on terrestrial SRE invertebrate fauna and habitat within the Study Area. Habitat removal will remove potential invertebrate habitat resulting in habitat reduction and fragmentation. Terrestrial SRE invertebrate species typically have poor powers of dispersal and are therefore unable to emigrate from land as it is being cleared. Land clearing will reduce the population size of SRE species that occur within the Development Envelope (**Section 3.3**). Habitat fragmentation has the potential to create habitat isolates in previously unrestricted habitats. The dispersal ability of invertebrate species located within these isolates can be severely reduced. Habitat fragmentation may also separate existing invertebrate populations, limiting gene flow and genetic differentiation in the species (Fanomezana 2006). Consequently, the clearing of any habitat with a high or medium potential to support terrestrial SRE invertebrate species, such as Internal Drainage and Seasonal Drainage Surface habitat types (**Section 3.2**), should be avoided where practicable.

Northern Minerals have committed to clearing no more than 711 ha within the 2,590 ha Development Envelope for the Project. The Development Envelope has been specifically designed to exclude the Internal Drainage habitat and associated Rocky Rise habitat to protect from clearing and subsequently minimise the impacts to SRE fauna within the Study Area. The Internal Drainage habitat has a high potential to support SRE species and the surrounding Rocky Rise habitat is important to the surface water hydrology of the Internal Drainage habitat (**Appendix A**, **Appendix B**).

Table 3: Habitats in the Study Area, Development Envelope and Development Footprint

Invertebrate fauna habitat	Regional Context[1]	Potential to support SRE species	Extent in		
			Study Area	Development Envelope[2]	Development Footprint[2]
Sand Plain	Not restricted	Low	12,838 ha	1,996 ha (15.5%)	557 ha (4.3%)
Flood Plain	Not restricted	Low	1,937 ha	344 ha (17.8%)	71 ha (3.6%)
Rocky Rise	Not restricted	Low	1,392 ha	208 ha (14.9%)	66 ha (4.7%)
Seasonal Drainage Surface	Restricted	Medium	121 ha	42 ha (34.7%)	17 ha (14.0%)
Internal Drainage	Restricted	High	6 ha	0 ha	0 ha
		Totals[3]	16,294	2,590	711 ha

[1] Widespread habitats are those occupying more than 10% of the Study Area while habitats of limited extent are those occupying less than 10% of the Study Area.
[2] Percentages indicate the amount of each habitat present in the Development Envelope and Proposed Development Footprint, respectively, as a proportion of the amount of that habitat type known to occur in the Study Area.
[3] Areas may not equal actual area values due to rounding errors.

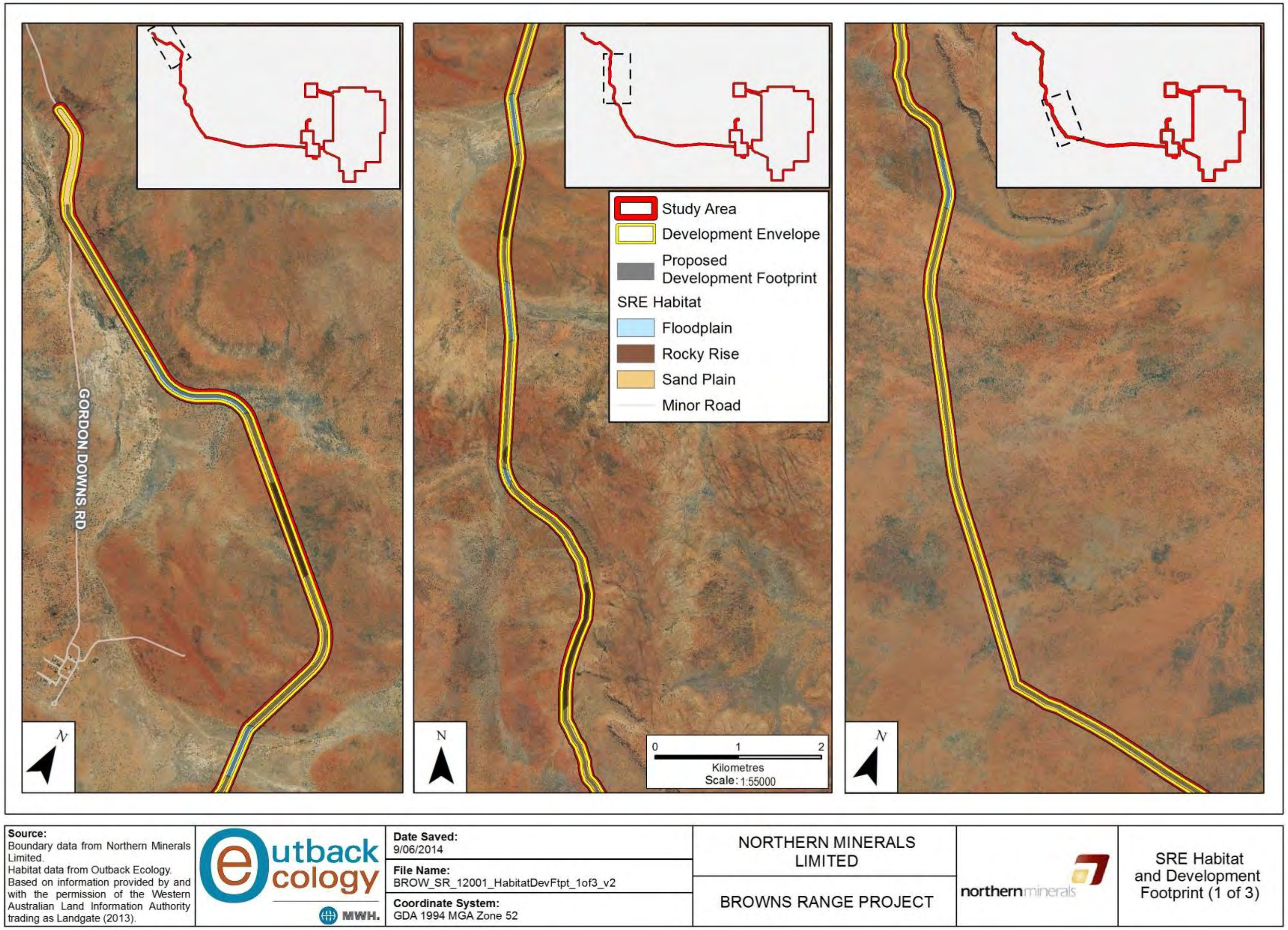


Figure 9: Invertebrate habitat occurring within the Study Area with respect to the Development Envelope and Development Footprint (1 of 3)

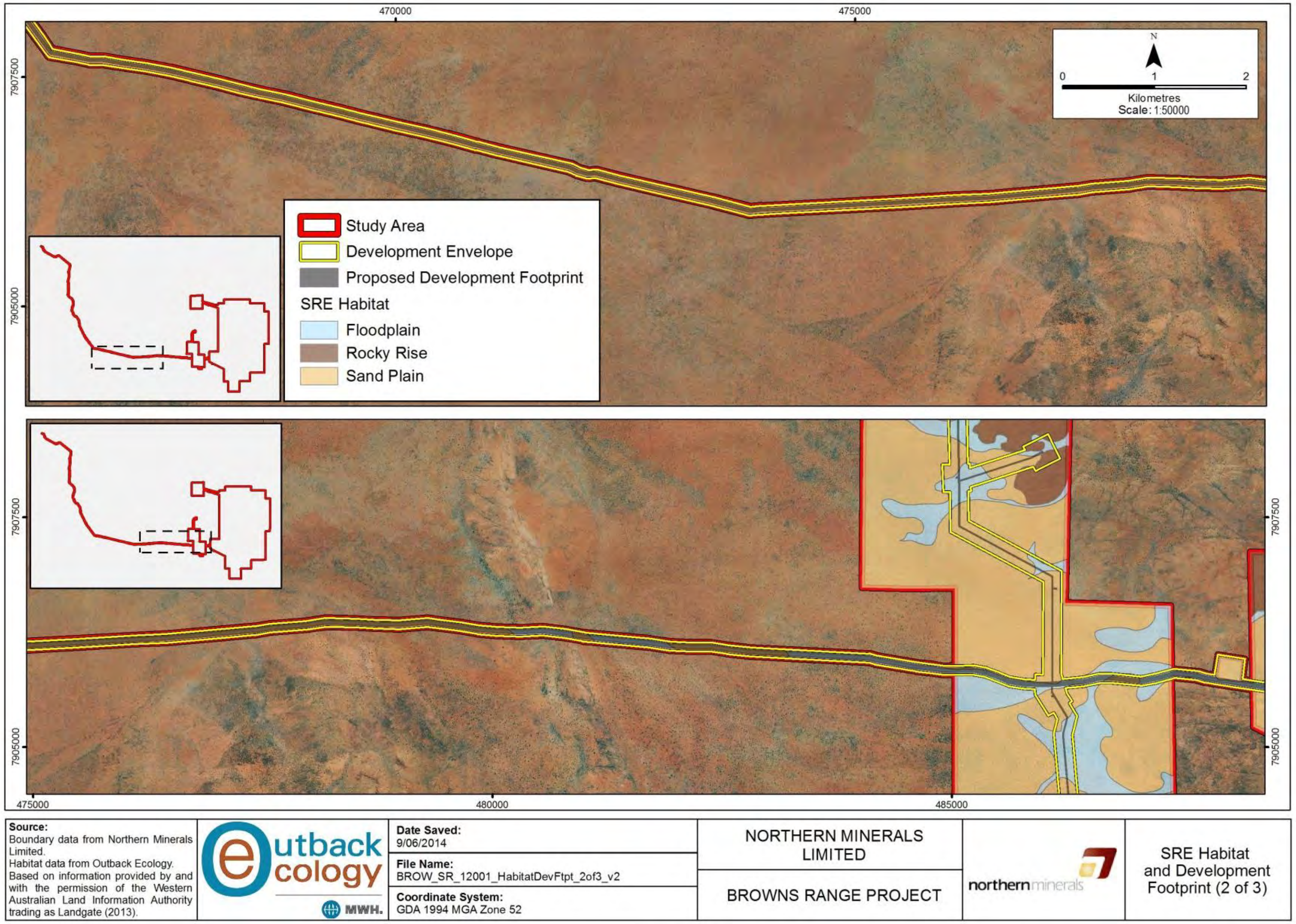


Figure 10: Invertebrate habitat occurring within the Study Area with respect to the Development Envelope and Development Footprint (2 of 3)

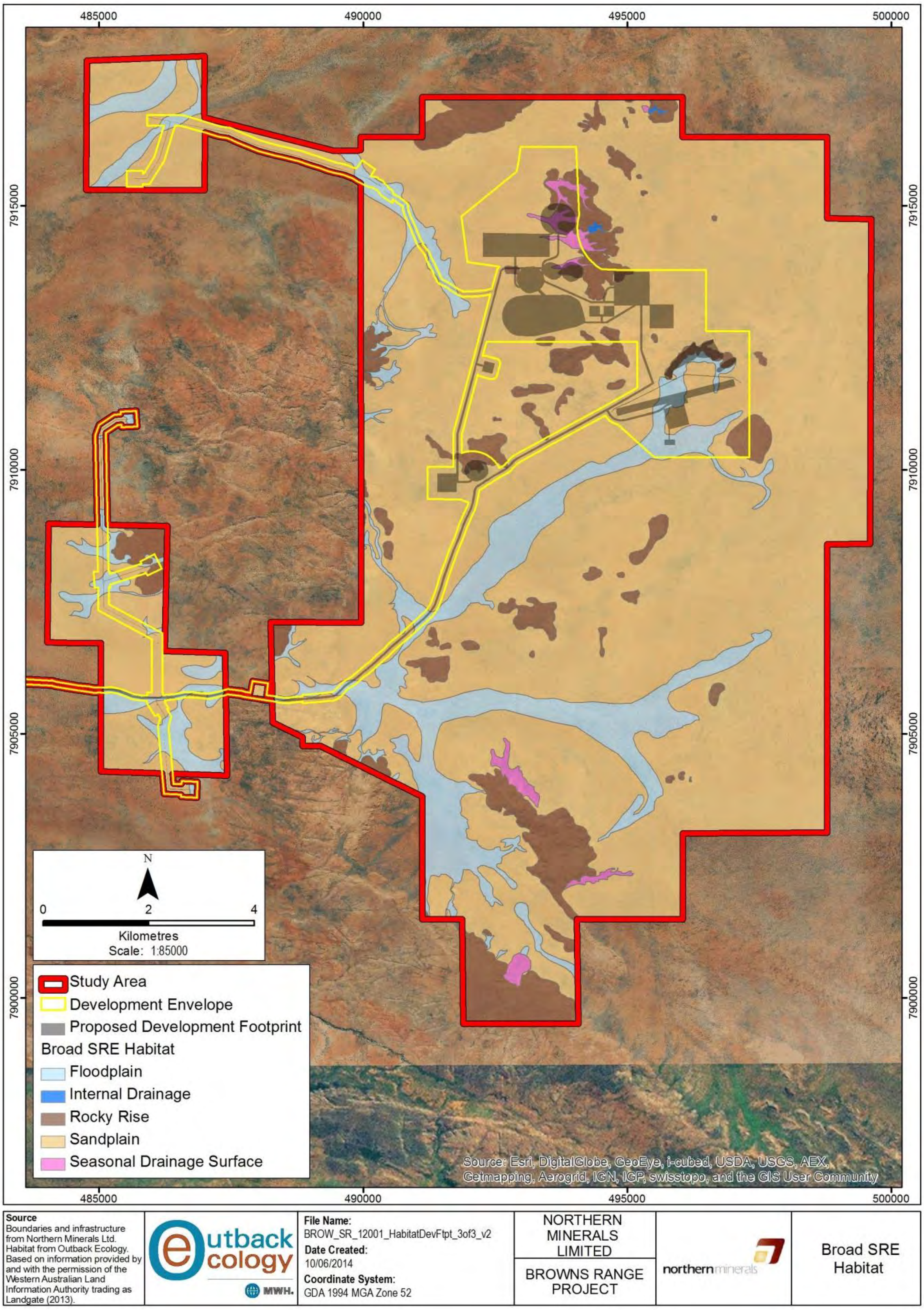


Figure 11: Invertebrate habitat occurring within the Study Area with respect to the Development Envelope and Development Footprint (3 of 3)

3.1.2 Inappropriate Fire Regime

The development and ongoing operation of the Project may alter the fire regime of the Study Area through the introduction of unplanned fire resulting from vehicle movements and/or other Project activities (e.g. hot work). Fire may impact invertebrate fauna via direct contact, or indirectly by long-term habitat modification brought about by inappropriate fire frequency and intensity. Fire is a common event within the Coolindie and Winnecke land systems (Burrows *et al.* 2006, Turner *et al.* 2008). Signs of fire (e.g. recovering vegetation) were observed during the baseline survey and there have been fire events within the Study area since. Appropriate management of fire in the Study Area can reduce the frequency of hot extensive fires which have a greater impact upon fauna and fauna habitat than low-intensity introduced fire.

The majority of the Study Area comprised mixed grasslands which generally experience fire events from time to time. In this situation fire refuges exist in areas that contain less flammable material. The Rocky Rise habitat type exhibits some characteristics of a fire refuge, such as expanses of non-combustible material (lateritic rock) and sparse or fragmented vegetation. This habitat type is likely to remain unburnt for longer periods of time when compared to the surrounding habitat types. As a result, this habitat type may contain areas of leaf litter accumulation which have the potential to create invertebrate microhabitat. Invertebrate species that occur within these habitat types are likely to have evolved in the absence of frequent fire events.

Given the prevalence of natural fire events in the Study Area, impacts of infrequent, low-intensity introduced fire events are likely to be low. More substantial change to the existing fire regime, however, such as an increase in the frequency and/or intensity of fire events (i.e. large, hot fires late in the dry season), is likely to have adverse effects on fauna habitat that could alter fauna assemblages present in the Study Area. The impact of inappropriate fire regimes may be reduced through the implementation of an appropriate fire management plan.

3.1.3 Introduced Flora

Environmental weeds may be brought in by mobile equipment during construction and operation of the Project. Weed invasion is widely recognised as having a negative impact on fauna species, as it can fundamentally alter the composition and structure of native vegetation communities (Cowie and Werner 1993, Gordon 1998). In the extreme, entire ecosystems can be modified (Sodhi and Ehrlich). Invasion by non-native species typically results in declines in native plant species richness, but the response of fauna may be more complicated with individual invasions potentially resulting in increase, decrease or no-change scenarios for different assemblages (Grice 2006). For example, even at low densities, Buffel Grass (*Cenchrus ciliaris*) can affect the composition of ground vegetation, birds and ant fauna, leading to declines in some species (Binks *et al.* 2005, Smyth *et al.* 2009). There is potential for substantial change to occur to vegetation communities in the Study Area, should invasive flora be introduced and become established.

Several weed species were recorded in low numbers and frequency within the Study Area: *Malvastrum americanum* (Spiked Malvastrum), *Panicum antidotale* (Giant Panic Grass), *Echinochloa* *colona* (Awnless Barnyard Grass) and *Portulaca oleracea* (Purslane) (Outback Ecology 2013a). These species are unlikely to diminish the biological diversity of the Study Area as the majority are generally found in low numbers and are spread by fauna and water vectors. However along the proposed access road route, two additional species *Cenchrus setiger* (Birdwood Grass) and *Stylosanthes hamata* (Verano Stylo) were recorded in patches, mostly alongside the road verge and sometimes in very large populations.

The Project may result in the introduction or spread of environmental weeds from mobile mining equipment. The invasion of weeds may have a negative impact on terrestrial SRE invertebrate species (EPA 2009) as they can fundamentally alter the composition and structure of the naturally occurring vegetation communities (Cowie and Werner 1993, Gordon 1998). It is therefore, important to implement management strategies to reduce the occurrence and spread of weeds during mining operations. Management practices which will minimise the risk of spread of *Cenchrus setiger* and *Stylosanthes hamata* should include ensuring that any machinery (particularly for earthworks) entering the Project should be subject to quarantine/hygiene measures that ensure that no contaminated soils or weed seeds enter the area. Typically this would involve using a wash down bay or station, and educating the workforce with environmental inductions. Within the Project area, machinery used in earthworks in areas with known populations of the less aggressive weeds should also be cleaned prior to entering uncontaminated areas and where practical larger populations of these species should be controlled.

3.1.4 Changes to Surface Hydrology

Availability of water and nutrients is the primary limiting factor in arid and semi-arid environments (James et al. 1995). The degree to which ecosystems depend on the retention of water after substantial rainfall, varies with the particular structure and function of ecosystems, which in turn are likely to vary over time. Rainfall in the Tanami bioregion can be highly localized and unpredictable, with substantial fluctuations occurring spatially and temporally (BOM 2014). Consequently, the vast majority of ecosystems present do not feature accessible water for any length of time. However, small occurrences of productive, water-dependent ecosystems are distributed within the region and these provide critical refuge and habitat for organisms in times of drought (James *et al.* 1995).

Surface water-dependent ecosystems are those that rely on the retention of accessible water following substantial rainfall; that is, they require the input of water to maintain their current composition and functioning (Murray *et al.* 2003). These ecosystems are typically limited in their extent, but they represent a key resource to a diversity of fauna (Murray *et al.* 2003). Surface water-dependent ecosystems in the Study Area include the Internal Drainage and to a lesser extent, Seasonal Drainage Surface and Flood Plain habitat types (**Table 2**). Additionally, some groundwater dependent vegetation may occur within Flood Plain habitat and include deep rooted species such as *Eucalyptus victrix*. Removal of water from these habitat types, or a change in the timing, quantity, quality or distribution of water available to them, may impact negatively upon the invertebrate fauna assemblages that occur within.

Additionally, drainage control structures may increase sediment loading or cause temporary flooding of invertebrate habitat adjacent to mining areas. Appropriate drainage control structures in the mining area and along the access road have potential to mitigate impacts to Internal Drainage, Seasonal Drainage and Flood Plain habitat types.

3.1.5 Noise and Vibration

Noise and vibration from the Project will be associated with blasting, crushing and screening, vehicle movements, diesel power generation and general machine operation necessary for mine operation. Information on the potential effects of noise and vibration on SRE species is limited. A trial that tests the effect of exploration drilling on the SRE Shield-backed trapdoor spider has been conducted at Jack Hills in the Murchison by Crosslands Resources (DMP 2010). In the trial, spiders were observed in their burrows while vibration simulating drilling was produced. Preliminary results suggest that the effects of vibration on spiders may be limited; however; the intrusion of burrows by endoscopic camera may have also influenced spider behaviour.

Raven (2008) suggests that vibrations created by blasting and heavy earthmoving equipment may actually attract spiders and other arachnids, which subsequently places these individuals at risk of direct contact with mining activities. Scorpions may also be affected by vibration as they rely on vibrations for prey detection, navigation and courting (Volschenk 2011). Without further research, it is not possible to predict or quantify the noise and vibration impacts on terrestrial SRE invertebrate species.

3.1.6 Light

The Project will result in an increase in the exposure of terrestrial SRE invertebrate species to artificial light. Most SRE invertebrate fauna in the Tanami bioregion are active during the hours of darkness and it is possible that artificial light will influence feeding and breeding behaviour. To reduce possible impacts of artificial light on SRE species, lighting should be designed to illuminate designated operations areas rather than the surrounding landscape.

3.1.7 Dust

The development and operation of the Project will create dust emissions due to construction, blasting, haulage and general traffic activities. Dust emissions may affect surrounding vegetation. High levels of dust have been associated with a reduction in plant growth and productivity, resulting in degradation of the overall ecosystem and an increased risk of disease in plants (Farmer 1993). Dust has also been linked to changes in soil chemistry and the structure of vegetation communities (Farmer 1993). Changes in vegetation as a result of dust may reduce the suitability of some habitats for invertebrate fauna within close proximity to the Project; however, these effects are expected to be negligible to non-existent on a regional scale.

3.2 Impact on Terrestrial Invertebrate Habitat

Habitat loss is listed as a key threatening process under the EPBC Act, however it is recognised that this is a necessary and typical outcome of the development of the Project. The development of the

Project will result in the loss of 711 ha of habitat via land clearance within the 2,590 ha Development Envelope. It should be noted that the configuration of the Development Footprint may change and that clearing (up to the maximum of 711 ha) may occur anywhere within the Development Envelope according to Project requirements.

Five invertebrate habitat types were identified in the Study Area and categorised as having a high, medium or low potential to support terrestrial SRE invertebrate species based on the presence of sheltered micro-habitats or their propensity to form habitat isolates (**Table 2**, **Figure 6** - **Figure 8**). Internal Drainage and Seasonal Drainage Surface habitats were identified as restricted within the Study Area as they were limited in both their extent and connectivity within the Study Area. Habitat types that are restricted are more likely to support species with restricted distributions, and therefore support true SRE species. The remaining three habitats; Sand Plain, Flood Plain and Rocky Rise were not considered to be restricted within the Study Area and surrounding region. Habitat types that are not restricted are less likely to support species with restricted distributions. The 'potential SRE' status given by taxonomists to species collected from these unrestricted habitat types may reflect a lack of regional collection records and/or taxonomic knowledge, rather than being an accurate reflection of the SRE status of these species.

3.2.1 Internal Drainage

Internal Drainage habitat was identified as having a high potential to support SRE invertebrate species as it was restricted within the Study Area and was not identified outside of the Study Area during the targeted mygalomorph spider survey (**Appendix B**). Habitat within the Development Envelope may be subject to habitat removal, fragmentation and an altered surface hydrology as a result of the Project. Approximately 6 ha of this habitat type occurs within the Study Area, although none is located within the Development Envelope (**Table 2**, **Figure 8**). The Development Footprint was specifically established to exclude this habitat type, and the surrounding Rocky Rise habitat to protect from clearing and minimise impacts to SRE within the Study Area.

Although habitat within the Development Footprint will not be directly impacted upon as a result of the Project, it may be subject to secondary impacts such as dust, light and vibration. The surface hydrology within this habitat is unlikely to be affected by the Project because the majority of water in this habitat flows from the surrounding Rocky Rise habitat.

3.2.2 Seasonal Drainage Surface

Seasonal Drainage Surface habitat was identified as having a medium potential to support SRE invertebrate species as it was considered to be restricted within the Study Area (**Appendix A**). Approximately 121 ha of this habitat type occurs within the Study Area, of which 42 ha (34%) occurs within the Development Envelope (**Table 2**, **Figure 8**). Of the Seasonal Drainage Surface habitat that occurs inside the Development Envelope, 14% (17 ha, **Table 2**) occurs within the Development Footprint. An additional 58 ha of this habitat type has been identified outside the Study Area during the targeted mygalomorph spider survey (**Appendix B**). Habitat within the Development Envelope may be subject to habitat removal, fragmentation and an altered surface hydrology as a result of the

Project. As this habitat type is restricted, there is potential that SRE species that occur within it will be unable to disperse if the habitat type is impacted upon by the Project.

3.2.3 Rocky Rise

Rocky Rise habitat was identified as having a low potential to support SRE invertebrate species as it was not considered to be restricted within the Study Area and surrounding region (**Appendix A**). Additionally, Rocky Rise habitat does not provide sheltered areas suitable for SRE species as it is low in elevation and exposed to a similar degree as the surrounding Sand Plain habitat. Approximately 1,392 ha of this habitat type occurs within the Study Area, of which 208 ha (42%) occurs within the Development Envelope (**Table 2**, **Figure 6** - **Figure 8**). Of the Rocky Rise habitat that occurs inside the Development Envelope, 4.7% (66 ha, **Table 2**) occurs within the Development Footprint. Habitat within the Development Envelope may be subject to habitat removal, fragmentation, changes in fire regime and an altered surface hydrology as a result of the Project. The removal of this habitat is likely to result in a reduction in fire refuge areas within the Study Area. Although areas of this habitat that occur within the Development Envelope may be impacted upon by the Project, the habitat has a low potential of supporting SRE invertebrate species and is widespread in the surrounding region.

3.2.4 Flood plain

Flood plain habitat was identified as having a low potential to support SRE invertebrate species as it was not considered to be restricted within the Study Area or surrounding region (**Appendix A**).Approximately 1,937 ha of this habitat type occurs within the Study Area, of which 344 ha (17.8%) occurs within the Development Envelope (**Table 2**, **Figure 6** - **Figure 8**). Of the Flood plain habitat that occurs inside the Development Envelope, 3.6% (71 ha, **Table 2**) occurs within the Development Footprint. Habitat within the Development Envelope may be subject to habitat removal, fragmentation and an altered surface hydrology as a result of the Project. Although areas of this habitat that occur within the Development Envelope may be impacted upon by the Project, the habitat has a low potential of supporting SRE invertebrate species and is widespread in the surrounding region.

3.2.5 Sand plain

Sand plain habitat was identified as having a low potential to support SRE invertebrate species as it was not considered to be restricted within the Study Area and surrounding region (**Appendix A**). Approximately 12,838 ha of this habitat occurs within the Study Area, of which 1,996 ha (15.5%) occurs within the Development Envelope (**Table 2**, **Figure 6** - **Figure 8**). Of the Sand plain habitat that occurs inside the Development Envelope, only 4.3% (557 ha, **Table 2**) occurs within the Development Footprint. Habitat within the Development Envelope may be subject to habitat removal, fragmentation and an altered surface hydrology as a result of the Project. Although areas of this habitat that occurs within the Development Envelope may be impacted upon by the Project, the habitat has a low potential of supporting SRE invertebrate species and is widespread in the surrounding region.

3.3 Impact on Terrestrial SRE Invertebrate Fauna

Based on current scientific knowledge, none of the species collected were confirmed to be SRE species, however, 19 species recorded during this assessment were considered potential SRE species (**Table 4**) as defined by criteria used by the WAM (**Appendix C**), comprising:

- the mygalomorph spider *Aganippe* 'MYG260', *Aname* 'MYG258', *Aname* 'MYG287', *Aname* 'MYG288', *Idiommata* 'MYG259'. and *Kwonkan* 'MYG257';
- the selenopid spider *Karaops* 'sp. browns range';
- the scorpions *Isometroides* 'kimb1', *Lychas* 'annulatus2', *Urodacus* 'kimb2' and *Urodacus* 'yaschenkoi kimb1';
- the pseudoscorpions *Beierolpium* 'sp. 8/4' and *Xenolpium* 'PSE070';
- the millipedes 'DIPAAB' 'DIP043' and *Helicopodosoma* 'DIP044'; and
- the slaters *Acanthodillo* 'sp. browns range', *Buddelundia* sp.nov. 59, *Cubaris* 'sp. browns range' *and Spherillo* 'sp. browns range'.

Based on the WAM criteria, these species were considered potential SRE species on the basis of data deficiency and a lack of either geographic or taxonomic information to provide regional context. Of the 19 potential SRE species collected within the Study Area, the following nine species were recorded within and outside the Development Footprint, comprising:

- the mygalomorph spiders *Aname* 'MYG258' and Kwonkan 'MYG257';
- the selenopid spider *Karaops* 'sp. browns range';
- the scorpion *Urodacus* 'yaschenkoi kimb1';
- the pseudoscorpion *Beierolpium* 'sp. 8/4';
- the millipede 'DIPAAB' 'DIP043'; and
- the slaters *Acanthodillo* 'sp. browns range', *Buddelundia* sp.nov. 59, and *Cubaris* 'sp. browns range'.

Two potential SRE species; *Aname* 'MYG287' and *Karaops* 'sp. browns range' were only collected from inside the Development Envelope and may be impacted upon as a result of the Project.

For situations where SRE species have only been recorded inside potential impact areas, the EPA (2009) accepts that a risk based approach may be adopted in cases which meet the following criteria:

- a potential SRE taxon is represented by one or few specimens from only within proposed impact area;
- contextual data on the wider distribution and status of the taxon is unavailable from the WA Museum or the DEC; and
- additional targeted surveys appear unlikely to yield results in a reasonable timeframe.

The two potential SRE species fulfil all of the above criteria: each species is represented by between one and three specimens; contextual data on the distributions of these species is unavailable with the WAM, probably due to a lack of invertebrate surveys in the Tanami bioregion and an additional targeted survey completed one year after the baseline survey was unsuccessful in gaining a better understanding of the distribution of these species. In these situations, the EPA (2009) acknowledges that habitat can be used as a surrogate for inferring the distributional boundaries of the species.

Aname 'MYG287' was collected from Sand Plain and *Karaops* 'sp. browns range' was collected from Sand Plain and Rocky Rise habitat (**Figure 12**, **Table 4**). All of these habitat types have a low potential of supporting SRE species as they were widespread within the Study Area and surrounding region (**Section 3.2**). If habitat is used as a surrogate for inferring distributional boundaries of these species, it is assumed that they have distributions that extend outside of the Development Envelope and therefore the Project is unlikely to affect the long-term persistence of the species.

The remaining 17 species were collected from at least one location outside of the Development Envelope and consequently the development of the Project is unlikely to affect the long-term persistence of these species.

Table 4: SRE Specimens collected from the Study Area

Habitat	Site No.	Number of potential SRE specimens collected																			Total
		Aganippe 'MYG260'	*Aname* 'MYG258'	*Aname* 'MYG287'	*Aname* 'MYG288'	*Idiommata* 'MYG259'	*Kwonkan* 'MYG257'	*Karaops* 'sp. browns range'	*Isometroides* 'kimb1'	*Lychas* 'annulatus2'	*Urodacus* 'kimb2'	*Urodacus* 'yaschenkoi kimb1'	*Beierolpium* 'sp. 8/4'	*Xenolpium* 'sp. PSE070'	'DIPAAB' 'DIP043'	*Helicopodosoma* 'DIP044'	*Acanthodillo* 'sp. browns range'	*Buddelundia* sp. nov. 59	*Cubaris* 'sp. browns range'	Spherillo 'sp. browns range'	
Internal Drainage	1												3				1	7			**11**
	5 (T1)	1	2		1								1				1	6			**12**
Seasonal Drainage Surface	2									2					2		3				**7**
	4		2															2			**4**
	T2																				**0**
	T5						1														**1**
Rocky Rise	6												3		2			40			**45**
	7												1		8	1		38			**48**
	9							2										22	1		**25**
	13									2			16	1	2		5	2		1	**29**
	Target 1																				**0**
Sand Plain	3						1										2				**3**
	10						2	1				2	1					1			**7**
	8						1				1	1		1			1	4			**9**
	T4	1		1																	**2**
	Target 2																				**0**
Flood Plain	11								1		1		10				5	6	2		**25**
	12					1	1				5	1	2		2			9	9		**30**
	T3																				**0**
	T6																				**0**
Total		**2**	**4**	**1**	**1**	**1**	**6**	**3**	**1**	**4**	**7**	**4**	**37**	**2**	**16**	**1**	**18**	**137**	**12**	**1**	**258**

Shaded rows indicate sites located inside the Development Envelope

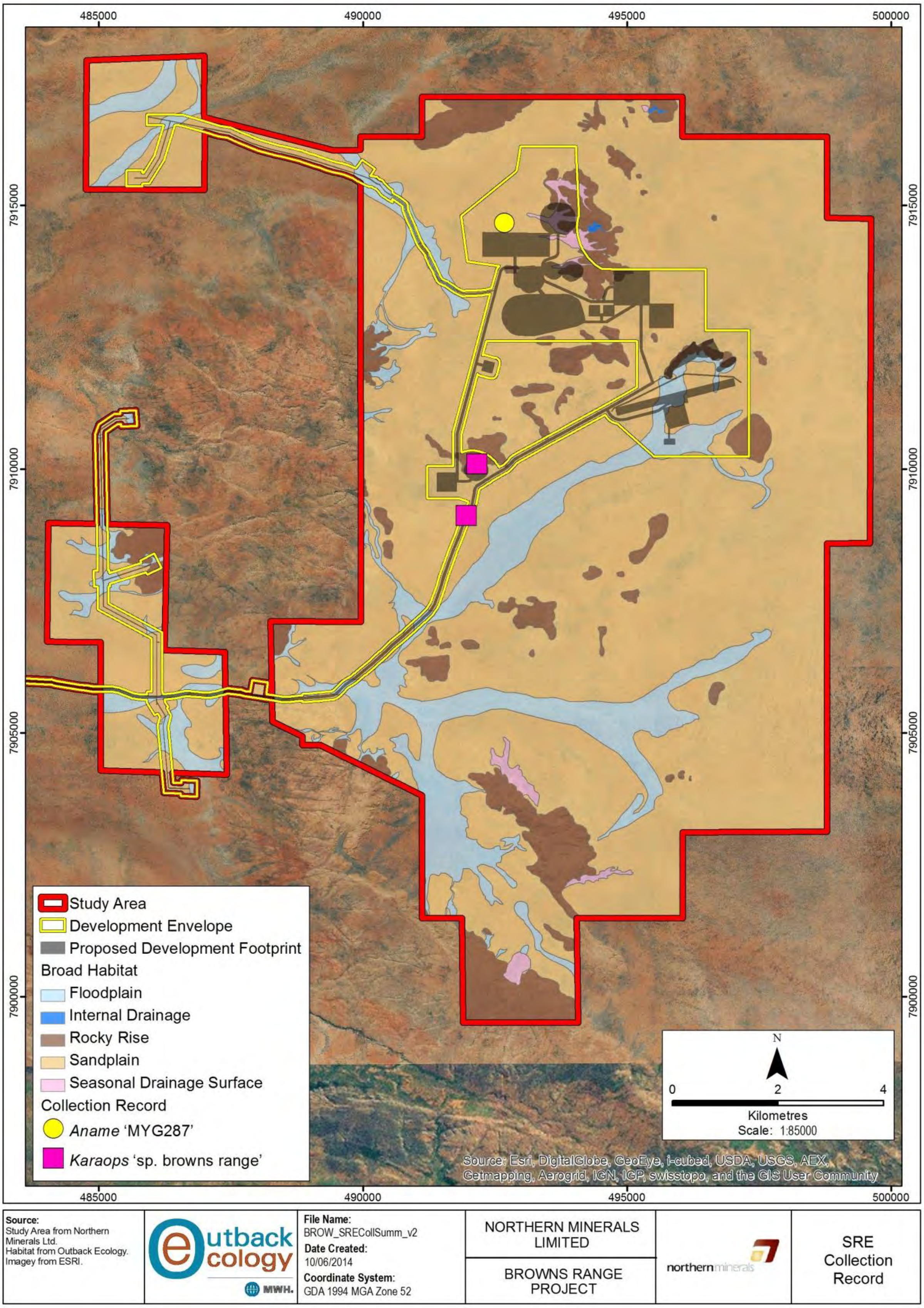


Figure 12: SRE Invertebrate Species Only Collected from within the Development Envelope

4. CONCLUSION

This report documents the terrestrial SRE invertebrate fauna impact assessment of the Browns Range Project. This assessment draws on information compiled from the Browns Range Terrestrial SRE Invertebrate Baseline Survey (Outback Ecology 2013c) and the Browns Range Targeted Mygalomorph Spider Survey (Outback Ecology 2013b).

The Project will result in the loss of a maximum of 711 ha of habitat within the 2,590 ha Development Envelope. A total of five invertebrate habitat types were identified in the Study Area; these habitats were categorised as having a high, medium or low potential to support SRE species based on the presence of sheltered micro-habitats or their propensity to form habitat isolates. Internal Drainage was considered to have a high potential of supporting SRE species although there is not perceived to be any impact to this habitat as it does not occur within the Development Envelope. The Development Envelope encompasses 42 ha of Seasonal Drainage Surface habitat which may be impacted upon by the Project. The remaining three habitats; Sand Plain, Flood Plain and Rocky Rise were not considered to be restricted within the Study Area and surrounding region, and although they will be impacted on a local scale via land clearing, impacts to these habitats on a regional scale are likely to be negligible.

Internal Drainage and Seasonal Drainage Surface habitats were considered to be restricted within the Study Area. Habitat types that are restricted are more likely to support species with restricted distributions, and therefore support true SRE species. Habitat types that are not restricted are generally widespread and are less likely to support species with restricted distributions. The ‘potential SRE’ status given by taxonomists to species collected from these unrestricted habitat types may be a result of a lack of regional collection records and/or taxonomic knowledge, rather than being an accurate reflection of the SRE status of these species.

Based on current scientific knowledge, none of the species collected were confirmed to be SRE species, however, 19 species recorded during this assessment were considered potential SRE species as defined by criteria used by the Western Australian Museum (**Appendix C**), comprising:

- the mygalomorph spider *Aganippe* ‘MYG260’, *Aname* ‘MYG258’, *Aname* ‘MYG287’, *Aname* ‘MYG288’, *Idiommata* ‘MYG259’. and *Kwonkan* ‘MYG257’;
- the selenopid spider *Karaops* ‘sp. browns range’;
- the scorpions *Isometroides* ‘kimb1’, *Lychas* ‘annulatus2’, *Urodacus* ‘kimb2’ and *Urodacus* ‘yaschenkoi kimb1’;
- the pseudoscorpions *Beierolpium* ‘sp. 8/4’ and *Xenolpium* ‘PSE070’;
- the millipedes ‘DIPAAB’ ‘DIP043’ and *Helicopodosoma* ‘DIP044’; and
- the slaters *Acanthodillo* ‘sp. browns range’, *Buddelundia* sp.nov. 59, *Cubaris* ‘sp. browns range’ *and Spherillo* ‘sp. browns range’.

Based on the WAM criteria, these species were considered potential SRE species on the basis of data deficiency and a lack of either geographic or taxonomic information to provide regional context. Of the 19 potential SRE species collected within the Study Area, the following nine species were recorded within and outside the Development Footprint, comprising:

- the mygalomorph spiders *Aname* ‘MYG258’ and Kwonkan ‘MYG257’;

- the selenopid spider *Karaops* ‘sp. browns range’;
- the scorpion *Urodacus* ‘yaschenkoi kimb1’;
- the pseudoscorpion *Beierolpium* ‘sp. 8/4’;
- the millipede ‘DIPAAB’ ‘DIP043’; and
- the slaters *Acanthodillo* ‘sp. browns range’, *Buddelundia* sp.nov. 59, and *Cubaris* ‘sp. browns range’.

Two potential SRE species; *Aname* ‘MYG287’ and *Karaops* ‘sp. browns range’ were only collected from inside the Development Envelope and may be impacted upon as a result of the Project.

Aname ‘MYG287’ was collected from Sand Plain and *Karaops* ‘sp. browns range’ was collected from Sand Plain and Rocky Rise habitat. All of these habitat types have a low potential of supporting SRE species as they were widespread within the Study Area and surrounding region. If habitat is used as a surrogate for inferring distributional boundaries of these species, it is assumed that they have distributions that extend outside of the Development Envelope and therefore the Project is unlikely to affect the long-term persistence of the species. The remaining 17 species were collected from at least one location outside of the Development Envelope and consequently the development of the Project is unlikely to affect the long-term persistence of these species.

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APPENDIX A

Outback Ecology (2012) Browns Range Project: Terrestrial Short-ranged Endemic Invertebrate Fauna Baseline Report





Northern Minerals Limited

Browns Range Project

Terrestrial Short-range Endemic Invertebrate Fauna Baseline Survey

January 2013

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Executive Summary

Northern Minerals Limited commissioned Outback Ecology to conduct a terrestrial short-range endemic (SRE) invertebrate fauna assessment of the Browns Range Project (the Project). The Project is located approximately 150 kilometres (km) south-east of Halls Creek, in the Kimberley Region of Western Australia (WA), and consists of three granted exploration licenses E80/3547, E80/3548, E80/4393 and one tenement application E80/4479. The Study area for this assessment encompasses a 7,675 hectare (ha) parcel of land.

The assessment comprised a desktop study and a level two terrestrial SRE invertebrate fauna survey of the Study area that was conducted between 14 January and 15 March 2012. For local and regional context, this report also presents a summary of results from previous terrestrial SRE invertebrate fauna surveys that have been conducted in the Study area and surrounds.

The specific objectives of this terrestrial SRE invertebrate fauna assessment were to:

- assess the occurrence and likely distribution of terrestrial SRE invertebrate fauna within the Study area;
- identify, describe and map potential terrestrial SRE invertebrate fauna habitat within the Study area;
- assess the survey findings in a regional context, by comparison with available data from other localities within the Tanami bioregion

The field survey was conducted in accordance with the Western Australia Environmental Protection Authority's (EPA) Guidance Statement No 20. Sampling of Short-range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (Environmental Protection Authority 2009); the EPA Guidance Statement No. 56, Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (Environmental Protection Authority 2004) and the EPA Position Statement No. 3, Terrestrial Biological Surveys as an Element of Biodiversity Protection (Environmental Protection Authority 2003).

Drawing on Outback Ecology's previous experience with SRE invertebrate fauna surveys and subsequent to consultation with invertebrate SRE specialists, the following invertebrate groups prone to short-range endemism were targeted during this assessment: mygalomorph spiders, selenopid spiders, scorpions, pseudoscorpions, millipedes, slaters and terrestrial snails.

The invertebrate collection methods have been previously endorsed by the WA Department of Environment and Conservation (DEC), and included wet pitfall trapping, leaf litter processing in Tullgren funnels, soil sieving and targeted searching. In total, the survey comprised 2,340 trapping nights, 30 hours of targeted searching, and the collection of 39 soil samples and 39 leaf litter samples. An SRE invertebrate fauna habitat assessment was conducted over the Study area, which involved characterising habitat according to condition, complexity and suitability for invertebrate taxa prone to short-range endemism.

Five broad fauna habitats occur within the Study area: internal drainage, seasonal drainage surface, rocky rise, sand plain and flood plain. Internal drainage and seasonal drainage surface habitats were considered to be restricted within the Study area. Internal drainage and seasonal drainage surface habitats comprised 6 ha (<1 %) and 103 ha (1.34 %) within the Study area respectively. The remaining habitats; rocky rise, sand plain and flood plain were not considered to be restricted habitats within the Study area.

The survey of the Study area yielded a total of 315 invertebrate specimens from 25 identifiable species and morphospecies. Based on current scientific knowledge, 17 of these species were considered SRE species, comprising;

- the mygalomorph spider *Aganippe* 'MYG260', *Aname* 'MYG258', *Idiommata* 'MYG259'. and *Kwonkan* 'MYG257'
- the selenopid spider *Karaops* 'sp. browns range'
- the scorpions *Isometroides* 'kimb1', *Lychas* 'annulatus2', *Urodacus* 'kimb2' and *Urodacus* 'yaschenkoi kimb1'
- the pseudoscorpions *Beierolpium* 'sp. 8/4' and *Xenolpium* 'sp. PSE070'
- the millipedes 'DIPAAB' 'DIP043' and *Helicopodosoma '*DIP044'; and
- the slaters *Acanthodillo* 'sp. browns range', *Buddelundia* sp.nov. 59, *Cubaris* 'sp. browns range' *and Spherillo* 'sp. browns range'.

Two SRE species, *Aganippe* MYG260' and *Aname* 'MYG258' were collected from restricted habitats within the Study area. The remaining 15 SRE species were collected from habitats that were not considered to be restricted within the Study area and the SRE status of these species may not represent a restricted distribution but rather a lack of regional survey work.

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1. INTRODUCTION

1.1. Project Location And Description

Northern Minerals Limited (Northern Minerals) is an ASX-listed company focused on the development of heavy rare earth elements (REE). The Browns Range Project (the Project) consists of three granted exploration licenses E80/3547, E80/3548, E80/4393 and one tenement application E80/4479. The Project previously formed part of the Gardiner-Tanami Project, but since 2009 has become a focus for Northern Minerals' REE exploration program. The Project covers an area of 7,675 hectares (ha) within Western Australia, located adjacent to the Western Australia/Northern Territory border approximately 150 kilometres (km) southeast of Halls Creek (**Figure 1**). The Project is located on Gordon Downs Station in the Shire of Halls Creek.

Four rare earth prospects with xenotime mineralisation have been identified at the Browns Range Project: Wolverine, Gambit, Area 5 and Area 5 North (**Figure 2**). Activities on site to date have focused on development and expansion of an extensive exploration program to evaluate REE resources. Current exploration work includes the expansion of a recently implemented diamond drilling program to further define the orientation and extent of the resource and the establishment of an expanded accommodation village, air strip and water supply. Mining activities will be by open pit, with crushing, grinding and separation on site. Concentrate will be transported to a port for export. Mining infrastructure will likely include pits, waste rock landforms, a crushing, grinding and separation facility, tailings storage facility, roads, borefield, pipelines, parking and laydown areas, a workshop, fuel and water storage, accommodation village and administration buildings.

1.2. Assessment Scope And Objectives

The assessment comprised a desktop study and an invertebrate fauna survey that was conducted over two phases between 14 January and 17 March 2012. For local and regional context, this report also presents a summary of results from previous terrestrial SRE invertebrate fauna surveys that have been conducted in the Study area and surrounds.

The specific objectives of this terrestrial SRE invertebrate fauna assessment were to:

- assess the occurrence and likely distribution of short-range endemic (SRE) invertebrate fauna within the Study area and surrounds;
- identify, describe and map potential terrestrial SRE invertebrate fauna habitat and any significant habitat within the Study area; and
- assess survey findings in the regional context by comparisons with available data from other localities within the Tanami bioregion.

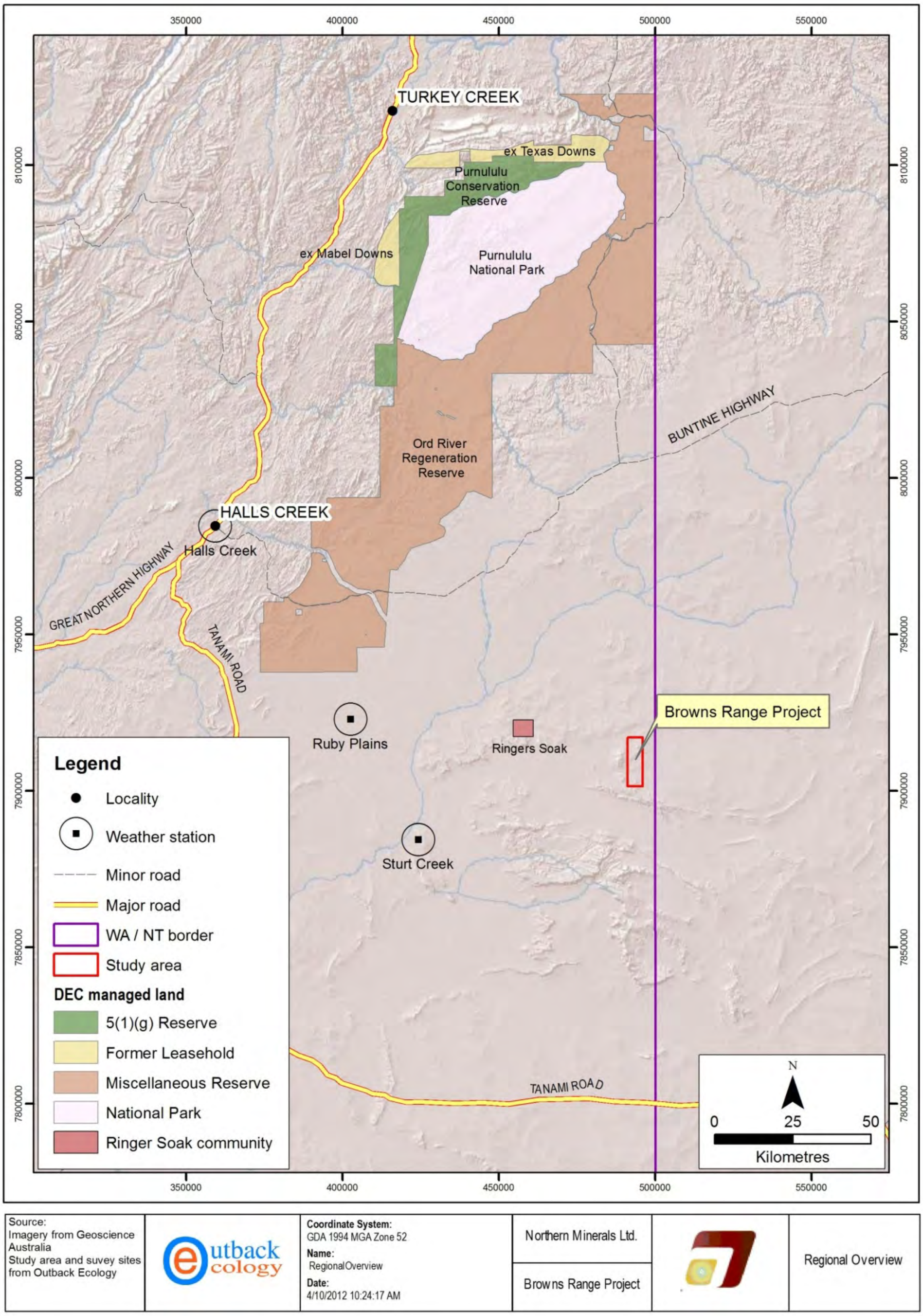


Figure 1: Regional location of the Study area

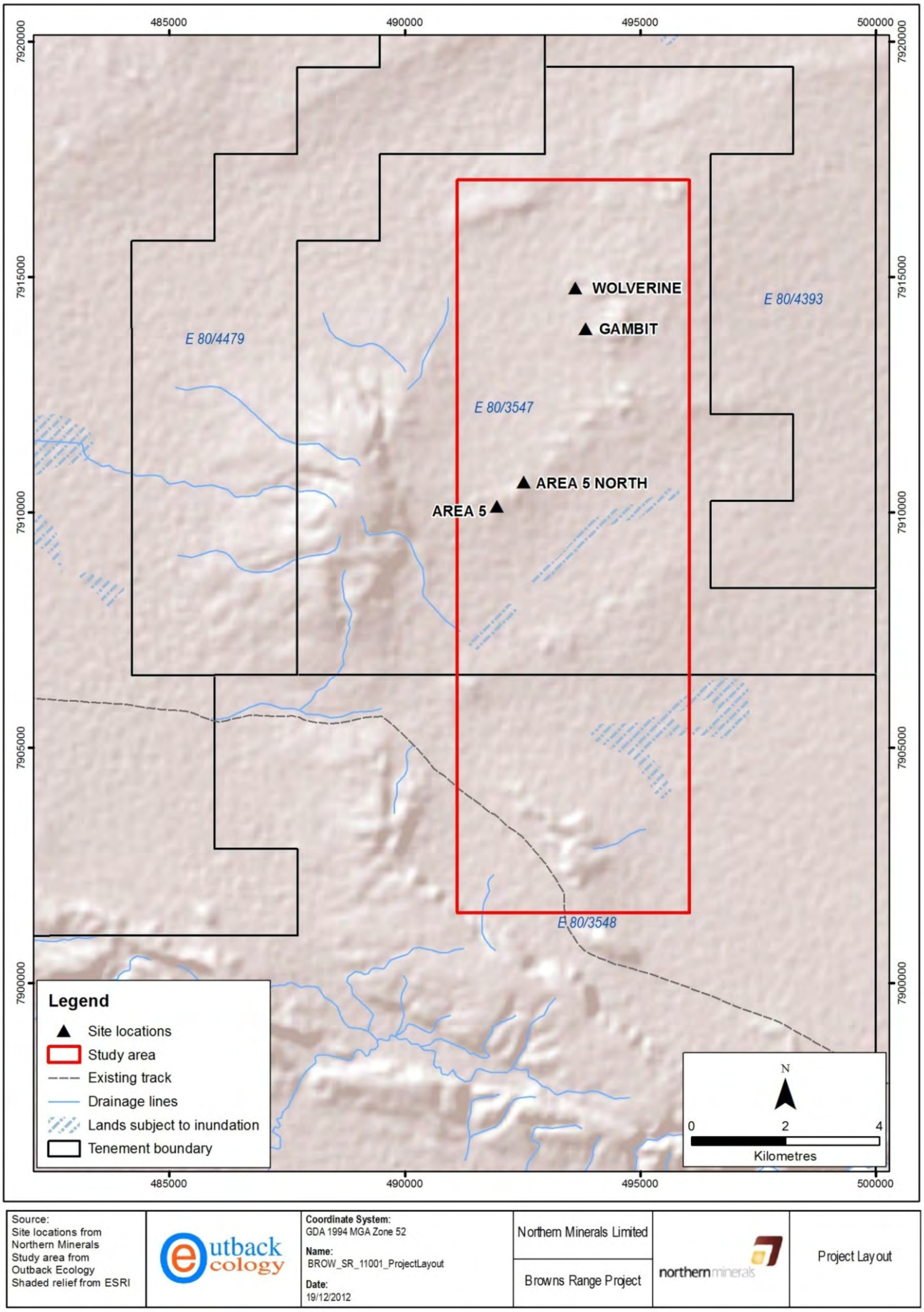


Figure 2: The Study area and proposed deposits

The survey was designed and conducted in accordance with:

- EPA Guidance No. 56*, Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (2004); and
- EPA Position Statement No. 3*, Terrestrial Biological Surveys as an Element of Biodiversity Protection* (2003).
- Western Australia (WA) Environmental Protection Authority (EPA) Guidance No. 20, *Sampling of Short-range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (2009);

The field sampling methodology used during this survey has been endorsed by the DEC.

1.3. Legislative Framework

Key legislation contributing to the protection of the biological diversity of native fauna in WA includes the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), Western Australian *Wildlife Conservation Act 1950* (WC Act), *Land Management Act 1984* and the *Environmental Protection Act 1986*. The Environmental Protection Authority (EPA) adopts the definition of biological diversity and the principles as defined in the National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth of Australia 1996). The EPA intends to ensure that, as far as possible, development proposals in WA are consistent with these principles, objectives and targets (Environmental Protection Authority 2004).

Additionally Section 4a of the Environmental Protection Act 1986 states that developments in WA must take into consideration to the following principles:

- The precautionary principle – where there are threats of serious and irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- The principle of intergeneration 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; and
- The principle of the conservation of biological diversity and ecological integrity – conservation of biological diversity and ecological integrity should be a fundamental consideration.

Comprehensive systematic reviews of different faunal groups often reveal the presence of SRE species (Harvey 2002). These species generally exist in relictual habitats formed as a result of widespread aridification and forest contraction since the Miocene and Pleistocene, which has resulted in population fragmentation and the evolution of new species. Particular attention should be given to these types of species in environmental impact assessments (EIAs) because habitat loss and degradation will further decrease their prospects for long-term survival (EPA 2004).

Some better known SRE species have been listed as threatened or endangered under State or Commonwealth legislation, but the majority have not (EPA 2009). Often the lack of knowledge about these species precludes their consideration for listing as threatened or endangered (EPA 2009). Listing under legislation should, therefore, not be the only conservation consideration in an EIA (EPA 2009). The EPA expects that an EIA will consider the potential impacts on the conservation status of SRE species (EPA 2004). The information provided in this document meets the standards, requirements and protocols as determined by the EPA.

1.4. Short-Range Endemic Invertebrate Taxa

Endemism refers to the restriction of a species to a particular area, at a continental, national or local scale. (Allen *et al.* 2002). A terrestrial SRE invertebrate species is broadly defined as a species with a geographic distribution of less than 10,000 square kilometres (km^2) (Harvey 2002). Harvey *et al*., (2011) acknowledge that many SRE species have very restricted distributions, with many having distributions of less than one square kilometre. The SRE invertebrate fauna of WA is typically associated with sheltered and mesic microhabitats, such as the south-east aspect of slopes, trees, boulders, rock piles, outcrops, mesas, as well as drainage systems, deep gorges, natural springs and fire refuges (EPA 2009).

In WA, many terrestrial SRE invertebrate species have Gondwanan origins and are relics of previously widespread species common to the continents of the southern hemisphere during the mesic climates of the Miocene (Harvey 2002). The subsequent aridification of Australia during the Miocene and Pleistocene resulted in the fragmentation and contraction of once common mesic habitats. Consequently, populations dependent on these mesic habitats were also fragmented, resulting in the evolution of SRE invertebrate fauna (Harvey 2002).

A combination of intrinsic and extrinsic factors, such as dispersal capabilities or opportunities, habitat preferences, life history attributes, physiological attributes, habitat availability, biotic and abiotic interactions and historical factors, determine not only the geographic distribution of a taxon, but its propensity for population differentiation and speciation (Ponder and Colgan 2002). Taxa prone to short-range endemism tend to share several ecological and life-history characteristics, such as poor powers of dispersal, confinement to discontinuous habitats, highly seasonal activity patterns and low fecundity (Harvey 2002).

The main invertebrate groups with these traits in WA include:

- Mygalomorph spiders;
- Selenopid spiders;
- Scorpions;
- Pseudoscorpions;
- Millipedes;
- Slaters; and
- Snails.

A description of the above invertebrate taxa prone to short-range endemism is presented in **Appendix A**.

2. EXISTING ENVIRONMENT

2.1. Biogeographic Region

The Study area is located within the northern edge of the Tanami Desert. It lies within the Tanami bioregion, as defined by the Interim Bioregions of Australia (IBRA) classification system (Graham 2001) (**Figure 3**). The majority of the Tanami bioregion extends eastward into the central Northern Territory, but a small portion of the bioregion extends westward into Western Australia, and contains the Study area. The Tanami bioregion is composed of three sub-bioregions: Tanami 1, Tanami 2 and Tanami 3. The Study area occurs in Tanami 1, which is the largest of the three sub-bioregions (**Figure 3**).

The Tanami 1 sub-bioregion is 3,214,599 ha in size and consists of red desert sand plains that support mixed shrub steppes and hummock grasslands, as well as hills and ranges that support wattle scrub and hummock grasslands (Graham 2001). Drainage occurs via Sturt Creek (the largest river system in the Tanami bioregion) and other ephemeral watercourses such as the Lander and Hanson Rivers and Winnecke Creek (ANRA: Australian Natural Resources Atlas 2009). The Tanami 1 sub-bioregion incorporates large areas of relatively untouched desert ecological communities, and as such is an important refuge area for biodiversity (ANRA 2009). While the sub-bioregion is generally in good ecological condition, significant threatening processes include feral predators, changing fire regimes and weeds (ANRA 2009, Graham 2001).

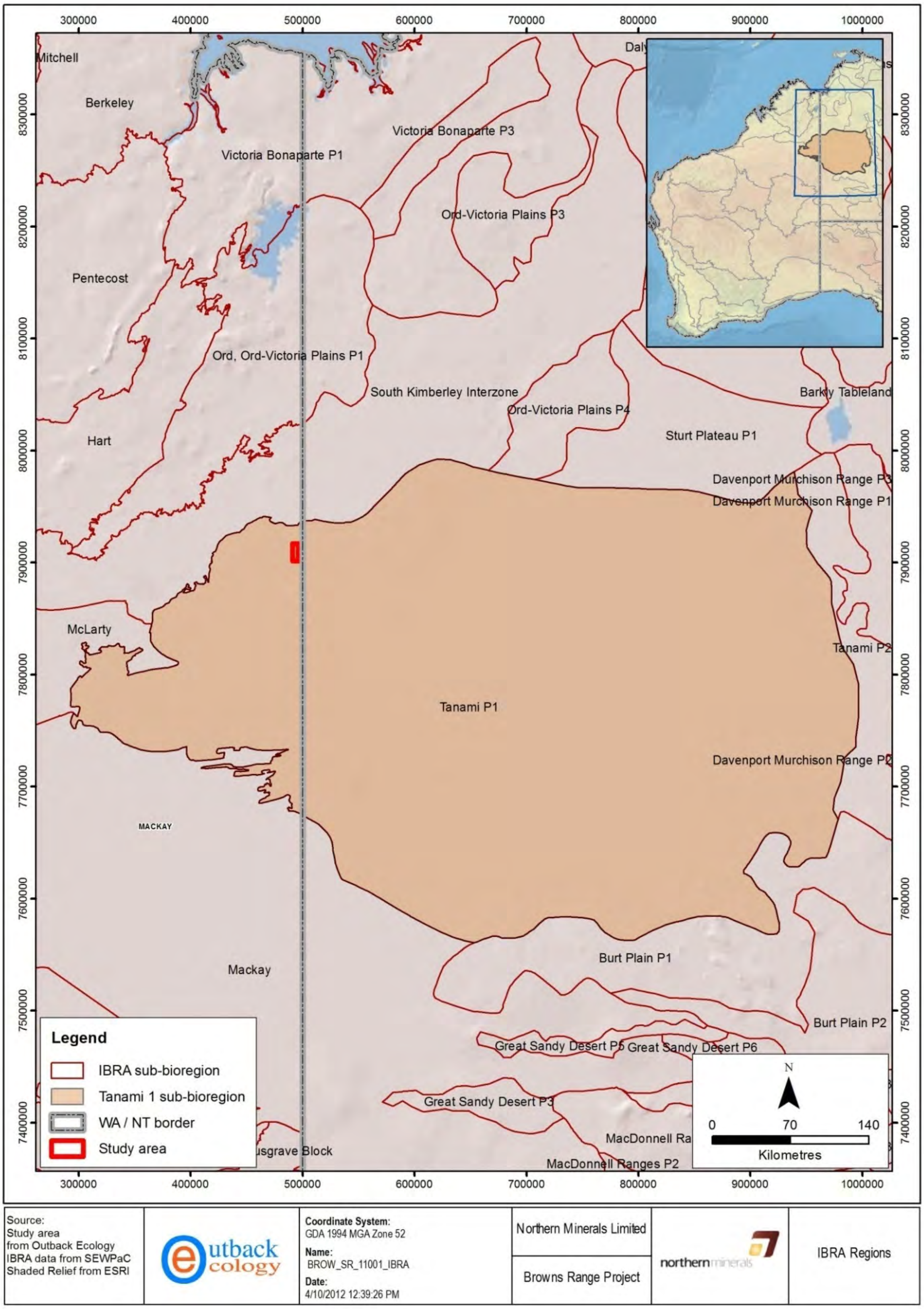


Figure 3: The location of the Study area with respect to IBRA subregions

2.2. Climate

The Tanami 1 sub-bioregion experiences an arid-tropical climate with mainly summer rainfall due to a monsoonal influence (Graham 2001). The Bureau of Meteorology (BOM) weather station at Halls Creek Airport, which is located approximately 150 km north-west of the Study area, is the closest locality with comprehensive climate data available and consequently provides climate information most relevant to the Study area (**Figure 4**). Mean maximum temperatures at Halls Creek range from 27.2 °C in July to 38.4 °C in November and peak temperatures are recorded from September to April (**Figure 4**). The mean minimum temperature in winter months ranges from 12.6 °C to 14.8 °C. The majority of rainfall consistently occurs between November and March (the 'wet season'), whereas very little rainfall is typically recorded in winter months (the 'dry season') (**Figure 4**). Halls Creek Airport has a mean annual rainfall of 635.8 mm and an average of 49 rain days per year (BOM 2012).

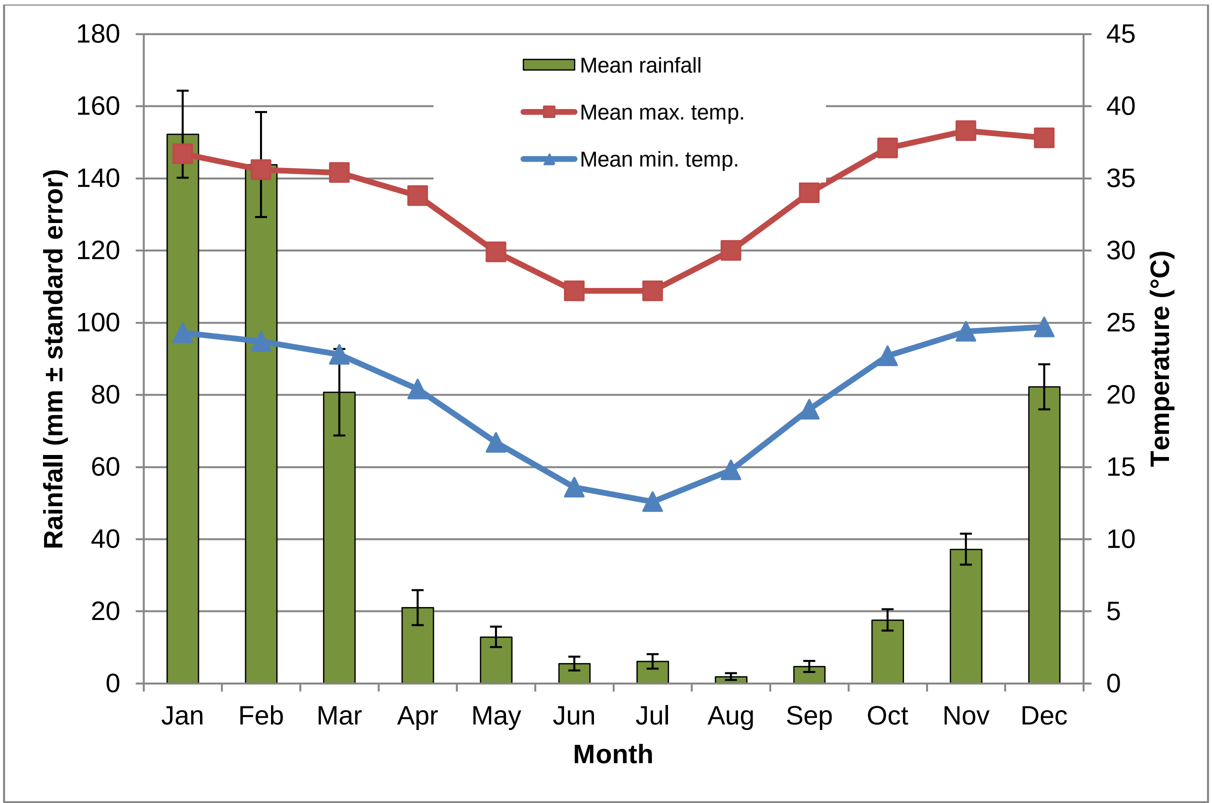


Figure 4: Mean rainfall and temperature data recorded from the Halls Creek meteorological station

Source data: BOM (2012), weather station 002012, 1944 to 2012

2.3. Land Systems In The Study Area

The Study area lies within the Kimberley region of Western Australia. Numerous rangelands resource surveys conducted since the 1940s have contributed to a comprehensive description of biophysical resources present within the Kimberley region, including the condition of soil and vegetation (Payne and Schoknecht 2011). This information has been used to classify and map the land systems of the Kimberley region based on landforms, soils, vegetation, geology and geomorphology. An assessment of these land systems provides an indication of the occurrence and distribution of relevant natural resources present within and surrounding the Study area. The Study area contains two land systems; Coolindie and Winnecke (**Table 1**). Of these, the Coolindie land system occupies the majority of the Study area (84.3 %) (**Figure 5**).

Table 1: Land systems within the Study area

Land System	Description	Area within Study Area (hectares)	Proportion of Study Area (%)	Area within Tanami sub-bioregion (ha)*	Proportion of the Tanami sub-bioregion (%)*
Coolindie	Consists of gently undulating red desert sandplains and dunes supporting *Acacia* shrublands, *Eucalyptus* woodlands and soft spinifex (*Triodia pungens*) grasslands. These grasslands are subject to frequent fires that cause short-term changes in floristic composition and abundance. Drainage lines are shallow, widely spaced and in sequent, and erosion is minimal.	6,473	84.3	432,858	14.4
Winnecke	Consists of stony hills and lowlands associated with red desert sands that support *Acacia* and *Eucalyptus* woodlands and soft spinifex (*Triodia pungens*) grasslands. These grasslands are subject to frequent fires that cause short-term changes in floristic composition and abundance. Intensive parallel drainage lines occur on upper slopes, while widely spaced angular drainage lines occur on lower slopes and terminate at the base of hills. Erosion is generally minimal, though some drainage floors are moderately susceptible.	1,202	15.7	446,025	14.8

*Land system information only available in the Western Australian portion of the Tanami sub-bioregion

Source: Payne and Schoknecht (2011)

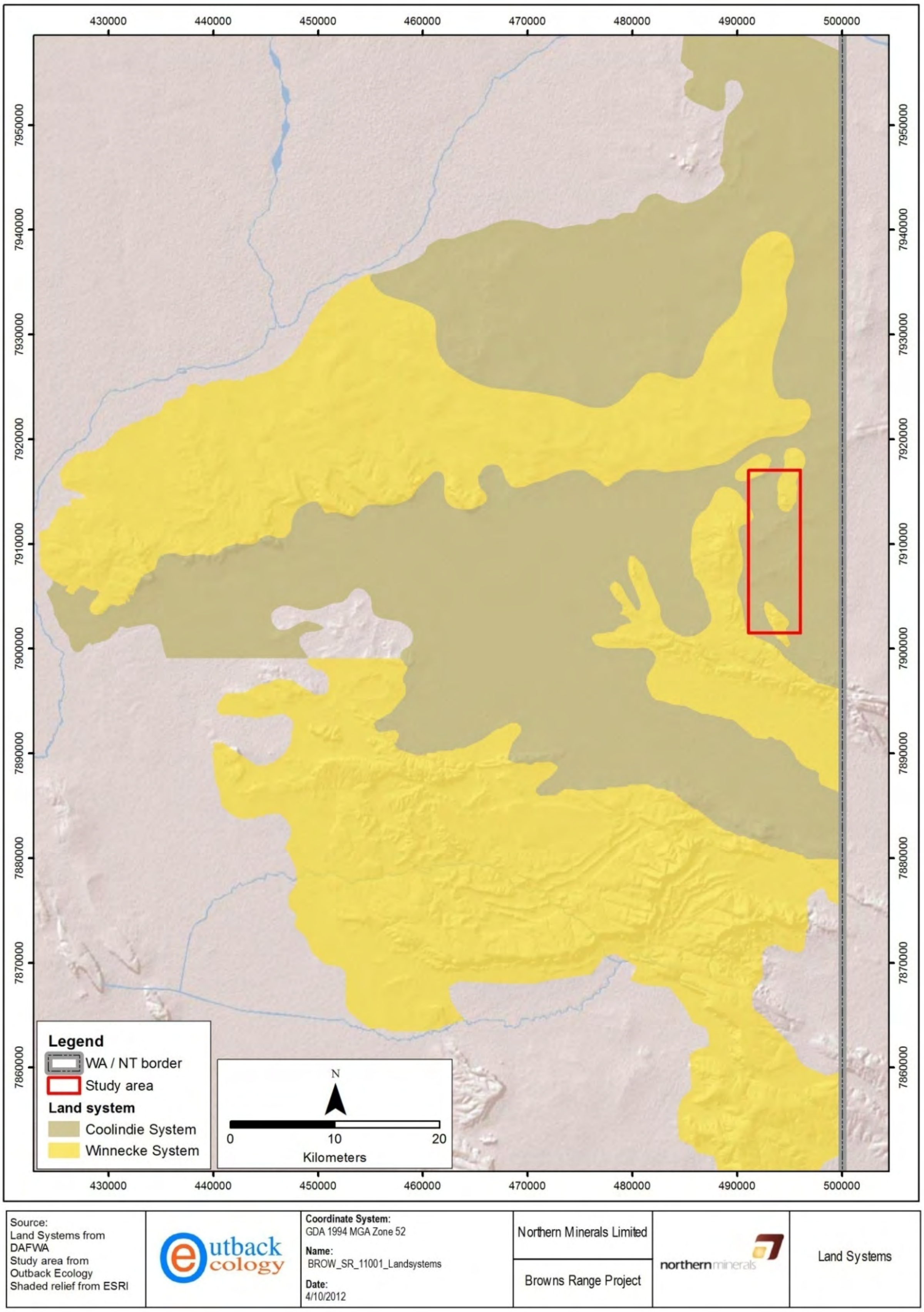


Figure 5: Land systems occurring within the Study area

2.4. Land Use

The majority of the land within the Tanami bioregion is Aboriginal freehold. This land continues to be used by traditional Aboriginal landowners for the hunting and gathering of food, and the practice of cultural ceremonies associated with the land (Stoll et al. 2005). The remaining land within the bioregion is Unallocated Crown Land or Crown leasehold used for pastoral leases and conservation reserves (ANRA 2009). Grazing occurs throughout one quarter of the bioregion, and mining (predominantly for gold) and tourism are also important industries (ANRA 2009).

The Study area is located within the Gordon Downs pastoral lease in the Shire of Halls Creek (**Figure 6**). While the land is primarily used for grazing cattle, pastoral activity within the Study area is limited by poor pasture production and inadequate water supplies. The Gardiner Range Conservation Reserve, an EPA Red Book Recommended Conservation Reserve managed by Western Australia's Department of Environment and Conservation (DEC), is located 10 km south of the Study area (DMP 1998). Other DEC-managed lands nearby include the Ord River Regeneration Reserve, approximately 100 km north-west, and the Wolfe Creek Crater National Park, approximately 120 km west-southwest of the Study area. The closest Aboriginal community to the Study area in WA is Ringer Soak (also known as Kundjat Djaru), located approximately 40 km to the west.

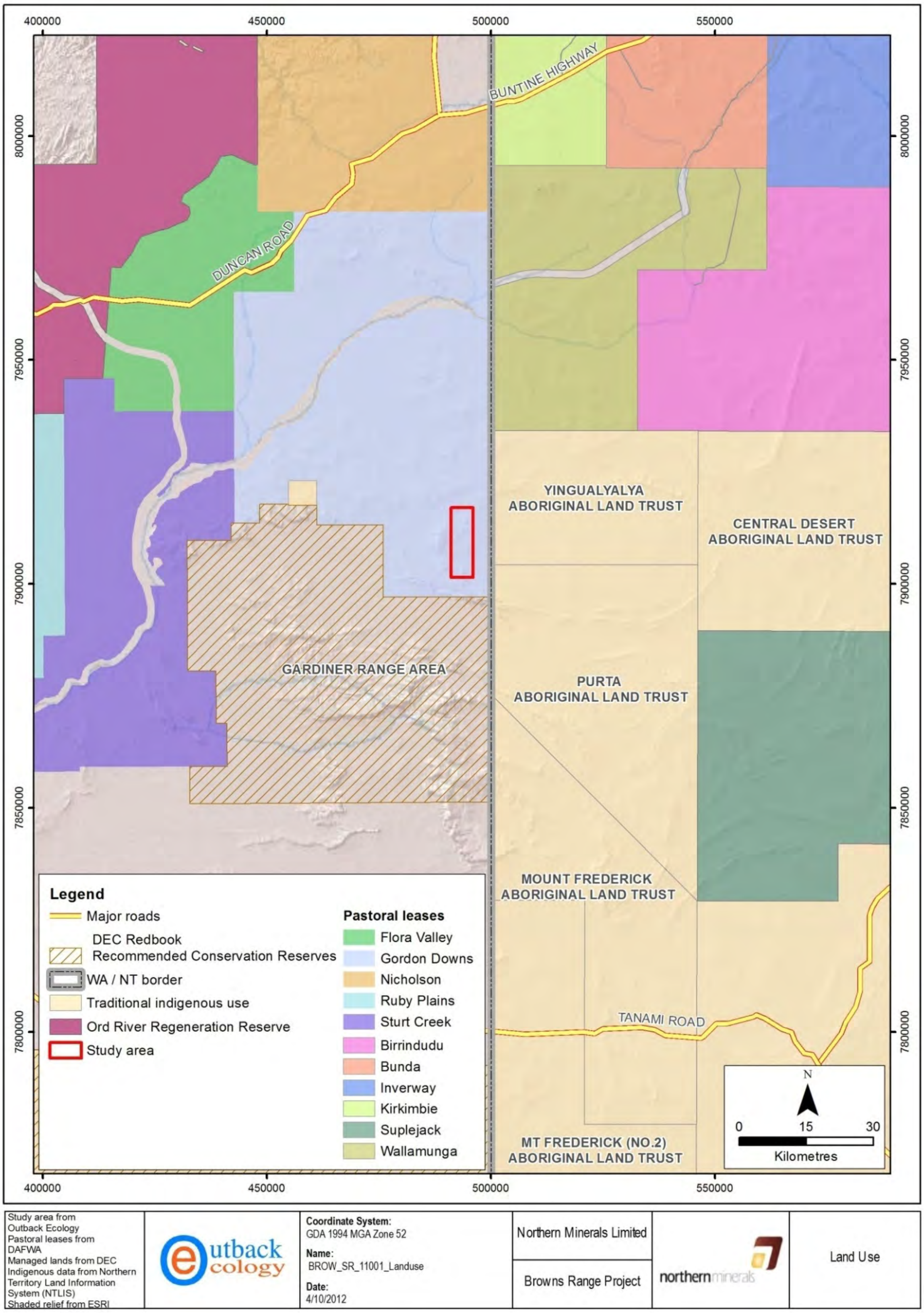


Figure 6: Land use within the Study area and surrounds

3. MATERIALS AND METHODS

The methods used to assess the presence of terrestrial SRE invertebrate fauna during this assessment include database searches (**Section 3.1**) and a two phase terrestrial SRE invertebrate fauna survey (**Section 3.2**).

3.1. Database Searches And Literature Review

A search of relevant databases and a literature review was undertaken prior to the field survey in order to:

- determine the SRE taxa that have been previously collected in the region;
- facilitate the identification of SRE invertebrate habitat within the Study area; and
- assist with the assessment of the conservation significance of the invertebrate species collected.

The results of the database searches and literature review are presented in **Section 4.2**.

3.1.1. Database Searches

The following databases were searched for SRE and conservation significant invertebrate collection records:

- NatureMap database (Department of Environment and Conservation 2011a);
- Threatened and Priority Fauna Database held by the DEC (Department of Environment and Conservation 2011b);
- The Australian Museum's database (Australian Museum 2011);
- Threatened Ecological Community and Priority Ecological Community Lists (Department of Environment and Conservation 2011c); and
- Western Australian Museum (WAM) Arachnid and Millipede Database (WAM 2012).

It should be noted that at present, the WAM is only able to conduct database searches for SRE spiders, scorpions, pseudoscorpions and millipedes. Snails or slaters are not included in the WAM database search.

3.2. Terrestrial Sre Invertebrate Fauna Field Survey

The field survey was conducted in accordance with the EPA Guidance Statement No 20, Sampling of Short-range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009) and incorporated recommendations by specialists from the DEC and the WAM.

3.2.1. Survey Timing

The survey was conducted between 14 January and 15 March 2012. Wet pitfall traps were deployed between 14 January and 21 January 2012 and collected between 13 March and 15 March 2012.

Targeted searches, soil and leaf litter collection and habitat assessments were conducted between 14 January and 21 January 2012.

3.2.2. Weather Conditions

The records from three Bureau of Meteorology weather stations were considered in this assessment, Ruby Plains, Sturt Creek and Halls Creek (**Figure 1**). Both temperature and rainfall data are recorded at Halls Creek weather station, whereas only rainfall data is recorded at Ruby Plains and Stuart Creek. The Halls Creek weather station is located approximately 145 km north-west of the Study area. The Stuart Creek and Ruby Plains weather stations are located 81 km south-west and 130 km west of the Study area respectively. Consideration of data collected from these three weather stations is useful in providing regional context given the localised nature of rainfall in the Tanami.

During the survey, the daily maximum temperatures recorded from the Halls Creek weather station ranged between 40.4 ºC and 27.2 ºC, with minimum between 28.3 ºC and 19.7 ºC (BOM 2011). A mean maximum temperature of 36.2 ºC and mean minimum of 23.7 ºC over the survey period were recorded at Halls Creek, which is similar to the long-term average (Bureau of Meteorology 2011). In the six weeks prior to the survey, 126.4 millimetres (mm) of rain was recorded at Sturt Creek, 160.6 mm from Ruby Plains and 173.2 mm from Halls Creek (**Figure 7**). During the survey period no rainfall was recorded at Sturt Creek, while 167.2 mm was recorded from Ruby Plains and 269.9 mm from Halls Creek (**Figure 8**). The rainfall recorded prior to and during the survey was typical of the long-term average for the period (BOM 2011).

The survey was conducted between November and April which is the optimum period for invertebrate surveys in the Kimberley region (Environmental Protection Authority 2009).

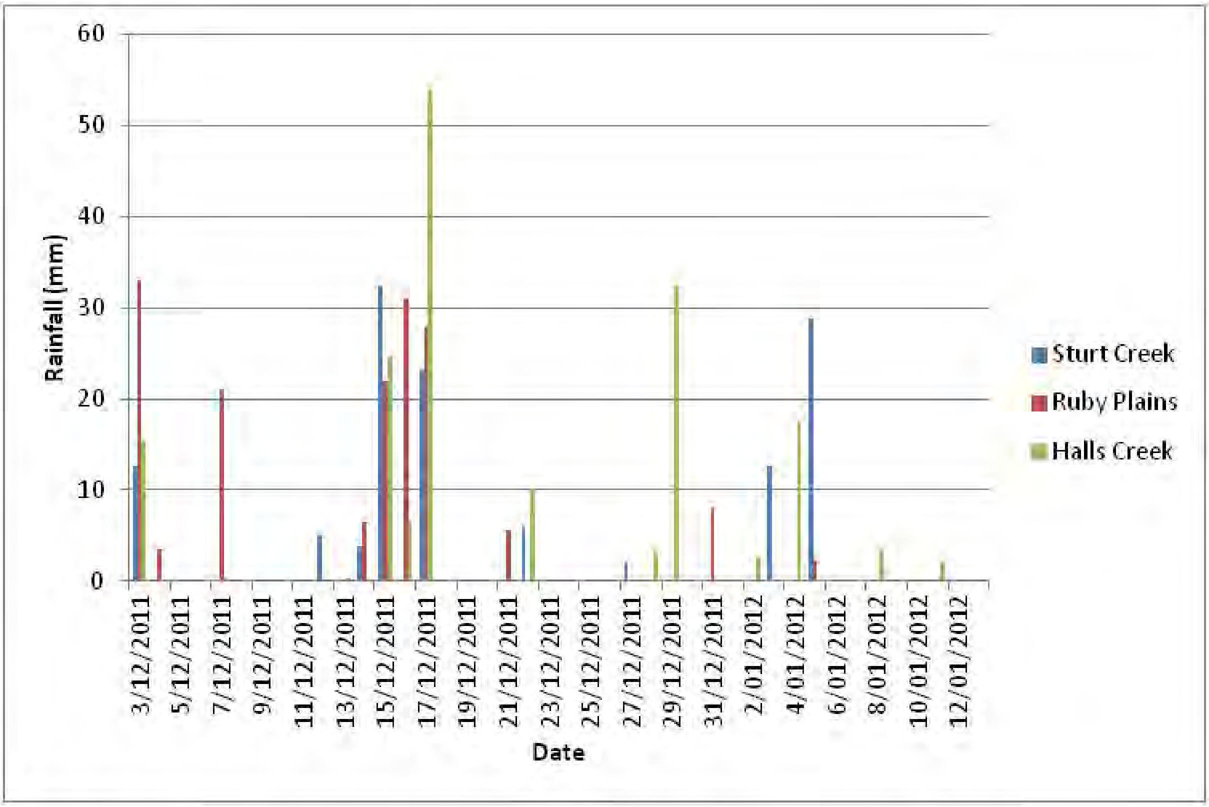


Figure 7: Rainfall recorded six weeks prior to the survey (BOM 2012)

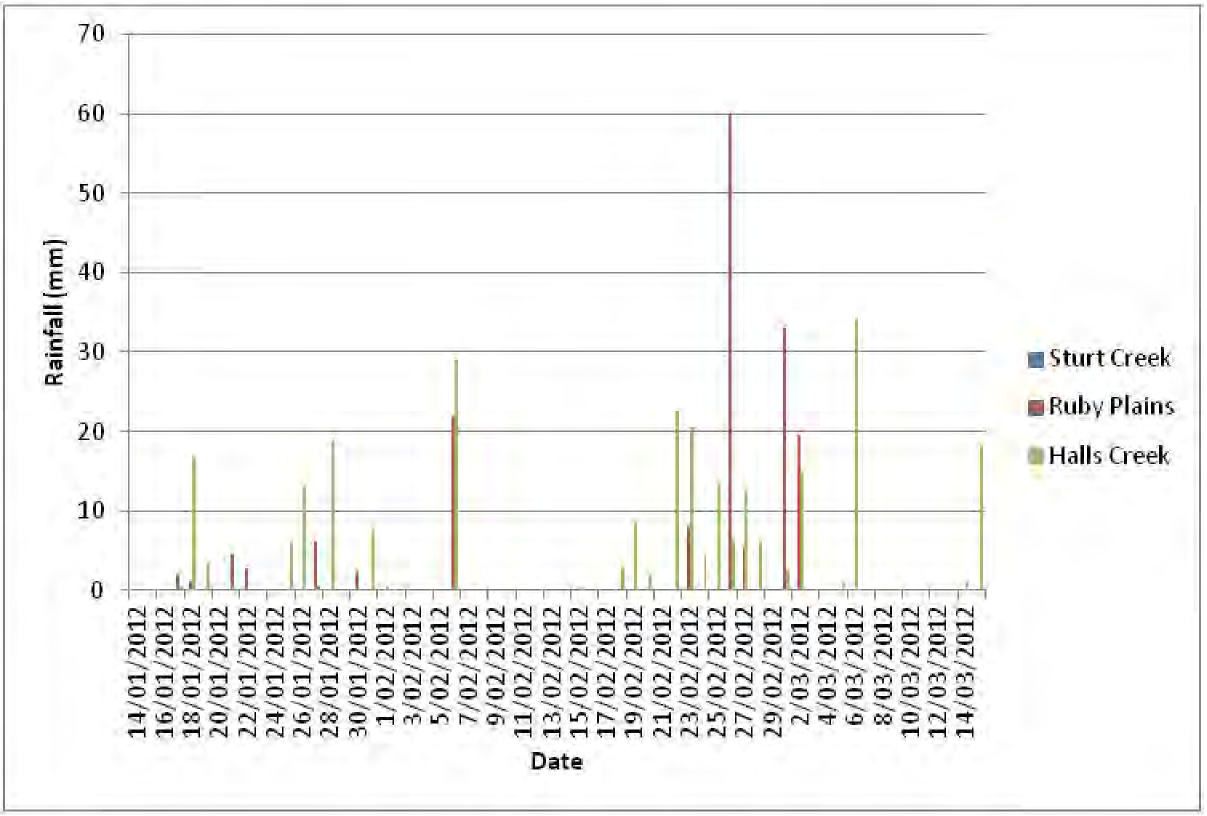


Figure 8: Rainfall recorded during the survey period (BOM 2012)

3.2.3. Survey Sites

Prior to the survey, a set of prospective survey sites were selected via desktop analysis of aerial imagery. These sites were ground truthed and final site selection was made based on the quality of a site, the geographical spread of all sites, the number of different habitat types to be sampled and vehicle accessibility. A total of 13 systematic survey sites and two targeted search sites were sampled during the survey (**Figure 9**; **Table 2**). Invertebrate collection methods employed at systematic survey sites comprised wet pitfall trapping, targeted searching and soil and litter collection (**Section 3.2.5**). Where possible, survey sites were established in representative habitats both inside and outside of the Project disturbance area. Site descriptions and photos are presented in **Appendix B**.

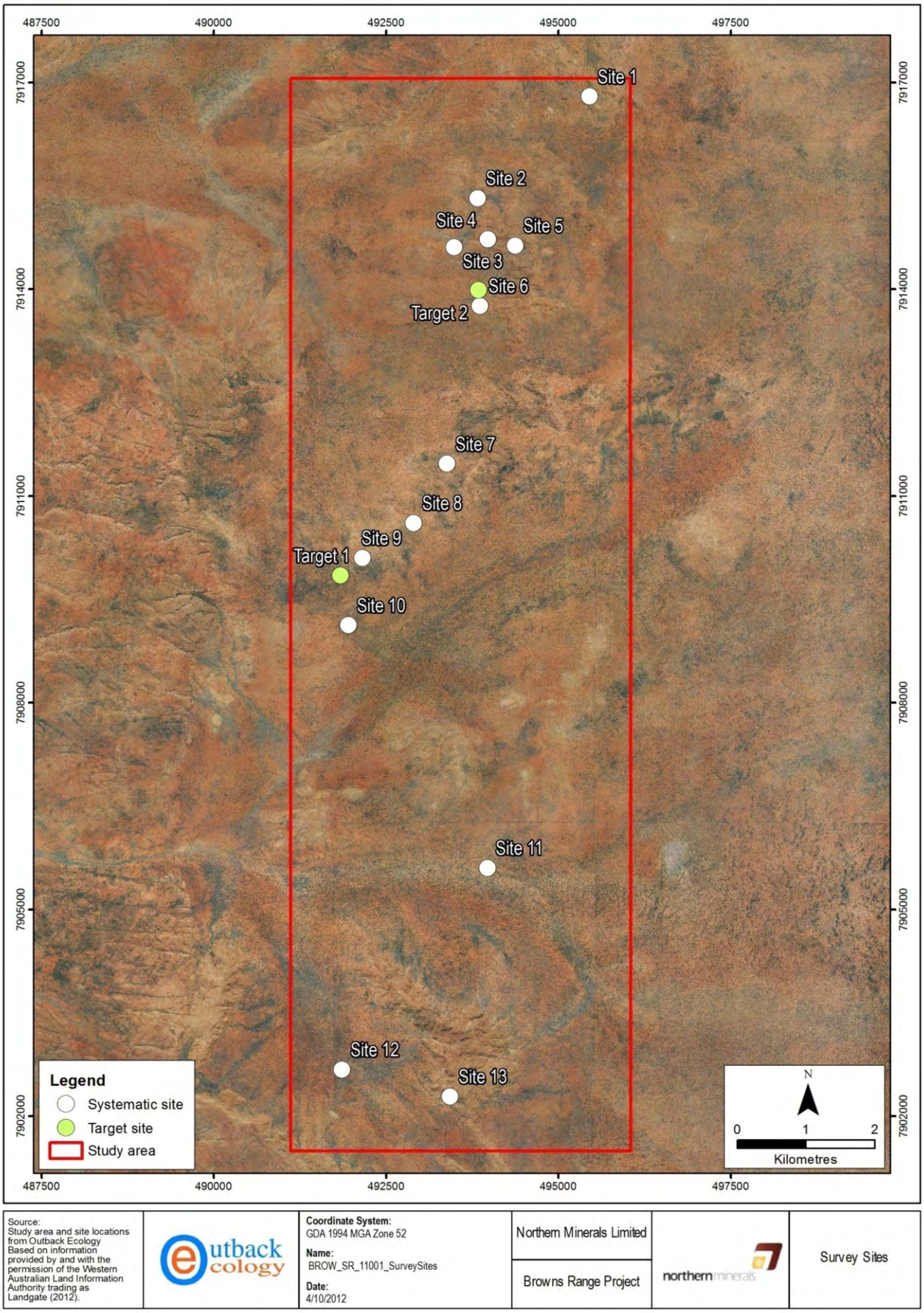


Figure 9: Location of systematic and targeted survey sites

Table 2: Survey sites for this assessment

Site	Habitat	Coordinates (GDA 94 MGA 52K)	
		Eastings	Northings
1	Internal drainage	495448	7916801
2	Seasonal drainage surface	493825	7915324
3	Sand plain	493487	7914616
4	Seasonal drainage surface	493978	7914731
5	Internal drainage	494370	7914636
6	Rocky rise	493860	7913761
7	Rocky rise	493384	7911471
8	Sand plain	492898	7910609
9	Rocky rise	492153	7910104
10	Sand plain	491951	7909126
11	Flood plain	493970	7905603
12	Flood plain	491857	7902678
13	Rocky rise	493427	7902287
Target 1	Rocky rise	491834	7909849
Target 2	Sand plain	493836	7913991

3.2.4. Sre Habitat Assessment

Habitat assessments form an important part of the EIA process as it relates to SRE invertebrate fauna. A habitat's potential for supporting SRE fauna can be used to identify habitats of conservation value and may also be used to identify the availability of suitable habitat for SRE species outside of a disturbance area.

Potential terrestrial SRE habitats within the Study area were identified and categorised based on complexity, quality, connectivity and extensiveness within the landscape. A SRE habitat assessment was conducted for each potential SRE habitat type present in the Study area. This assessment entailed:

- establishment of habitat assessment reference points of suitable replication within representative habitat inside and outside of the disturbance area (where possible), to characterise the extent of SRE habitat in the area; and
- a standardised habitat assessment field sheet was completed for each site. The assessment was made in an area of approximately 50 m x 50 m. Landscape position, outcropping, soil type, broad vegetation type, litter cover, existing disturbance, extensiveness and physical connectivity within the landscape were recorded.

There are no prescriptive guidelines for identifying potential SRE habitats, although the most prospective habitats tend to be those that are sheltered, isolated or both (Environmental Protection

Authority 2009, Harvey 2002). Information resulting from the habitat assessment of the Study area has been incorporated into the descriptions of each habitat type identified in the Study area (**Section 4.1**).

3.2.5. Collection Techniques

The methods used for collecting SRE taxa during this assessment are summarised in (**Table 3**) Table 3and described below. These methods are aligned with those specified by the EPA (2009) and have been endorsed by SRE invertebrate specialists of the WAM and the DEC.

Table 3: Summary of SRE Sampling Methods and Effort for the Survey

Sampling technique	Target group	Survey effort per site	Total effort
Wet pitfall trap	All groups	3 traps open for a total of 60 nights (13 sites)	2,340 trap nights
Targeted search	All groups	2 person hours (15 sites)	30 person hours
Litter search	All groups	3 samples (13 sites)	39 samples
Soil sieving	Terrestrial snails	3 samples (13 sites)	39 samples

Wet pitfall trapping

The DEC currently suggest that wet pitfall trapping for terrestrial SRE invertebrate fauna is likely to be a more effective sampling method than dry pitfall trapping (Brad Durrant pers. comm. January 2010). Wet pitfall trapping involves a longer trapping period, with traps left open for up to ten weeks. This increases the probability of trapping species that are active only briefly or sporadically, such as those which become active during rainfall. Wet pitfall traps were left open for 60 nights during the survey.

A wet pitfall trap comprises a plastic container that slots into a buried cylindrical PVC pipe (100 millimetres (mm) x 250 mm). Care was taken to ensure that the top of the container was flush with the top of the PVC pipe and the ground surface. The container was filled with approximately 500 millilitres (ml) of a preserving agent (100% propylene glycol) and a cover was suspended approximately 20 mm above the trap to reduce vertebrate by-catch and to limit rain entering the trap. To increase the effectiveness of the pitfall trap, two drift fences (flywire mesh) measuring approximately 750 mm in length and 150 mm in height were set on each side of the trap. The base of the fence was buried into the ground. Traps were placed at 5 to 10 m intervals where possible. The contents of wet pitfall traps were examined using a dissecting microscope in the Outback Ecology laboratory.

Vertebrates are sometimes inadvertently collected in wet pitfall traps. All vertebrates were identified by Outback Ecology vertebrate fauna specialists. The records of invertebrates and vertebrates identified from both phases of the survey were forwarded to the DEC as stipulated by the Regulation 17 fauna licence.

Targeted searching

Each site was searched for SRE invertebrates for two person hours. When present, microhabitats such as leaf litter, beneath logs, bark and rocks, crevices, the bases of shrubs and trees and beneath spinifex hummocks were searched. Burrows suspected to be those of mygalomorphs or scorpions were excavated and any occupants were collected.

Leaf litter collection

Three samples of leaf litter were collected from each site. The samples were collected by scraping back the top layer of litter to reveal the decomposition layer above the soil. Leaf litter samples were sealed in plastic bags and kept cool during fieldwork and subsequent transportation to the Outback Ecology laboratory. Tullgren funnels were used to extract invertebrates from the leaf litter samples. Tullgren funnels use light and heat generated above the sample to encourage the downward movement of invertebrates. Eventually the invertebrates exit the funnel and fall into a container of 100 % ethanol. Leaf litter samples were left in the Tullgren funnels for at least 72 hours. After this time, the collection containers beneath the Tullgren funnels were examined for invertebrates using a binocular microscope. The leaf litter remaining in the funnels was searched for invertebrates under magnification.

Soil sieving

At each systematic survey site, three soil samples, each approximately 2 L in volume, were collected and sieved. Areas targeted included potential terrestrial snail habitats, such as under bushes and trees, at the base of breakaways and under rock ledges. Sieved soil (1-10 mm fraction) was collected into sealed bags. The samples were transported and sorted under magnification at the Outback Ecology laboratory.

3.2.6. Specimen Preservation

All specimens were preserved in a way that allowed genetic analysis if required. Mygalomorph spiders and scorpions were placed in 75 % ethanol, after their third left leg had been removed and stored in 100 % ethanol. Pseudoscorpions and slater specimens were stored in 100 % ethanol. Land snails were kept live in a state of aestivation by storing them in well ventilated, cool, dry containers. Specimens belonging to taxa prone to short-range endemism were delivered to taxonomists for identification.

3.2.7. Specimen Processing And Identification

Specimens belonging to taxa prone to short range endemism were delivered to the Museum for registration and identification and delivery to taxonomists from other organisations. The taxonomists who identified invertebrate specimens are shown in **Table 4**.

Table 4: Invertebrate taxonomists and their specialisation

Speciality	SRE ID Specialist	Organisation
Arachnids and millipedes	Mark Harvey, Mark Castalanelli, Catherine Car	Western Australian Museum
Scorpions	Erich Volschenk	Scorpion ID
Slaters	Simon Judd	Independent consultant
Snails	Corey Whisson	Western Australian Museum

3.2.8. SRE Assessment Team And Licencing

The terrestrial SRE invertebrate fauna assessment was conducted by:

Matt Quinn	B.Sc (Marine Sci./Environ.Sci.)	Environmental Scientist
Arnold Slabber	B.Sc. (Environ. Biology) (Hons.)	Environmental Scientist

Licence to take fauna for scientific purposes (Regulation 17) – Licence No: SF008395

Date of issue: 03/01/2012

Valid from: 11/01/2012

Date of expiry: 10/01/2012

4. RESULTS AND DISCUSSION

4.1. Terrestrial Sre Invertebrate Fauna Habitats

Five broad habitat types were identified in the Study area (**Table 5**; **Figure 10**). These habitats were categorised as having a high, medium or low potential to support terrestrial SRE species based on the degree to which they were sheltered or formed habitat isolates (**Section 3.2.4**).

Table 5: Assessment of habitats within the Study area

Habitat	Category	Habitat Description	Area (ha) of habitat in the Study area	Percentage (%) of habitat in the Study area
Sand plain	Not restricted	Sand plain habitats are exposed for much of the day and provided limited sheltered areas for relictual species	5,727	74.62
Flood plain	Not restricted	Flood plain habitats are sheltered environments that tend to have elevated soil moisture content.	996	12.98
Rocky rise	Not restricted	Rocky rise habitats are exposed for much of the day and provided limited sheltered areas for relictual species	843	10.98
Seasonal drainage surface	Restricted	Seasonal drainage surfaces are generally isolated and have elevated levels of soil moisture, however are exposed for much of the day.	103	1.34
Internal drainage	Restricted	Internal drainage habitats are isolated, sheltered environments that tend to have elevated soil moisture content.	6	<1
Total			7,675	100

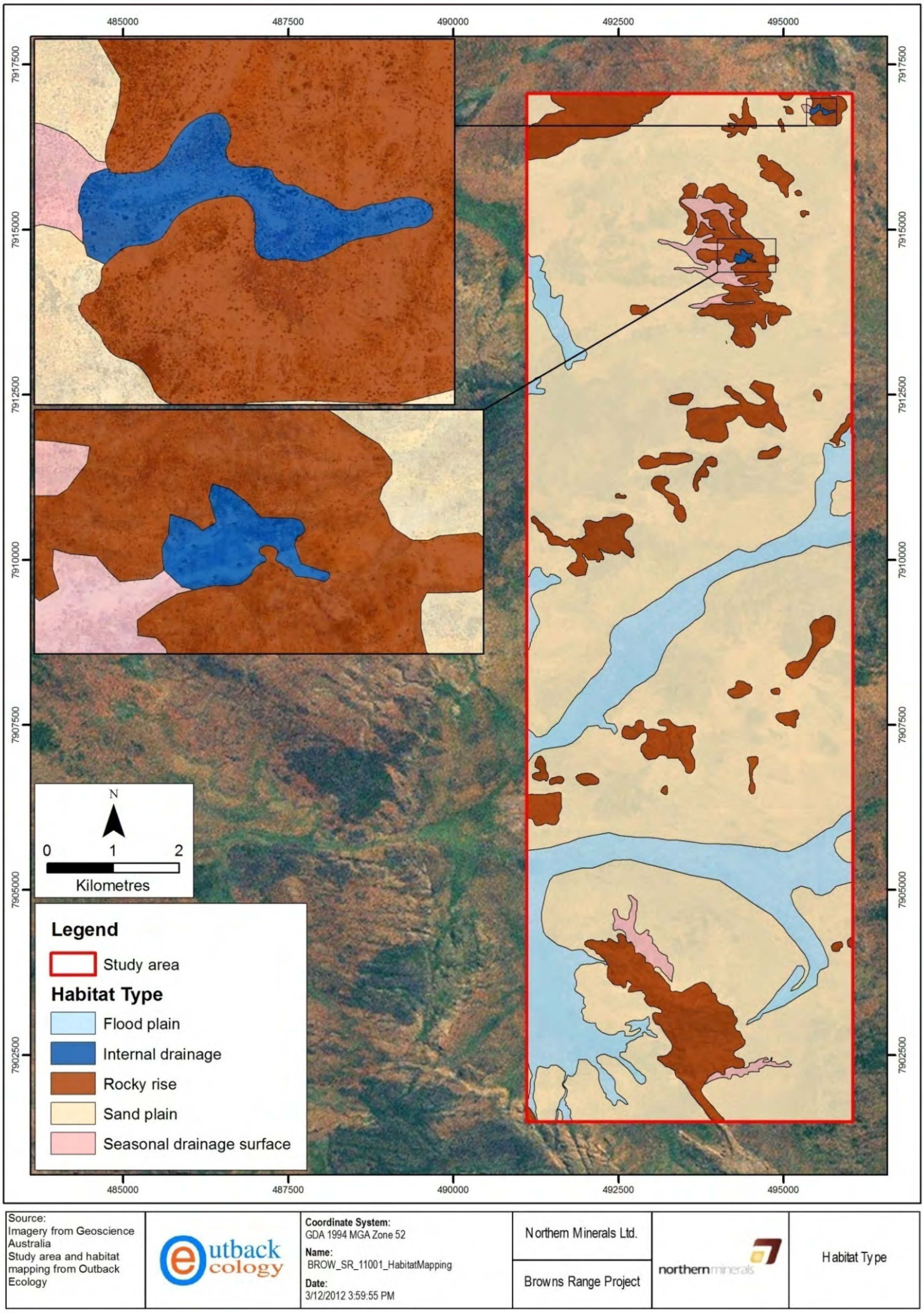


Figure 10: Habitat types within the Study area

4.1.1. Internal Drainage

Internal drainage habitat is restricted in the Study area and is disconnected from similar habitat in the surrounding region. Areas of internal drainage have a high potential for supporting SRE species as they form isolated and sheltered environments that tend to have elevated soil moisture content. Connectivity between areas of internal drainage is poor as these areas form in drainage basin landforms that are generally surrounded by areas of increased elevation. Vegetation in these habitats is typically denser when compared to habitats in the surrounding area. This vegetation provides increased levels of shelter and leaf litter accumulation, which creates important invertebrate microhabitats.

Vegetation primarily comprised very sparse *Acacia* spp. up to 3 m high, over a closed grassland of speargrass, with approximately 90% cover. The substrate consisted of fine brown sand over gravel which is subject to water logging.

Internal drainage habitat covers an area of approximately 6 ha, less than 1 % of the Study area (**Figure 10**). This habitat type was assessed at two systematic survey sites during this assessment (**Table 5**).

4.1.2. Seasonal Drainage Surface

Seasonal drainage surface habitat is restricted in the Study area and is relatively disconnected from similar habitat in the surrounding region. Areas of seasonal drainage surface have a medium potential for supporting SRE species, as they are isolated and tend to have elevated soil moisture content, however have limited shelter as they are exposed for much of the day. This habitat forms as a result of seasonal rainfall, which flows off the surrounding rocky rise habitat and inundates the sand plain habitat.

Vegetation primarily comprised scattered Eucalyptus/Corymbia spp. up to 8 m high, over a very sparse Acacia spp. shrubland over closed grassland, with up to 80% cover. The substrate consisted of a fine brown sand over gravel which is subject to water logging.

Seasonal drainage surface habitats cover an area of approximately 103 ha, representing 1.34 % of the Study area (**Figure 10**). This habitat type was assessed at four systematic survey sites during this assessment (**Table 5**).

4.1.3. Flood Plain

Flood plain habitat is not restricted within the Study area and occurs extensively in the surrounding region. Flood plains tend to have elevated soil moisture content, however these habitats are exposed for much of the day. Connectivity is generally good within flood plains, however they form in drainage systems that are isolated within the surrounding landscape during the dry season. Vegetation in these habitats is typically denser when compared to habitats in the surrounding area. This vegetation provides increased levels of shelter and leaf litter accumulation which creates important invertebrate microhabitats.

Vegetation primarily comprised scattered Eucalyptus spp. up to 4 m high, over a very sparse Acacia spp. shrubland over open grassland, with minimal cover. The substrate consisted of a Colluvium gravelly soil subject to water logging.
Flood plain habitat covers an area of approximately 996 ha, representing 12.98 % of the Study area (**Figure 10**). This habitat type was assessed at two systematic survey sites during this assessment (**Table 5**).

4.1.4. Rocky Rise

Rocky rise habitat is not restricted within in the Study area and occurs extensively in the surrounding region. This habitat has a low potential to support SRE species, as they are exposed for much of the day and provided limited sheltered areas for relictual species. Vegetation primarily comprised scattered Eucalyptus spp. up to 4 m high, over a very sparse Acacia spp. shrubland over open grassland with minimal cover. The substrate consisted of consisted of metamorphic outcrops with rocky soil throughout the Study area.

Rocky rise habitat covers an area of approximately 843 ha, representing 10.98 % of the Study area **(Figure 10**). This habitat type was assessed at four systematic survey sites and one targeted search site during this assessment (**Table 5**).

4.1.5. Sand Plain

Sand plain habitat is not restricted within the Study area and occurs extensively in the surrounding landscape. This habitat has a low potential to support SRE species, as they have limited sheltered areas for relictual species. Vegetation primarily comprised scattered Eucalyptus/Corymbia spp. up to 8 m high, over a very sparse Acacia spp. shrubland over a closed grassland of Triodia sp. and speargrass, with up to 80% cover. The substrate consisted of a fine red sand over gravel plain.

Sand plain habitat covers an area of approximately 5,727 ha, representing 74.62 % of the Study area (**Figure 10**). This habitat type was assessed at two systematic survey sites and one targeted search site during this assessment (**Table 5**).

4.2. SRE Species Previously Recorded From The Study Area Surround And Wider Region

No specimens have been previously collected from inside the Study area. No SRE invertebrate species were identified in either the literature review or WAM and DEC database searches. The absence of collection records from the region highlights the remote nature of the Project and the lack of survey work that has been undertaken in the region.

4.3. Terrestrial SRE Invertebrate Species Recorded From The Study Area

The survey of the Study area yielded a total of 315 invertebrate specimens from 25 identifiable species and morphospecies. For brevity, the term 'species' will be used to refer to both species and morphospecies in the remainder of the report. A number of specimens from each target group were not able to be identified to species, as they were of an inappropriate sex or life stage. These specimens are not considered further in this report as it is not possible to draw conclusions on their distributions without undertaking comparative genetic analysis with reference collections.

A summary of the number of specimens and species collected from each of the invertebrate groups targeted in the survey are presented in **Table 6**. Slaters were the most numerous group to be collected (168 individuals from four identifiable species), followed by pseudoscorpions (57 specimens from two identifiable species), scorpions (33 specimens from seven species), mygalomorph spiders (29 specimens from seven species), millipedes (22 specimens from three species) and snails (six specimens from two species).

Table 6: Summary of the terrestrial SRE invertebrate taxa collected during the survey

Target group	Number of specimens	Number of identifiable species
Mygalomorph spiders	29	7
Pseudoscorpions	57	2
Scorpions	33	7
Slaters	168	4
Millipede	22	3
Snails	6	2
TOTAL	**315**	**25**

The survey of the Study area yielded a total of 315 invertebrate specimens from 25 identifiable species and morphospecies. Based on current scientific knowledge, 17 of these species were considered SRE species, comprising;

- the mygalomorph spider *Aganippe* 'MYG260', *Aname* 'MYG258', *Idiommata* 'MYG259'. and *Kwonkan* 'MYG257'
- the selenopid spider *Karaops* 'sp. browns range'
- the scorpions *Isometroides* 'kimb1', *Lychas* 'annulatus2', *Urodacus* 'kimb2' and *Urodacus* 'yaschenkoi kimb1'
- the pseudoscorpions *Beierolpium* 'sp. 8/4' and *Xenolpium* 'sp. PSE070'

- the millipedes 'DIPAAB' 'DIP043' and *Helicopodosoma '*DIP044'; and
- the slaters *Acanthodillo* 'sp. browns range', *Buddelundia* sp.nov. 59, *Cubaris* 'sp. browns range' *and Spherillo* 'sp. browns range'.

Two SRE species, Aganippe MYG260' and Aname 'MYG258' were collected from restricted habitats within the Study area. The remaining 15 SRE species were collected from habitats that were not considered to be restricted within the Study area and the SRE status of these species may not represent a restricted distribution but rather a lack of regional survey work.

The location and the number of specimens collected of these species is summarised in **Table 7**, and detailed taxonomic reports are included in **Appendix C** to **Appendix G**.

Table 7: SRE Specimens collected from the Study area showing site, number of specimens and associated habitat

Habitat	Site	Number of potential SRE species collected																	Total
		Aganippe 'MYG260'	*Aname* 'MYG258'	*Idiommata* 'MYG259'	*Kwonkan* 'MYG257'	*Karaops* 'sp. browns range'	*Isometroides* 'kimb1'	*Lychas* 'annulatus2'	*Urodacus* 'kimb2'	*Urodacus* 'yaschenkoi kimb1'	*Beierolpium* 'sp. 8/4'	*Xenolpium* 'sp. PSE070'	'DIPAAB' 'DIP043'	*Helicopodosoma* 'DIP044'	*Acanthodillo* 'sp. browns range'	*Buddelundia* sp. nov. 59	*Cubaris* 'sp. browns range'	*Spherillo* 'sp. browns range'	
Internal drainage (5)	1										3				1	7			11
	5	1	2								1				1	6			11
Seasonal drainage surface (5)	2							2					2		3				7
	4		2													2			4
Rocky rise (10)	6										3		2			40			45
	7										1		8	1		38			48
	9					2										22	1		25
	13							2			16	1	2		5	2		1	29
	Target 1																		0
Sand plain (8)	3				1										2				3
	10				2	1				2	1					1			7
	8				1				1	1		1			1	4			9
	Target 2																		0
Flood plain (10)	11						1		1		10				5	6	2		25
	12			1	1				5	1	2		2			9	9		30
Total		**1**	**4**	**1**	**5**	**3**	**1**	**4**	**7**	**4**	**37**	**2**	**16**	**1**	**18**	**137**	**12**	**1**	**254**

4.3.1. Mygalomorph Spiders

Four SRE mygalomorph spider species; Aganippe 'MYG260', Aname 'MYG258', Idiommata 'MYG259' and Kwonkan 'MYG257', were collected during the survey (**Appendix C**). A single Aganippe 'MYG260' specimen was collected from internal drainage habitat which is restricted within the Study area (**Figure 11**; **Table 6**). Internal drainage covers an area of approximately 6 ha (<1 %) within the Study area (**Table 5**). Aganippe 'MYG260' is considered a SRE species as it is only known to occur within the Study area (**Appendix C**) and was collected from a restricted habitat within the Study area.

Four Aname 'MYG258' specimens were collected from internal drainage and seasonal drainage surface habitat in the Study area (**Figure 11**; **Table 6**). Additionally, five Aname sp. specimens were collected from all other habitats that occur within the Study area, however these specimens could not be identified to species level as they were either the incorrect age or sex for morphological identification (**Appendix C**). Mygalomorph spiders must be adult males for species level identification. It is possible that these juvenile and female specimens represent the species Aname 'MYG258' as this was the only Aname species known to occur within the Study area. Genetic work was undertaken to compare Aname 'MYG258' and Aname sp. specimens collected from the Study area, however genetic samples from the Aname sp. specimens failed to amplify and genetic comparisons could not be completed (**Appendix D**). At present, Aname 'MYG258' is only known to occur within internal drainage and seasonal drainage habitat. Seasonal drainage surface and internal drainage cover an area of approximately 103 ha (1.43 %) and 6 ha (<1 %) within the Study area respectively (**Table 5**). Both of these habitats are restricted within the Study area and surrounding landscape. Aname 'MYG258' is considered a SRE species as it is only known to occur within the Study area (**Appendix C**) and was collected from two restricted habitats within the Study area.

A single Idiommata 'MYG259' specimen was collected from flood plain habitat in the Study area (**Figure 11**; **Table 6**). Flood plain habitat covers an area of approximately 996 ha (12.98 %) and is not considered to be restricted within the Study area (**Table 5**). Assuming that Idiommata 'MYG259' occurs in association with flood plain habitat, which is contiguous and widespread throughout the Tanami sub-bioregion, this species has the potential to occur outside of the Study area. Idiommata 'MYG259' is considered a SRE species as it is only known to occur within the Study area (**Appendix C**), however this species was collected from a habitat that was not considered to be restricted within the Study area.

Five Kwonkan 'MYG257' specimens were collected from sand plain and flood plain habitat in the Study area (**Figure 11**; **Table 6**). Sand plain and flood plain habitat covers an area of approximately 5,727 ha (74.62 %) and 996 ha (12.98 %) within the Study area respectively (**Table 5**). Both sand plain and flood plains habitats were not considered to be restricted within the Study area. Assuming that Kwonkan 'MYG257' occurs in association with sand plain and flood plain habitat, which are both contiguous and widespread throughout the Tanami sub-bioregion, this species has the potential to occur outside of the Study area. Kwonkan 'MYG257' is considered a SRE species as it is only known to occur within the Study area (**Appendix C**), however this species was collected from two habitats that were not considered to be restricted within the Study area.

Other non-SRE mygalomorph spider species collected during the survey included *Aurecocrypta sp., Synothele karara* and *Selenotholus* sp. Members of these genera generally have a wide distribution, therefore these species were not considered to be SRE species (**Appendix C**).

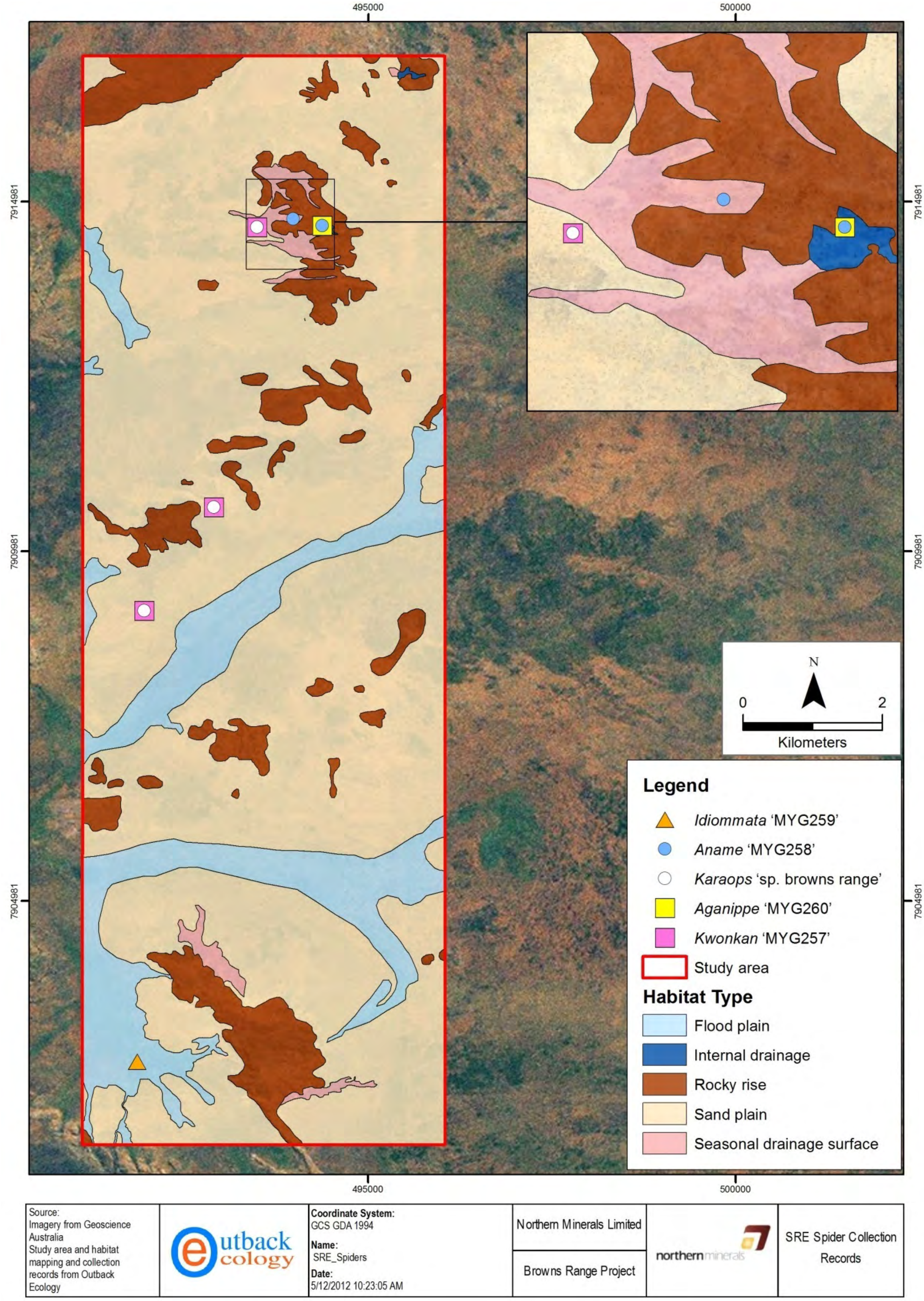


Figure 11: SRE spider collection records from within the Study area

4.3.2. Selenopid Spiders

A single SRE selenopid species, Karaops ‘sp. browns range’ was collected during the survey (**Appendix C**). Three specimens of Karaops ‘sp. browns range’ were collected from two sites occurring in rocky rise and sand plain habitat in the Study area (**Figure 11**; **Table 6**). A juvenile Karaops sp. specimen was collected from rocky rise habitat, however could not be identified to species level as it was the incorrect age for morphological identification (**Appendix C**). Sand plain and rocky rise habitats cover an area of approximately 5,727 ha (74.62 %) and 843 ha (10.98 %) within the Study area respectively (**Table 5**). Both sand plain and rocky rise plains habitats were not considered to be restricted within the Study area. It is likely that this juvenile specimen represents Karaops ‘sp. browns range’ as it is the only Karaops species known to occur within the Study area. The closest Karaops specimens, geographically speaking, have been recorded approximately 300 km west of the Study area and are morphologically different to those collected from within the Study area (**Appendix C**). Karaops ‘sp. browns range’ is considered a SRE species as it is only known to occur within the Study area (**Appendix C**), however this species was collected from two habitats that were not considered to be restricted within the Study area.

4.3.3. Scorpions

Four SRE scorpion species; Isometroides 'kimb1', Lychas 'annulatus 2', Urodacus 'kimb2' and Urodacus 'yaschenkoi kimb1’ were collected during the survey (**Appendix E**). A single Isometroides 'kimb1' specimen was collected from flood plain habitat in the Study area (**Figure 12**; **Table 6**). Flood plain habitat covers an area of approximately 996 ha (12.98 %) and is not considered to be restricted within the Study area (**Table 5**). Assuming that Isometroides 'kimb1' occurs in association with flood plain habitat, which is contiguous and widespread throughout the Tanami sub-bioregion, this species has the potential to occur outside of the Study area. Isometroides 'kimb1' is considered a SRE species as it is only known to occur within the Study area (**Appendix E**), however this species was collected from a habitat that was not considered to be restricted within the Study area.

Four Lychas 'annulatus 2' specimens were collected from seasonal drainage surface and rocky rise habitats in the Study area (**Figure 12**; **Table 6**). . Rocky rise and seasonal drainage area cover an area of approximately 843 ha (10.98 %) and 103 ha (1.34 %) within the Study area respectively (**Table 5**). Season drainage surface habitat is restricted where as rocky rise habitat was not considered to be restricted within the Study area. Assuming that Lychas 'annulatus 2' occurs in association with rocky rise habitat, which is contiguous and widespread throughout the Tanami sub-bioregion, this species has the potential to occur outside of the Study area. Lychas 'annulatus 2' is considered a SRE species as it is only known to occur within the Study area (**Appendix E**), however this species was collected from both a restricted and non-restricted habitat within the Study area.

Urodacus 'kimb2' and Urodacus 'yaschenkoi kimb1’ specimens were collected from sand plain and flood plain habitats in the Study area (**Figure 12**; **Table 6**). Sand plain and flood plain habitats cover n area of approximately 5,727 ha (74.62 %) and 996 ha (12.98 %) within the Study area respectively

(**Table 5**). Both sand plain and flood plains habitats were not considered to be restricted within the Study area. Assuming that both of these Urodacus species occur in association with sand plain and flood plain habitats, which are contiguous and widespread throughout the Tanami sub-bioregion, these species have the potential to occur outside of the Study area. Urodacus 'kimb2' is considered a SRE species as it is only known to occur within the Study area (**Appendix E**), however this species was collected from two habitats that were not considered to be restricted within the Study area.

Other non-SRE scorpion species collected during the survey included Lychas 'adonis', Lychas bituberculatus and Lychas 'multipunctatus'. Members of these genera generally have a wide distribution, therefore these species were not considered to be SRE species (**Appendix E**).

4.3.4. Pseudoscorpions

Two SRE pseudoscorpion species; Beierolpium ‘sp. 8/4’ and Xenolpium ‘sp. PSE070’, were collected during the survey (**Appendix C**). Thirty-seven Beierolpium ‘sp. 8/4’ specimens were collected from internal drainage, rocky rise, flood plain and sand plain habitats in the Study area (**Figure 13**; **Table 6**). An additional eight juvenile Beierolpium sp. specimens were collected from sand plain, rocky rise and internal drainage habitats that could not be identified to species level, as they were the incorrect age for morphological identification (**Appendix C**). It is likely that these juvenile specimens represent Beierolpium ‘sp. 8/4’, as this is the only Beierolpium species known to occur within the Study area. Beierolpium ‘sp. 8/4’ does not appear to be a habitat specialist, as it was collected from a wide range of habitats and it is likely that this species occurs outside of the Study area. Beierolpium ‘sp. 8/4’ is considered a SRE species as it is only known to occur within the Study area (**Appendix C**), however this species was collected from a number of habitats that were not considered to be restricted within the Study area.

Two Xenolpium ‘sp. PSE070’ specimens were collected from rocky rise and sand plain habitats in the Study area (**Figure 13**; **Table 6**). Sand plain and rocky rise habitats cover an area of approximately 5,727 ha (74.62 %) and 843 ha (10.98 %) within the Study area respectively (**Table 5**). Both sand plain and rocky rise habitats were not considered to be restricted within the Study area. Assuming that Xenolpium ‘sp. PSE070’ occurs in association with rocky rise and sand plain habitats, which are contiguous and widespread throughout the Tanami sub-bioregion, this species has the potential to occur outside of the Study area. Xenolpium ‘sp. PSE070’ is considered a SRE species as it is only known to occur within the Study area (**Appendix C**), however this species was collected from a number of habitats that were not considered to be restricted within the Study area.

Other non-SRE pseudoscorpion species collected during the survey included Oratemnus sp., Haplochernes sp., Austrohorus sp. and Indolpium spp. Members of these genera generally have a wide distribution, therefore these species were not considered to be SRE species (**Appendix C**).

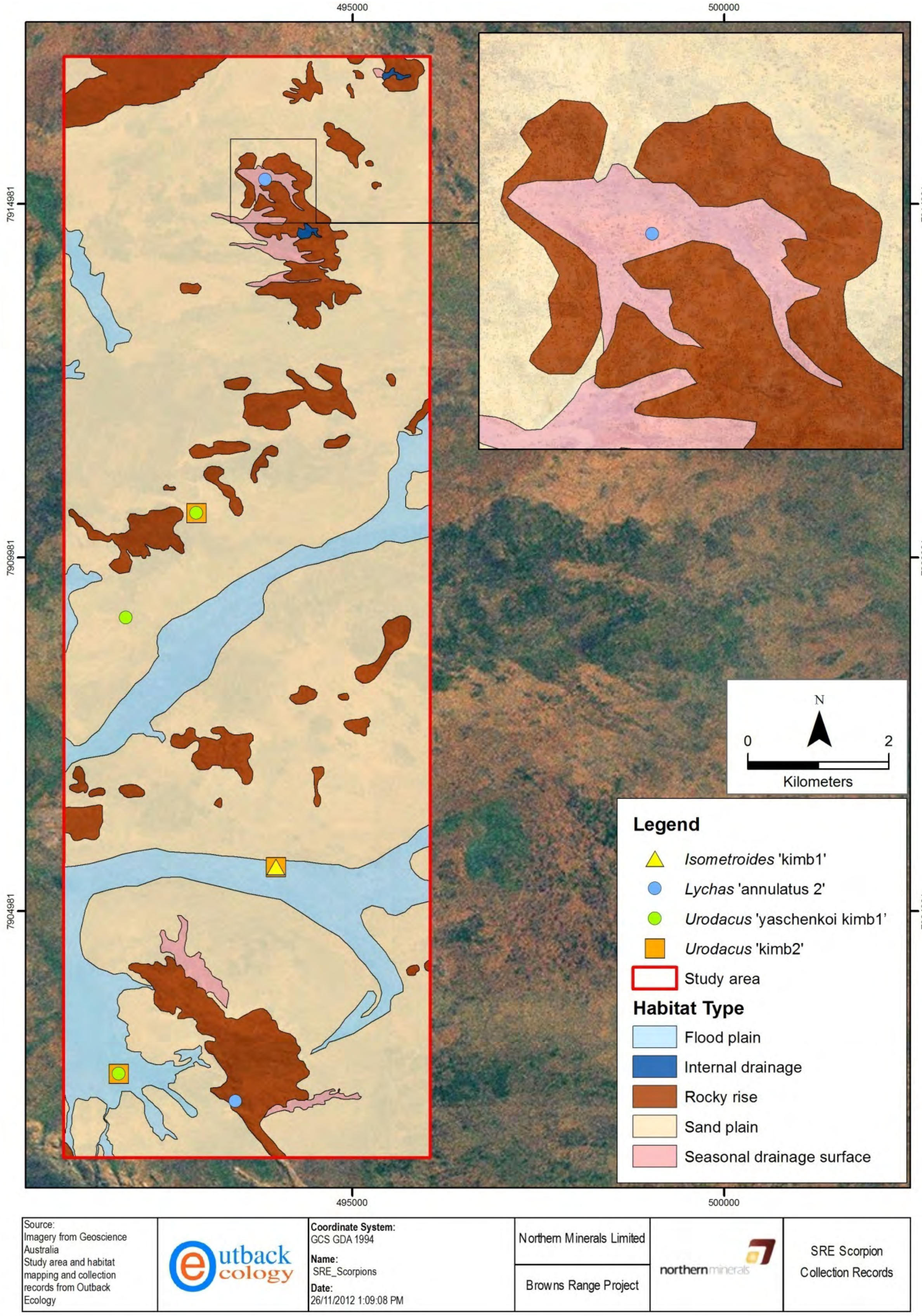


Figure 12: SRE scorpion collection records from within the Study area

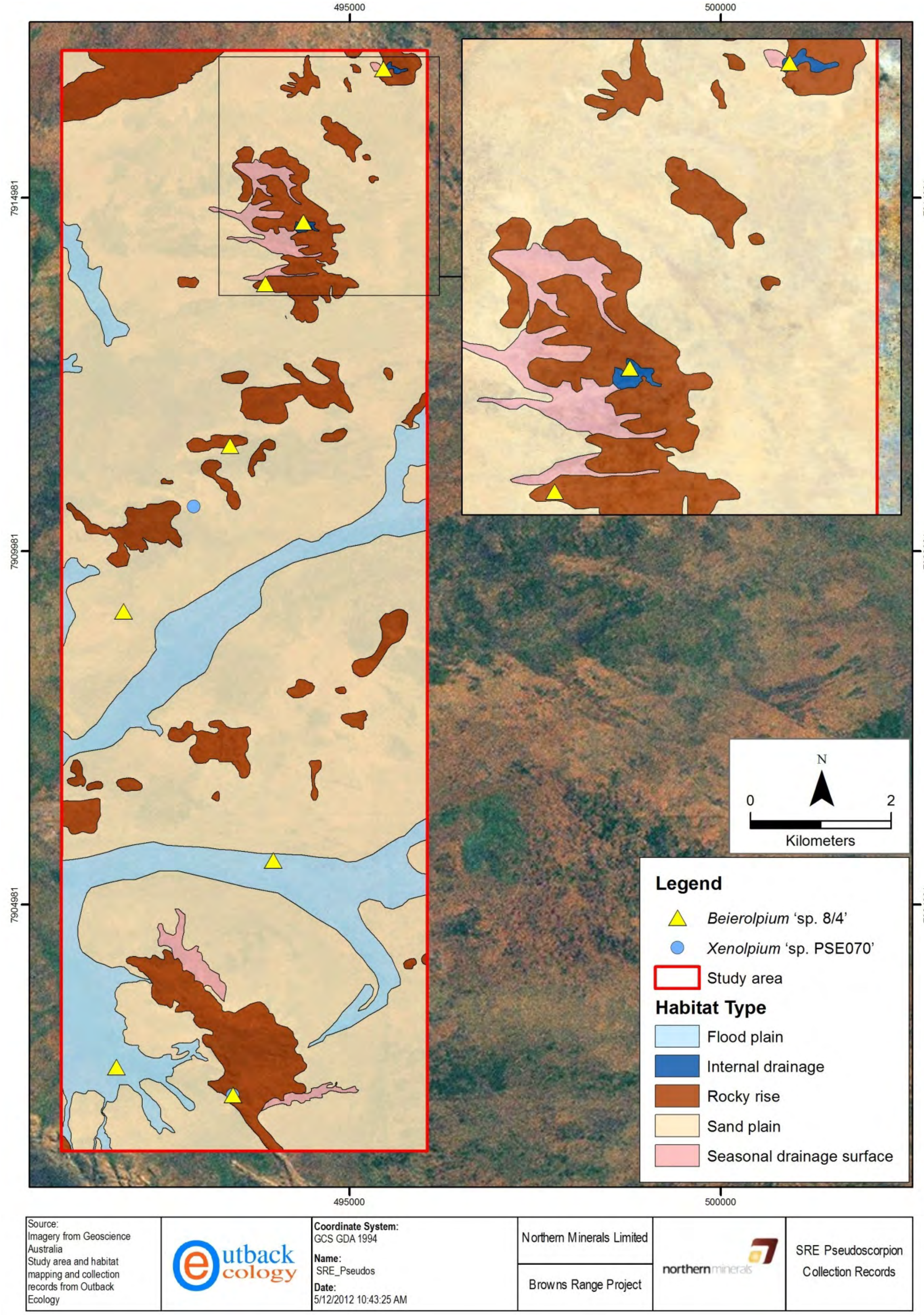


Figure 13: SRE pseudoscorpion collection records from within the Study area

4.3.5. Millipedes

Two SRE millipede species, 'DIPAAB' 'DIP043' and Helicopodosoma 'DIP044', were collected during the survey (**Appendix C**). Sixteen 'DIPAAB' 'DIP043' specimens were collected from seasonal drainage surface, rocky rise and flood plain habitats in the Study area (**Figure 14**; **Table 6**). 'DIPAAB' 'DIP043' does not appear to be a habitat specialist as it was collected from three habitats within the Study area and it is likely that this species occurs outside of the Study area. 'DIPAAB' 'DIP043' is considered a SRE species as it is only known to occur within the Study area (**Appendix C**), however this species was collected from a number of habitats that were not considered to be restricted within the Study area.

A single Helicopodosoma 'DIP044' was collected from rocky rise habitat in the Study area (**Figure 14**; **Table 6**). Rocky rise habitat is not considered to be restricted and covers an area of approximately 843 ha (120.98 %) within the Study area (**Table 5**). Assuming that Helicopodosoma 'DIP044' occurs in association with rocky rise habitat, which is widespread throughout the Tanami sub-bioregion, this species has the potential to occur outside of the Study area. Helicopodosoma 'DIP044' is considered a SRE species as it is only known to occur within the Study area (**Appendix C**), however this species was collected from a habitat that was not considered to be restricted within the Study area.

Other non-SRE millipede species collected during the survey included Oratemnus sp., Haplochernes sp., Austrohorus sp. and Indolpium spp. Members of these genera generally have a wide distribution, therefore these species were not considered to be SRE species (**Appendix C**).

4.3.6. Slaters

Four SRE slater species, Acanthodillo 'sp. browns range', Buddelundia sp.nov. 59, Cubaris 'sp. browns range' and Spherillo 'sp. browns range', were collected during the survey (**Appendix F**). Eighteen Acanthodillo 'sp. browns range' specimens were collected from internal drainage, seasonal drainage surface, rocky rise, sand plain and flood plain habitats within the Study area (**Figure 15**; **Table 6**). Acanthodillo 'sp. browns range' does not appear to be a habitat specialist, as it was collected from all habitats that occur within the Study area. A number of habitats that occur within the Study area are contiguous and widespread throughout the Tanami sub-bioregion. Assuming Acanthodillo 'sp. browns range' occurs in association with these habitats, this species is likely to occur outside of the Study area. Acanthodillo 'sp. browns range' is considered a SRE species as it is only known to occur within the Study area (**Appendix F**), however this species was collected from a number of habitats that were not considered to be restricted within the Study area.

One hundred and thirty seven specimens of Buddelundia sp.nov. 59 were collected from internal drainage, seasonal drainage surface, rocky rise, sand plain and flood plain habitats within the Study area (**Figure 15**; **Table 6**). Buddelundia sp.nov. 59 does not appear to be a habitat specialist, as it was collected from all habitats that occur within the Study area. A number of habitats that occur within the Study area are contiguous and widespread throughout the Tanami sub-bioregion.

Assuming that Buddelundia sp.nov. 59 occurs in association with these habitats, this species is likely to occur outside of the Study area. Buddelundia sp.nov. 59 is considered a SRE species as it is only known to occur within the Study area (**Appendix F**), however this species was collected from a number of habitats that were not considered to be restricted within the Study area.

Twelve Cubaris 'sp. browns range' specimens were collected from rocky rise and flood plain habitats (**Figure 15**; **Table 6**). Flood plain and rocky rise habitats cover an area of approximately 996 ha (12.98 %) and 843 ha (10.98 %) within the Study area respectively (**Table 5**). Both flood plain and rocky rise habitats were not considered to be restricted within the Study area. Assuming that Cubaris 'sp. browns range' occurs in association with these habitats, this species has the potential to occur outside of the Study area. Cubaris 'sp. browns range' is considered a SRE species as it is only known to occur within the Study area (**Appendix F**), however this species was collected from a number of habitats that were not considered to be restricted within the Study area.

A single Spherillo ‘sp. browns range’ specimen was collected from rocky rise habitat within the Study area (**Figure 15** ; **Table 6**). Rocky rise habitat is not considered to be restricted and covers an area of approximately 843 ha (10.98 %) within the Study area (**Table 5**). Assuming Spherillo ‘sp. browns range’ occurs in association with rocky rise habitat, which is widespread throughout the Tanami sub-bioregion, this species has the potential to occur outside of the Study area. Spherillo ‘sp. browns range’ is considered a SRE species as it is only known to occur within the Study area (**Appendix C**), however this species was collected from a habitat that was not considered to be restricted within the Study area.

4.3.7. Snails

Pupoides pacificus and Eremopeas interioris have a wide distribution and are therefore not considered to be SRE species (**Appendix G**).

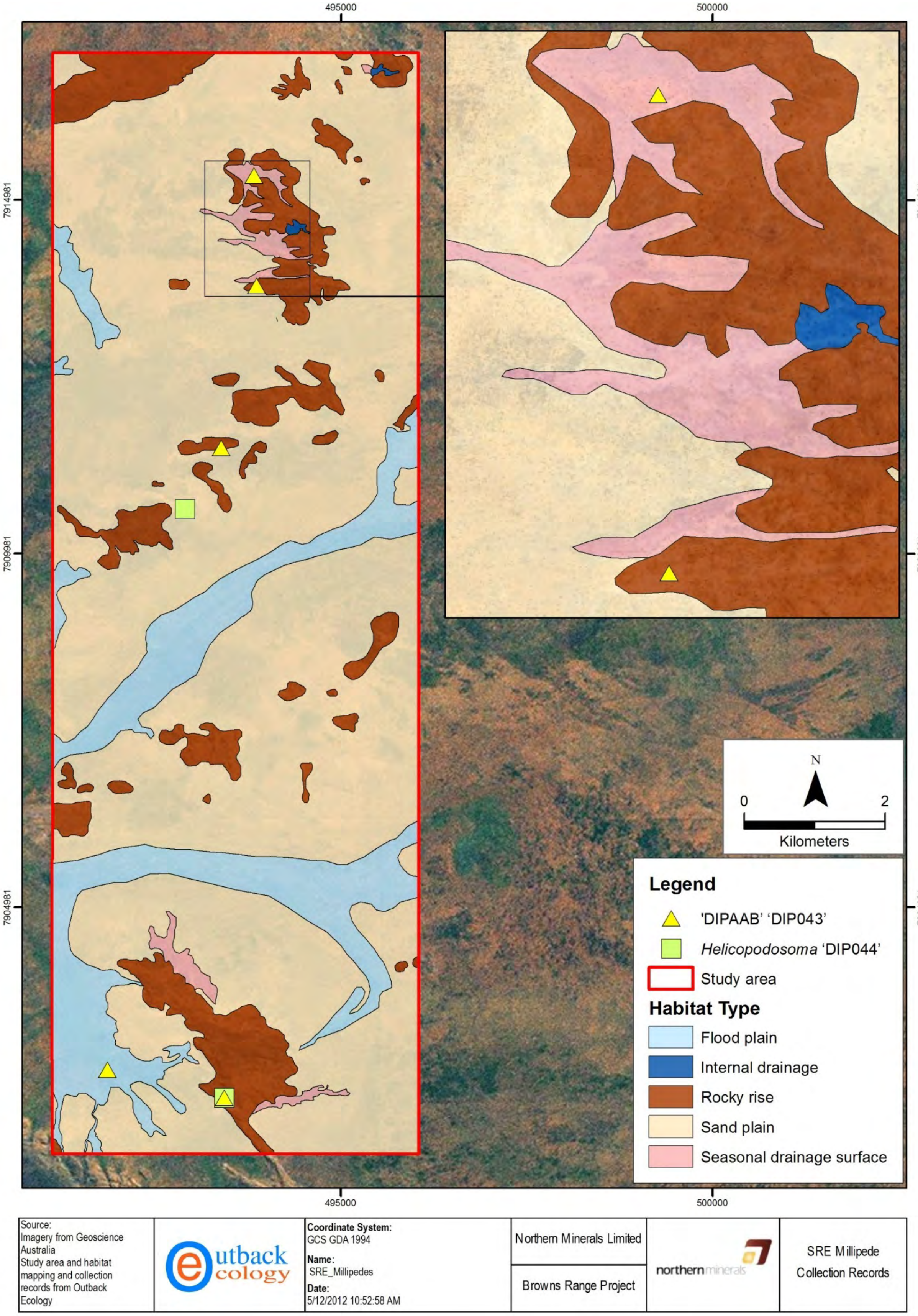
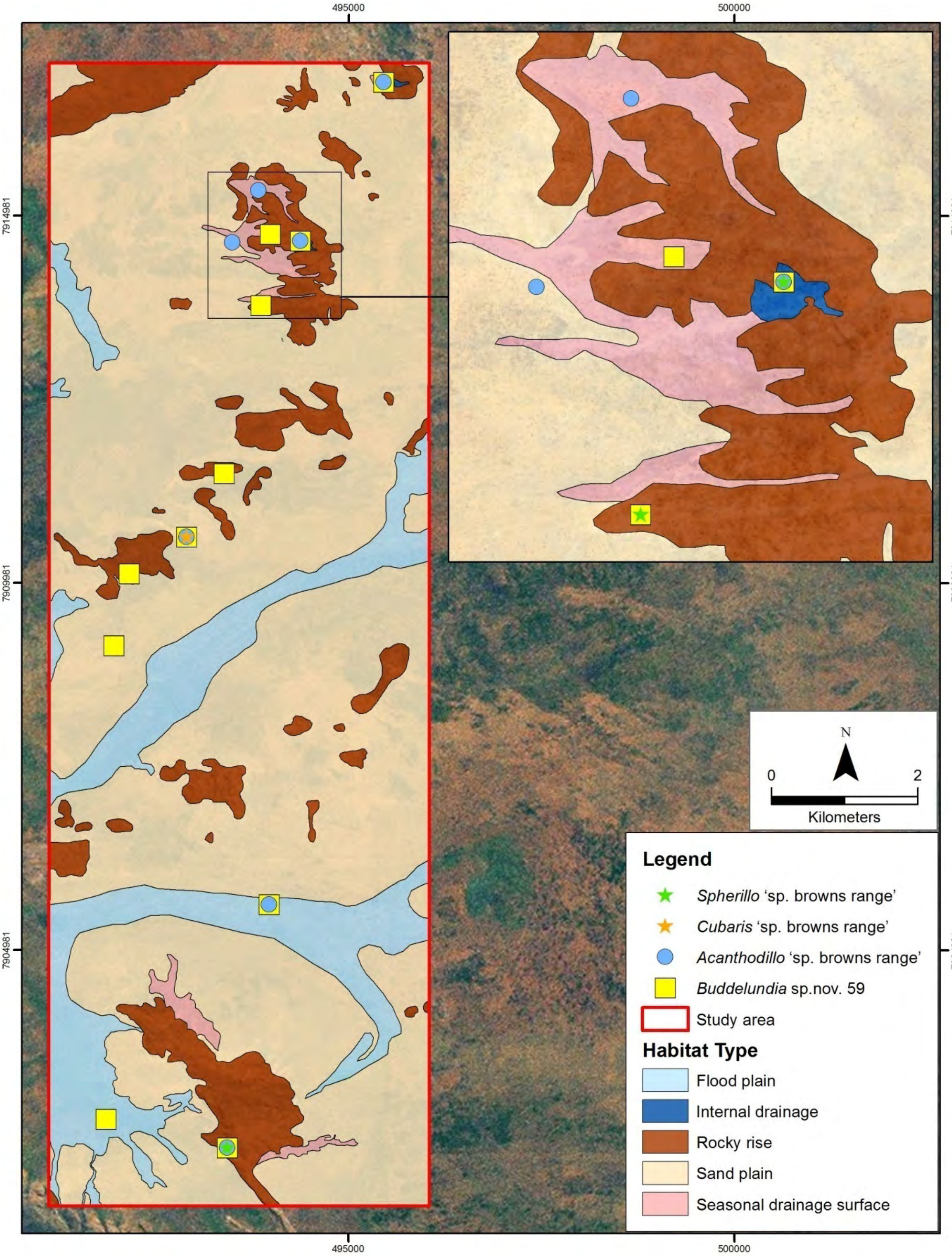


Figure 14: SRE millipede collection records from within the Study area



Source: Imagery from Geoscience Australia Study area and habitat mapping and collection records from Outback Ecology	Outback Ecology	Coordinate System: GCS GDA 1994 Name: BROW_SR_11001_SRE_Slaters Date: 19/12/2012 12:46:37 PM	Northern Minerals Limited Browns Range Project	northern minerals	SRE Slater Collection Records

Figure 15: SRE slater collection records from within the Study area

5. SURVEY LIMITATIONS AND CONSTRAINTS

A number of factors can influence the design and intensity of a fauna survey. The EPA (2004) lists possible limitations and constraints that can impinge on the adequacy of a fauna survey. These are assessed in **Table 8**. All fauna surveys are limited to some degree by time and seasonal factors and in an ideal situation several surveys would be undertaken over a number of years and during different seasons. Nevertheless, all potential limitations and constraints identified by the EPA (2004) were considered and satisfied.

Table 8: Summary of Potential Survey Limitations and Constraints

Aspect	Constraint?	Current survey
Competency/experience of consultants	no	Members of the survey team have many years experience undertaking SRE invertebrate fauna surveys of this kind in WA. Invertebrate specimens were identified by recognised taxonomic specialists.
Scope	no	Terrestrial SRE invertebrate fauna were assessed using established and standardised sampling techniques.
Proportion of fauna identified, recorded and/or collected	partial	The survey of the Study area yielded a total of 315 invertebrate specimens from 21 identifiable species and morphospecies. Slaters were the most numerous group to be collected (168 individuals from four identifiable species), followed by pseudoscorpions (57 specimens from two identifiable species), scorpions (33 specimens from seven species), mygalomorph spiders (29 specimens from seven species), millipedes (22 specimens from three species) and snails (six specimens from two species). Database and literature review did not identify any SRE species occurring within a 100 km radius of the Study area. All specimens collected from groups prone to short-range endemism were submitted to the WAM or relevant specialists for identification. Identification of SRE invertebrate fauna can be problematic due to a lack of taxonomic knowledge for some groups. Additionally, specific life stages (usually mature male specimens) are required for accurate identification for most groups. For these reasons not all specimens could be identified to species level. The level of taxonomic identification of specimens and their SRE status is described in **Section 4.3**. The survey was designed to maximise the collection of specimens belonging to target groups, however, it is recognised that surveys across years and seasons may be necessary to collect all species in an area.
Sources of information (e.g. previously available data as distinct from new data)	no	Previously available data relevant to this survey was obtained via database searches (**Section 3.1.1**) and by undertaking a literature review (**Section 3.1.2**). The results of the database searches and literature review are presented in **Section 4.2**.
Proportion of task achieved, and further work which might be needed	no	Representative sites from all habitats in the Study area were sampled using a range of collection methods. Specimens belonging to target SRE groups were collected from 13 sampling sites. All specimens from target groups were identified by relevant taxonomic experts.

Aspect	Constraint?	Current survey
Timing, weather, season, cycle	no	The phase one level two SRE survey was conducted during the optimum survey period for the Tanami (i.e. November to April) as recommended by the EPA (2009). The temperature during the survey was typical of the time of year and rainfall was above average (**Section 3.2.2**).
Disturbances	no	Parts of the Study area were disturbed by clearing and drilling activities associated with resource exploration. Some evidence of fire was observed in the Study area but was typical of the wider region.
Intensity	no	All potential SRE habitats occurring within the proposed disturbance areas were surveyed through the establishment of thirteen survey sites. A further six sites were sampled in representative habitat outside of the potential disturbance areas. This resulted in a total of 2,340 trapping nights within the Study area. Additionally, 30 hours of targeted searching, 39 litter samples and 39 soil samples were taken. It is possible that greater collecting intensity outside of the potential disturbance areas could have increased the total number of species collected; however, this survey intensity is considered adequate given the scale of the proposed impact and the existing environment.
Completeness	no	All habitats within the Study area were adequately surveyed, both at sites within the potential disturbance areas and at reference sites.
Resources	no	Resources were adequate to complete the survey. Field personnel were competent in the collection of invertebrates and identification of the habitats encountered during the survey.
Remoteness and access problems	no	Helicopters were used to provide access throughout the Study area and to ensure that adequate survey coverage was achieved.
Availability of contextual information	Partial	Contextual information on the occurrence of SREs in the region was not available and could not be sourced through the WAM Database, Australian Museum Database or through a literature review of regional SRE invertebrate fauna surveys. Additional information was also considered, including DEC's Threatened and Priority Fauna Database and DECs NatureMap database.

6. CONCLUSION

Five broad fauna habitats occur within the Study area: internal drainage, seasonal drainage surface, rocky rise, sand plain and flood plain. Internal drainage and seasonal drainage surface habitats were considered to be restricted within the Study area. Internal drainage and seasonal drainage surface habitats comprised 6 ha (<1 %) and 103 ha (1.34 %) within the Study area respectively. The remaining habitats; rocky rise, sand plain and flood plain were not considered to be restricted habitats within the Study area.

The survey of the Study area yielded a total of 315 invertebrate specimens from 25 identifiable species and morphospecies. Slaters were the most numerous group to be collected (168 individuals from four identifiable species), followed by pseudoscorpions (57 specimens from two identifiable species), scorpions (33 specimens from seven species), spiders (29 specimens from seven species), millipedes (22 specimens from three species) and snails (six specimens from two species).

Based on current scientific knowledge, 17 of these species were considered SRE species, comprising;

- the mygalomorph spider *Aganippe* ‘MYG260’, *Aname* ‘MYG258’, *Idiommata* ‘MYG259’. and *Kwonkan* ‘MYG257’
- the selenopid spider *Karaops* ‘sp. browns range’
- the scorpions *Isometroides* ‘kimb1’, *Lychas* ‘annulatus2’, *Urodacus* ‘kimb2’ and *Urodacus* ‘yaschenkoi kimb1’
- the pseudoscorpions *Beierolpium* ‘sp. 8/4’ and *Xenolpium* ‘sp. PSE070’
- the millipedes ‘DIPAAB’ ‘DIP043’ and *Helicopodosoma ‘*DIP044’; and
- the slaters *Acanthodillo* ‘sp. browns range’, *Buddelundia* sp.nov. 59, *Cubaris* ‘sp. browns range’ *and Spherillo* ‘sp. browns range’.

Two SRE species, Aganippe MYG260’ and Aname ‘MYG258’ were collected from restricted habitats within the Study area. The remaining 15 SRE species were collected from habitats that were not considered to be restricted within the Study area and the SRE status of these species may not represent a restricted distribution but rather a lack of regional survey work.

7. REFERENCES

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APPENDIX A

Description Of Taxa Prone To Short-Range Endemism

Mygalomorph spiders

Class: Arachnida

Order: Araneae

Sub-order: *Mygalomorphae*

Represented by some 10 families and 241 named species, Mygalomorphae is a primitive group of spiders which constitute approximately 13 % of Australia's described spider species (Brunet 1996, Main 2005). In Western Australia the mygalomorph fauna is vast and despite long term and ongoing research by Barbara Y. Main (University of Western Australia) and Robert Raven (Queensland Museum), the mygalomorph fauna remains taxonomically poorly known (Durrant *et al.* 2010).

Mygalomorphs have several distinctive morphological features that differentiate them from modern araneomorph spiders including: parallel fangs, two pairs of book-lungs and the presence of four (sometimes six) spinnerets ((ABRS 2012), Brunet 1996). Unlike araneomorphs, mygalomorphs generally do not construct a web for capturing prey but instead build a burrow in which they wait for prey (Main 1982). Some species can spend their entire life in a single burrow (Main 1982). Burrow morphology is highly variable and a burrow may be up to 60 cm deep depending on the species and terrain (Brunet 1996). Females rarely venture from the burrow and it is usually the males which are observed above ground when they are wandering in search of females (Main 1982).

Harvey (2002) indicates that Mygalomorphae is likely to have SRE taxa, at least partly due to the group's limited powers of dispersal and low fecundity. The cryptic lifestyle and highly seasonal variation in above ground abundance makes collecting mygalomorphs problematic. The use of pitfall traps during the wetter parts of the year generally yield wandering males, whereas both sexes can be dug from the burrow at anytime. Mature male specimens are usually required for definitive species identifications based on morphology.

Araneomorph spiders (Selenopids)

Class: Arachnida

Order: Araneae

Sub-order: Araneomorphae

In May 2010, the DEC indicated that some araneomorph spiders, such as those from the family Selenopidae, are potentially SREs. Selenopids are extremely dorsoventrally flattened and superficially resemble Huntsman spiders. Their flat body shape allows them to live in narrow crevices between rocks, under bark and in a variety of other microhabitats (Crews and Gillespie 2010). They are extremely fast, and are primarily found in the tropics and subtropics (Crews and Gillespie 2010).

The dispersal capabilities of selenopids are generally unknown; however, some species appear to disperse very well (Volker Framenau pers. comm. 2010). Selenopids can be broadly grouped into those that live in rocky habitats and those that live beneath bark. Those that inhabit isolated rocky outcrops are predisposed to having restricted ranges and are more likely to be SRE compared with the bark dwelling species that tend to exist in contiguous habitats (Volker Framenau pers. comm. 2010). Currently only a single species of Australian selenopid has been described, however, there is likely to be many more species present in Australia (Volker Framenau pers. comm. 2010). The described Australian selenopid is found on the east coast and is a bark dwelling species, and as such is unlikely to be a SRE.

Selenopids are typically cryptic and tend to be difficult to collect. Their preference to live between rocks and under bark ensures that they are rarely captured in pitfall traps. The primary method of collection is through actively searching under rocks and bark and in crevices; however, night searching with spotlights may also be effective (Sarah Crews pers. comm. 2010).

Scorpions

Class: Arachnida

Order: Scorpionida

Current classifications of the scorpions usually recognise five superfamilies, but only members of the Scorpionoidea and Buthoidea are present in Australia (ABRS 2012). Scorpions are nocturnal, solitary, predatory arachnids that have a pair of pincer-like pedipalps and an elongate metasoma (tail) tipped with a sting. Australian scorpions may reach up to 12 cm in length (Harvey and Yen 1989). Some species construct spiral burrows that can extend up 70 cm below ground.

Currently, many Australian scorpions belong to species-complexes into which a number of 'species' are grouped. With future taxonomic revision, the number of SRE species is likely to increase. Mature male specimens are usually required for definitive species identifications based on morphology. Males are generally active above ground on warm or humid nights, when they can be located using a UV spotlight under which they fluoresce. Scorpions can also be dug from their burrows and wandering males can be collected using pitfall traps.

Pseudoscorpions

Class: Arachnida

Order: Pseudoscorpionida

It is estimated that there are more than 700 species of pseudoscorpion in Australia; however, currently there are only 150 species described in Australia with many specimens awaiting description. Pseudoscorpions are found in virtually all terrestrial habitats and are generally found amongst leaf litter and beneath rocks and bark (Harvey and Yen 1989). Pseudoscorpions are usually no more than several millimetres long and have a pair of pincer-like pedipalps which they use to subdue small invertebrate prey (Harvey and Yen 1989). Very few terrestrial pseudoscorpions are currently known to be SREs (Environmental Protection Authority 2009). Hand collection, soil sieving, the processing of leaf litter in Tullgren funnels and wet pitfall trapping can be used to collect pseudoscorpions. Mature male specimens are usually required for definitive species identifications based on morphology.

Millipedes

Class: Diplopoda

Orders: eg. Polydesmida, Chordeumatida, Polyzoniida, Spirostreptida, Sphaerotheriida

There are nine millipede orders present in Australia, represented by some 250 described species (ABRS 2012). Millipedes are elongate; generally detritivorous arthropods that usually have two legs per body segment. Little is known of the biology and ecology of Australian millipedes. The orders Polydesmidae, Chordeumatida and Sphaerotheriida either have, or are likely to have representatives which are SREs (Environmental Protection Authority 2009). The propensity for short-range endemism in other millipede orders is unknown but considered low.

Millipedes are typically collected from mesic habitats and microhabitats and are commonly found among leaf litter and beneath rocks and bark in sheltered locations. Hand collection, soil sieving, the processing of leaf litter in Tullgren funnels and wet pitfall trapping are used to collect millipedes. Mature males which are generally present during the wetter parts of the year are usually required for species identification based on morphology.

Slaters

Class: Malacostraca

Order: Isopoda

Slaters are terrestrial isopods that belong to the crustacean suborder Oniscoidea. They are generally detritivorous and usually do not exceed 15 mm in length. Seven families of slaters are known from Australia and nearly all species are undescribed (ABRS 2012). Slaters are found in tropical to arid climates, where they inhabit moist and sheltered locations such as those beneath rocks, logs and bark. Slaters can be collected by hand or by using wet pitfall traps. Species diversity amongst slaters is strongly linked to leaf litter composition and specialisation often occurs in microhabitats created by the mixing of leaf litter from different flora species (Wardle 2006). Slaters are likely to contain species which are SREs (Environmental Protection Authority 2009). Species identification based on morphology generally requires adult male specimens.

Snails

Class: Gastropoda

Order: Eupulmonata

The Eupulmonata includes almost all terrestrial snails and slugs. There is approximately 1,000 species of slugs and snails in Australia. Snails tend to be either herbivorous or detritivorous. Snails prefer moist habitats and microhabitats and can be found in leaf litter, under rocks and logs and in crevices. In dryer areas snails may aestivate for an extended period up to 50 cm below ground. The best methods of collecting snails are by hand and by sieving leaf litter and soil. Many terrestrial snails have extremely restricted ranges and numerous species are known to be SREs, indeed some families consist entirely of SRE species (Environmental Protection Authority 2009, Harvey 2002). Mature live specimens are usually required for definitive species identifications based on morphology.

APPENDIX B

Site Descriptions

<table>
<tr><td>Site 1

Habitat type: Internal drainage
Vegetation: Low, very open overstorey of Eucalyptus/Corymbia spp over closed grassland comprising Triodia/Speargrass spp with 90% cover
Leaf litter: 25-50%
Substrate: fine brown loamy sand
Disturbance: Nil</td><td></td></tr>
<tr><td>Site 2

Habitat type: Seasonal drainage surface
Vegetation: Very low open woodland of Eucalyptus spp over a mixed Acacia spp. Shrubland up to 3 m high, with up to 80% cover over a Tussock and hummock grasses
Leaf litter: 10-25 %
Substrate: Fine red/brown sandy loam
Disturbance: Nil</td><td></td></tr>
<tr><td>Site 3

Habitat type: Sand plain
Vegetation: A mixed Acacia spp. Shrubland up to 3 m high, with up to 40% cover over a Tussock and hummock grasses.

Leaf litter: 10-25%
Substrate: Sandy to clayey sand
Disturbance: Nil</td><td></td></tr>
</table>

Site 4 **Habitat type:** Seasonal drainage surface **Vegetation:** Low, very open overstorey of *Eucalyptus/Corymbia* spp over closed grassland comprising *Triodia* spp with 40% cover. **Leaf litter:** 25-50 % **Substrate:** Fine red/brown sandy loam **Disturbance:** Nil	
Site 5 **Habitat type:** Internal Drainage **Vegetation:** A mixed *Acacia* spp. Shrubland up to 3 m high, with up to 40% cover over a Tussock and hummock grasses with 95% cover. Speargrass dominant. **Leaf litter:** 25-50 % **Substrate:** fine brown loamy sand **Disturbance:** Nil	
Site 6 **Habitat type:** Rocky rise **Vegetation:** Sparse *Eucalyptus/Corymbia* spp over closed grassland comprising *Triodia* spp with 40% cover. **Leaf litter:** 10% **Substrate:** Sandy clay loam to sandy clay **Disturbance:** Nil	

Site 7 **Habitat type:** Rocky rise **Vegetation:** Sparse *Eucalyptus/Corymbia* spp over closed grassland comprising *Triodia* spp with 70% cover. **Leaf litter:** < 10% **Substrate:** Sandy clay loam to sandy clay **Disturbance:** Nil	
Site 8 **Habitat type:** Sandy plain **Vegetation:** Very low open woodland of Eucalyptus spp over a mixed *Acacia* spp. Shrubland up to 3 m high, with up to 60% cover over a Tussock and hummock grasses **Leaf litter:** 10-25 % **Substrate:** Sandy to clayey sand **Disturbance:** Fire scars approximately +10 years	
Site 9 **Habitat type:** Rocky rise **Vegetation:** *Eucalyptus/Corymbia* spp over closed grassland comprising *Triodia* spp with 50% cover **Leaf litter:** 25-50 % **Substrate:** Rocky 80 % **Disturbance:** Fire scars approximately +10 years	

<table>
<tr><td>Site 10

Habitat type: Sand plain
Vegetation: A mixed Acacia spp. Shrubland up to 2 m high, with up to 40% cover over a Tussock and hummock grasses with 60% cover.
Leaf litter: 25-50%
Substrate: Sandy to clayey sand
Disturbance: Fire approximately 2 + years</td><td></td></tr>
<tr><td>Site 11

Habitat type: Flood plain
Vegetation: Low, very open Eucalyptus/Corymbia spp over a mixed Acacia spp. Shrubland up to 3 m high over a closed grassland comprising Triodia spp with 70% cover.
Leaf litter:
Substrate:
Disturbance: Nil</td><td></td></tr>
<tr><td>Site 12

Habitat type: Flood plain
Vegetation: Low, very open Eucalyptus/Corymbia spp over a mixed Acacia spp. Shrubland up to 3 m high over a closed grassland comprising Triodia spp with 75% cover.
Leaf litter:
Substrate:
Disturbance: Nil</td><td></td></tr>
</table>

Site 13 **Habitat type:** Rocky rise **Vegetation:** *Acacia* spp. Shrubland up to 2 m high, with up to 40% cover over a Tussock and hummock grasses with 50% cover. **Leaf litter:** **Substrate:** Sandy clay **Disturbance:** Nil	
Target 1 **Habitat type:** Rocky rise **Vegetation:** *Eucalyptus/Corymbia* spp over closed grassland comprising various species with 70% cover **Leaf litter:** 10-25 % **Substrate:** Rocky 60 % cover **Disturbance:** Nil	
Target 2 **Habitat type:** Sand plain **Vegetation:** Very low open woodland of Eucalyptus spp over a mixed *Acacia* spp. Shrubland up to 3 m high, with up to 80% cover over a Tussock and hummock grasses **Leaf litter:** 10-25 % **Substrate:** Sandy to clayey sand **Disturbance:** Nil	

APPENDIX C

Arachnids And Myriapods From Browns Range, Western Australia

Arachnids and Myriapods from Browns Range, Western Australia BROW_SR_11001

Report to *Outback Ecology*

3 September 2012

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Summary

The samples submitted to the Western Australian Museum on the 2nd May 2012 included millipedes from the families Paradoxosomatidae (*Antichiropus*) and Polyxenidae (*Unixenus*); pseudoscorpions from the families Atemnidae (*Oratemnus*), Chernetidae (*Haplochernes*), Olpiidae (*Beierolpium, Indolpium, Xenolpium*), araneomorph spiders from the family Selenopidae (*Karaops*), and mygalomorph spiders from the families Barychelidae (*Aurecocrypta, Idiommata,* and *Synothele*), and Nemesiidae (*Aname* and *Kwonkan*), and Theraphosidae (*Selenotholus*).

The new species of paradoxosomatid millipedes (`DIPAAB` `DIP043` and *Helicopodosoma* `DIP044`) that were collected during this survey are considered a short-range endemic species whereas the polyxenid millipedes are widespread.

At the current level of taxonomic knowledge of the pseudoscorpions, we are uncertain of the distributional status of *Austrohorus, Beierolpium* `sp. 8/4` and the *Xenolpium* `sp. PSE070` specimens, which could potentially be short-range endemics. It is unlikely that the *Haplochernes*, *Indolpium,* and *Oratemnus* samples are SREs.

Four new species of mygalomorph spiders were collected during this survey, a single barychelid (*Idiommata* `MYG259`*),* a single idiopid (*Aganippe* `MYG260`), and two nemesiids (*Aname* `MYG258` and *Kwonkan* `MYG257`). It is difficult to determine if these newly identified species are SRE species due to the lack of previous sampling within the Tanami region; however, they could potentially be SREs.

Short-Range Endemism

The terrestrial invertebrate fauna of inland Australia contains a plethora of species, and just the arthropods were recently estimated to consist of more than 250,000 species (Yeates, Harvey et al. 2004; Chapman 2009). The vast majority of these are found within the Insecta and Arachnida, although significant numbers of millipedes are to be expected. For many years, the prospect of including invertebrates in assessments of biological systems subject to modification proved daunting because of the large numbers of unknown species. These animals were largely ignored, as they were too diverse and their taxonomy too little known for them to be considered in environmental surveys that require a rapid turn-around time.

In a recent publication, the issue of Short-Range Endemism in the Australian invertebrate fauna was examined (Harvey 2002),. Species that could be defined as Short-Range Endemics (SRE) were those that had a naturally small range of less than 10,000 km^2. Harvey (2002) found that those species possessed a series of distinct ecological and life-history traits that contributed to their limited distributions, including:

- poor powers of dispersal;
- confinement to discontinuous habitats;
- usually highly seasonal, only active during cooler, wetter periods; and
- low levels of fecundity.

A number of major invertebrate groups have a high proportion of individual species that show these traits and can be considered SRE's. The Western Australian fauna contains a number of SRE taxa, including millipedes, land snails, trap-door spiders, some pseudoscorpions, slaters, and onychophorans and these represent focal groups in Environmental Impact Assessment studies in the state (EPA 2009). The south coast region is relatively well known compared with other regions of the state (Framenau, Moir et al. 2008), but there are many poorly known species and gaps in our understanding of the distributions of many species.

Methods

Arachnids and myriapods collected by *Outback Ecology* from the Browns Range area were submitted to the Western Australian Museum on 2nd May 2012. The specimens were examined at the WA museum using Leica dissecting microscopes (MZ6, MZ16). Scorpions were also submitted with this survey, but have been sent to an external expert, Dr Erich Volschenk, for identification. The scorpion results will be sent separately.

ARACHNIDA

ORDER ARANEAE

Infraorder Araneomorphae

Family Selenopidae

Spiders from the family Selenopidae are dorsoventrally flattened spiders that are well camouflaged by their mottled colouring. Species of this family are found worldwide in tropical and subtropical regions (Crews and Harvey 2011).

***Karaops* `sp. Browns Range` (family Selenopidae)**

Spiders of the genus *Karaops* are found throughout mainland Australia. Some species in this genus seem to have fairly widespread distributions, however; current literature suggests there is cryptic speciation in this genus due to the large range of some species, yet stable morphology in isolated populations (Crews and Harvey 2011) and while species in this genus are not officially recognised as SREs, evidence is pointing towards localised distributions of species. Two males and two juvenile specimens were collected during this survey. The juveniles are likely to be of the same species as the males, but based on morphology alone we cannot confidently associate the juveniles to a species level identification. The morphology of the male is unique and interesting (see Figure 1) therefore these specimens have been given the morphospecies name of *Karaops* `sp. Browns Range`. The closest specimens, geographically speaking, we have in the museum collection (rego numbers T28020 and 54979) come from around 300 km west of these specimens (see Figure 2). They are only juveniles and therefore not able to be matched based on morphology.

Figure 1. *Karaops* `sp. Browns Range` male. A: dorsal view; B: male pedipalp, ventral view; C: male pedipalp, prolateral view; D: male pedipalp, retrolateral view. *(Photos courtesy of Mieke Burger)*

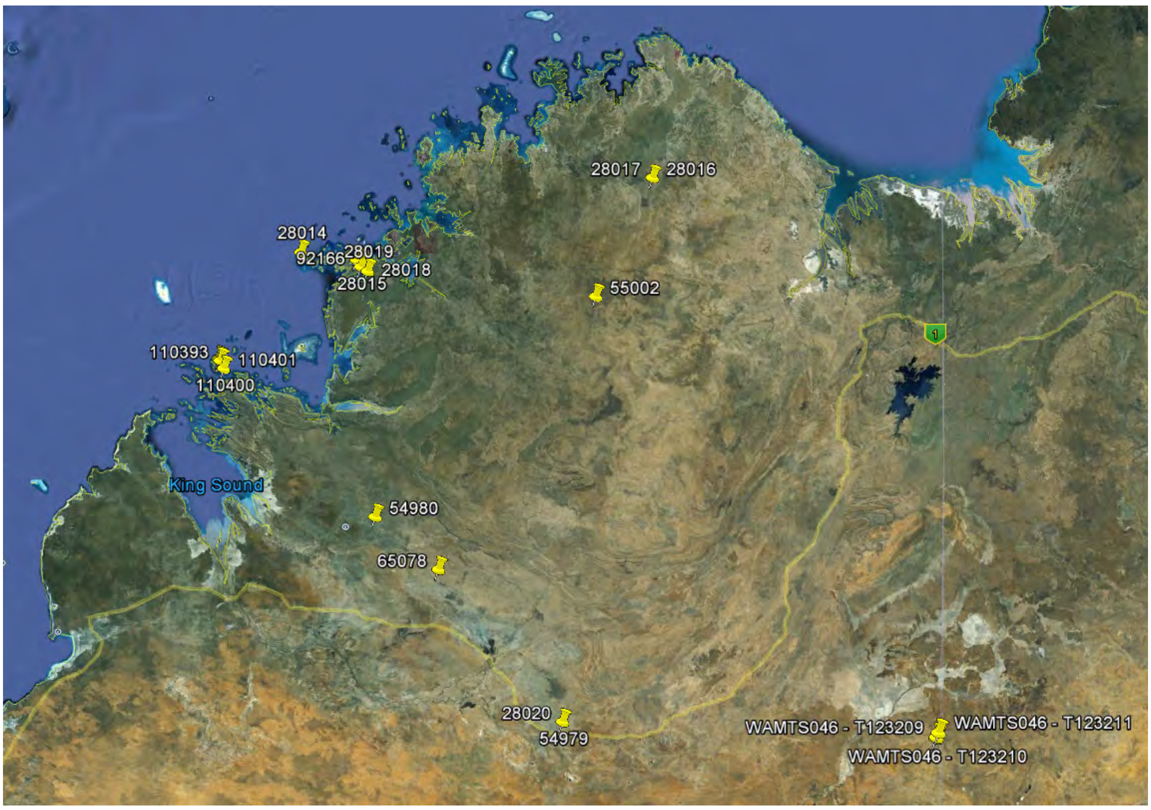

Figure 2. Geographic localities of WAM *Karaops* specimens from the Kimberley. Specimens from this survey have the prefix WAMTS046.

Infraorder Mygalomorphae (Trapdoor Spiders)

Mygalomorph ("trapdoor") spiders belong to one of the focal groups in surveys of short-range endemic taxa (Harvey 2002). Many mygalomorph spiders show low dispersal capabilities, may be restricted to relictual habitats, and have long life cycles with low fecundity. A number of mygalomorph spiders, e.g. *Aganippe castellum*, *Idiosoma nigrum*, *Kwonkan eboracum*, *Moggidgea tingle*, are listed on Schedule 1 ("Fauna that is rare or likely to become extinct" of the Wildlife Conservation (Specially Protected Fauna) Notice 2008 of the Western Australian Government. The Western Australian mygalomorph fauna is vast and, despite long-term and ongoing research by Drs Barbara Main (University of Western Australia) and Robert Raven (Queensland Museum), remains taxonomically poorly known for many families and genera (e.g. Barychelidae: *Idiommata*; Idiopidae: *Aganippe*; Nemesiidae: *Aname*, *Chenistonia*, *Kwonkan*).

The best taxonomic features to distinguish mygalomorph spiders are found within the genitalia of males. Females or juveniles may be indistinguishable, although burrow morphology may allow identification to species level in some cases (B.Y. Main, personal communication). The Western Australian Museum has recently initiated a reference collection of male mygalomorph morphospecies to facilitate an assessment of distribution patterns of these spiders. This collection is assembled in cooperation with Dr Barbara Main and will eventually be consolidated with her collection at the University of Western Australia. Mygalomorph morphospecies are consecutively numbered ("MYG001", "MYG002" etc.) to allow a comparison of taxa between different surveys.

Family Barychelidae

***Aurecocrypta* `sp. indet. (juv.)`**

Aurecocrypta is widespread throughout Western Australia with only a few specimens described (Raven 1994). Species level identification was not possible on the single juvenile specimen collected during this survey, but it most closely matched the *Aurecocrypta katersi* description outlined by Raven (1994).

***Idiommata* `MYG259`**

Idiommata is a poorly resolved genus taxonomically that was not treated in Raven's monograph of the Barychelidae (see Raven 1994). A single male was collected during this survey. Due to the lack of sampling within the surround areas it is possibly an SRE species.

***Synothele karara* Raven, 1994**

Synothele is widespread throughout Western and South Australia and a number of species are currently described from Western Australia (Raven 1994). Many species have a very limited distribution fulfilling the requirements of short-range endemism (Harvey 2002). A single male specimen was identified as *Synothele karara* and is not considered an SRE.

Family Idiopidae

The mygalomorph spider family Idiopidae includes a number of genera in WA, including *Aganippe, Anidiops, Gaius, Arbanitis, Euoplos, Blakistonia, Cataxia, Eucyrtops, Idiosoma* and *Misgolas* (Main 1957; Main 1985; Raven and Wishart 2006). They comprise the 'typical' trap door spiders, i.e. those species that usually close the burrow with a hinged door. Spiders of this family are abundant, in particular in relatively stable habitats in temperate to tropical regions (Main 1985).

***Aganippe* `MYG260`**

The idiopid genus *Aganippe* is common throughout Western Australia. Fourteen species are described from Australia and many new species await description (Main 1985). A single male *Aganippe* was collected (Appendix 1). This was the first time this species has been observed and may be a SRE.

Family Nemesiidae

Members of the mygalomorph spider family Nemesiidae are represented in WA by several genera, including *Aname*, *Chenistonia*, *Yilgarnia*, *Stanwellia*, *Teyl*, *Kwonkan* and *Swolnpes* (Main and Framenau 2009). They usually dig burrows in the soil, and do not cover their burrow entrances with lids.

***Aname* `sp. indet. (female)` and `sp. indet. (juv.)`**

Aname are one of the most commonly collected mygalomorph spiders in the Pilbara. A single female and four juvenile *Aname* were collected which could not be identified to species. It is not possible to determine if this species is a SRE.

***Aname* `MYG258`**

This group of specimens were morphologically unique and have not been previously reported. Since these specimens represent the first record of this morphospecies and little is known about it distribution, it is possible that this species could represent a short-ranged endemic.

***Kwonkan* `MYG257`**

This group of specimens were morphologically unique and have not been previously reported. Since these specimens represent the first record of this morphospecies and little is known about it distribution, it is possible that this species could represent a short-ranged endemic.

Family Theraphosidae

***Selenotholus* sp. indet.**

The genus *Selenotholus* is distributed throughout Australia and contains several species. *Selenotholus* species are widely distributed and not considered SREs. Seven specimens were collected during this survey and included one female and six juveniles, but were not identifiable to species.

ORDER PSEUDOSCORPIONES

The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families. 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 habitats. The material from this survey included 84 individual from the families Atemnidae, Chernetidae and Olpiidae (Appendix 1).

Family Atemnidae

***Oratemnus* sp. (family Atemnidae)**

Two males, one female, and three juvenile specimens of *Oratemnus* were collected during this survey (Appendix 1). There were some obvious morphological differences between the specimens collected which might indicate the presence of more than one species. Atemnids are frequently found under bark of trees in Western Australia, but the systematics of the group, particularly of the genus *Oratemnus*, is uncertain and the taxonomy of most individual species unclear. However, based upon current evidence, it seems that most species will eventually be found to be widely distributed. For this reason, we do not believe that these specimens represent short-range endemic species.

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).

***Haplochernes* sp. (family Chernetidae)**

The genus *Haplochernes* is found throughout many different regions of Australasia (Harvey 2011) and species of this genus are unlikely to be SREs. Two males, three females and a juvenile of *Haplochernes* were collected during this survey (Appendix 1), probably from a single species.

Family Olpiidae

***Austrohorus* sp. (family Olpiidae)**

Two female specimens of *Austrohorus* sp. was collected during this survey (Appendix 1). Based on our current levels of knowledge, it is not possible to state whether this species is a short-range endemic.

***Beierolpium* `sp. 8/4` (family Olpiidae)**

Fifteen males, 14 females and 15 juveniles of *Beierolpium* `sp. 8/4` were collected during the survey (Appendix 1). Some of the specimens were in a much smaller size cohort and may represent a different species to the other Beierolpium `sp. 8/4` specimens. At present it is not possible to firmly establish the identity of these species. The "8/4" representation refers to the number of trichobothria (sensory hairs) on the fixed and movable chelal fingers in the adults, which is a characteristic that could coincide with species distinction. It is possible that these specimens represent short-range endemic species, but a full taxonomic revision of the genus *Beierolpium* in Western Australia is necessary to confirm the specimens' identity and SRE status.

***Indolpium* spp. (family Olpiidae)**

A total of 33 specimens of *Indolpium* were collected during the survey (Appendix 1) with the possibility of multiple species, but difficult to definitively determine based on the knowledge at hand. Similar specimens have been collected from other regions of Western Australia and until we gather more data on these morphogroups we have not yet assigned them species codes. Based on our current levels of knowledge however, it is unlikely that these specimens represent short-range endemic species.

***Xenolpium* `sp. PSE070` (family Olpiidae)**

A single male and a single female of *Xenolpium* were sampled in this survey and given the new WAM species code: *Xenolpium* `PSE070` (Appendix 1). Species of this genus need more taxonomic investigation to determine their short-range endemism status but there is a possibility that this is a SRE.

DIPLOPODA

ORDER POLYDESMIDA (FLAT BACKED MILLIPEDES)

Family Paradoxosomatidae

`DIPAAB` `DIP043`

An undescribed new genus of paradoxosomatid millipede was recently identified from the Pilbara region and tagged `DIPAAB`. The species was tagged `DIP022`. The genus is quite distinct from *Antichiropus*, which is the dominant genus in Western Australia. The specimens collected during this survey at Browns Range represent the second species that has been collected from this genus and has been tagged `DIP043`. Individuals are relatively small (<10 mm when adult) and nothing at all is known about the genus nor the overall distribution of either species in this new genus. Since these are the only records of this species, it is possible that `DIPAAB` `DIP043` could represent a SRE species.

***Helicopodosoma* `DIP044`**

There are three described species in the genus *Helicopodosoma* (Polydesmida: Paradoxosomatidae) two of which have been found in the Kimberley region. A single male specimen of a new species, tagged *H*. `argyle`or *H*. `DIP044` was found at Browns Range. Since these are the only records of this species, it is possible that *H*. `DIP044` could represent a SRE species.

ORDER POLYXENIDA

Family Polyxenidae

***Unixenus mjoebergi* (Verhoeff, 1924) (family Polyxenidae)**

Two specimens from the species *Unixenus mjoebergi* were collected during this survey. In a recent publication by Short and Huynh (2011), this species is recognised as occurring throughout Western Australia including the Pilbara and Kimberley and is not a SRE.

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Appendix 1. Specimen data for arachnids and myriapods collected from Browns Ranges

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	AUTHORITY	LATITUDE	LONGITUDE	M	F	Juv.	TOTAL
123117	Site 12-39	Diplopoda	Polydesmida	Paradoxosomatidae	\`DIPAAB\`	\`DIP043\`		18°58\`5.9"S	128°55\`21.5"E	1		1	2
123118	Site 7-109	Diplopoda	Polydesmida	Paradoxosomatidae	\`DIPAAB\`	\`DIP043\`		18°53\`19.8"S	128°56\`13.8"E	1		3	4
123119	Site 9-50	Diplopoda	Polydesmida	Paradoxosomatidae	\`DIPAAB\`	\`sp.\`		18°54\`4.3"S	128°55\`31.7"E			2	2
123120	Site 11-53	Diplopoda	Polyxenida	Polyxenidae	*Unixenus*	*mjoebergi*	(Verhoeff, 1924)	18°56\`30.8"S	128°56\`33.8"E				1
123121	Site 2-61	Diplopoda	Polydesmida	Paradoxosomatidae	\`DIPAAB\`	\`sp.\`		18°51\`14.5"S	128°56\`29"E			1	1
123122	Site 13-69	Diplopoda	Polydesmida	Paradoxosomatidae	\`DIPAAB\`	\`DIP043.\`		18°58\`18.6"S	128°56\`15.2"E	1		1	2
123123	Site 12-73	Diplopoda	Polydesmida	Paradoxosomatidae	\`DIPAAB\`	\`sp.\`		18°58\`5.9"S	128°55\`21.5"E			1	1
123124	Site 2-88	Diplopoda	Polydesmida	Paradoxosomatidae	\`DIPAAB\`	\`DIP043.\`		18°51\`14.5"S	128°56\`29"E	1		1	2
123125	Site 1-100	Diplopoda	Polyxenida	Polyxenidae	*Unixenus*	*mjoebergi*	(Verhoeff, 1924)	18°50\`26.4"S	128°57\`24.5"E				1
123126	Site 6-111	Diplopoda	Polydesmida	Paradoxosomatidae	\`DIPAAB\`	\`DIP043.\`		18°52\`5.3"S	128°56\`30.1"E	1			1
123127	Site 7-114	Diplopoda	Polydesmida	Paradoxosomatidae	\`DIPAAB\`	\`DIP043.\`		18°53\`19.8"S	128°56\`13.8"E	4			4
123128	Site 6-127	Diplopoda	Polydesmida	Paradoxosomatidae	\`DIPAAB\`	\`DIP043.\`		18°52\`5.3"S	128°56\`30.1"E		1		1
123129	Site 9-3	Arachnida	Aranae	Theraphosidae	*Selenotholus*	\`sp. indet. (juv.)\`		18°54\`4.3"S	128°55\`31.7"E			1	1
123130	Target 1-1	Arachnida	Aranae	Nemesiidae	*Aname*	\`sp. indet. (juv.)\`		18°54\`12.6"S	128°55\`20.9"E			1	1
123131	Site 2-7	Arachnida	Aranae	Theraphosidae	*Selenotholus*	\`sp. indet. (juv.)\`		18°51\`14.5"S	128°56\`29"E			1	1
123132	Site 2-8	Arachnida	Aranae	Theraphosidae	*Selenotholus*	\`sp. indet. (juv.)\`		18°51\`14.5"S	128°56\`29"E			1	1
123133	Target 2-16	Arachnida	Aranae	Theraphosidae	*Selenotholus*	\`sp. indet. (female)\`		18°51\`57.8"S	128°56\`29.3"E		1		1
123134	Site 12-17	Arachnida	Aranae	Theraphosidae	*Selenotholus*	\`sp. indet. (juv.)\`		18°58\`5.9"S	128°55\`21.5"E			1	1
123135	Site 12-24	Arachnida	Aranae	Theraphosidae	*Selenotholus*	\`sp. indet. (juv.)\`		18°58\`5.9"S	128°55\`21.5"E			1	1
123136	Site 12-23	Arachnida	Aranae	Barychelidae	*Aurecocrypta*	\`sp. indet. (juv.)\`		18°58\`5.9"S	128°55\`21.5"E			1	1
123137	Site 11-22	Arachnida	Aranae	Theraphosidae	*Selenotholus*	\`sp. indet. (juv.)\`		18°56\`30.8"S	128°56\`33.8"E			1	1
123138	Site 13-106	Arachnida	Aranae	Nemesiidae	*Aname*	\`sp. indet. (juv.)\`		18°58\`18.6"S	128°56\`15.2"E			1	1
123139	Site 12-36	Arachnida	Aranae	Barychelidae	*Synothele*	*karara*	Raven, 1994	18°58\`5.9"S	128°55\`21.5"E	1			1
123140	Site 8-43	Arachnida	Aranae	Nemesiidae	*Aname*	\`sp. indet. (juv.)\`		18°53\`47.9"S	128°55\`57.2"E				1

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	AUTHORITY	LATITUDE	LONGITUDE	M	F	Juv.	TOTAL
123141	Site 12-58	Arachnida	Aranae	Barychelidae	*Idiommata*	\`MYG259\`		18°58\`5.9"S	128°55\`21.5"E	1			1
123142	Site 12-57	Arachnida	Aranae	Nemesiidae	*Kwonkan*	\`MYG257\`		18°58\`5.9"S	128°55\`21.5"E	1			1
123143	Site 10-65	Arachnida	Aranae	Nemesiidae	*Kwonkan*	\`MYG257\`		18°54\`36.1"S	128°55\`24.8"E	2			2
123144	Site 12-74	Arachnida	Aranae	Nemesiidae	*Aname*	\`sp. indet. (female)\`		18°58\`5.9"S	128°55\`21.5"E		1		1
123145	Site 3-78	Arachnida	Aranae	Nemesiidae	*Kwonkan*	\`MYG257\`		18°51\`37.5"S	128°56\`17.4"E	1			1
123146	Site 11-86	Arachnida	Aranae	Nemesiidae	*Aname*	\`sp. indet. (juv.)\`		18°56\`30.8"S	128°56\`33.8"E			1	1
123147	Site 8-94	Arachnida	Aranae	Nemesiidae	*Kwonkan*	\`MYG257\`		18°53\`47.9"S	128°55\`57.2"E	1			1
123148	Site 5-116	Arachnida	Aranae	Idiopidae	*Aganippe*	\`MYG260\`		18°51\`36.8"S	128°56\`47.6"E	1			1
123149	Site 5-118	Arachnida	Aranae	Nemesiidae	*Aname*	\`MYG258\`		18°51\`36.8"S	128°56\`47.6"E	2			2
123150	Site 4-119	Arachnida	Aranae	Nemesiidae	*Aname*	\`MYG258\`		18°51\`33.8"S	128°56\`34.2"E	1			1
123151	Site 4-120	Arachnida	Aranae	Nemesiidae	*Aname*	\`MYG258\`		18°51\`33.8"S	128°56\`34.2"E	1			1
123152	Site 4-13	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. indet. (juv.)\`		18°51\`33.8"S	128°56\`34.2"E			1	1
123153	Site 4-14	Arachnida	Pseudoscorpiones	Chernetidae	*Haplochernes*			18°51\`33.8"S	128°56\`34.2"E	2	1	5	8
123154	Site 5-20	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. 8/4\`		18°51\`36.8"S	128°56\`47.6"E	1			1
123155	Site 13-9	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°58\`18.6"S	128°56\`15.2"E		1		1
123156	Site 13-29	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. indet. (juv.)\`		18°58\`18.6"S	128°56\`15.2"E			4	4
123157	Site 2-30	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. indet. (juv.)\`		18°51\`14.5"S	128°56\`29"E			1	1
123158	Site 12-31	Arachnida	Pseudoscorpiones	Atemnidae	*Oratemnus*	\`sp. indet. (juv.)\`		18°58\`5.9"S	128°55\`21.5"E			1	1
123159	Site 1-32	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. indet. (juv.)\`		18°50\`26.4"S	128°57\`24.5"E			1	1
123160	Site 3-28	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. indet. (juv.)\`		18°51\`37.5"S	128°56\`17.4"E			1	1
123161	Site 12-38	Arachnida	Pseudoscorpiones	Olpiidae	*Austrohorus*			18°58\`5.9"S	128°55\`21.5"E		2		2
123162	Site 7-107	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. 8/4\`		18°53\`19.8"S	128°56\`13.8"E	1			1
123163	Site 9-42	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°54\`4.3"S	128°55\`31.7"E	1		1	2
123164	Site 8-46	Arachnida	Pseudoscorpiones	Olpiidae	*Xenolpium*	\`PSE070\`		18°53\`47.9"S	128°55\`57.2"E	1			1
123165	Site 2-48	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°51\`14.5"S	128°56\`29"E	1			1
123166	Site 9-51	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°54\`4.3"S	128°55\`31.7"E	3	1	1	5
123167	Site 11-55	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°56\`30.8"S	128°56\`33.8"E	3		1	4

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	AUTHORITY	LATITUDE	LONGITUDE	M	F	Juv.	TOTAL
123168	Site 13-63	Arachnida	Pseudoscorpiones	Olpiidae	*Xenolpium*	\`PSE070\`		18°58\`18.6"S	128°56\`15.2"E		1		1
123169	Site 10-66	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. 8/4\`		18°54\`36.1"S	128°55\`24.8"E	1			1
123170	Site 10-67	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°54\`36.1"S	128°55\`24.8"E	1			1
123171	Site 9-82	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°54\`4.3"S	128°55\`31.7"E	4		1	5
123172	Site 11-84	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. 8/4\`		18°56\`30.8"S	128°56\`33.8"E	3	5	2	10
123173	Site 10-90	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°54\`36.1"S	128°55\`24.8"E	1			1
123174	Site 8-95	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°53\`47.9"S	128°55\`57.2"E	1			1
123175	Site 1-99	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. 8/4\`		18°50\`26.4"S	128°57\`24.5"E		1		1
123176	Site 4-103	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. indet. (juv.)\`		18°51\`33.8"S	128°56\`34.2"E			1	1
123177	Site 6-110	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. indet. (juv.)\`		18°52\`5.3"S	128°56\`30.1"E			1	1
123178	Site 7-115	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°53\`19.8"S	128°56\`13.8"E	1			1
123179	Site 6-104	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. 8/4\`		18°52\`5.3"S	128°56\`30.1"E	3			3
123180	Site 1-122	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. 8/4\`		18°50\`26.4"S	128°57\`24.5"E	1			1
123181	Site 6-124	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°52\`5.3"S	128°56\`30.1"E		1		1
123182	Site 1-130	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. 8/4\`		18°50\`26.4"S	128°57\`24.5"E	1			1
123183	Site 7-132	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°53\`19.8"S	128°56\`13.8"E	2			2
123209	Site 9-40	Arachnida	Aranae	Selenopidae	*Karaops*	\`sp. Browns Range\`		18°54\`4.3"S	128°55\`31.7"E	1		1	2
123210	Site 10-97	Arachnida	Aranae	Selenopidae	*Karaops*	\`sp. Browns Range\`		18°54\`36.1"S	128°55\`24.8"E	1			1
123211	Site 6-126	Arachnida	Aranae	Selenopidae	*Karaops*	\`sp. indet. (juv.)\`		18°52\`5.3"S	128°56\`30.1"E			1	1
125976	Site 7-109	Diplopoda	Polydesmida	Paradoxosomatidae	*Helicopodosoma*	\`DIP044\`		18°53\`19.8"S	128°56\`13.8"E	1			1
126367	Site 4-13	Arachnida	Pseudoscorpiones	Chernetidae	*Haplochernes*			18°51\`33.8"S	128°56\`34.2"E		2	1	3
126368	Site 5-20	Arachnida	Pseudoscorpiones	Atemnidae	*Oratemnus*			18°51\`36.8"S	128°56\`47.6"E	2	1	2	5
126369	Site 13-9	Arachnida	Pseudoscorpiones	Chernetidae	*Haplochernes*	\`sp. indet. (juv.)\`		18°58\`18.6"S	128°56\`15.2"E			2	2
126370	Site 12-38	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	\`sp. 8/4\`		18°58\`5.9"S	128°55\`21.5"E	2			2
126371	Site 12-38	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°58\`5.9"S	128°55\`21.5"E	1			1

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	AUTHORITY	LATITUDE	LONGITUDE	M	F	Juv.	TOTAL
126372	Site 8-46	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°53`47.9"S	128°55`57.2"E	1			1
126373	Site 13-63	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/4`		18°58`18.6"S	128°56`15.2"E	2	8	3	16
126374	Site 13-63	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°58`18.6"S	128°56`15.2"E	1	1		2
126375	Site 1-99	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°50`26.4"S	128°57`24.5"E	1			1
126376	Site 4-103	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*			18°51`33.8"S	128°56`34.2"E	1	1	1	3

APPENDIX D

Browns Range Genetic Comparison Of Aname Specimens

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Outback Ecology DNA Bar-coding Project

M. A. Castalanelli & M. S. Harvey

Summary

Specimens T123130 and T123150 were all genetically different (85.8% pairwise similarity), which suggests that they represent two species. Furthermore, no match was returned when these two specimens were BLAST against the Western Australian Museum's Mygalomorphae DNA reference database.

Brief

Sequence eight Mygalomorphae specimens provided by Outback Ecology with the aim to compare the five unknown *Aname* to the morphological reference *Aname* `MYG258` and BLAST the sequences against the Western Australian Museum's Mygalomorphae DNA reference database.

Deliverables

- BLAST results (Table 3).

Method

Amplification of the bar-coding fragment was performed using primers outlined in Table 1.

Table 1. Primers used to amplify the DNA bar-coding fragment.

Primer	Sequence `5-3`	Reference	Primer Pair
LCO1490	GGTCAACAAATCATAAAGATATTGG	(Folmer et al., 1994)	1 & 2
HCO2198	TAAACTTCAGGGTGACCAAAAAATCA	(Folmer et al., 1994)	1
C1-N-2191	CCCGGTAAAATTAAAATATAAACTTC	(Simon et al., 1994)	2
C1-J-1718F-mygal	GGAGGATTTGGAAATTGATTAGTTCC	Modified (Simon et al., 1994)	3
C1-N-2191	CCCGGTAAAATTAAAATATAAACTTC	(Folmer et al., 1994)	3

The sequences were edited using Geneious Pro 5.5.6 (Biomatters Ltd) and aligned with the reference dataset using Geneious' building in alignment algorithm. Geneious Pro 5.5.6 was used to detect the presence of NuMTs by translating each *COI* sequence with the standard invertebrate and *Drosophila* codes. The successfully amplified sequences were BLAST against the Western Australian Museum's mygalomorphae sequence database.

Table 2. Samples provided by Outback Ecology including sequencing status.

REGNO	FAMILY	GENUS	SPECIES	SITE	LATITUDE	LONGITUDE	COllMETH	PRIMER PAIRS		
								1	2	3
T123130	Nemesiidae	Aname	\`sp juv\`	Browns Range, c. 280 km S. Lake Argyle	18°54\`12.6"S	128°55\`20.9"E	active search	Fail	Fail	Pass
T123138	Nemesiidae	Aname	\`sp juv\`	Browns Range, c. 280 km S. Lake Argyle	18°58\`18.6"S	128°56\`15.2"E	wet pitfall	Fail	Fail	Fail
T123140	Nemesiidae	Aname	\`sp juv\`	Browns Range, c. 280 km S. Lake Argyle	18°53\`47.9"S	128°55\`57.2"E	wet pitfall	Fail	Fail	Fail
T123144	Nemesiidae	Aname	\`sp female\`	Browns Range, c. 280 km S. Lake Argyle	18°58\`5.9"S	128°55\`21.5"E	wet pitfall	Fail	Fail	Fail
T123146	Nemesiidae	Aname	\`sp juv\`	Browns Range, c. 280 km S. Lake Argyle	18°56\`30.8"S	128°56\`33.8"E	wet pitfall	Fail	Fail	Fail
T123149	Nemesiidae	Aname	\`MYG258\`	Browns Range, c. 280 km S. Lake Argyle	18°51\`36.8"S	128°56\`47.6"E	wet pitfall	Fail	Fail	Fail
T123150	Nemesiidae	Aname	\`MYG258\`	Browns Range, c. 280 km S. Lake Argyle	18°51\`33.8"S	128°56\`34.2"E	wet pitfall	Fail	Fail	Fail
T123151	Nemesiidae	Aname	\`MYG258\`	Browns Range, c. 280 km S. Lake Argyle	18°51\`33.8"S	128°56\`34.2"E	wet pitfall	Fail	Fail	Pass

Results

BLAST Results

Table 3. Unknown specimens that were provided by Outback Ecology and BLAST against the Western Australian Museum's mygalomorphae sequence database.

Unknowns				Blast Results				
REGNO	FAMILY	GENUS	SPECIES	REGNO	Identity	Morphologically Determined By	Similarity (%)	Outcome
T123130	Nemesiidae	Aname	\`sp juv\`	T105892	T105892_Aname_\`MYG001\`	V.W.Framenau	86.4	No Match
T123150	Nemesiidae	Aname	\`MYG258\`	T82311	T82311_Aname		89	No Match

- Specimens T123130 and T123150 were all genetically different (85.8% pairwise similarity), which suggests that there are two distinct species
- The closest match to T123130 was T105892 which was morphologically identified as *Aname* \`MYG001\` by V.W.Framenau, but with only an 86.4% pairwise similarity it is highly unlikely that these are same species.
- The closest match to T123150 was T82311 which was morphologically identified as *Aname*, but with only an 89% pairwise similarity it is highly unlikely that these are same species.

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Appendix I

```
>T123130
ATTAGTTCCTTTGATATTAGGGGCTCCTGATATAGCTTTTCCTCGAATAAA
TAACTTGAGATTTTGACTTTTACCTCCCTCGTTATTATTATTAATTTTATCT
TCTTTGACGGATGTAGGGGTTGGAGCTGGATGGACAATTTATCCTCCTTTA
TCTTCTGTTATTGGGCATGGGGGGGGTGGTATAGATTTTGCTATTTTTTCTT
TACATTTAGCGGGGGCATCTTCGATTATAGGGGCTATTAATTTTATTTCTA
CTATTGTAAATATACGTTCAGTAGGTATAACTATAGAGCGAGTCCCTTTAT
TTGTTTGGTCAGTATTAATTACGGCTATTTTGTTATTGTTGTCTCTTCCTGT
TCTAGCAGGGGCTATTACTATATTATTAACAGATCGTAATTTTAATACTTC
TTTTTTTGATCCTGCGGGAGGGGGAGATCCTATTTTGTTTCAACATTTGTTT
TGATTTTTTGGTCACCCTGAAGTTTATATTTTA
>T123151
------------------------------------------------------------
TTTTGATTATTACCTCCTTCTTTATTATTGTTAATTTTGTCTTCACTTACTGA
TGTTGGGGTGGGGGCAGGATGAACAATTTATCCCCCTTTATCTTCATTTAT
TGGGCATGGAGGGGGGGGGATAGATTTTGCGATTTTTTCTTTACATTTAGC
TGGTGCATCTTCTATTATAGGAGCAATTAATTTTATTTCGACAATTTTAAA
TATGCGTTCAGTGGGGATAACGATGGAACGGGTTCCATTATTTGTTTGATC
AGTATTAATTACGGCTATTCTTTTGTTATTGTCTCTTCCTGTGTTGGCGGGG
GCTATTACTATATTATTGACTGATCGTAATTTTAATACTTCATTTTTTGACC
CTGC---------------------------------------------------------------------
```

APPENDIX E

Browns Range Scorpion Identification Report

ScorpionID

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Browns Range Scorpion Identification Report

Report ID: OE.BR.2012.06
Prepared for: Outback Ecology
By Dr Erich S. Volschenk
Saturday, 23 June 2012

Outback Ecology is undertaking a short-range endemic survey at Browns Range, and has requested:
- Taxonomic identifications of scorpion from the survey and SRE assessment of the species represented in the collection.

The collection is comprised of 26 samples.

FAMILY: Buthidae CL Koch, 1837

The family Buthidae is the most diverse and wide spread of all scorpion families (Fet & Lowe 2000). In Australia, Buthidae is represented by the genera *Australobuthus* Locket; *Isometrus* Ehrenberg; *Isometroides* Keyserling , *Lychas* C.L. Koch, and *Hemilychas* Hirst. In Western Australia, only the genera *Isometrus*, *Isometroides* and *Lychas*, 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* (Volschenk unpublished data). Most Authors refer to LE Koch (1977) for keys and identification. That 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 that publication is not up to date. Most Australian buthid species appear to have wide distributions; however, a few taxa have confirmed SRE distributions (Volschenk unpublished data).

GENUS: *Isometroides* Keyserling, 1885

The taxonomy of the species in this genus is extremely poorly known. Only two species are presently recognised, *Isometroides vescus* Karsch (1880) and *Isometroides angusticaudus* Keyserling (1885); however, many undescribed species are known. *Isometroides* are ground dwelling scorpions and are the only scorpion species known to be a predatory specialist. Main (1956) described the association of this species with burrowing spiders and numerous records have followed of this species preying on, and being found in trapdoor spider (Mygalorphae and Lycosidae) burrows (Volschenk Pers. Obs.). Species in this genus never appear to be particularly abundant in pitfall trapping samples; the ground disturbance surrounding the pitfall trap may deter them. While their taxonomy is poorly resolved, most morphospecies appear to have fairly wide distributions; however this may change with further work on their systematics.

Species: *Isometroides* 'kimb1' Morphospecies

SRE STATUS
Isometroides 'kimb1' is a potential SRE.

TAXONOMIC RESOLUTION
Isometroides 'kimb1' is morphologically distinct from other morphospecies of *Isometroides*.

DISTRIBUTION
Isometroides 'kimb1' is only known from the specimen presented in this collection. Most *Isometroides* morphospecies are not SRE's, however in the absence of data to the contrary, this species is considered a potential SRE.

RECOMENDATIONS
If this specimen was collected from within a proposed impact area, then efforts should be made to demonstrate the presence of one or more populations of this species outside of the impact area.

WAM Rego.	Client Rego.	♂	♀	Juv.	Location	Notes
123194	Site 11-54			1	Browns Range, c. 280 km S. Lake Argyle	WAMTS046

Number of samples: 1

==

GENUS: *Lychas* CL Koch, 1845

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 & Lowe 2000). All of the Australian species are endemic and are currently under revision by ES Volschenk. Most species of *Lychas* appear to have wide distributions; however, a small number of undescribed species are known to be SRE's.

Species: *Lychas* 'adonis' Morphospecies

SRE STATUS
Lychas 'adonis' is not an SRE.

TAXONOMIC RESOLUTION
Lychas 'adonis' is a well-defined and clearly recognised morphospecies.

DISTRIBUTION
Lychas 'adonis' has wide distribution across arid Australia. Its distribution is Eyrean, where it inhabits various habitats including sparse Mallee forests on sand to Spinifex covered dunes. This species has been recorded from Victoria, South Australia and Western Australia. This species appears to prefer sandy spinifex dominated habitats.

RECOMENDATIONS
Lychas 'adonis' is not an SRE and no management is recommended.

WAM Rego.	Client Rego.	♂	♀	Juv.	Location	Notes
123191	Site 12-37			1	Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123192	Site 8-44			1	Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123202	Site 3-77		1		Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123199	Site 13-70	1		2		WAMTS046

Number of samples: 4

==

Species: *Lychas* 'annulatus 2' Morphospecies

SRE STATUS
Lychas 'annulatus 2' is a potential SRE.

TAXONOMIC RESOLUTION
Lychas 'annulatus 2' is closely related to *Lychas* ‘annulatus’ and is part of the *L.* ‘annulatus’ complex. It differs from other morphospecies within the annulatus complex, but the morphometrics of the pedipalps chela.

DISTRIBUTION
Lychas 'annulatus 2' is only known from the specimen presented in this collection. Most species from the annulatus complex do not appear to be SRE’s; however in the absence of data to the contrary, this species is considered a potential SRE.

RECOMENDATIONS
If this specimen was collected from within a proposed impact area, then efforts should be made to demonstrate the presence of one or more populations of this species outside of the impact area.

WAM Rego.	Client Rego.	♂	♀	Juv.	Location	Notes
123205	Site 2-87	1			Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123193	Site 2-47			1	Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123199	Site 13-70		1	1	Browns Range, c. 280 km S. Lake Argyle	WAMTS046

Number of samples: 3

==

Species: *Lychas* bituberculatus Pocock, 1891

SRE STATUS
Lychas bituberculatus is not an SRE.

TAXONOMIC RESOLUTION
Lychas bituberculatus is a well-defined and clearly recognised species.

DISTRIBUTION
Lychas bituberculatus has been recorded widely throughout the Midwest, Pilbara and Kimberley regions of Western Australia.

RECOMENDATIONS
Lychas bituberculatus is not an SRE and no management is recommended.

WAM Rego.	Client Rego.	♂	♀	Juv.	Location	Notes
123197	Site 13-62	1		3	Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123207	Site 10-96			1	Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123198	Site 10-68			1	Browns Range, c. 280 km S. Lake Argyle	WAMTS046

Number of samples: 3

==

Species: *Lychas* 'multipunctatus' Morphospecies

SRE STATUS
Lychas 'multipunctatus' is not an SRE.

TAXONOMIC RESOLUTION
Lychas 'multipunctatus' is a well-defined and clearly recognised morphospecies.

DISTRIBUTION
Lychas 'multipunctatus' has been recorded widely throughout the Pilbara region of Western Australia, where it is one of the most common scorpion species.

RECOMENDATIONS
Lychas 'multipunctatus' is not an SRE and no management is recommended.

WAM Rego.	Client Rego.	♂	♀	Juv.	Location	Notes
123195	Site 12-60			1	Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123201	Site 12-75	1			Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123204	Site 11-83	1			Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123208	Site 1-129	1			Browns Range, c. 280 km S. Lake Argyle	WAMTS046

Number of samples: 4

==

FAMILY: Urodacidae Pocock, 1893{, #11964}

The family Urodacidae is endemic to Australia (Fet 2000; Prendini 2000; Prendini 2003; Volschenk *et al.* 2000) where it is represented by the genera *Urodacus* Peters, 1861 and *Aops* Volschenk and Prendini, 2008.

GENUS: *Urodacus* Peters, 1861

Urodacus has been considered a member of the family Scorpionoidea for many years, but in a revision of the superfamily Scorpionoidea Latreille, Prendini (2000) placed *Urodacus* in its own family. Unlike the species designations for Buthidae, LE Koch's (1977) species' of *Urodacus* have been mostly supported by subsequent authors (Harvey & Volschenk 2002; Volschenk & Prendini 2008; Volschenk *et al.* 2000). The biggest issue confronting *Urodacus* taxonomy is the number of undescribed species being uncovered through current revisionary work (Volschenk unpublished data). Currently 22 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. During a large-scale survey of the Pilbara fauna, Volschenk, et. al. (Volschenk *et al.*) recorded nine undescribed species and only one formerly describes species were reported in that study.

Species: *Urodacus* 'kimb2' Morphospecies

SRE STATUS

Urodacus 'kimb2' is a potential SRE.

TAXONOMIC RESOLUTION

Urodacus 'kimb2' is unlike any other Urodacus species or morphospecies I have seen before. I believe this species to be new and undescribed.

DISTRIBUTION

Urodacus 'kimb2' is only known from the specimen presented in this collection, from a very small area. In the absence of data to the contrary, this species is considered a potential SRE.

RECOMENDATIONS

If this specimen was collected from within a proposed impact area, then efforts should be made to demonstrate the presence of one or more populations of this species outside of the impact area.

WAM Rego.	Client Rego.	♂	♀	Juv.	Location	Notes
123200	Site 12-72	1			Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123203	Site 11-80	1			Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123206	Site 8-93	1			Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123190	Site 12-34			1	Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123189	Site 12-33			1	Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123187	Site 12-18	1			Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123196	Site 12-56	1			Browns Range, c. 280 km S. Lake Argyle	WAMTS046

Number of samples: 7

==

Species: *Urodacus* 'yaschenkoi kimb1' Morphospecies

SRE STATUS
Urodacus 'yaschenkoi kimb1' is a potential SRE.

TAXONOMIC RESOLUTION
Urodacus 'yaschenkoi kimb1' is closely related to *Urodacus yaschenkoi* Birula. It differs from *U. yaschenkoi* by the morphometrics of the metasoma and the carapace granulation. The absence of adult males of this species from the collection also make identification difficult and more conclusive identification will require either DNA sequencing to be undertaken on the specimens collected or collection of an adult male from the area that these samples came from.

DISTRIBUTION
Urodacus 'yaschenkoi kimb1' is only known from the specimen presented in this collection, from a very small area. In the absence of data to the contrary, this species is considered a potential SRE.

RECOMENDATIONS
If these specimens were collected from within a proposed impact area, then efforts should be made to demonstrate the presence of one or more populations of this species outside of the impact area.

WAM Rego.	Client Rego.	♂	♀	Juv.	Location	Notes
123184	Site 8-2		1		Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123188	Site 12-21		1		Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123186	Site 10-6			1	Browns Range, c. 280 km S. Lake Argyle	WAMTS046
123185	Site 10-5			1	Browns Range, c. 280 km S. Lake Argyle	WAMTS046

Number of samples: 4

==

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APPENDIX F

Terrestrial Isopod Identification For Browns Range

Dr Simon Judd
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Outback Environment
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Attn: Arnold Slabber, Paul Bolton

25th September 2012

Terrestrial Isopod Identification For Browns Range.

Introduction

This report details the identification of specimens collected from Browns Range by Outback Ecology between January and March 2012. Four species were identified, none of these are known currently from any other locations and all should be considered potential SRE species. This is largely because the I have no material from anywhere close to this project area and the distribution of each of these species is unknown. Nothing is known about the terrestrial isopods of the Kimberley or the Great Sandy Desert.

Each of the 4 species collected was from a different genus and the assemblage was similar to those found in the Lake Maitland, Yakabindie and Wiluna area. It is not typical of those found in the Pilbara. All specimens included in the datasheet that accompanies this report have been examined. Any pertinent observations are given below. The species collected here are given species names reflecting the collection locality since this is the first record of them. This may be changed to numbers or to other names if the species are described at a later date.

Methods & material examined

A datasheet which includes taxonomic information for each of the vials accompanies this report. Each of the vials examined was given a unique reference. This is shown in the column "OLDNO" and will be superseded by a Museum registration number in due course. None of the species examined here has yet been formally described but I am in the process of revising the genus *Buddelundia* and descriptions of the *Buddelundia* species collected may be prepared and published in due course. Initially, all of the of the specimens in each vial were examined and the number of species found in the project was determined. The full range of morphological characters was examined for at least one male and one female specimen of all the species identified in this report. Dissections were made where necessary, but mouthparts which are of limited diagnostic use in the Armadillidae were not examined. There is significant sexual dimorphism in some *Buddelundia* and male specimens are required for an accurate determination. Male specimens were present here. Once a species had been established, adult specimens in the best condition were compared to specimens found elsewhere. Those specimens that were found to be the same species as those collected in this project (comparative material examined) are listed. No relevant, comparative material was available for this project. However, specimens of the *Buddelundia* species were compared to all similar species. This assists in determining the range of each species, thereby assessing whether it occurs outside of the survey area, and whether it should be considered an SRE species. Detailed methods and additional rationale are given for each species in the following sections where needed.

***Acanthodillo* sp. browns range**

Isopods of this type I currently allocate temporarily to the genus *Acanthodillo*. However, a review of the Australian Armadillidae is needed and these specimens almost certainly belong to another (or new) genus or possibly to the same as those considered *Cubaris* below. *Acanthodillo* is used only because it reflects the current state of taxonomy. This genus is the most widespread of the Armadillidae after *Buddelundia* and is found throughout Western Australia including the Pilbara. In this project a good number of males and females were collected from six sites. This species has quite prominent and distinctive dorsal ornamentation. I consider this to be a different species from those I have seen in northern WA but I have not carried a comprehensive comparative analysis of all available material because this is beyond the scope of this report. This genus has a number of SRE species and this should also be considered a potential SRE species. Significantly more work on the group of isopods and material surrounding region is needed to determine its distribution. Isopods of this genus are usually collected in the summer months in northern Western Australia.

***Buddelundia* sp.nov. 59**

This is a species of *Buddelundia* I have not seen before and consequently I have allocated it a species number. The morphology of this species is typical of the *Buddelundia* found in the arid zone. The species was the most common collected and was found at all sites except Sites 2 & 3. There are a number of SRE species of *Buddelundia* similar to this one and very few are widely distributed. This species should be considered a SRE species but it may possibly have a wider distribution. Further survey work over a wider area is be required to establish its distribution.

***Cubaris* sp. browns range.**

Isopods of this type I currently allocate temporarily to the genus *Cubaris*. However, a review of the Australian Armadillidae is needed and these specimens almost certainly belong to another (or new) genus. *Cubaris* is used only because it reflects the current state of taxonomy and I am using it until such time as a revision is possible. This is definitely a new species and I have not seen it before. This species was found only at Sites 9, 11 & 12. Isopods of this genus are more difficult to identify than *Buddelundia* and require more dissection and detailed investigation. Some of the adult specimens collected here are notably large and I can't remember seeing specimens of this genus as large as the largest collected here. Two species of this genus have been found in the Pilbara and its distribution in northern Australia is unknown. A different species has also been collected in the Wiluna area. This is highly likely to be a SRE species but further survey work over a wider area is be required.

***Spherillo* sp. browns range.**

Isopods of this type I currently allocate temporarily to the genus *Spherillo*. However, a review of the Australian Armadillidae is needed and these specimens almost certainly belong to another (or new) genus. *Spherillo* is used only because it reflects the current state of taxonomy and I am using it until such time as a revision is possible. This species was represented by a single female specimen collected at Site 13. I am not sure whether this specimen is an adult and I have done very little at work on this genus. Species of this type are more common in the south-west of Western Australia, and all are relatively small and look very similar. Not much can be determined from the single female specimen collected here and any distributional information is significantly beyond the scope of this report. However, this is a genus of small and cryptic isopods likely to be comprised of many SRE species. This species should be considered a SRE species. Comments made about the previous species apply to this species also. More material is also needed from the project area.

END OF REPORT

Yours sincerely,

Simon Judd.

APPENDIX G

Non-Marine Molluscs From Browns Range, Western Australia

Non-Marine Molluscs from Brown Range, Western Australia

Brief Report to *Outback Ecology*

11 May 2012

Corey S. Whisson

Department of Aquatic Zoology, Western Australian Museum,
Locked Bag 49, Welshpool DC, Western Australia 6986, Australia

Summary

The samples submitted to the Western Australian Museum on the 2nd May 2012, contained two species of non-marine molluscs belonging to the families Pupillidae ad Subulinidae (Appendix A). None of the species are considered short-range endemics.

Appendix A: Non-marine molluscs from the Brown Range

Site	Family	Genus	Species	Reg. No. (WAM S)	No. Specimens
11-27	Pupillidae	*Pupoides*	*pacificus*	83669	2 dead-taken
11-27	Subulinidae	*Eremopeas*	*interioris*	83770	1 live-taken
1-26	Pupillidae	*Eremopeas*	*interioris*	83771	3 dead-taken

APPENDIX B

Outback Ecology (2013) Browns Range Project: Targeted Mygalomorph Spider Survey Report

Northern Minerals Limited

Browns Range Project

Targeted Mygalomorph Spider Survey

October 2013

Outback Ecology (MWH Australia Pty Ltd)
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Browns Range Project: Targeted Mygalomorph Spider Survey

Distribution:

Company	Copies	Contact Name
Northern Minerals Ltd.	1 Electronic Copy	Robin Jones Lisa Chandler

Document Control for Job Number: BROW-IT-13001

Document Status	Author	Reviewer	Signature	Date of Issue
Draft Report V1	A. Slabber	P. Bolton	A.S., P.B.	01/10/13
Draft Report V2	A. Slabber	B. Parsons	A.S., P.B.	07/10/13
Final Report	A. Slabber	D. Jasper	A.S. D.J.	15/10/13

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Executive Summary

Northern Minerals Limited (Northern Minerals) commissioned Outback Ecology to conduct a targeted survey of mygalomorph spiders at the proposed Browns Range Project (the Project) and surrounds between October 2012 and April 2013. Previously, Outback Ecology collected two short-range endemic (SRE) mygalomorph spider species during the *Browns Range: Terrestrial Short-range Endemic Invertebrate Fauna Baseline Survey,* conducted in January 2012. *Aganippe* 'MYG260' and *Aname* 'MYG258' were collected from habitats of limited extent within close proximity to the Development Footprint. *Aganippe* 'MYG260' was collected from Internal Drainage habitat; and *Aname* 'MYG258' was collected from Seasonal Drainage Surface habitat and Internal Drainage habitat. Both of these habitat types were considered restricted within the Study Area and occurred within close proximity to the proposed Development Footprint. Further survey work was considered necessary to establish whether the distribution of *Aganippe* 'MYG260' and *Aname* 'MYG258' extended outside the baseline Study Area. To this end, Outback Ecology conducted a two phase targeted mygalomorph spider survey between 17 October 2012 and 11 April 2013 to better ascertain the distribution of these species.

The specific objectives of this targeted mygalomorph spider survey were to:

- collect mygalomorph spider specimens from within the 2012 baseline Study Area and surrounds;
- further define the habitat where *Aname* 'MYG258' and *Aganippe* 'MYG260' were collected and use detailed habitat assessments to evaluate the occurrence of this habitat in the surrounding landscape; and
- describe habitats of limited extent identified in the 2012 baseline survey and map their occurrence outside the Study Area.

The collection methods used in this survey have been endorsed by the WA Department of Environment Regulation (DER), and included wet pitfall trapping and targeted searching at six survey sites. These sites were up to two km beyond the 2012 survey area. In total, the survey comprised 2,520 trapping nights and 18 hours of targeted searching. An invertebrate fauna habitat assessment was conducted at each of the survey sites, which involved characterising habitat according to condition, complexity and suitability for invertebrate taxa prone to short-range endemism.

Internal Drainage and Seasonal Drainage Surface habitat were considered to be restricted habitat within the baseline Study Area. Approximately 6 hectares of Internal Drainage and 103 hectares of Seasonal Drainage Surface habitat was identified during the original baseline survey. As a result of the survey reported here, an Additional 76.6 ha of Seasonal Drainage Surface habitat was identified outside the baseline Study Area. No additional Internal Drainage habitat was identified during this survey.

This survey yielded a total of five mygalomorph spider specimens from four identifiable SRE species, comprising *Aganippe* 'MYG260', *Aname* 'MYG287', *Aname* 'MYG288' and *Kwonkan* 'MYG257'. Of

the two target species, *Aname* ‘MYG258’ and *Aganippe* ‘MYG260’, a single *Aganippe* ‘MYG260’ specimen was collected from Sand Plain habitat, which is considered to be widespread and continuous within the surrounding area. *Aganippe* ‘MYG260’ was previously recorded from Internal Drainage habitat and therefore, the species does not appear to be a habitat specialist. No *Aname* ‘MYG258’ specimens were collected during this survey.

Of the three additional SRE species collected during this survey, *Aname* ‘MYG287’ was collected from Sand Plain habitat, which is considered widespread and continuous in the surrounding region. A single *Aname* ‘MYG288’ specimen was collected from Internal Drainage habitat, which is of limited extent within the baseline Study Area and does not occur elsewhere within the vicinity of the Study Area. A single *Kwonkan ‘*MYG257’ specimen was recorded from Seasonal Drainage Surface habitat during this survey. *Kwonkan ‘*MYG257’ has previously been recorded at four locations within Sand Plain and Flood Plain habitat types.

Of the above species, *Aganippe* ‘MYG260’, *Kwonkan ‘*MYG257’ and *Aname* ‘MYG287’ occur from habitats that are considered widespread and continuous within the region and therefore, these species are likely to have distributions that are similarly widespread and continuous. Conversely, *Aname* ‘MYG288’ is currently known from a single specimen collected from Internal Drainage habitat. This habitat type is considered of limited extent within the baseline Study Area and has not been found in the surrounding area during this survey.

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1. INTRODUCTION

1.1. Project Location and Background

Northern Minerals Limited (Northern Minerals) commissioned Outback Ecology to conduct a targeted survey of mygalomorph spiders at the proposed Browns Range Project (the Project) and surrounds between October 2012 and April 2013. The Project is located approximately 150 kilometres (km) southeast of Halls Creek, in the Tanami bioregion of Western Australia (WA) (**Figure 1**).

During previous survey work prepared for Northern Minerals by Outback Ecology in 2012 - *Terrestrial Short-range Endemic Invertebrate Fauna Baseline Survey* - two SRE mygalomorph spider species, *Aganippe* 'MYG260' and *Aname* 'MYG258', were collected from restricted habitats (as defined in Outback Ecology 2013b) in close proximity to the Development Footprint (**Figure 2**). A single specimen of *Aganippe* 'MYG260' was collected from Internal Drainage habitat. Two specimens of *Aname* 'MYG258' were collected from Seasonal Drainage Surface habitat and two specimens collected from Internal Drainage habitat. Further work was considered necessary to:

1. establish whether the distribution of *Aganippe* 'MYG260' and *Aname* 'MYG258' extended outside the Development Footprint; and
2. establish the occurrence of Internal Drainage habitat and Seasonal Drainage Surface habitat outside the Study Area.

Consequently, Outback Ecology conducted a two phase targeted mygalomorph spider survey between 17 October 2012 and 11 April 2013.

Five mygalomorph spider specimens from the genus *Aname* were collected during the baseline survey but were unable to be identified to species level for the baseline report as they were either the incorrect age or sex for morphological identification (Outback Ecology 2013a). Molecular analysis was undertaken to clarify their taxonomy because there was the possibility that one or more of these specimens represented the species *Aname* 'MYG258' and presented the opportunity to extend the known distribution of the species. This report presents the results of this molecular analysis.

This report is to be read in conjunction with the Browns Range Project Terrestrial SRE Invertebrate Fauna Baseline Survey (Outback Ecology 2013a) and the Terrestrial Invertebrate Impact Assessment (Outback Ecology 2013b).

1.2. Assessment Scope and Objectives

The assessment comprised a targeted SRE invertebrate fauna survey that was conducted over two phases between 17 October 2012 and 11 April 2013. The specific objectives of this assessment were to:

- collect mygalomorph spider specimens from within the baseline Study Area and surrounds;
- further define the habitat where *Aname* 'MYG258' and *Aganippe* 'MYG260' were collected and use detailed habitat assessments to evaluate the occurrence of this habitat in the surrounding landscape; and

- identify, describe and map restricted habitats that occur outside the Study Area covered in the 2012 baseline survey (Outback Ecology 2013a)

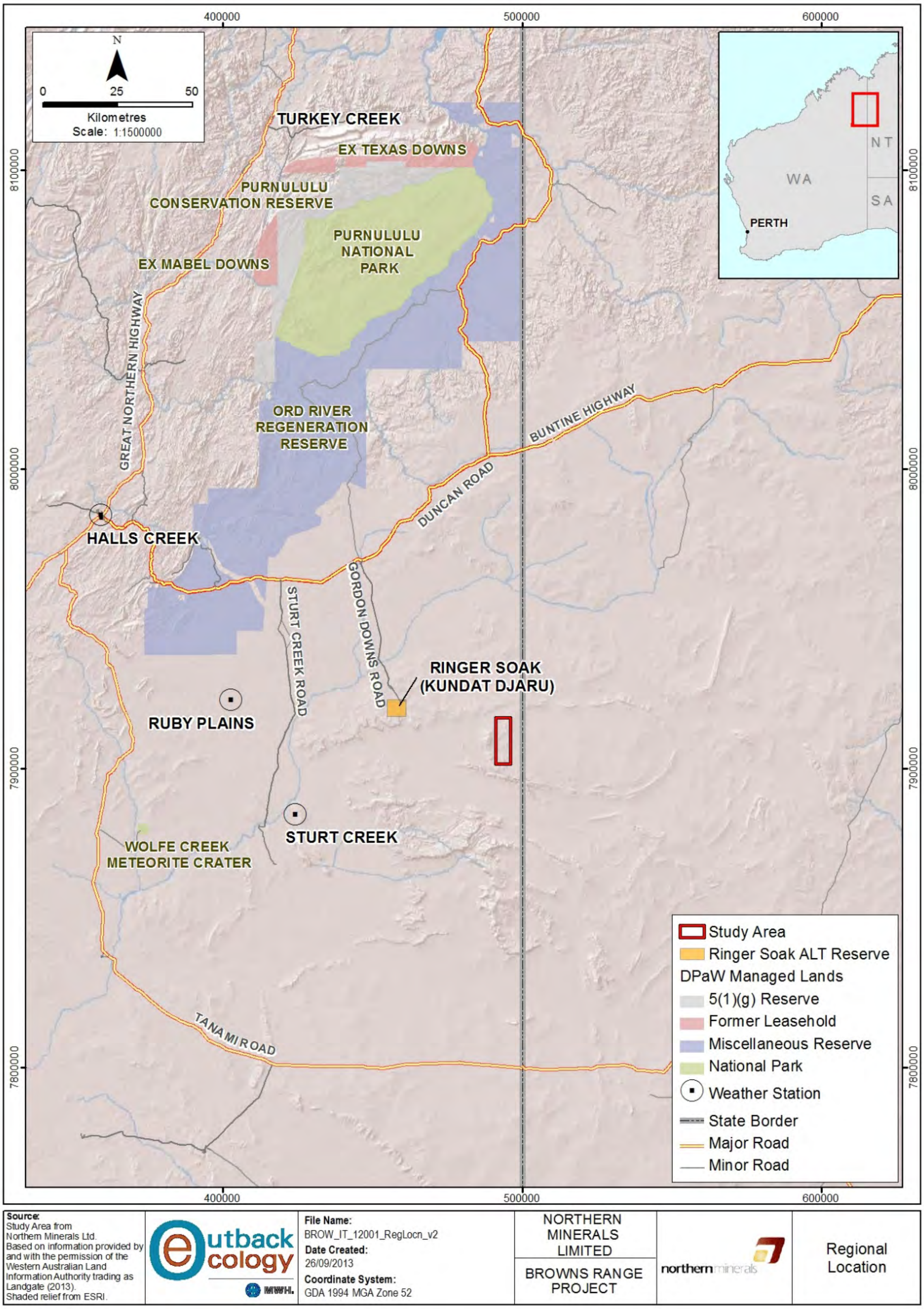


Figure 1: Regional location of the Project

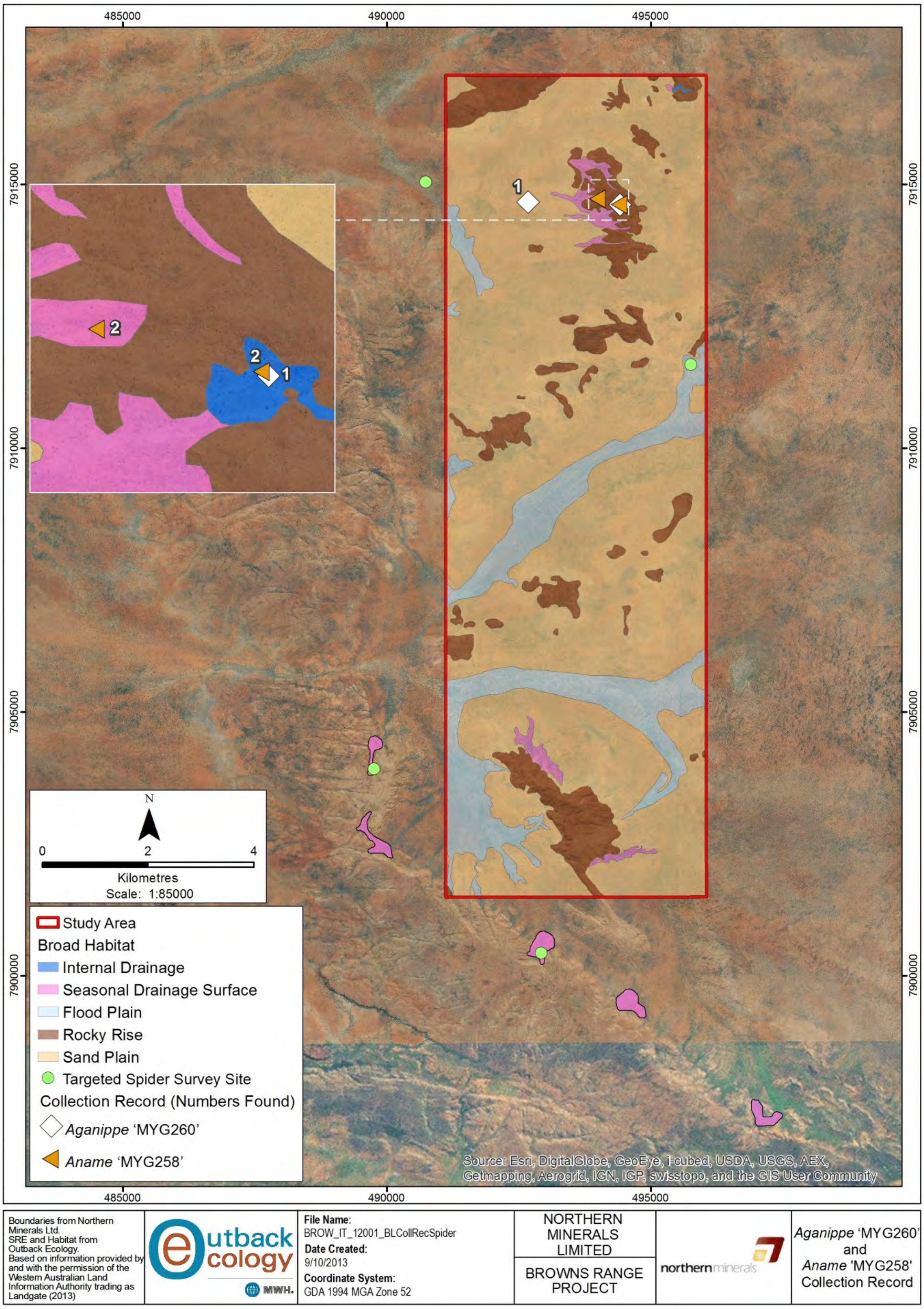


Figure 2: Location and number of previously recorded *Aganippe* 'MYG260' and *Aname* 'MYG258' specimens

This survey was designed and conducted in accordance with:

- Western Australia (WA) Environmental Protection Authority (EPA) Guidance No. 20, *Sampling of Short-range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (2009);
- EPA Guidance No. 56*, Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (2004); and
- EPA Position Statement No. 3*, Terrestrial Biological Surveys as an Element of Biodiversity Protection* (2003).

The field sampling methodology used during this survey has been previously endorsed by the DER.

1.3. Legislative Framework

Key legislation contributing to the protection of the biological diversity of native fauna in WA includes the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), Western Australian *Wildlife Conservation Act 1950* (WC Act), *Land Management Act 1984* and the *Environmental Protection Act 1986*. The Environmental Protection Authority (EPA) adopts the definition of biological diversity and the principles as defined in the National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth of Australia 1996). The EPA intends to ensure that, as far as possible, development proposals in WA are consistent with these principles, objectives and targets (Environmental Protection Authority 2004).

Additionally Section 4a of the *Environmental Protection Act 1986* states that developments in WA must take into consideration to the following principles:

- The precautionary principle – where there are threats of serious and irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- The principle of intergeneration 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; and
- The principle of the conservation of biological diversity and ecological integrity – conservation of biological diversity and ecological integrity should be a fundamental consideration.

Comprehensive systematic reviews of different faunal groups often reveal the presence of SRE species (Harvey 2002). These species generally exist in relictual habitats formed as a result of widespread aridification and forest contraction since the Miocene and Pleistocene, which has resulted in population fragmentation and the evolution of new species. Particular attention should be given to these types of species in environmental impact assessments (EIAs) because habitat loss and degradation will further decrease their prospects for long-term survival (EPA 2004).

Some better-known SRE species have been listed as threatened or endangered under State or Commonwealth legislation, but the majority have not (EPA 2009). Often the lack of knowledge about these species precludes their consideration for listing as threatened or endangered (EPA 2009). Listing under legislation should, therefore, not be the only conservation consideration in an EIA (EPA 2009). The EPA expects that an EIA will consider the potential impacts on the conservation status of SRE species (EPA 2004). The information provided in this document meets the standards, requirements and protocols as determined by the EPA.

2. MATERIALS AND METHODS

This survey was conducted in accordance with the EPA Guidance Statement No 20. *Sampling of Short-range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009) and after consultation with specialists from the DER and the Western Australian Museum (WAM). The recommendations and information given by the specialists was incorporated into the survey design.

2.1. Survey Timing

The survey was conducted over two trapping phases: Phase One - 18 January to 20 February 2013; and Phase Two - 21 February 2013 to 11 April 2013. Targeted searches and habitat assessments were conducted between 17 and 20 October 2012.

2.2. Weather Conditions

Two environmental climatic factors that are known to have a significant influence on invertebrate ecology are temperature and rainfall. Peak activity of invertebrate fauna often coincides with rainfall events, and taxa such as mygalomorph spiders often reach maturity at the beginning of the wet season (EPA 2009). Both phases of this survey were conducted between October and April, which is the optimum time for invertebrate surveys in the northern regions of Western Australia (EPA 2009).

The records from three Bureau of Meteorology weather stations were considered in this assessment, Ruby Plains, Sturt Creek and Halls Creek (**Figure 1**). Both temperature and rainfall data are recorded at Halls Creek weather station, whereas only rainfall data was available from Ruby Plains and Sturt Creek. The Halls Creek weather station is located approximately 145 km north-west of the baseline Study Area. The Stuart Creek and Ruby Plains weather stations are located 81 km south-west and 130 km west of the baseline Study Area respectively. Consideration of data collected from these three weather stations is useful in providing regional context given the localised nature of rainfall in the Tanami.

During Phase One of the survey, the daily maximum temperatures recorded from the Halls Creek weather station ranged between 33.6ºC and 40.6ºC, with minimum between 20.8ºC and 27.5ºC (BOM 2013). A mean maximum temperature of 37.3ºC and mean minimum of 24.7ºC over the survey period were recorded at Halls Creek, which is similar to the long-term average (BOM 2013). In the six weeks prior to the survey, 31 millimetres (mm) of rain was recorded at Sturt Creek, 215 mm from Ruby Plains and 118 mm from Halls Creek (**Figure 3**). During Phase One, 67 mm of rain was recorded at Sturt Creek, 74 mm from Ruby Plains and 151 mm from Halls Creek (**Figure 4**).

During Phase Two of the survey, the daily maximum temperatures recorded from the Halls Creek weather station ranged between 22.6ºC and 39.8ºC, with minimum between 21.7ºC and 26.6ºC (BOM 2013). A mean maximum temperature of 34.8ºC and mean minimum of 23.2ºC were recorded at Halls Creek during the survey period, which is similar to the long-term average (BOM 2013). During Phase Two, 16 mm of rainfall was recorded at Sturt Creek, 58 mm from Ruby Plains and 169 mm from Halls Creek (**Figure 5**). The rainfall recorded prior to and during the survey was typical of the long-term average (BOM 2013).

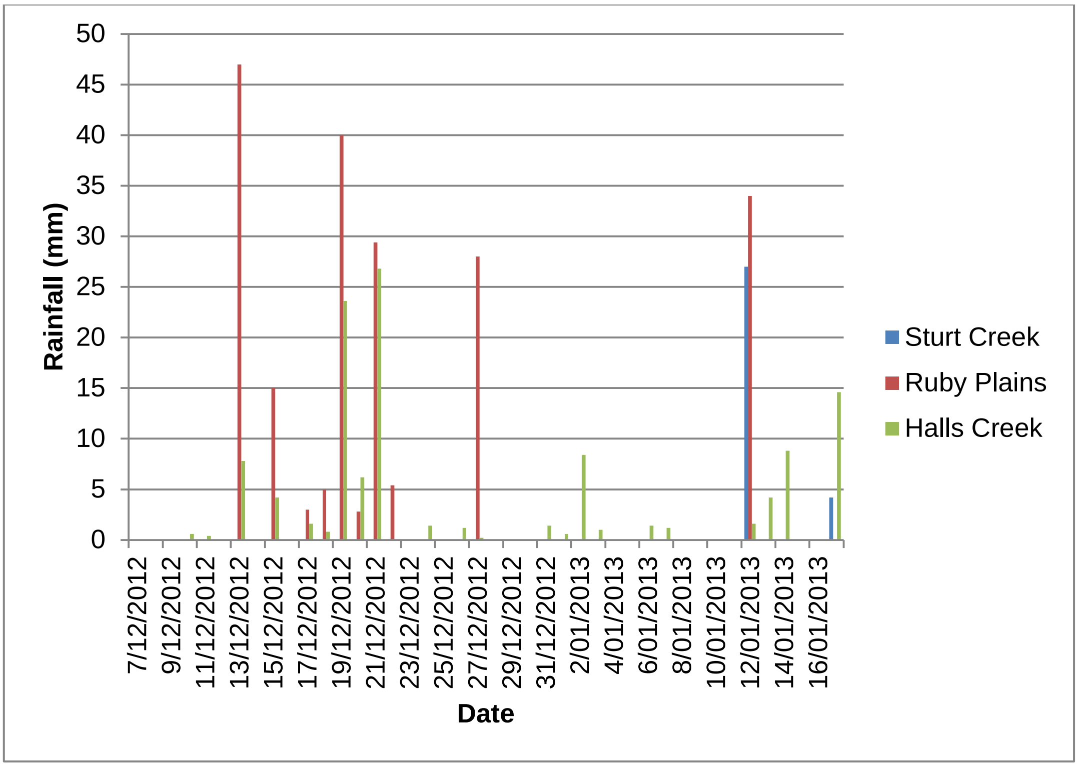


Figure 3: Rainfall received during the six weeks prior to Phase One wet pitfall trapping at three weather stations in the region of the Study Area

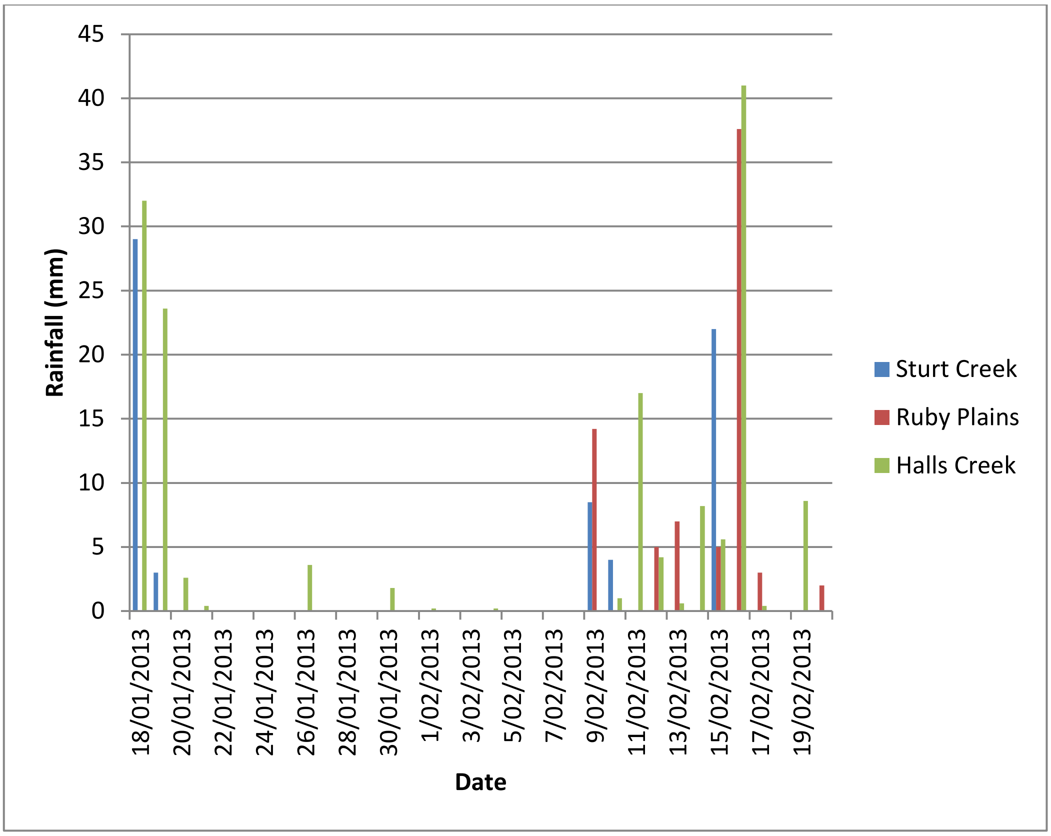


Figure 4: Rainfall received during Phase One of wet pitfall trapping at three weather stations in the region of the Study Area

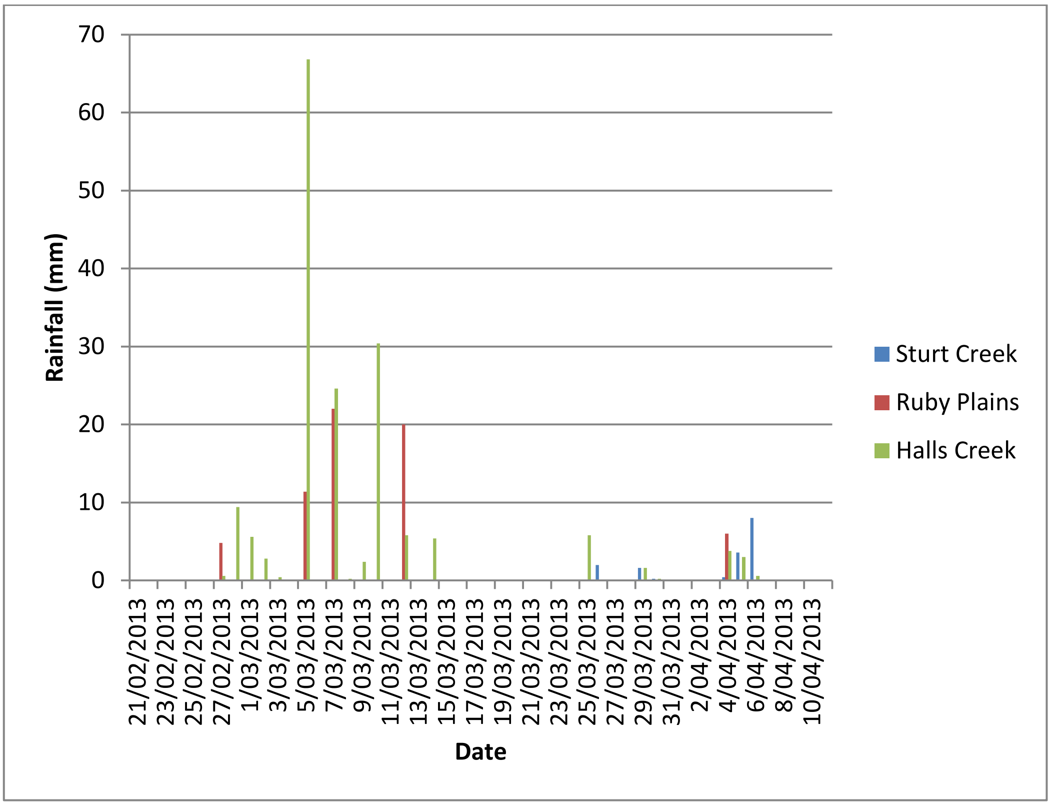


Figure 5: Rainfall received during Phase Two of wet pitfall trapping at three weather stations in the region of the Study Area

2.3. Survey Sites

Prior to the survey, a set of prospective survey sites were selected via analysis of aerial imagery and habitat mapping conducted during the baseline survey (Outback Ecology 2013a). These sites were then ground-truthed in the field and sites were selected in areas that exhibited similar characteristics to Internal Drainage and Seasonal Drainage Surface habitat types (i.e. vegetation cover/composition, soil type and surface hydrology). Final site selection was made based on the attributes of a site, its proximity to the baseline Study Area and vehicle accessibility at the time of the survey.

A total of six sites were systematically surveyed during the survey (**Figure 6**, **Table 1**). As both *Aganippe* 'MYG260' and *Aname* 'MYG258' were previously recorded at a site located within Internal Drainage habitat during the baseline survey (Outback Ecology 2013a), this particular site (Site 1) was re-surveyed to ascertain if these species were active during the survey period. An additional five sites were established in habitats that exhibited similar characteristics to Seasonal Drainage Surface and Internal Drainage habitats (**Appendix A**).

Table 1: Survey sites

Site	Habitat	Coordinates (GDA 94 MGA 52K)	
		Eastings	Northings
1	Internal Drainage	494371	7914636
2	Seasonal Drainage Surface	492915	7900436
3	Flood Plain	490733	7915044
4	Sand Plain	492666	7914662
5	Seasonal Drainage Surface	489754	7903925
6	Flood Plain	495755	7911584

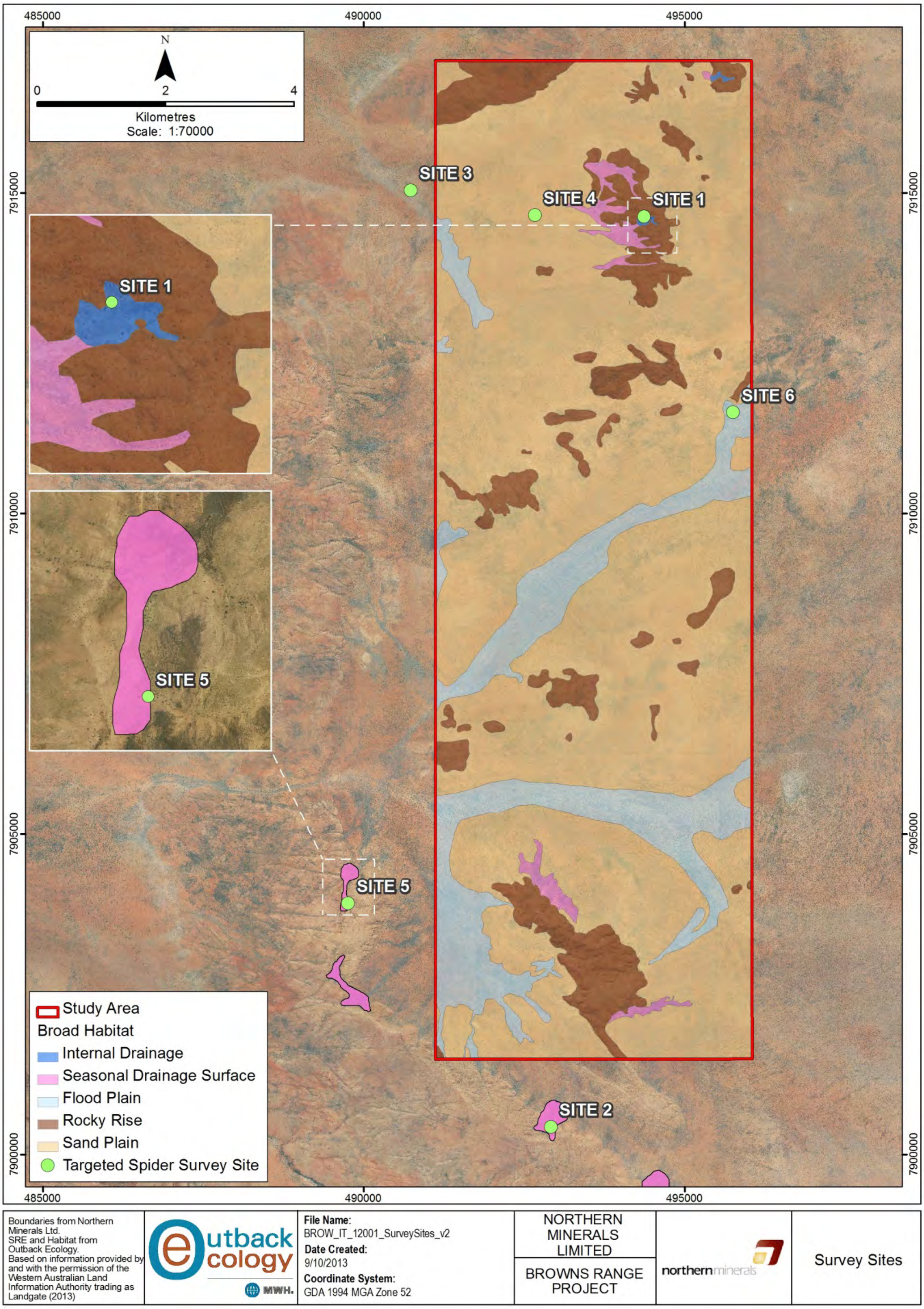


Figure 6: Location of Survey sites

2.4. Collection Techniques

Wet pitfall trapping (**Section 2.4.1**) and targeted searching (**Section 2.4.2**) were conducted to collect mygalomorph spiders during this survey (**Table 2**).

Table 2: Summary of SRE sampling methods and effort for Phase 1 and Phase 2 surveys

Sampling technique	Target group	Sampling effort per site		Total effort
		Phase 1 survey	Phase 2 survey	
Wet pitfall trapping	All groups	1,020 trap nights (six sites open for 34 nights)	1,500 trap nights (six sites open for 50 nights)	2,520 trap nights
Targeted searching	All groups	3 person hours (six sites)	N/A	18 person hours

2.4.1. Wet Pitfall Trapping

Wet pitfall trapping is an effective sampling method for mygalomorph spiders since it can achieve substantial trap effort (extended deployment) for minimal investment of labour. Applying this method increased the probability of collecting species which are active only briefly or sporadically, such as species that become active during or after rainfall.

2.4.1.1. Wet Pitfall Trap Setup

Wet pitfall trapping involved placing plastic containers into a buried, vertical, cylindrical PVC pipe (100 mm x 250 mm). Care was taken to ensure that the top of the container was flush with the top of the PVC pipe and the ground surface. The container was filled with approximately 500 millilitres (ml) of a preserving agent (100% propylene glycol) and a cover was suspended approximately 20 mm above the trap to reduce vertebrate by-catch and to limit rain entering the trap. To increase the effectiveness of the pitfall trap, two drift fences (flywire mesh) measuring approximately 750 mm in length and 150 mm in height were set on each side of the trap. The base of the fence was buried into the ground. Traps were placed at 5 to 10 m intervals where possible. The contents of wet pitfall traps were examined using a dissecting microscope in the Outback Ecology laboratory.

Vertebrates are sometimes inadvertently collected in wet pitfall traps. All vertebrates collected during this survey were identified by Outback Ecology vertebrate fauna specialists. The records of invertebrates and vertebrates species identified in this survey were forwarded to the DER as stipulated by the Regulation 17 fauna licence.

2.4.2. Targeted Searching

Each of the six sites were searched for mygalomorph spiders and/or burrows for a total of three person hours. Where present, microhabitats such as leaf litter at the base of trees, rock edges, and the sides of drainage features were searched. Burrows suspected to be those of mygalomorphs were excavated and any occupants were collected.

2.5. Specimen Identification

Mygalomorph spider specimens from this survey were delivered to the Western Australian Museum (WAM) for registration and identification (**Table 3**).

Table 3: WAM Specialists involved in specimen identification

Identification Technique	WAM Specialist
Morphological identification of Mygalomorph spider specimens	Dr. Mark A. Castalanelli Dr. Mark S. Harvey
Molecular Identification of *Aname* species	Dr. Gaynor Dolman Dr. Mark A. Castalanelli

2.6. SRE Habitat Assessment

A habitat's potential to support SRE invertebrate fauna can be used to identify habitats of conservation value and may also be used to identify the availability of suitable habitat for SRE species outside a Development Envelope or Development Footprint. Potential terrestrial SRE habitats identified within the Study Area during the baseline survey were categorised as having a high, medium or low potential to support terrestrial SRE invertebrate species based on complexity, physical attributes, connectivity and extensiveness within the landscape (Outback Ecology 2013a). Habitat assessments during this survey were conducted using the same standardised habitat assessment sheets as used during the baseline survey (Outback Ecology 2013a). This ensured comparable data from both surveys.

Habitat assessments entailed:

- establishment of habitat assessment reference points of suitable replication within representative habitat outside the baseline Study Area, to characterise the extent of SRE habitat in the surrounding area; and
- completion of a standardised habitat assessment for each site. The assessment was made in an area of approximately 50 m x 50 m. Landscape position, outcropping, soil type, broad vegetation type, litter cover, existing disturbance, extensiveness and physical connectivity within the landscape were recorded.

2.7. SRE Assessment Team and Licensing

The terrestrial SRE invertebrate fauna assessment was conducted by:

Matt Quinn	B.Sc (Marine Sci./Environ.Sci.)	Environmental Scientist
Arnold Slabber	B.Sc. (Environ. Biology) (Hons.)	Environmental Scientist

Licence to take fauna for scientific purposes (Regulation 17) – Licence No: SF008914

Date of issue: 15/10/2012

Valid from: 17/10/2012

Date of expiry: 16/10/2013

3. RESULTS AND DISCUSSION

3.1. Restricted Habitats

During the baseline survey, Internal Drainage and Seasonal Drainage Surface habitat were identified as being restricted within the Study Area and comprised 6 ha (<1%) and 103 ha (1.34%) of the baseline Study Area, respectively (Outback Ecology 2013a) (**Figure 7**). This survey identified an additional 76.6 ha of Seasonal Drainage Surface habitat that occurred outside the baseline Study Area. No additional Internal Drainage habitat was identified outside the baseline Study Area during this survey (**Figure 7**).

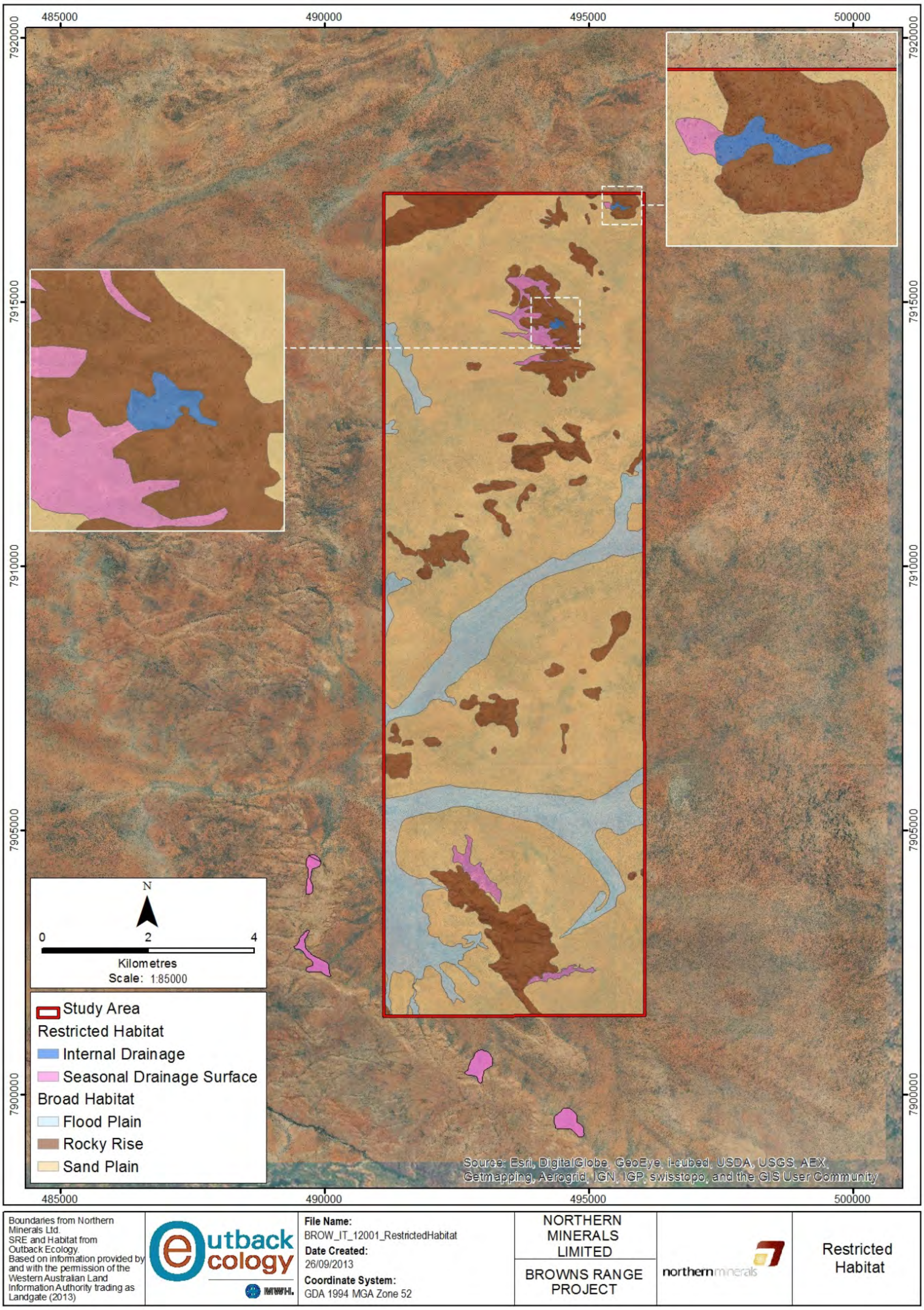


Figure 7: Restricted habitats in the vicinity of the Project

3.2. Mygalomorph Spiders

This survey yielded a total of five mygalomorph spider specimens from four identifiable SRE species, comprising Aganippe 'MYG260', Aname 'MYG287', Aname 'MYG288' and Kwonkan 'MYG257'.

The results from the molecular analysis of the five specimens from the *Aname* genus collected during the baseline survey were inconclusive (**Appendix B**). The molecular analysis was undertaken because there was the possibility that one or more of these specimens represented the species *Aname* 'MYG258'. The genetic samples from the specimens failed to amplify and genetic comparisons could not be completed.

Table 4: Mygalomorph spiders collected during the survey, showing site, number of specimens and associated habitat

Habitat	Site	Number of potential SRE species collected				Total
		Aganippe 'MYG260'	*Aname* 'MYG287'	*Aname* 'MYG288'	*Kwonkan* 'MYG257'	
Internal Drainage	1			1		1
Seasonal Drainage Surface	2					0
	5				1	1
Sand Plain	4	1	1			2
Flood Plain	3					0
	6					0
Total		**1**	**1**	**1**	**1**	**4**

3.2.1. *Aganippe* 'MYG260'

A single *Aganippe* 'MYG260' specimen was collected from Site 4 in Sand Plain habitat during this survey (**Figure 8**). An additional *Aganippe* 'MYG260' specimen was collected from Internal Drainage habitat in the baseline survey (Outback Ecology 2013a) (**Figure 8**). Sand Plain habitat is not restricted within the Study Area and occurs extensively in the surrounding landscape (Outback Ecology 2013a). Internal Drainage habitat is highly restricted in the Study Area and is disconnected from similar habitat in the surrounding region (Outback Ecology 2013a). Sand Plain and Internal Drainage habitat covers an area of approximately 5,727 ha (74.62 %) and 6 ha (<1 %) of the baseline Study Area respectively.

Given only two specimens of *Aganippe* 'MYG260' have been collected to date; there is a lack of geographic and taxonomic information regarding this species. Consequently, there is insufficient data available to make a definitive statement on the distribution, habitat preference and SRE status of this species (**Appendix C**). However, given that *Aganippe* 'MYG260' has been collected from two habitat types, one of which is extensive in the surrounding landscape, it does not appear to be a habitat specialist.

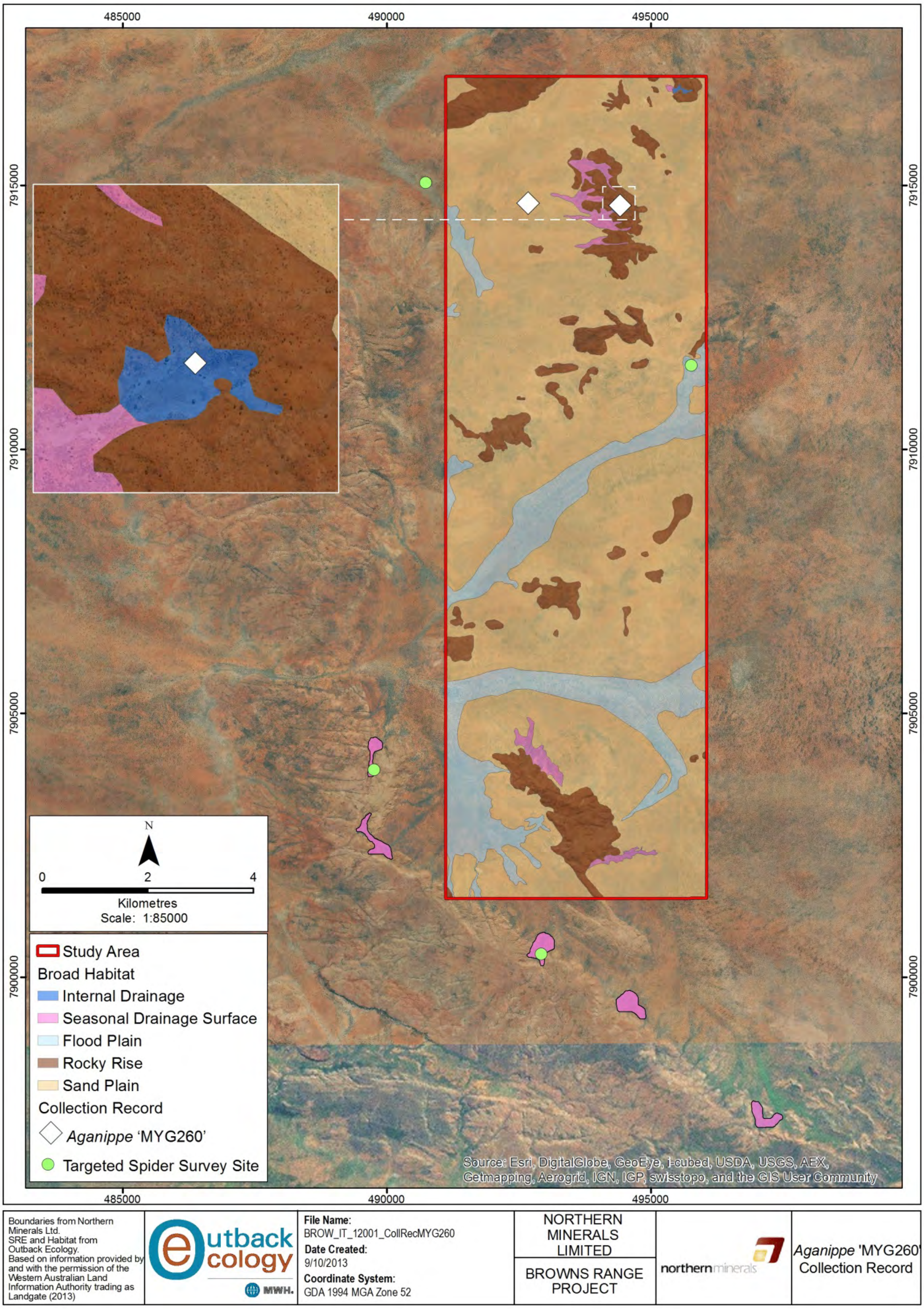
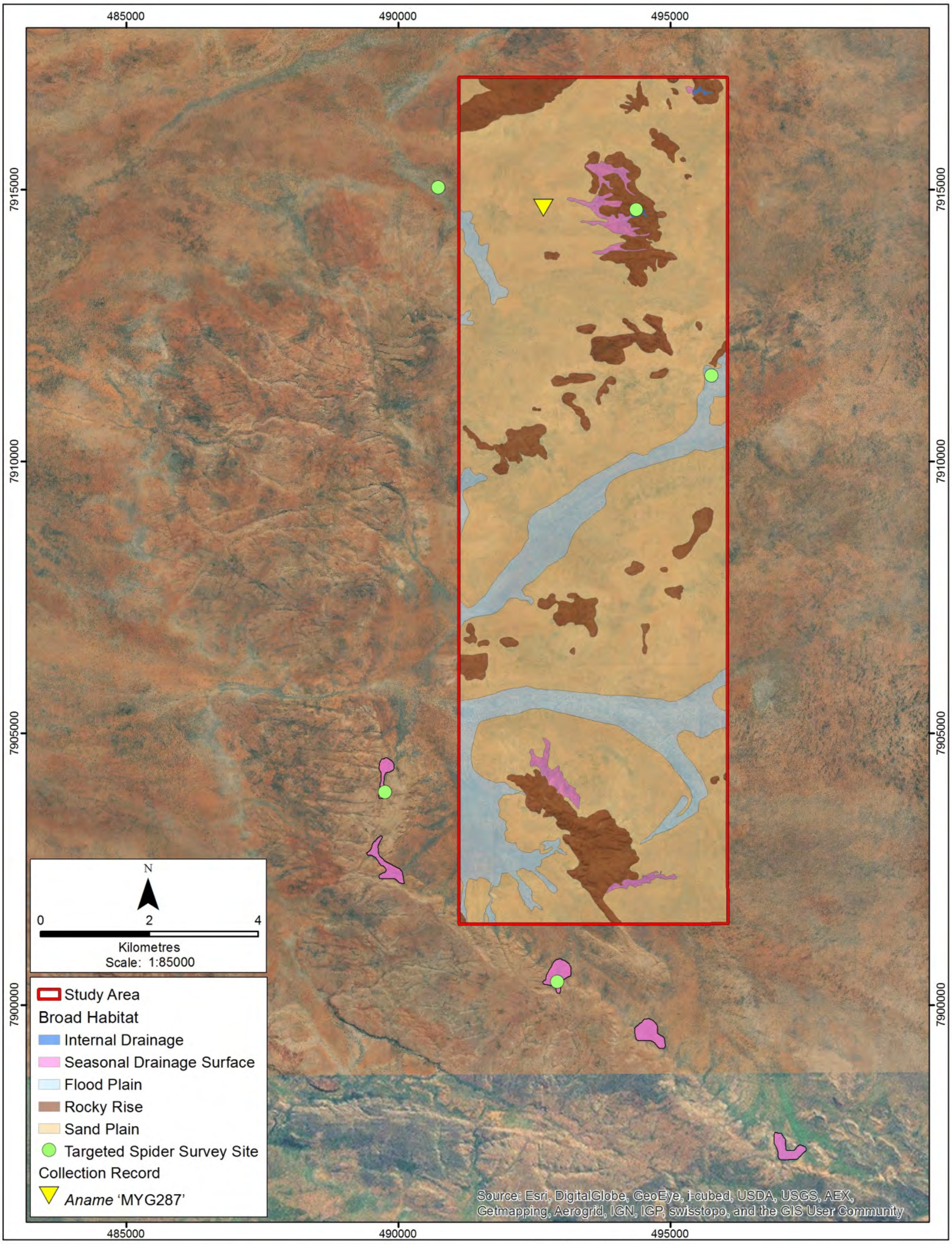


Figure 8: *Aganippe* 'MYG260' collection records in the vicinity of the Project

3.2.2. *Aname* ‘MYG287’

A single *Aname* ‘MYG287’ specimen was collected at Site 4 from Sand Plain habitat during this survey (**Figure 9**). As this specimen was juvenile, it was unable to be identified to species level using morphology. Subsequently, genetic analysis revealed that this species was distinct from other members of the *Aname* lineage that occur within the baseline Study Area (**Appendix D**). This species was not recorded during the baseline survey (Outback Ecology 2013a). *Aname* ‘MYG287’ was collected from Sand Plain habitat which was not restricted within the baseline Study Area and surrounding region (Outback Ecology 2013a). Sand Plain habtiat encompasses 5,727 ha (74.62 %) of land within the baseline Study Area (Outback Ecology 2013a).

Given that only one specimen of *Aname* ‘MYG287’ has been collected; there is a lack of geographic and taxonomic information regarding this species. Consequently, there is insufficient data available to make a definitive statement on the distribution, habitat preference and SRE-status of this species (**Appendix C**). However given that this species has been collected from a habitat that is extensive in the surrounding landscape, it appears unlikely that this species is restricted to the Study Area.



Boundaries from Northern Minerals Ltd. SRE and Habitat from Outback Ecology. Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2013)	outback ecology MWH.	**File Name:** BROW_IT_12001_CollRecMYG287 **Date Created:** 9/10/2013 **Coordinate System:** GDA 1994 MGA Zone 52	NORTHERN MINERALS LIMITED BROWNS RANGE PROJECT	northernminerals	*Aname* 'MYG287' Collection Record

Figure 9: *Aname* 'MYG287' collection records in the vicinity of the Project

3.2.3. *Aname* 'MYG288'

A single *Aname* 'MYG288' specimen was collected at Site 1 from Internal Drainage habitat during this survey (**Figure 10**). As this specimen was juvenile, it was unable to be identified to species level using morphology. Subsequent, genetic analysis revealed that this species was distinct from other members of the *Aname* lineage that occur within the Study Area (**Appendix D**). This species was not recorded during the baseline survey (Outback Ecology 2013a). Internal Drainage habitat is considered highly restricted within the baseline Study Area (<1%) (Outback Ecology 2013a);. No Internal Drainage habitat was identified outside the baseline Study Area during this survey.

Given that only one specimen of *Aname* 'MYG288' has been collected; there is a lack of geographic and taxonomic information regarding this species. Consequently, there is insufficient data available to make a definitive statement on the distribution, habitat preference and SRE-status of this species (**Appendix C**). Currently, *Aname* 'MYG288' is only known from a single record that occurs in Internal Drainage habitat which is considered restricted within the vicinity of the baseline Study Area (Outback Ecology 2013b).

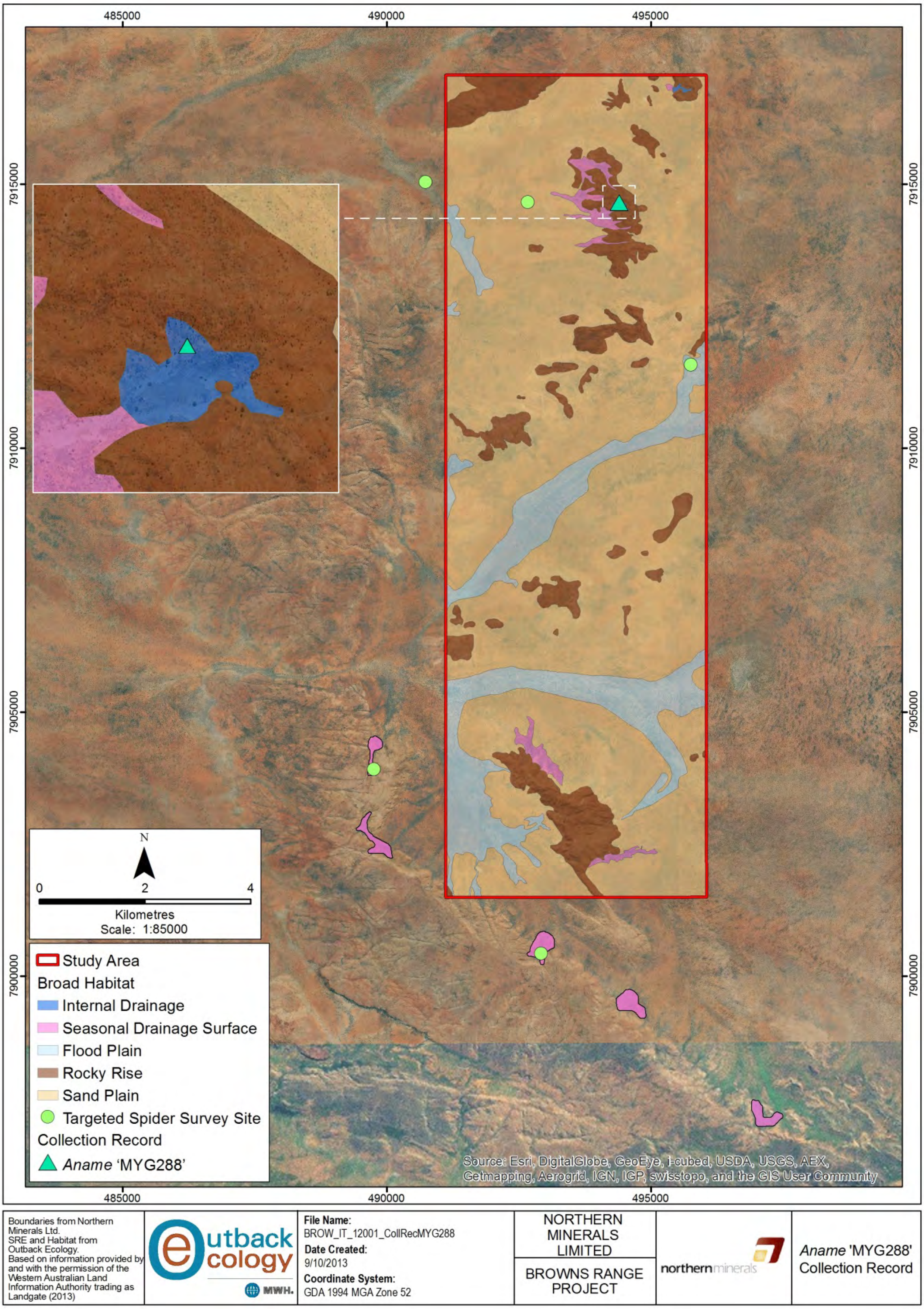


Figure 10: *Aname* 'MYG288' collection records in the vicinity of the Project

3.2.4. *Kwonkan* 'MYG257'

A single *Kwonkan '*MYG257' specimen was collected from Site 5 in Seasonal Drainage Surface habitat during this survey (**Figure 11**). Five Kwonkan 'MYG257' specimens were collected from Sand Plain and Flood Plain habitat in the baseline survey (Outback Ecology 2013a) (**Figure 11**). Seasonal Drainage Surface habitat was considered to be restricted within the Study Area while Sand Plain and Flood Plain habitats were not considered restricted and both occurred extensively in the surrounding landscape (Outback Ecology 2013a). Sand Plain, Flood Plain and Seasonal Drainage Surface habitat cover an area of approximately 5,727 ha (74.62 %), 996 ha (12.98 %) and 103 ha (1.34 %) within the baseline Study Area respectively.

Given that only six specimens of *Kwonkan '*MYG257' have been collected; there is a lack of geographic and taxonomic information regarding this species. Consequently, there is insufficient data available to make a definitive statement on the distribution, habitat preference and SRE-status of this species (**Appendix C**). However given that this species has been collected from three habitats, two of which are extensive in the surrounding landscape, it appears unlikely that this species is restricted to the Study Area.

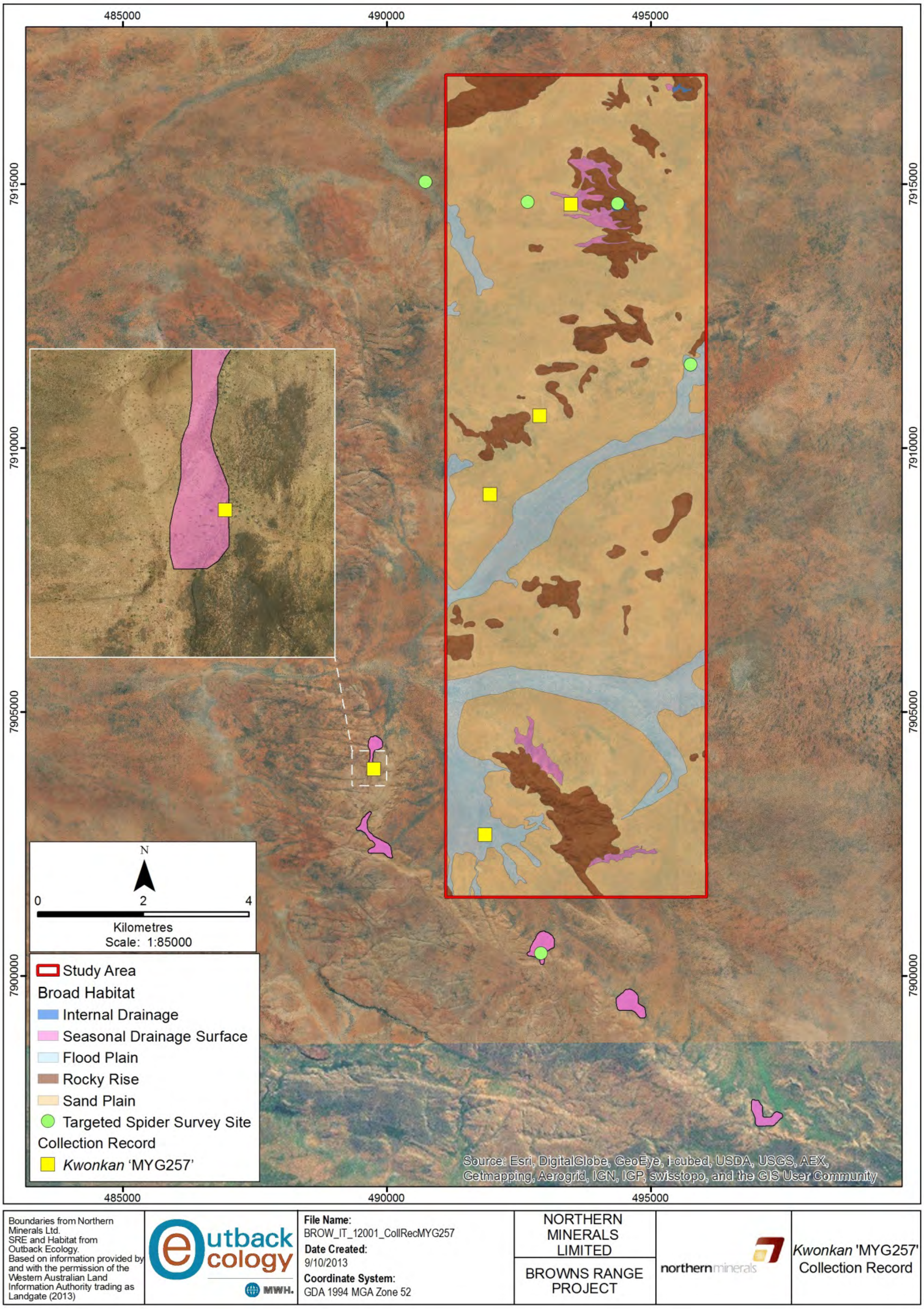


Figure 11: *Kwonkan* 'MYG257' collection records in the vicinity of the Project

4. CONCLUSIONS

This report documents the findings of the targeted mygalomorph spider survey in the areas surrounding the Browns Range Project. This work builds on the findings of the original baseline survey which established that two SRE mygalomorph spider species, *Aganippe* 'MYG260' and *Aname* 'MYG258', occurred in habitats that were restricted in the Study Area and within close proximity to the Development Footprint.

This targeted survey yielded a total of five mygalomorph spider specimens from four identifiable SRE species, comprising *Aganippe* 'MYG260', *Aname* 'MYG287', *Aname* 'MYG288' and *Kwonkan* 'MYG257'. Of these species, *Aganippe* 'MYG260', *Kwonkan* 'MYG257' and *Aname* 'MYG287' occur from habitats that are considered widespread and continuous within the region and these species are likely to have distributions to match. Conversely, *Aname* 'MYG288' is currently known from a single specimen collected from Internal Drainage habitat. This habitat type is considered highly restricted within the baseline Study Area and has not been identified in the surrounding area during this survey.

Internal Drainage and Seasonal Drainage Surface habitat was considered to be restricted habitats in the Study Area. This survey identified an additional 76.6 ha of Seasonal Drainage Surface habitat outside of the baseline Study Area. No additional Internal Drainage habitat was identified during this survey.

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Outback Ecology. (2013b) *Browns Range Project: Terrestrial Short-range Endemic Invertebrate Fauna Impact Assessment*, report prepared for Northern Minerals Limited.

APPENDIX A

Site Descriptions

Site 1 **Habitat type:** Internal Drainage **Vegetation:** Low, very open overstorey of *Eucalyptus* sp. and *Corymbia* sp. over closed grassland comprising *Triodia sp. and* *Heteropogon contortus* (90% cover). **Leaf litter:** 25-50% **Substrate:** fine brown loamy sand **Disturbance:** Nil	
Site 2 **Habitat type:** Seasonal Drainage Surface **Vegetation:** Very open over storey of *Eucalyptus* sp. with closed shrub land of *Acacia* sp. over *Heteropogon contortus.* **Leaf litter:** 10-25 % **Substrate:** Sandy loam to silt loam **Disturbance:** Extensive Fire Damage	
Site 3 **Habitat type:** Flood Plain **Vegetation:** Very open woodland of *Eucalyptus* sp. over open shrub land of *Acacia* sp. with 70 % *Heteropogon contortus* and *Triodia* sp. cover. **Leaf litter:** 10-25 % **Substrate:** Sandy to Clayey sand **Disturbance:** History of Fire	

<table>
<tr><td>Site 4

Habitat type: Sand Plain
Vegetation: Very open woodland of Eucalyptus sp. over open shrub land of Acacia sp. with 10 % Heteropogon contortus and Triodia sp. cover.

Leaf litter: 10-25 %
Substrate: Sandy to Clayey sand
Disturbance: Minimal fire disturbance</td><td></td></tr>
<tr><td>Site 5

Habitat type: Seasonal Drainage Surface
Vegetation: Open woodland of Eucalyptus sp. over various shrubs over 50% Triodia spp cover.

Leaf litter: 25-50 %
Substrate: Sandy loam to silt loam
Disturbance: Nil</td><td></td></tr>
<tr><td>Site 6

Habitat type: Flood Plain
Vegetation: Very open woodland of Eucalyptus sp. over 90 % Heteropogon contortus cover
Leaf litter: 10-25 %
Substrate: Sandy to Clayey sand
Disturbance: Nil</td><td></td></tr>
</table>

APPENDIX B

Browns Range Genetic Comparison of *Aname* Specimens

Locked Bag 49, Welshpool DC. WA 6986
49 Kew Street, Welshpool, WA 6106
Phone (08) 9212 3700

Outback Ecology DNA Bar-coding Project

M. A. Castalanelli & M. S. Harvey

Summary

Specimens T123130 and T123150 were all genetically different (85.8% pairwise similarity), which suggests that they represent two species. Furthermore, no match was returned when these two specimens were BLAST against the Western Australian Museum's Mygalomorphae DNA reference database.

Brief

Sequence eight Mygalomorphae specimens provided by Outback Ecology with the aim to compare the five unknown *Aname* to the morphological reference *Aname* `MYG258` and BLAST the sequences against the Western Australian Museum's Mygalomorphae DNA reference database.

Deliverables

- BLAST results (Table 3).

Method

Amplification of the bar-coding fragment was performed using primers outlined in Table 1.

Table 1. Primers used to amplify the DNA bar-coding fragment.

Primer	Sequence `5-3`	Reference	Primer Pair
LCO1490	GGTCAACAAATCATAAAGATATTGG	(Folmer et al., 1994)	1 & 2
HCO2198	TAAACTTCAGGGTGACCAAAAAATCA	(Folmer et al., 1994)	1
C1-N-2191	CCCGGTAAAATTAAAATATAAACTTC	(Simon et al., 1994)	2
C1-J-1718F-mygal	GGAGGATTTGGAAATTGATTAGTTCC	Modified (Simon et al., 1994)	3
C1-N-2191	CCCGGTAAAATTAAAATATAAACTTC	(Folmer et al., 1994)	3

The sequences were edited using Geneious Pro 5.5.6 (Biomatters Ltd) and aligned with the reference dataset using Geneious' building in alignment algorithm. Geneious Pro 5.5.6 was used to detect the presence of NuMTs by translating each *COI* sequence with the standard invertebrate and *Drosophila* codes. The successfully amplified sequences were BLAST against the Western Australian Museum's mygalomorphae sequence database.

Table 2. Samples provided by Outback Ecology including sequencing status.

REGNO	FAMILY	GENUS	SPECIES	SITE	LATITUDE	LONGITUDE	COllMETH	PRIMER PAIRS		
								1	2	3
T123130	Nemesiidae	Aname	\`sp juv\`	Browns Range, c. 280 km S. Lake Argyle	18°54\`12.6"S	128°55\`20.9"E	active search	Fail	Fail	Pass
T123138	Nemesiidae	Aname	\`sp juv\`	Browns Range, c. 280 km S. Lake Argyle	18°58\`18.6"S	128°56\`15.2"E	wet pitfall	Fail	Fail	Fail
T123140	Nemesiidae	Aname	\`sp juv\`	Browns Range, c. 280 km S. Lake Argyle	18°53\`47.9"S	128°55\`57.2"E	wet pitfall	Fail	Fail	Fail
T123144	Nemesiidae	Aname	\`sp female\`	Browns Range, c. 280 km S. Lake Argyle	18°58\`5.9"S	128°55\`21.5"E	wet pitfall	Fail	Fail	Fail
T123146	Nemesiidae	Aname	\`sp juv\`	Browns Range, c. 280 km S. Lake Argyle	18°56\`30.8"S	128°56\`33.8"E	wet pitfall	Fail	Fail	Fail
T123149	Nemesiidae	Aname	\`MYG258\`	Browns Range, c. 280 km S. Lake Argyle	18°51\`36.8"S	128°56\`47.6"E	wet pitfall	Fail	Fail	Fail
T123150	Nemesiidae	Aname	\`MYG258\`	Browns Range, c. 280 km S. Lake Argyle	18°51\`33.8"S	128°56\`34.2"E	wet pitfall	Fail	Fail	Fail
T123151	Nemesiidae	Aname	\`MYG258\`	Browns Range, c. 280 km S. Lake Argyle	18°51\`33.8"S	128°56\`34.2"E	wet pitfall	Fail	Fail	Pass

Results

BLAST Results

Table 3. Unknown specimens that were provided by Outback Ecology and BLAST against the Western Australian Museum’s mygalomorphae sequence database.

Unknowns				Blast Results				
REGNO	FAMILY	GENUS	SPECIES	REGNO	Identity	Morphologically Determined By	Similarity (%)	Outcome
T123130	Nemesiidae	Aname	\`sp juv\`	T105892	T105892_Aname_\`MYG001\`	V.W.Framenau	86.4	No Match
T123150	Nemesiidae	Aname	\`MYG258\`	T82311	T82311_Aname		89	No Match

- Specimens T123130 and T123150 were all genetically different (85.8% pairwise similarity), which suggests that there are two distinct species
- The closest match to T123130 was T105892 which was morphologically identified as *Aname* \`MYG001\` by V.W.Framenau, but with only an 86.4% pairwise similarity it is highly unlikely that these are same species.
- The closest match to T123150 was T82311 which was morphologically identified as *Aname*, but with only an 89% pairwise similarity it is highly unlikely that these are same species.

References

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Ronquist, F. & Huelsenbeck, J. P. (2003). MRBAYES 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics* **19**: 1572-1574.

Appendix I

>T123130
ATTAGTTCCTTTGATATTAGGGGCTCCTGATATAGCTTTTCCTCGAATAAA
TAACTTGAGATTTTGACTTTTACCTCCCTCGTTATTATTATTAATTTTATCT
TCTTTGACGGATGTAGGGGTTGGAGCTGGATGGACAATTTATCCTCCTTTA
TCTTCTGTTATTGGGCATGGGGGGGGTGGTATAGATTTTGCTATTTTTTCTT
TACATTTAGCGGGGGCATCTTCGATTATAGGGGCTATTAATTTTATTTCTA
CTATTGTAAATATACGTTCAGTAGGTATAACTATAGAGCGAGTCCCTTTAT
TTGTTTGGTCAGTATTAATTACGGCTATTTTGTTATTGTTGTCTCTTCCTGT
TCTAGCAGGGGCTATTACTATATTATTAACAGATCGTAATTTTAATACTTC
TTTTTTTGATCCTGCGGGAGGGGGAGATCCTATTTTGTTTCAACATTTGTTT
TGATTTTTTGGTCACCCTGAAGTTTATATTTTA
>T123151

TTTTGATTATTACCTCCTTCTTTATTATTGTTAATTTTGTCTTCACTTACTGA
TGTTGGGGTGGGGGCAGGATGAACAATTTATCCCCCTTTATCTTCATTTAT
TGGGCATGGAGGGGGGGGGATAGATTTTGCGATTTTTTCTTTACATTTAGC
TGGTGCATCTTCTATTATAGGAGCAATTAATTTTATTTCGACAATTTTAAA
TATGCGTTCAGTGGGGATAACGATGGAACGGGTTCCATTATTTGTTTGATC
AGTATTAATTACGGCTATTCTTTTGTTATTGTCTCTTCCTGTGTTGGCGGGG
GCTATTACTATATTATTGACTGATCGTAATTTTAATACTTCATTTTTTGACC
CTGC---

APPENDIX C

Report by Western Australian Museum: Mygalomorphs from Browns Range, Western Australia

WAMTS174: Arachnida/ Myriapoda

Mygalomorphs from Browns Range, Western Australia

(Outback Ecology Project Northern Minerals)

Detailed Report to Outback Ecology

20 Jun 2013

Mark A. Castalanelli & Mark S. Harvey

Department of Terrestrial Zoology, Western Australian Museum,

Locked Bag 49, Welshpool DC, Western Australia 6986, Australia

SUMMARY

WAMTS174 specimens were submitted to the Western Australian Museum on the 2 May 2013. The project contained mygalomorph spiders (n=5). A summary of specimen identifications together with their SRE status may be found in Table 1. A full explanation of the SRE categories used by the Western Australian Museum may be found in Appendix 1.

Table 1. Summary of WAMTS143 specimen identifications and SRE status.

FAMILY	GENUS	SPECIES	# OF SPECIMENS	SRE STATUS
Idiopidae	*Aganippe*	\`MYG260\`	1	Potential SRE; (A)
Nemesiidae	*Kwonkan*	\`MYG257\`	1	Potential SRE; (A)
Nemesiidae	*Aname*	\`sp juv and female\`	3	Potential SRE; (A)

SHORT-RANGE ENDEMISM

The terrestrial invertebrate fauna of inland Australia contains a plethora of species, and just the arthropods were recently estimated to consist of more than 250,000 species (Yeates, Harvey et al. 2004; Chapman 2009). The vast majority of these are found within the Insecta and Arachnida, although significant numbers of millipedes are to be expected. For many years, the prospect of including invertebrates in assessments of biological systems subject to modification proved daunting because of the large numbers of unknown species. These animals were largely ignored, as they were too diverse and their taxonomy too little known for them to be considered in environmental surveys that require a rapid turn-around time.

In a recent publication, the issue of Short-Range Endemism in the Australian invertebrate fauna was examined (Harvey 2002),. Species that could be defined as Short-Range Endemics (SRE) were those that had a naturally small range of less than 10,000 km^2. Harvey (2002) found that those species possessed a series of distinct ecological and life-history traits that contributed to their limited distributions, including:

- poor powers of dispersal;
- confinement to discontinuous habitats;
- usually highly seasonal, only active during cooler, wetter periods; and
- low levels of fecundity.

A number of major invertebrate groups have a high proportion of individual species that show these traits and can be considered SRE's. The Western Australian fauna contains a number of SRE taxa, including millipedes, land snails, trap-door spiders, some pseudoscorpions, slaters, and onychophorans and these represent focal groups in Environmental Impact Assessment studies in the state (EPA 2009). The south coast region is relatively well known compared with other regions of the state (Framenau, Moir et al. 2008), but there are many poorly known species and gaps in our understanding of the distributions of many species.

METHODS

Mygalomorph specimens collected by *Outback Ecology* from Browns Range, WA, were submitted to the Western Australian Museum on the 2 May 2013. The specimens were examined at the WA museum using Leica dissecting microscopes (MZ6, MZ16). The SRE status of each taxonomic group was given using the SRE categorisation system developed and implemented by the Western Australian Museum. A full explanation of the WAM SRE categories is available in Appendix 1.

IDENTIFICATIONS & SHORT-RANGE ENDEMIC STATUS

ARACHNIDA

INFRAORDER MYGALOMORPHAE (TRAPDOOR SPIDERS)

Mygalomorph ("trapdoor") spiders belong to one of the focal groups in surveys of short-range endemic taxa (Harvey 2002). Many mygalomorph spiders show low dispersal capabilities, may be restricted to relictual habitats, and have long life cycles with low fecundity. A number of mygalomorph spiders, e.g. *Aganippe castellum*, *Idiosoma nigrum*, *Kwonkan eboracum*, *Moggidgea tingle*, are listed on Schedule 1 ("Fauna that is rare or likely to become extinct" of the Wildlife Conservation (Specially Protected Fauna) Notice 2008 of the Western Australian Government. The Western Australian mygalomorph fauna is vast and, despite long-term and ongoing research by Drs Barbara Main (University of Western Australia) and Robert Raven (Queensland Museum), remains taxonomically poorly known for many families and genera (e.g. Barychelidae: *Idiommata*; Idiopidae: *Aganippe*; Nemesiidae: *Aname*, *Chenistonia*, *Kwonkan*).

The best taxonomic features to distinguish mygalomorph spiders are found within the genitalia of males. Females or juveniles may be indistinguishable, although burrow morphology may allow identification to species level in some cases (B.Y. Main, personal communication). The Western Australian Museum has recently initiated a reference collection of male mygalomorph morphospecies to facilitate an assessment of distribution patterns of these spiders. This collection is assembled in cooperation with Dr Barbara Main and will eventually be consolidated with her collection at the University of Western Australia. Mygalomorph morphospecies are consecutively numbered ("MYG001", "MYG002" etc.) to allow a comparison of taxa between different surveys.

Family Idiopidae

***Aganippe `MYG260`* (Family Idiopidae)**

The idiopid genus *Aganippe* is common throughout Western Australia. Fourteen species are described from Australia and many new species await description (Main 1985). A single adult specimen was identified as *Aganippe* `MYG260` (Appendix 2). No distribution area could calculated for this due to lack of specimens (n=2).

SRE Category: Potential SRE; (A) Data Deficient. W*e lack the geographic context to make a definitive statement on the SRE-status of this taxon.*

Family Nemesiidae

***Kwonkan `MYG257`* (Family Nemesiidae)**

A single adult specimen belonging to the genus Nemesiidae was collected during this study (Appendix 2). To date only five specimens have been recorded and lodged at the Western Australia Museum. Based on our current records the distribution area for this species is ~7.9 km^2.

SRE Category: Potential SRE; (A) Data Deficient. W*e lack the geographic context to make a definitive statement on the SRE-status of this taxon.*

***Aname `sp female and juv`* (Family Nemesiidae)**

Aname are one of the most commonly collected mygalomorph spiders in the North of Western Australia. A single female and two juveniles were collected during this study (Appendix 2).

SRE Category: Potential SRE; (A) Data Deficient. W*e lack the taxonomic and geographic context to make a definitive statement on the SRE-status of this taxon.*

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Main, B. Y. (1985). "Further studies on the systematics of ctenizid trapdoor spiders: a review of the Australian genera (Araneae: Mygalomorphae: Ctenizidae)." Australian Journal of Zoology, Supplementary Series **108**: 1-84.

Yeates, D. K., M. S. Harvey, et al. (2004). "New estimates for terrestrial arthropod species-richness in Australia." Records of the South Australian Museum, Monograph Series **7**: 231-241.

APPENDIX 1. WAM SHORT-RANGE ENDEMIC CATEGORIES

<table>
<tr><th></th><th>Taxonomic Certainty</th><th>Taxonomic Uncertainty</th></tr>
<tr><td>Distribution < 10 000km^2</td><td>Confirmed 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.</td><td rowspan="2">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</td></tr>
<tr><td>Distribution > 10 000km^2</td><td>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.</td></tr>
</table>

SRE SUB-CATEGORIES

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

A. <u>Data Deficient:</u>
- 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.
  - The individuals sampled (e.g. juveniles) may prevent identification to species level.

B. <u>Habitat Indicators:</u>
- It is becoming increasingly clear that habitat data can elucidate SRE status.
  - Below are some examples of habitats that are currently known to be associated with SRE taxa and vice versa.

C. <u>Morphology Indicators:</u>
- A suite of morphological characters are characteristic of SRE taxa.
- Below are some examples of morphological characters associated with SRE taxa and vice-versa.

D. <u>Molecular Evidence:</u>
- If molecular work has been done on this taxon (or a close relative), it may reveal patterns congruent or incongruent with SRE status.
- Below are some examples of phylogenetic patterns associated with SRE taxa and vice-versa.

E. <u>Research & Expertise:</u>
- Previous research and/ or WAM expertise elucidates taxon SRE status.
- This category takes into account the expert knowledge held within the WAM.

APPENDIX 2. SPECIMEN DATA FOR MYGALOMORPHS COLLECTED FROM BROWNS RANGE, WESTERN AUSTRALIA

REGNO	FLDNO	ORDER	FAMILY	GENUS	SPECIES	STATE	SITE	LATITUDE	LONGITUDE	SEX	M	F	J	Total
130451	Jan-39	Araneae	Nemesiidae	Aname	\`sp juv\`	W.A.	WA: c. 280km S Lake Argyle	18°51\`36.9"S	128°56\`47.6"E				1	1
130452	5-Mar	Araneae	Nemesiidae	Kwonkan	\`MYG257\`	W.A.	WA: c. 280km S Lake Argyle	18°57\`25.3"S	128°54\`9.6"E	M	1			1
130453	Apr-40	Araneae	Nemesiidae	Aname	\`sp juv\`	W.A.	WA: c. 280km S Lake Argyle	18°51\`36"S	128°55\`49.3"E				1	1
130454	Apr-16	Araneae	Idiopidae	Aganippe	\`MYG260\`	W.A.	WA: c. 280km S Lake Argyle	18°51\`36"S	128°55\`49.3"E	M	1			1
130455	Mar-38	Araneae	Nemesiidae	Aname	\`sp female\`	W.A.	WA: c. 280km S Lake Argyle	18°51\`23.5"S	128°54\`43.3"E	F		1		1

APPENDIX D

Molecular Identification of *Aname* species from ca. 280km S Lake Argyle, WA

Molecular Identification of *Aname* species from ca. 280km S Lake Argyle, WA

Brief report to *Outback Ecology*

23 August 2013

Gaynor Dolman

Department of Terrestrial Zoology, Western Australian Museum,
Locked Bag 49, Welshpool DC, Western Australia 6986, Australia

SUMMARY

WAMTS174 specimens were submitted to the Western Australian Museum on the 2 May 2013 by *Outback Ecology*. The original morphological identification project contained mygalomorph spiders (n=5). The morphological report was completed on 20 June 2013. As specimens of *Aname* species (n=3) were either juvenile or female and unidentifiable to species level through morphology, *Outback Ecology* then requested molecular identification of these specimens on 25 July 2013 (see Appendix 1 for specimen details).

DNA was extracted and DNA barcoding sequences (CO1) were amplified by PCR in the Western Australian Museum Molecular Systematics Unit (MSU) and sequenced at the Australian Genomic Research Facility (AGRF) Perth node. DNA sequences were BLASTED against the Western Australian Museum DNA database and a simple distance-based phylogenetic analysis was used to contextualise species relationships.

A summary of specimen identifications together with their SRE status may be found in Table 1. A full explanation of the SRE categories used by the Western Australian Museum may be found in Appendix 2.

Table 1. Summary of WAMTS174 specimen identifications and SRE status.

FAMILY	GENUS	SPECIES	# OF SPECIMENS	SRE STATUS
Nemesiidae	Aname	*Aname* `MYG287-DNA`	1	Potential SRE (molecular Evidence, data deficient)
Nemesiidae	Aname	*Aname* `MYG288-DNA`	1	Potential SRE (molecular Evidence, data deficient)

RESULTS

DNA barcodes (COI) were amplified and successfully sequenced from two of the three *Aname* specimens. PCR amplification failed in specimen T130455. Amplification of the two queried *Aname* barcode sequences were compared to the Western Australian Museum's DNA barcode database. The top 200 hits from the BLAST search were then trimmed and a distance based analysis (Neighbour-Joining) was performed on sequences of equal length. A summary of these results is provided in Table 2. Details of museum specimens that were identified in BLAST searches and Distance-based phylogenetic analyses are provided in Table 3. DNA sequences of queried specimens are provided in Appendix 3.

Table 2. Summary of BLAST analysis

<table>
<tr><th>REGNO</th><th>SPECIES</th><th>SUMMARY OF RESULTS</th></tr>
<tr><td>T130451</td><td>Aname `MYG288-DNA`</td><td>T130451 formed a distinct lineage of its own. This lineage has an average distance from its sister-lineage (Aname ellenae) of 89.5% according to the data available currently.</td></tr>
<tr><td>T130453</td><td>Aname `MYG287-DNA`</td><td>T130453 is 99.1% similar to T123130. Together these specimens form a distinct lineage. This lineage has an average distance from its nearest (non-sister) lineages of 85.2% (T105216) and 84.7% (Aname mellosa) according to the data available currently.</td></tr>
<tr><td></td><td></td><td>For further information, T123151 (Aname `MYG258'), collected from the same area (specimen details provided in Table 4) is yet another distinct lineage according to DNA barcodes. Genetic pairwise distances between the three lineages:
<table>
<tr><th></th><th>Aname `MYG287-DNA`</th><th>Aname `MYG258'</th><th><i>Aname</i> `MYG288-DNA`</th></tr>
<tr><td>Aname `MYG287-DNA`</td><td></td><td>85.2%</td><td>84.4%</td></tr>
<tr><td>Aname `MYG258'</td><td>85.2%</td><td></td><td>88.5%</td></tr>
<tr><td>Aname `MYG288-DNA`</td><td>84.4%</td><td>88.5%</td><td></td></tr>
</table>
</td></tr>
</table>

Table 3. Details of registered WAM samples belonging to the same lineage as the queried *Aname* specimen (T130453)

Reg. No.	Order	Family	Genus	Species	Locality	Collection method	Male	Female	Juvenile	Latitude	Longitude	Habitat
T123130	Araneae	Nemesiidae	Aname	\`sp. indet. (juv.)\`	Browns Range, c. 280 km S. Lake Argyle	active search	0	0	1	-18.9035	128.923	stony rise
T123150	Araneae	Nemesiidae	Aname	\`MYG258\`	Browns Range, c. 280 km S. Lake Argyle	wet pitfall	1	0	0	-18.8594	128.943	sand plain

Table 4. Details of registered WAM sample with sequence data in WAM DNA database representing third distinct lineage in the area of interest.

Reg. No.	Order	Family	Genus	Species	Locality	Collection method	Male	Female	Juvenile	Latitude	Longitude	Habitat
T123150	Araneae	Nemesiidae	Aname	\`MYG258\`	Browns Range, c. 280 km S. Lake Argyle	wet pitfall	1	0	0	-18.8594	128.943	sand plain

CONCLUSIONS

DNA barcoding of two *Aname* species collected by Outback Ecology from ca. 280km S Lake Argyle support the existence of two distinct lineages of *Aname* species in this area. *Aname* \`MYG287-DNA\` (T130453) is represented by DNA sequence data from one other specimen (T123130) in the WAM DNA database. These two specimens (T130453 and T123130) were collected ca. < 5km apart. *Aname* \`MYG288-has no other representative DNA sequence data in the WAM DNA database. Notably, a third specimen in the WAM DNA database, not queried here, represents **a third distinct lineage of *Aname* in this area**. All three of these lineages are Potential SREs and their sub-category status is D) molecular evidence, and A) data deficient.

ACKNOWLEDGEMENTS

Thank you to Dr Mark Castalanelli for assignment of MYG- DNA numbers.

Appendix 1. Specimen data of three queried *Aname* specimens

Reg. No.	Order	Family	Genus	Species	Locality	Collection method	Male	Female	Juvenile	Latitude	Longitude	Habitat
T130451	Araneae	Nemesiidae	Aname	\`MYG288-DNA\`	ca. 280km S Lake Argyle	Targeted Searching	0	0	1	-18.8603	128.947	Internal Drainage
T130453	Araneae	Nemesiidae	Aname	\`MYG287-DNA\`	ca. 280km S Lake Argyle	Targeted Searching	0	0	1	-18.86	128.93	Spinifex Sand Plain
T130455	Araneae	Nemesiidae	Aname	\`sp female\`	ca. 280km S Lake Argyle	Wet Pitfall Trap	0	1	0	-18.8565	128.912	Flood Plain

Note: PCR amplification failed for T13045

Appendix 2. WAM Short-Range Endemic Categories

<table>
<tr><th></th><th>Taxonomic Certainty</th><th>Taxonomic Uncertainty</th></tr>
<tr><td>Distribution < 10 000km^2</td><td>Confirmed SRE
• A known distribution of < 10 000km².
• The taxonomy is well known.
• The group is well represented in collections and/ or via comprehensive sampling.</td><td rowspan="2">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</td></tr>
<tr><td>Distribution > 10 000km^2</td><td>Widespread (not an SRE)
• A known distribution of > 10 000km².
• The taxonomy is well known.
• The group is well represented in collections and/ or via comprehensive sampling.</td></tr>
</table>

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.
  - 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.
  - Below are some examples of habitats that are currently known to be associated with SRE taxa and vice versa.

C. *Morphology Indicators:*

- A suite of morphological characters are characteristic of SRE taxa.
- Below are some examples of morphological characters associated with SRE taxa and vice-versa.

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.
- Below are some examples of phylogenetic patterns associated with SRE taxa and vice-versa.

E. *Research & Expertise:*

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

Appendix 3. COI DNA sequence data for queried *Aname* samples

```
>T130451
AACTTTATATTTGATTTTTGGTGTTTGGTCGGCTATGGTAGGGACGGCTATAAGAGTAATTATTCGTA
CAGAGTTGGGGCAGGTGGGAAGATTGTTAGGGGATGATCATTTGTACAATGTTGTAGTAACGGCTCAT
GCTTTAGTAATGATTTTTTTTATAGTGATGCCTATCATAATTGGGGGGTTTGGCAATTGGTTAGTACC
TTTAATGTTAGGGGCCCCTGATATAGCGTTTCCTCGAATGAATAATCTTAGTTTTTGGTTATTACCTC
CTTCTTTGTTTTTATTAGTTTTGTCTTCTCTTACTGATGTGGGTGTAGGAGCTGGGTGAACAATTTAT
CCTCCTTTGTCTTCTGTAATTGGGCATGGAGGGGGGGGTATGGATTTTGCTATTTTTTCTTTACATTT
AGCTGGTGCTTCTTCTATTATGGGTGCGATTAATTTTATTTCTACAATTTTGAATATGCGTTCTGTTG
GGATAAGAATGGAACGGGTTCCTTTATTTGTTTGGTCAGTATTGATTACAGCTATTCTCTTATTATTG
TCTCTTCCTGTGTTGGCGGGCGCTATTACGATATTATTGACGGATCGGAATTTTAATACTTCGTTTTT
TGATCCTGCTGGGGGGGGAGACCCTATTTTATTTCAACATTTATTT
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>T130453
GACTTTATATCTAATTTTTGGGGTGTGGTCTGCAATGGTGGGGACGGCTATAAGAGTAATTATCCGGA
CGGAATTAGGACAAGTAGGGAGAATATTAGGGGATGATCATTTATATAACGTAGTGGTTACTGCTCAT
GCATTAGTTATAATTTTCTTTATGGTAATGCCTATTATAATTGGGGGGTTTGGTAATTGATTGGTTCC
TTTGATATTAGGGGCTCCTGATATAGCTTTTCCTCGAATAAATAACTTGAGATTTTGACTTTTACCTC
CCTCGTTATTATTATTAATTTTATCTTCTTTGACGGATGTAGGGGTTGGAGCTGGATGGACAATTTAT
CCTCCTTTATCCTCTGTTATTGGGCATGGGGGGGGTGGTATAGATTTTGCTATTTTTTCTTTACATTT
AGCGGGGGCATCTTCGATTATGGGGGCTATTAATTTTATTTCTACTATTGTAAATATACGTTCAGTAG
GTATAACTATAGAGCGAGTCCCTTTATTTGTTTGGTCAGTATTAATTACGGCTATTTTGTTATTGTTG
TCTCTTCCTGTTCTAGCAGGGGCTATTACTATATTATTAACAGATCGTAATTTTAATACTTCTTTTTT
TGATCCTGCGGGAGGGGGAGACCCTATTTTGTTTCAACATTTGTTT
```

APPENDIX C

WAM Short-range Endemic Categories: June, 2013

WAM SHORT-RANGE ENDEMIC CATEGORIES

<table>
<tr><th></th><th>Taxonomic Certainty</th><th>Taxonomic Uncertainty</th></tr>
<tr><td>Distribution < 10 000km^2</td><td>Confirmed 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.</td><td rowspan="2">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</td></tr>
<tr><td>Distribution > 10 000km^2</td><td>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.</td></tr>
</table>

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.
  - 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.
- 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.
- 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.
- This category takes into account the expert knowledge held within the WAM.