Bennelongia Environmental Consultants

Mallina Gold Project Short Range Endemic Fauna Survey Report (Hemi Mining Area)

Prepared for:

RPM Global

December 2023

Final Report

Short-Range Endemics | Subterranean Fauna

Waterbirds | Wetlands

Mallina Gold Project SRE Fauna Survey Results (Hemi Mining Area)

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Revised	Kevin Sagastume-Espinoza	Robin Hare	email	16-09-2022
Final	Kevin Sagastume-Espinoza		Email	21-12-2022
Final V2	Kevin Sagastume-Espinoza	Erin Lee; Sarah Thomas	Email	28-07-2023
Final V2.2	Kevin Sagastume-Espinoza	Erin Lee; Sarah Thomas	Email	04-08-2023
Final V3	Kevin Sagastume-Espinoza	Stuart Halse	Email	05-12-2023

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EXECUTIVE SUMMARY

The Hemi Gold Project is a tenement package located approximately 85 km south south-west of Port Headland. Future mining operations have the potential to impact upon terrestrial short-range endemic (SRE) fauna through the clearing of habitat. This report presents details of the SRE fauna surveys conducted in the Hemi mining area and potential conservation values of terrestrial SRE fauna in the area.

Eighteen sites were sampled at Hemi, comprising five main habitats: sandplains, drainage sandplains, sand dunes, outcrop/stony hills, and creek drainage. Most of the sampled sites were located in sandplains. In general, sandplain habitat is not considered a highly suitable habitat for most SRE Groups, however, the extense acacia and eucalyptus trees within this landform appear to be a preferred habitat for the Potential SRE pseudoscorpion species listed below.

Six hundred and eighty-five records of animals belonging to SRE Groups (i.e., invertebrate groups with high proportions of SRE species) were collected from Hemi. These records represented 28 species, with most being pseudoscorpions, followed by slaters, centipedes, and millipedes. Mygalomorph spiders and harvestman were the least abundant SRE Groups with only three records representing two species. Six of the 28 species represent Potential SREs:

Pseudoscorpions
- *Afrosternophorus* `BPS436` (Unlikely Potential SRE)
- *Oratemnus* `BPS437` (Unlikely Potential SRE)
- *Austrohorus* `BPS411` (Unlikely Potential SRE)

Opilionids
- *Dampetrus* `BOP017` (Unlikely Potential SRE)

Mygalomorph spiders
- *Synothele* `BMYG195` (Unlikely Potential SRE)

Isopods
- *Laevophiloscia* `BIS546` (Data Deficient Potential SRE)

The other 22 species are either known to be widespread or are considered not to be SREs because of their apparent habitat use and their abundance both inside and outside the Hemi area.

Mining at Hemi is not expected to impact directly upon any of the recorded species. The six species with potentially restricted distributions are expected to be found outside of the Development Envelope given they were found in habitats that extend well beyond Hemi. However, extended periods of interruption in habitat connectivity can potentially decrease some pseudoscorpion species' local populations, especially those associated with eucalypts.

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1. INTRODUCTION

De Grey Mining Ltd is currently undertaking exploration and pre-feasibility studies at the Mallina Gold Project (MGP), which covers an area of approximately 1200 km^2 in the western Pilbara. The Hemi mining area is one of the components of the MGP, which comprises six known deposits. Gold was first discovered at the Hemi deposit in late 2019 and is the focus of this report.

The Hemi deposit is located approximately 85 km south-west of Port Hedland in the Pilbara region of Western Australia (Figure 1). The prospective gold mine will consist of mine pits, associated infrastructure, mining village and airstrip, processing plant, and tailings storage facility (TSF). The clearing of native vegetation for the development of Hemi has the potential to detrimentally impact terrestrial Short-Range Endemic (SRE) invertebrate fauna inhabiting the project footprint. "SRE fauna" is a term used to cover various taxonomic groups of ground-dwelling invertebrates that have a high proportion of species with small ranges (notionally less than 10,000 km^2; Harvey 2002). More information about SREs is provided by various Environmental Protection Authority (EPA) guidance statements and other documents (especially EPA 2016a). Impacts on SRE fauna are considered by the EPA, together with vertebrate fauna, when assessing the environmental impact of development projects (EPA 2016b).

This report describes two surveys undertaken for SREs in the Hemi mining area and provides the results of those surveys. The specific aims of the report are:

- Report the occurrence of species collected in SRE fauna surveys conducted at Hemi mining area.
- Evaluate the ranges and habitats of taxa detected to identify the occurrence of Potential SRE species at Hemi.
- Identify potential changes to the environment at Hemi and assess whether these may lead to conservation-significant impacts on Potential or Confirmed SRE species.

2. LANDSCAPE SETTING

2.1. Climate

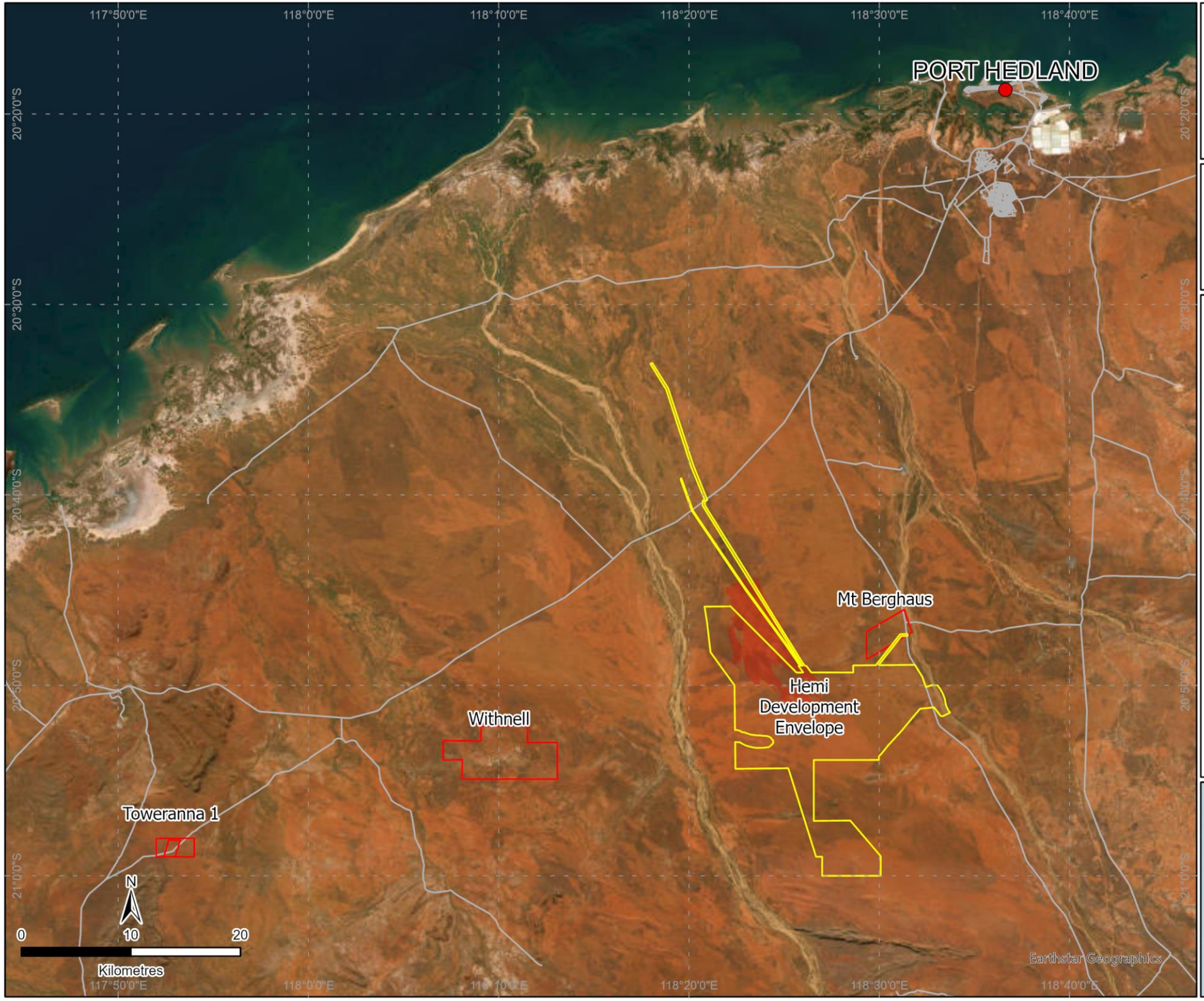
According to van Vreeswyk *et al*. (2004), the Pilbara region falls within two bioclimatic regions: a semi-desert - tropical region in the higher rainfall inland areas and the cooler areas nearer the coast; and a desert - summer rain region in the higher temperature and lower rainfall areas.

The Bureau of Meteorology (BOM) has classified the Pilbara region more or less into the same two zones, using slightly different terminology, based on temperature and humidity. One zone has a hot humid summer with a warm winter, while the other has a hot dry summer with a mild winter. Combining all the meteorological variables of temperature, rainfall, humidity, wind, and solar radiation reveals a single wet season for the whole Pilbara extending from December through to the end of March, and a dry season extending from July to November (van Vreeswyk *et al.* 2004).

2.2. Geology

The Pilbara Craton is subdivided into the Archaean granite-greenstone terrane in the north and the Archaean and Proterozoic Hamersley Basin in the south. The northern terrane comprises various deformed and metamorphosed granitic phases that are locally intruded by younger veins and dykes. The Hamersley Basin overlies the older Archaean Pilbara Craton and comprises mafic and felsic volcanics, shale, siltstone, sandstone, and conglomerate, as well as dolomite and banded iron formations (Figure 2).

The Carnarvon Basin overlaps the western margin of the Pilbara Craton and comprises a multi-layered sedimentary sequence overlying Proterozoic basement rocks. The sequence is mostly less than 500 m



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GCS GDA 1994
Author: K. Sagastume
Date: 12/12/2023

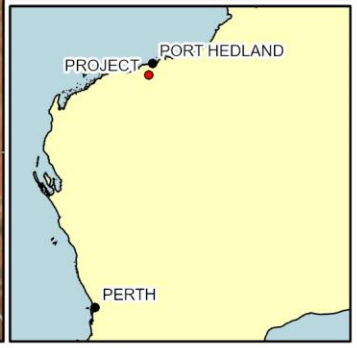
Figure 1. Location of the Greater Hemi Project in the Pilbara region.

Legend

- Hemi Proposal Boundary
- Other Tenements

Layer

- PORT HEDLAND
- Major tracks



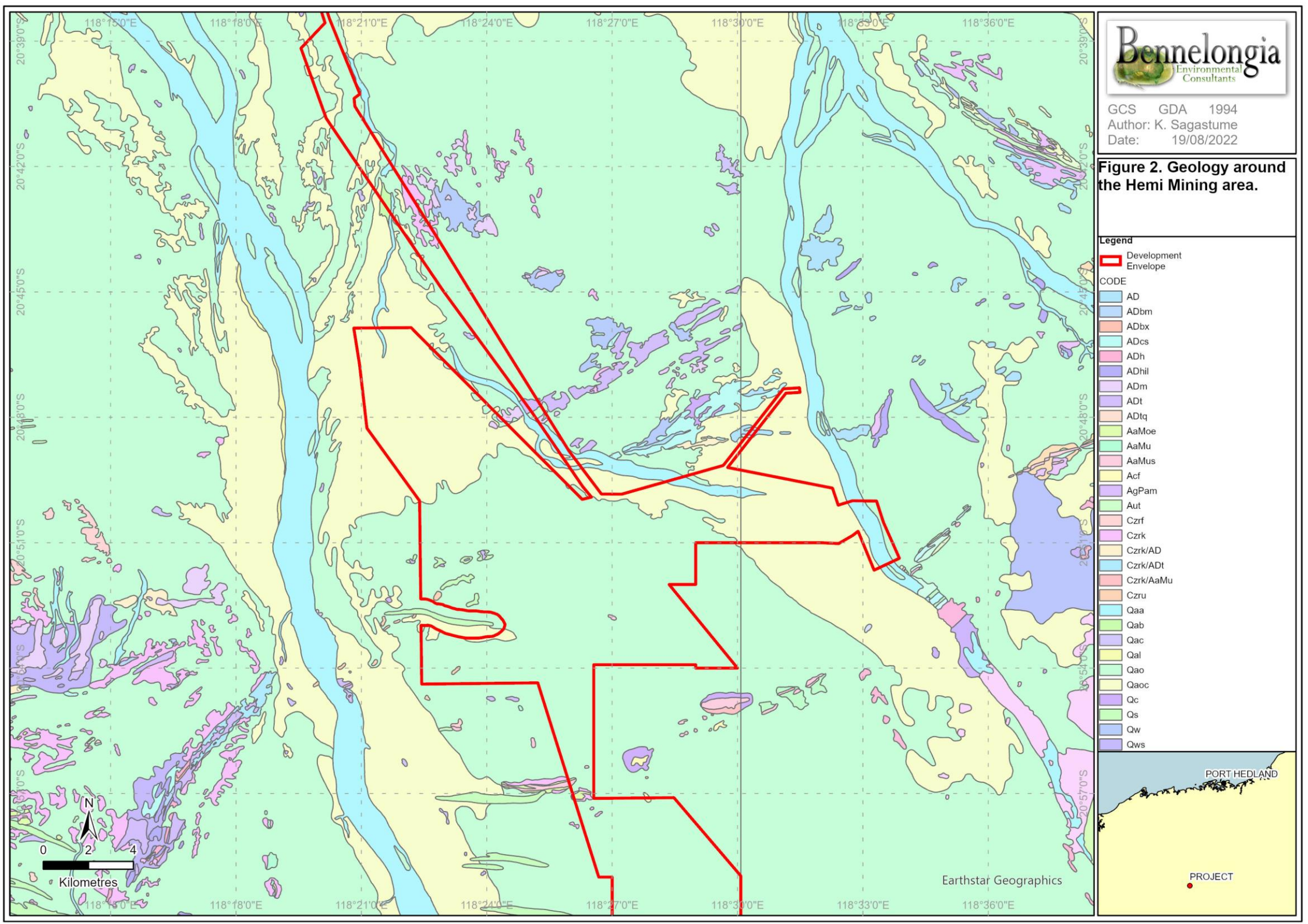

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Figure 2. Geology around the Hemi Mining area.
Legend
Development Envelope
CODE
AD
ADbm
ADbx
ADcs
ADh
ADhil
ADm
ADt
ADtq
AaMoe
AaMu
AaMus
Acf
AgPam
Aut
Czrf
Czrk
Czrk/AD
Czrk/ADt
Czrk/AaMu
Czru
Qaa
Qab
Qac
Qal
Qao
Qaoc
Qc
Qs
Qw
Qws
PORT HEDLAND
PROJECT
N
0
2
4
Kilometres
Earthstar Geographics
118°15'0"E
118°18'0"E
118°21'0"E
118°24'0"E
118°27'0"E
118°30'0"E
118°33'0"E
118°36'0"E
20°39'0"S
20°42'0"S
20°45'0"S
20°48'0"S
20°51'0"S
20°54'0"S
20°57'0"S

thick. It comprises Late Devonian to Tertiary sediments of cavernous dolomite, claystone, shale, siltstone, sandstone, glauconitic sand, and marly limestone.

A variety of Cainozoic units are deposited over the basement rocks and sedimentary basins. Jointed and cavernous pisolitic limonite occurs in the ancient Fortescue River valley and many other valleys in the Hamersley Range. These are often located close to existing drainages and may be greater than 70 m thick. Deposits of calcrete and minor silcrete occur throughout the Pilbara. They lie mostly in or adjacent to drainage channels and may be up to 65 m thick; outcrops may be up to 20 km wide. Colluvium material of scree and talus is present over much of the western Pilbara and obscures the basement geology. It consists of poorly sorted clay, silt, sand, and gravel that has been transported over short distances by gravity (van Vreeswyk *et al.* 2004).

The Hemi mining area is located in the north-western part of the Archaean Pilbara Craton and contains rocks belonging to the Pilbara granite-greenstone terrain. Clastic sedimentary rocks of the De Grey Group dominate outcrops and include coarse to fine-grained subarkose, wacke, and shale. Four basement rock types exist in the area, including metamorphosed siliciclastic rocks, metamorphosed silicified (mafic) volcanic rocks, metamorphosed ultramafic rocks, and surrounding granitic rock types.

An east-trending, 1 km-wide zone of shearing termed the Mallina Shear Zone occurs in the region (Smithies (1999). This shear zone is characterised by a network of anastomosing faults that form a low ridge of calcrete and silicified rocks of the De Grey Group (Smithies, 1999). Most rocks of the De Grey Group north of the shear zone are wacke and shale of the Mallina Formation. The De Grey Group south of the shear zone includes rocks assigned to the Constantine Sandstone, which underlies the Mallina Formation. In the southern area, peridotite and other ultramafic rocks belonging to the Millindinna Intrusion intrudes into the De Grey Group. In the northern area the Portree Granitoid Complex intrudes into the De Grey Group and the Peawah Granodiorite intrudes in the southwestern part. Ferruginous chert and banded iron formations in the south-eastern corner of the Yule are interpreted to underlie the De Grey Group, but no stratigraphic contacts are exposed.

2.3. Vegetation

The Hemi mining area is located on the juncture of the Roebourne and Chichester subregions of the Pilbara IBRA Bioregion (DCCEEW 2021). The Roebourne Subregion comprises Quaternary alluvial and older colluvial coastal and sub-coastal plains, with grass savannahs of mixed bunch and hummock grasses and dwarf shrub steppes of various *Acacia* species. Uplands are dominated by spinifex (*Triodia*) hummock grassland, while drainage lines support various woodland associations (Kendrick and Stanley 2001). The Chichester Subregion comprises plains supporting shrub steppes characterised by *Acacia* and spinifex hummock grassland associations, with eucalyptus tree steppes occurring rarely on the ranges (Kendrick and McKenzie 2001). In general, vegetation in the area is dominated by shrub steppes of hummock grasses and widely spaced shrubs.

Within the Hemi mining area specifically, five vegetation system associations (VSAs) have been identified: Abydos Plain-Chichester_93, Abydos Plain-Chichester_619, Abydos Plain_93, Abydos Plain_589, and Abydos Plain_647 (see Table 5.2 in Umwelt-Australia (2022). The pre-European extents of all five VSAs remain almost entirely intact, with the lowest remaining value being 99.8% for the Abydos Plain_589, followed by 99.9% remaining for both Abydos Plain-Chichester_93 and Abydos Plain_93, and 100% remaining for both Abydos Plain-Chichester_619 and Abydos Plain_647. Among these, VSAs including grasslands and shrub steppes are the most abundant; VSAs that include woodlands and spinifex are present in less density.

The majority of soil landscape units reported for Hemi (see Table 5.3 in Umwelt-Australia (2022) are composed of sandy surfaces or plains, with varying associations with grasslands and spinifex and occasional scattered *Acacia* shrubs. The river system and river beds (also known as drainage lines or

creek drainage) act as seasonally active floodplains which may support tall shrublands or woodlands of *Acacia* and eucalypts, or be barren areas with no vegetation cover (Umwelt-Australia 2022).

Soil types and therefore vegetation associations differ between the northern and southern regions of the Hemi mining area. The northern section of the Project has clayier soils than the southern section, with two predominant vegetation types: low-lying plains with hummock grassland dominated by spinifex and very few shrubs; and elevated areas of sandy rises with low shrublands of *Acacia* and hummock grasslands of spinifex. Other vegetation types, such as woodlands and *Eriachne* hummock grasslands along the flow (drainage) lines, also occur. Vegetation in the northern section of the Project appears to be slightly taller and arranged in a more complex mosaic pattern than in the southern section (Umwelt-Australia 2022).

The southern section of the Hemi mining area consists primarily of an extensive sandy loam plain transitioning to a clay loam plain in the north. The vegetation types found in this area consist of spinifex hummock grassland, especially on the sandier and clayier soils. Tall shrubby *Acacia* can also be found overlapping with spinifex on this stratum.

Throughout both northern and southern sections, isolated areas are also occasionally found with unique vegetation associations. For example, occasional areas of low rocky or stony hills support various species of spinifex and shrubs. Low granite outcrops also occur, and are generally dominated by *Acacia* spp. and spinifex, while also supporting ephemeral species. The Turner River, on the eastern edge of the Hemi mining area, also supports discrete vegetation types unique to the Project area. It consists of woodland dominated by *Melaleuca* and *Eucalyptus* spp. The stony rises and plains on the edge of the river channel are dominated by spinifex associations and shrub strata.

3. SRE FRAMEWORK

3.1. Conservation Framework

The *Biodiversity Conservation Act 2016* (BC Act) in Western Australia deals with the protection, conservation, and sustainable use of the state's biodiversity, and provides general protection for all native species. Some species are given special protection under the BC Act, primarily because they are rare, and are referred to as Threatened species. Species may also be recognised and protected as Threatened at the national level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). There is a general concordance of species listed under the two acts, but the BC Act has greater invertebrate coverage. Additionally, the Department of Biodiversity, Conservation and Attractions (DBCA) lists some Priority species for conservation; species are typically listed as Priority primarily when they are considered potentially under threat but there is insufficient evidence to support listing as Threatened.

Ecological communities are defined as naturally occurring biological assemblages associated with a particular type of habitat (DEC 2010). Both the BC and EPBC Acts list certain communities as Threatened Ecological Communities (TECs), with the BC Act list for Western Australia being larger. In addition to TECs, Priority Ecological Communities (PECs) are also listed by the DBCA. PECs are communities that do not meet the survey criteria to be listed as TECs but may be vulnerable to disturbance.

Information available from the BC and EPBC Acts, as well as from the DBCA's list of Priority species, is often used to complement a species' SRE assessment. Additionally, when a taxon listed in these sources is found in a project area, the potential impact of development on that taxon requires additional consideration of that taxon's taxonomy, distribution, and habitat requirements.

3.2. Short Range Endemics

In addition to having ranges notionally less than 10,000 km^2, SRE species usually have patchy distributions within their range, slow growth, low fecundity, and poor dispersal capabilities. Guidelines for the consideration and assessment of SRE invertebrates in Western Australia are provided in the *Environmental Factor Guideline: Terrestrial Fauna* (EPA 2016a) and *Technical Guidance: Sampling of short range endemic invertebrate fauna* (EPA 2016b). Assessment focusses on SRE Groups, which are higher-level taxonomic groupings known to contain moderate to high proportions of SRE species. SRE Groups relevant to the Pilbara region include land snails (Gastropoda), millipedes (Diplopoda), centipedes (Chilopoda), pseudoscorpions (Pseudoscorpiones), scorpions (Scorpiones), spiders (Araneae; mainly trapdoor spiders, Mygalomorphae) and slaters (Isopoda). Some other groups, such as velvet worms (Onychophora) and earthworms (Oligochaeta), are treated as SRE Groups in mesic landscapes.

Not all species in SRE Groups have restricted ranges; some or indeed many may be widespread. Determining whether a species belonging to an SRE Group is in fact an SRE is often difficult. One approach is to assume that the distribution of a species reflects the extent of its preferred or obligate habitat(s), and that species found only in restricted or patchy habitats have smaller ranges than those collected from extensive or common habitats. However, in cases where short range endemism is driven by life history characteristics, a species may be a true SRE but inhabit a widespread, apparently well-connected habitat (Harvey 2002; Harvey *et al.* 2015b; Harvey *et al.* 2011; Rix *et al.* 2015). Therefore, several factors are considered in conjunction when evaluating the SRE status of a species, and the likelihood of threat to that species. These factors including the known range of the species; habitat(s) at the collection site(s), and the spatial extent and connectivity of these habitats; and the distribution patterns of phylogenetically related surrogate species (ideally members of the same genus).

In order to synthesise investigations of these factors in the context of determining SRE status, this report follows the Western Australia Museum (WAM) classification system for SREs in recognising three categories:

1. **Confirmed SRE** species have a known distribution range smaller than 10,000 km^2. The taxonomy is well known, and the group well represented in collections and/or via comprehensive sampling.
2. **Potential SRE** species belong to a group with gaps in our knowledge of its distribution, either because the group is not well represented in collections, taxonomic knowledge is incomplete, or the distribution is poorly understood due to insufficient sampling.
3. **Widespread (not SRE)** species have a known distribution range larger than 10,000 km^2. The taxonomy is well known, and the group well represented in collections via comprehensive sampling.

In many surveys, most species fit the **Potential SRE** category, but the likelihood of species within the category actually being SREs varies substantially. In an attempt to increase the accuracy of categorisation, for the purposes of this report the Potential SRE category is further sub-divided into three categories:

A. **Data deficient**, indicating that insufficient data are available to determine SRE status. Insufficiency of data may be caused either by a lack of geographic or taxonomic information, or because the individuals sampled are not identifiable to species level (e.g. wrong sex, juvenile, damaged). This category is applied only to those species that belong to a known SRE Group, rather than being applied to any undescribed species in the survey.
B. **Unlikely SRE** species are either from taxonomic groups that are not usually SREs or were collected from many sites and/or widespread or multiple habitats.
C. **Potential SRE** species (in this case no modifying word is added) are from taxonomic groups in which SREs are likely, and when specimens have been collected from one or very few sites and/or habitats.

In the context of these categories, identifying a species as a Potential or Confirmed SRE is often only the first step in determining the impacts of mining activities on that species. Even a Confirmed SRE species may be locally widespread around a project area, and therefore at minimal risk of disturbance. The actual level of threat to an SRE species depends on its distribution relative to the development footprint, rather than its SRE status alone. Determining the likely level of threat to a species therefore requires further consideration of the extent of the species' preferred habitat, both within and beyond the area of activity.

4. DESKTOP STUDY

Existing records of terrestrial invertebrates and associated habitat information were examined to assess the likelihood of SRE and/or conservation-listed invertebrate species occurring in the vicinity of Hemi and to help determine the requirement for a field survey.

4.1. Previous records

A review was conducted of terrestrial invertebrate species records using the databases of the Western Australian Museum (WAM), the Atlas of Living Australia, and Bennelongia Environmental Consultants, in conjunction with published research papers and environmental reports. The data were compiled for a search area of 100 by 100 km centred around Hemi (defined by the decimal coordinates -20.411[N], 117.980[W] and -21.310[S], 118.879[E]; Figure 3).

Using species records as a proxy for sampling coverage, the effort to collect terrestrial invertebrates (particularly targeting SRE Groups) is concentrated in the south-eastern and eastern sides of the search area (Figure 3).

Three hundred and sixty individuals of at least 50 species belonging to SRE Groups were recovered in the desktop search area (Appendix 1), including nine species of mygalomorph spiders, two species of araneomorph spiders, 13 species of pseudoscorpions, one species of harvestmen (order Opiliones), three species of scorpions, two species of centipedes, one species of millipede, 17 species of isopods, and two species of land snail (Bennelongia 2021).

Nine different taxa were identified to higher order only because the specimens collected were of a life stage (juvenile) or sex (usually female) that does not allow species-level identification. Some of these records might belong to other species already recorded (e.g. *Tyrannochthonius* sp.). In contrast, the records designated 'Opiliones sp.' must represent at least one additional species because no other species from that order were recorded in the search area. The same is true for *Austrohorus* sp. and *Beierolpium* sp. of the pseudoscorpion family Olpiidae; Scutigeromorpha sp.; *Cryptops* sp; and *Laevophiloscia* sp.

4.1.1. Listed Invertebrate Species and Communities in the Search Area

There are no PECs or TECs in the vicinity of the search area that have been listed on the basis of their SRE fauna. There are, however, nine Priority species, including two dragonflies (*Antipodogomphus hodgkini* and *Notosticta pilbara*), six undescribed millipedes of the genus *Antichiropus*, and a single land snail (*Dupucharopa millestriata*). The type locality of both dragonflies is Millstream Spring, but *Antipodogomphus hodgkini* has also been recorded north of Mardie and along the De Grey River, resulting in a linear range of 363 km (Pinder *et al.* 2010). *Notosticta pilbara* is known from near Onslow through to Millstream Chichester National Park (linear range of 232 km; (ALA 2023; Pinder *et al.* 2010)).

There are currently no records of these species inside the desktop search area, but Hemi does occur within the inferred range of both dragonflies. The land snail is known only from Depuch Island, east-northeast of Roebourne (outside the search area; (Solem 1984)) and is unlikely to occur at Hemi. The six undescribed terrestrial millipedes are of the diverse and exclusively Western Australian genus *Antichiropus,* all of which are listed as Priority 1 species and have been recorded in the central and eastern Pilbara. The species of *Antichiropus* recorded at Roy Hill, Mining Area C, Cloudbreak, and Mt

Bruce (Karijini National Park) are considered unlikely to occur within the Hemi mining area, as this would be a significant range extension. *Antichiropus* sp. DIP005 has been recorded approximately 78 km southeast of Hemi, and possibly occur around the Project's area.

4.2. Likelihood of SRE species

Based on the desktop review, the SRE Groups most likely to be found around the Hemi mining area are:

- Araneomorph spiders of the genus *Karaops* (family Selenopidae).
- Mygalomorph spiders.
- Pseudoscorpions.
- Isopods of the genus *Buddelundia*.

Individuals from several other SRE Groups have been recorded but the Groups above are more likely to be found within the Hemi mining area given their habitat requirements.

Araneomorph spiders

Two species of wall crab spiders (or 'flatties') from the genus *Karaops* have been recorded in the search area. This genus currently contains 37 described species throughout Australia, and potentially many undescribed species (Crews and Harvey 2011; Crews 2013). The closest record, identified to the undescribed taxon *Karaops* `*aurizon*` occurred approximately 23 km northeast of the Hemi development envelope. The described species *K. kariyarra* has been recorded in the Wodgina area, 50km southeast of the Project are), as well as approximately 11 km northeast of the Hemi area. It is possible that both species occur in the Hemi area, but of the two, *K. kariyarra* is the most likely to occur. Whereas *K.* `*aurizon*` is still undescribed and therefore considered a Potential SRE, we here consider *K. kariyarra* a Confirmed SRE as it known from two records separated less than 100 km apart and appears to have a restricted distribution in the northern Pilbara (Crews 2013).

Mygalomorph spiders

Nine species of mygalomorph spiders from three families have been recorded in the search area.

Open-holed trapdoor spiders (family Anamidae)

The family Anamidae was represented by at least six species in two genera in the search area. The genus *Aname* contains a very large and diverse complex of described and undescribed species, and whereas the Pilbara fauna is relatively well studied (Castalanelli *et al.* 2020; Rix *et al.* 2021), there are still many recognised but undescribed species in the area. *Aname* `MYG372` and *Aname* `MYG682` are both only known from single locations, approximately 31 km and 25 km, respectively, southeast of the Hemi area. They are both considered Potential SREs that are moderately likely to occur in the Hemi area. However, out of these two species, only *A.* `MYG372` has received genetic validation of its status as a separate species to any currently described species of the genus (Rix *et al.* 2021).

Two other described species of *Aname* have been recorded in the search area: *A. mellosa* and *A. mcalpinei*. *A. mellosa* was treated as a species complex until recently, when Castalanelli *et al.* (2020) described 11 new species of the genus from arid WA and Rix *et al.* (2021) investigated the genus genetically, identifying 17 different species belonging to the '*mellosa* group'. The records of *A. mellosa* from the search area are now considered to be the true *A. mellosa*, a relatively widespread species in the Pilbara. Meanwhile, *A. mcalpinei* is considered a Confirmed SRE.

The genus *Kwonkan* is represented by nine described species from Western Australia and South Australia, but numerous other undescribed species are known from museum collections, and molecular data suggest a highly diverse fauna (Castalanelli *et al.* 2014; Harvey *et al.* 2018). Two undescribed morphospecies of this genus were identified from the search area, both considered Potential SREs known from a single location each: *K.* `MYG089` is only known from a site approximately 48 km north-northwest of the Hemi area, whereas *K.* `MYG209` is only known from a site approximately 31 km north of the Hemi area.

Brush-footed trapdoor spiders (family Barychelidae)
Spiders of the family Barychelidae are among the most cryptic of the trapdoor spiders (Raven 1994), possessing incredibly well camouflaged burrow doors and unique foot pads that appear iridescent under the microscope. The family includes many undescribed species in Western Australia, and even the described species are often known from one or very few specimens, often from a single location. Two species of brush-footed trapdoor spiders are known from the search area, *Aurecocrypta* sp. B01 and *Synothele* sp. B02. Whereas the first species is known from two locations 45 km apart, the second species is known from a single location. They are both considered Potential SREs that might occur inside the Hemi area, as they both occur in a location approximately 39 km to the southeast of the Hemi mining area.

Spiny trapdoor spiders (family Idiopidae)
The Idiopidae is a highly diverse group of trapdoor spiders, famous for their longevity and the conservation significance of some species (Rix *et al.* 2017). One species of this family has been recorded in the search area, *Idiosoma* `MYG084`. This species is known from three locations approximately 160 km apart, including Dixon Island, a site 5km north of Lake Poongkaliyarra, and another site 57 km south-southeast of Port Hedland. This last location is approximately 30 km no of the Hemi, so this species is likely to occur in the Hemi area; however, given the minimum extent of its known linear range, it is considered unlikely to be a true SRE (i.e. Unlikely SRE category).

Pseudoscorpions
Epigean pseudoscorpion species are generally considered to have widespread distributions, and it has been suggested that few species are SREs (Harvey 2002). Notably, however, some species are restricted to specialist habitats including granite outcrops, and accordingly have limited distributions (Harvey 2010, 2012; Harvey 2018; Harvey *et al.* 2015a). Phoresy (dispersal by means of attachment to a host organism) has been documented for many families of pseudoscorpion (Jhasser Martínez *et al.* 2018a; Lira and Tizo-Pedroso 2017; Muchmore 1972), which might allow movement outside of restricted habitats. However, pseudoscorpion taxonomy is poorly resolved, largely due to high diversity, and thus accurate range determination can be difficult. At least 13 species of pseudoscorpions have been recorded in the search area, representing eight genera that are contained in five different families.

Family Atemnidae
One species of the family Atemnidae is known from the search area. *Oratemnus* `PSE060` has been recorded in two sites, one 80 km south-southeast of Port Hedland and another one further south, 170 km south-southeast of Port Hedland. The first location is approximately 23 km east-southeast of Hemi, so this species is likely to occur in the Hemi area; however, given its minimum known linear range of approximately 93 km, it is considered unlikely to be a true SRE (i.e. Unlikely SRE category).

Family Chernetidae
This cosmopolitan family is very diverse but poorly defined taxonomically. Two species from the family Chernetidae have been recorded in the Study Area. *Austrochernes* `sp. nov. 001` has only been recorded in two locations, both within the abandoned pit of the now permanently closed Mount Dove mine. Nothing is known about the current distribution of this species, but it is expected to occur elsewhere within the Hemi development envelope. It is here considered a Potential SRE. Meanwhile, *Sundochernes* `PSE021` is known from a location approximately 14 km east of the Hemi area, as well as Turee Creek Station, 254 km south-southwest in the Hamersley range. This species is considered widespread.

Family Garypidae
Five species of the genus *Synsphyronus* have been recorded in the search area. Whereas *Synsphyronus* `PSE094` (`long chelal hand`) is a widespread species, the other four species are Potential SREs. *Synsphyronus* `PSE008` and *S.* sp. B01 are known from a single location each. Meanwhile, *Synsphyronus* `PSE128` and *S.* `PSE012` have minimum known linear ranges of 25 km and 42 km, respectively. The five

species of *Synsphyronus* have at least one record that is less than 50 km from Hemi and are therefore considered moderately likely to occur within the project's development envelope.

Family Olpiidae
Several juveniles from the family Olpiidae have been recorded in the search area and assigned to the genera *Beierolpium* and *Austrohorus*. Individuals of *Beierolpium* sp. have been recorded inside and outside of the Hemi development envelope, whereas individuals identified as *Austrohorus* sp. have been recorded approximately 34 km southeast of Hemi. An SRE assessment of these records is not possible, given the higher order identification. Meanwhile, the species *Indolpium* `long chelal hand` and *Indolpium* sp. B01 are both considered widespread and likely to occur in the Hemi area.

Family Chthoniidae
The species *Tyrannochthonius aridus* was considered widespread in the Pilbara, but recent studies suggest these records represented a species complex. Currently, a new species, identified as *Tyrannochthonius* `sp. nov. near *aridus*` by the WAM, is known from Mount Dove (within Hemi's development envelope), as well as from Abydos, approximately 71 km east-southeast. This species is considered unlikely to be a true SRE (i.e. Unlikely SRE category).

Scorpions
Four species of potential SRE scorpions from the family Urodacidae (burrowing scorpions) were recorded in the search area. The framework for formal scorpion identification in Australia needs revision (Luna-Ramirez *et al.* 2017), so determining the distribution of morphospecies of urodacids requires comparison with a range of specimens from the region. The genus *Urodacus*, to which all samples in the search area were identified, is endemic to Australia. There are currently 20 described species, but several undescribed species are known from the WAM collection. Some of the described species are widespread, but even in these species the populations are restricted and only occupy small and patchy areas of the available habitat. At the same time, other *Urodacus* species are Confirmed SREs; therefore, undescribed *Urodacus* taxa are usually considered Potential SREs.

Urodacus ?butleri was recorded approximately 50 km southeast of the Hemi area. *Urodacus butleri* is a widespread species found from Barrow Island to the Chichester Range, and if the specimen detected in the search area is in fact that species (currently recorded as "cf."), it is not an SRE. *Urodacus* `pilbara 2` (also recorded as *Urodacus* `SCO035`) is known to occur from near Whim Creek Hotel to a location 78 km east of Meentheena Outcamp; therefore, it constitutes an undescribed but clearly widespread species that is very likely to occur in the Hemi area. Meanwhile, *Urodacus* `sp. 7` (also recorded as *Urodacus* `pilbara 7`) has been recorded near the Whim Creek Hotel, approximately 42 km northwest of Hemi, as well as at Marda Pool, approximately 200 km to the west. This undescribed species is treated as a highly Unlikely Potential SRE.

Centipedes
Records of centipedes identifiable only to the levels of genus (*Cryptops* sp.) or order (Scolopendrida sp. and Scutigeromorpha sp.) were detected approximately 33 km southeast of Hemi. Whereas centipedes of the order Scutigeromorpha are normally not considered SREs, the genus *Cryptops* (in the order Scolopendrida) is known to contain SRE species. However, the higher order identifications do not currently allow conclusive SRE assessments.

Millipedes
Only one species of millipede, *Antichiropus* `DIP033, wodgina`, was recorded in the search area. This diverse genus has been extensively studied recently (Car and Harvey 2014; Car *et al.* 2019; Car *et al.* 2013), and the vast majority of species are now considered Confirmed SREs. *Antichiropus* `DIP033, wodgina` is only known from three locations 6km apart, near Wodgina Mine. This species is therefore a Potential SRE, previously recorded 12km south of the Hemi mining area and hence likely to occur within its development envelope.

Isopods

In Australia, the order Isopoda contains a largely undescribed and diverse group of terrestrial epigean crustaceans (suborder Oniscidae) that, due to poor dispersal capabilities and specific habitat preferences, are often SREs (Judd 2004; Judd and Horwitz 2003; Judd and Tati 2011). Three genera of these isopods have been recorded in the search area.

The species ?*Hybodillo* sp. B01 is known from three locations approximately 50 km apart, with a midpoint about 38 km southeast of Hemi. Meanwhile, *Acanthodillo* sp. B01 is known from four locations approximately 55 km apart, also from a midpoint about 38 km southeast of Hemi. These two species are Potential SREs, and both are likely to occur in the Hemi's development envelope. *Spherillo wodgina* is known from locations 53 km apart, from Port Hedland to the Wodgina area, and it is therefore considered a Potential SRE that is likely to occur in Hemi, given that it has been recorded in sites 14 km east of it.

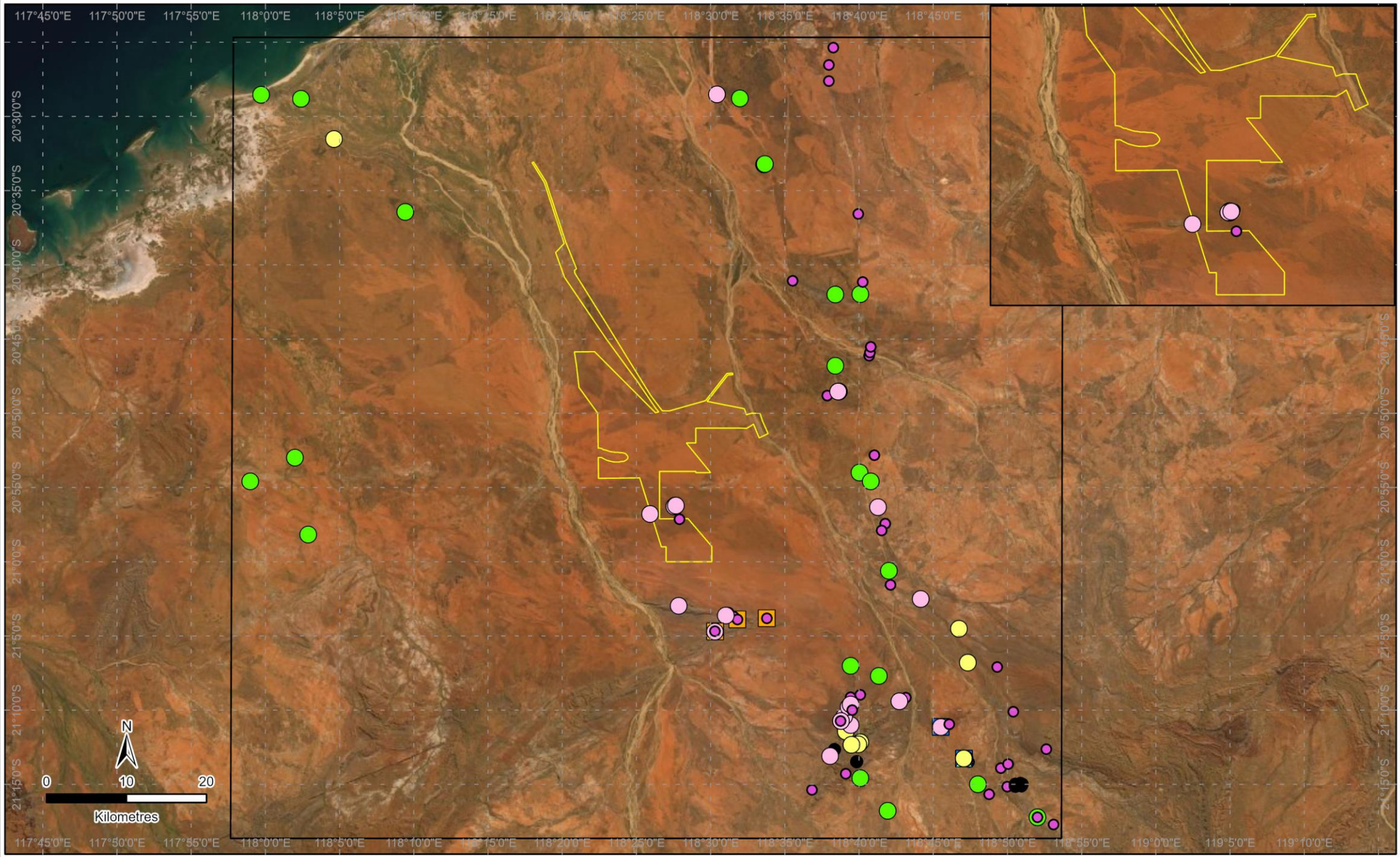
At least 13 species of the genus *Buddelundia* were recorded, although their SRE statuses vary greatly. The species *Buddelundia* `sp. 10`, *Buddelundia* `sp. 13`, *Buddelundia* `sp. 14`, *Buddelundia* `sp. 17`, *Buddelundia* `sp. 18`, and *Buddelundia* `sp. 19` are all Unlikely SREs or Widespread. Only *B*. `sp. 10` and *B*. `sp. 17` have been recorded within Hemi's development envelope, but *B*. `sp. 13`, *B*. `sp. 14`, *B*. `sp. 19`, and *B*. `sp. 21` are also very likely to occur there.

Meanwhile, *Buddelundia* `sp. 14re`, despite a possible future alignment with `sp. 14`, is currently only known from one location 14 km east of Hemi and is currently considered a Potential SRE likely to occur within the Hemi development envelope. *Buddelundia* `sp. 21` is known from around Mount Dove mine (within the development envelope of Hemi) and the Wodgina airport area, approximately 38 km apart, and is a Potential SRE. Similarly, *Buddelundia* `sp. 31` is known from around the Wodgina airport area, a site 15 km east of Hemi, and the Abydos area; these sites are approximately 50 km apart, so *B*. `sp. 31` is a Potential SRE. *Buddelundia* `sp. 36` is known from sites 12 and 35 km south of Hemi, and it is also a Potential SRE likely to occur in Hemi. Finally, *Buddelundia* sp. B11 and *Buddelundia* sp. B18 are Potential SREs known from locations approximately 38-39 km SE of Hemi.

In the family Philosciidae, the genus *Laevophiloscia* has been recorded 27 km south-southeast of Hemi, but the high-level identification does not allow an SRE assessment of those records currently.

Land snails (Gastropoda)

The family Camaenidae constitutes the dominant group of land snails in northern Australia (Taylor *et al.* 2015), and two species of this family were recorded in the search area. *Quistrachia turneri* was recorded 45 km southeast of the Hemi area. Originally considered an SRE, a genetic study of the genus extended the known distribution of *Q. turneri* to near Karratha (O'Neill *et al.* 2014), resulting in the assessment as a Widespread species here. Meanwhile, an undescribed species, identified as *Gen. nov. cf. `Z` n.sp.* in the WAM database, is known from locations 31 km south-southeast of Hemi, in the Abydos area, and 22 km north of Skull Springs, resulting in a minimum linear known range of approximately 250 km, indicative of a Widespread (not SRE) species.



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Date: 7/09/2022

Legend

- Development Envelope
- Araneae
- Isopoda
- Opiliones
- Millipedes
- Pseudoscorpiones
- Centepedes
- Scorpiones
- Centepedes
- Land snails
- Symphyla
- Search area 10,000 km2

Figure 3. Records of SRE groups in the search area surrounding the Project.

Inset shows those records close to the Project.

5. FIELD SURVEY

5.1. Methods

A two-season survey targeting invertebrates belonging to the SRE Groups was carried out from 23 to 29 November 2021 (Round 1; conducted by Huon Clark, Bruno Buzzato, Vitor Marques, and Sam Chidgzey) and from 4 – 11 April 2022 (Round 2; conducted by Huon Clark, Will Fleming, Monique Moroney, and Kevin Sagastume-Espinoza). The aim of the survey was to collect species from recognised SRE Groups from representative habitat types in the vicinity of the Hemi area and immediate surrounds, focussing on those species recorded during the previous desktop assessment (Bennelongia 2021).

5.1.1. Site Selection

Prior to the survey, aerial imagery of the Study Area was examined and prospective areas for SREs were identified. Prospective habitats for SREs in the Pilbara include south-facing slopes, gorges, gullies, drainage lines, and isolated habitats. Field-based observations and categorisations of sites are further used to characterise the extent of habitat types during subsequent mapping (section 5.1.3). A total of 18 sites (10 reference and 8 impact) selected prior to fieldwork were sampled at the Hemi mining area (Figure 4; site details and photos appear in Appendices 2-4). Various active search methods were employed at each site according to habitat, knowledge of the biology of certain taxa, and visual observations of burrows or other tell-tale signs of target species.

5.1.2. Sampling techniques

Sampling techniques followed published guidelines (EPA 2016b). At least one hour was spent on each site with two team members (two sampling hours/site) conducting the different techniques depending on the site type. Two sampling techniques were used: hand foraging and wet trapping.

Hand foraging consisted of actively searching for taxa belonging to SRE Groups in their preferred habitats making basic assumptions about the target species' (or Group's) biology. Hand foraging techniques included:

- Burrow excavation: digging up a burrowing mygalomorph spider or *Urodacus* scorpion. The burrow entrance was identified visually, often after leaf blowing. A loose zip tie was inserted into the burrow to mark the entrance. Soil around the burrow was removed using trowels, spoons, and kitchen knives until the end of the burrow was revealed, determined by the inability to insert the zip tie further. If the animal had not exited the burrow at this time, the burrow was gently lifted from beneath to stimulate movement. As the animal exited the burrow it was collected and immediately immersed in ethanol in a vial.
- Log flipping and raking: turning over and breaking apart logs and dead wood in search of isopods, myriapods, and pseudoscorpions. Raking also helps to uncover camouflaged mygalomorph spider burrows or to uncover buried land snails that may aestivate below the surface.
- Rock flipping: turning over rocks and other debris in search of harvestmen, centipedes, and isopods. Rocks were returned to their natural position when possible.
- Leaf litter sieving: sieving leaf litter to target litter- and soil-dwelling species. Leaf litter sieving also uncovers small-bodied SRE species (such as pseudoscorpions, millipedes, and land snails). Two leaf litter samples per site were collected and transported in cloth bags to the laboratory and placed in Tullgren funnels to collect litter-dwelling invertebrates.
- Leaf blowing: hand-held leaf blowers were used to remove leaf litter and reveal mygalomorph spider burrows covered by litter or otherwise difficult to identify unaided. If found, burrows were examined; burrows likely to house a mygalomorph spider were then excavated.

- Bark peeling and tree digging: removing pieces of bark from trees with smooth and exfoliating bark for inspection, and removing dirt from the bases of trees to search for SRE taxa. These techniques were only applied at sites containing trees (i.e. not only shrubs or spinifex).
- Spinifex hummocks searches: where possible, spinifex hummocks were inspected and ripped apart in search of species belonging to SRE Groups inhabiting under the plants shade or root system.
- Night searching: with the aid of ultraviolet torches, selected sites were visited at night in search of scorpions, which fluoresce under ultraviolet light and are thereby easily detected.

Wet trapping was also employed to collect wandering SREs that may have evaded hand foraging techniques. Three pitfall traps were left at each trapping site for approximately 40 d (Appendix 2). Each trap consisted of a 500-ml polycarbonate tube with a 70-mm aperture filled with 300 ml preservation fluid (30% propylene glycol; 70% ethanol) buried within 1 cm of the aperture. A 150 x 150-mm sheet of mesh (25 x 25-mm holes) was placed over the top of the tube to prevent vertebrates from entering while allowing SRE species, which tend to be small, to enter (Appendix 5). A 30-cm lid on brackets was installed above each trap to provide shelter and to prevent the traps from filling with rain. Drift fences, which tend to channel vertebrates into traps, were not used.

5.1.3. Habitat Assessment and Mapping

During the survey, habitat details of each site were collected. Habitat details documented were:

- Habitat type
- Landform
- Slope
- Shade
- Whether moisture was evident
- Soil type
- Soil distribution
- The type of rock outcrop, if present
- Rock size
- The amount of leaf litter
- Time since last fire
- Evidence of disturbance

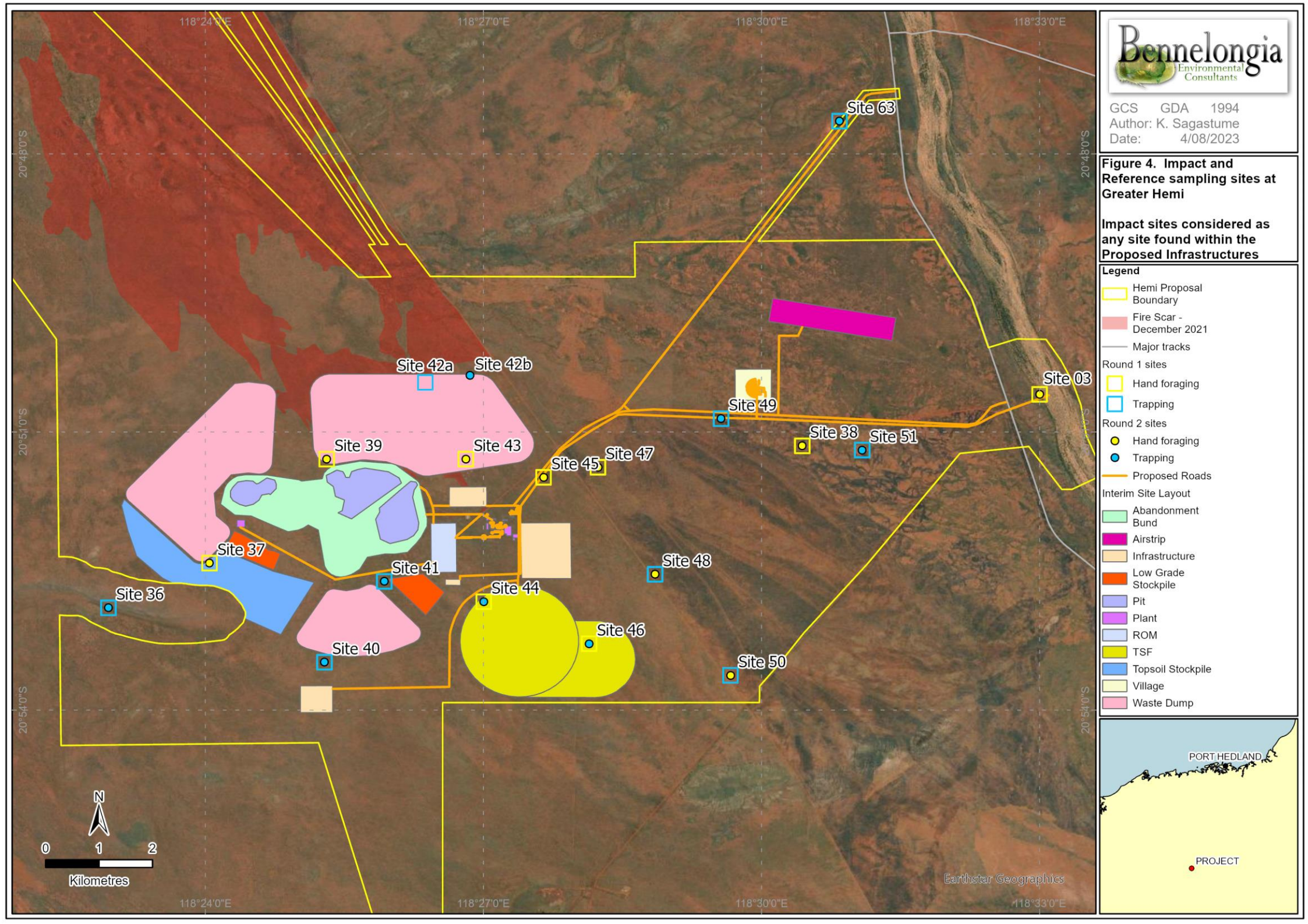
Following the survey, boundaries between habitat types were drawn in ArcGIS Pro 2.9 over aerial imagery and vegetation system associations identified as occurring in the Project area (Umwelt-Australia 2022). Habitat continuous with a sample site was assigned the same category as that sample site; boundaries were drawn based on changes in vegetation, elevation, and/or soil type identified in aerial imagery and informed by ground truthing performed by the team on-site during the survey.

5.1.4. Preservation and identification techniques

Specimens collected in the field through hand foraging techniques were placed in 100% ethanol. Specimens collected through all foraging techniques were transported to Bennelongia's laboratory for identification. Specimens were first sorted and separated from by-catch. When a specimen belonging to an SRE Group was found during this process, it was transferred to a labelled vial of 100% ethanol vial for further identification.

Several team members were involved in the identification process (Table 1), each on their own area of expertise and following any available literature that might aid the process. Leica stereomicroscopes were used for assisting the identification process. Thirty animals belonging to 17 species were lodged at WAM.

Specimens were identified to described species where possible using available keys and species descriptions. In many cases among SRE Groups, species descriptions and taxonomic frameworks are lacking. In these cases, specimens may be identified morphologically and/or genomically as belonging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Author: K. Sagastume
Date: 4/08/2023
Figure 4. Impact and Reference sampling sites at Greater Hemi
Impact sites considered as any site found within the Proposed Infrastructures
Legend
Hemi Proposal Boundary
Fire Scar - December 2021
Major tracks
Round 1 sites
Hand foraging
Trapping
Round 2 sites
Hand foraging
Trapping
Proposed Roads
Interim Site Layout
Abandonment Bund
Airstrip
Infrastructure
Low Grade Stockpile
Pit
Plant
ROM
TSF
Topsoil Stockpile
Village
Waste Dump
Site 63
Site 42a
Site 42b
Site 49
Site 03
Site 38
Site 51
Site 39
Site 43
Site 45
Site 47
Site 37
Site 41
Site 48
Site 36
Site 44
Site 46
Site 40
Site 50
118°24'0"E
118°27'0"E
118°30'0"E
118°33'0"E
20°48'0"S
20°51'0"S
20°54'0"S
N
0 1 2
Kilometres
Earthstar Geographics
PORT HEDLAND
PROJECT

to discrete species that await formal description; such species are usually assigned placeholder codes (e.g. `B01`). When the taxonomic framework is exceptionally poor and/or the specimen in question is damaged, juvenile, or of the nondiagnostic sex, the specimen is classified to the lowest level possible. These specimens often carry the miscellaneous designation "sp." Where possible, such specimens are analysed genetically to improve taxonomic resolution.

Table 1. Details of personnel involved in the Hemi Mining area surveys.

Name	Contribution	Role	Taxonomic group
Stuart Halse	Report revision	Director	
Kevin Sagastume-Espinoza	Field survey; report writing, morphological id's	Principal Biologist	Spiders and scorpions
Huon Clark	Field survey; morphological id's	Principal Biologist	Isopods and harvestmen
Bruno Buzatto	Field survey; desktop review	Associate	
Melanie Fulcher	Morphological id's, DNA interpretations	Senior Biologist	Centipedes
Jane McRae	Morphological id's	Senior Taxonomist	Pseudoscorpions
Heather McLetchie	Morphological id's, DNA extraction	Biologist	
Vitor Marques	Field survey; GIS	Biologist	
Monique Moroney	Field survey	Biologist	
Will Fleming	Field survey	Biologist	

5.1.5. Molecular methods

During the identification process, unidentifiable specimens (e.g. juvenile or damaged specimens) were flagged for DNA sequencing. Twenty-seven animals from the Hemi mining area and four additional reference animals from the surrounding tenements were identified and subsequently sequenced using this method.

For all samples, DNA was extracted using a Qiagen DNeasy Blood & Tissue kit (Qiagen 2006). For smaller animals such as pseudoscorpions, legs, and other body parts (e.g. sections of the abdomen) were used for DNA extraction. For larger animals, and where possible, internal tissue was collected from the legs. Elute volumes varied from 25 µL to 100 µL, and were dependent on the age, condition, and quantity of material available.

Primer combinations used for PCR amplifications were: LCO1490:HCO2198, C1J1718:HCO2198, and LCO1490:HCOoutout, targeting the COI region of the mitochondrial genome (Folmer *et al.* 1994); (Schwendinger and Giribet 2005). PCR products were sequenced using dual-direction Sanger sequencing carried out by the Australian Genome Research Facility (AGRF). The returned sequences were edited and aligned manually in Geneious (version 2022.2.2; Kearse *et al.* (2012). Geneious was also used to calculate neighbour-joining phylogenetic trees, 1,000 bootstrap permutations.

Tamura-Nei genetic distances were measured as uncorrected *p*-distances (total percentage of nucleotide differences between squares). Sequences on GenBank and in grey literature were included in the phylogenetic analysis to provide a framework for assessing intra- and interspecific variation, as well as to examine levels of differentiation among individuals within described species across their geographic ranges.

5.2. Survey timing and limitations

Species of many SRE Groups are most active and, therefore, most likely to be collected during and immediately following substantial rainfall. Although the survey was completed during the optimal time recommended for the Pilbara region (November to April), no rain fell on the sites during either round of the survey. The weather station at Port Hedland shows no rainfall recorded before Round 1 of fieldwork survey (0 mm for November 2021, late in the dry season) and 3.4 mm of rain during the time

the wet traps were active for this round. The same station recorded limited rain (21.8 mm for March 2022) immediately prior to Round 2 of the fieldwork survey (early April 2022), and 29.6 mm of rain during the time the wet traps were active for this round. Fires in December 2021 (Figure 1; Appendix 3) destroyed five traps, at sites 41, 42, 48, and 51. Following the December 2021 fire, site 42 was relocated to a nearby location with the same habitat type and assigned a new site code, site 69.

Layouts of the proposed development were not available prior to either sampling round. Sites were therefore selected based on apparent habitats, as inferred from satellite images. None of the sites selected from surveys transpired to coincide with proposed pit outlines, although several coincide with proposed infrastructure and waste dump areas (Figure 4). Regardless, based on the habitat characterisation of the area (Figure 5), it is not expected that new or restricted species are likely to occur directly over the proposed pit areas.

5.3. Habitat

Five main habitats were identified and sampled, covering an area of 22,196.51 hectares (estimated via satellite image and projected habitat mapping). Characteristics of the habitats observed and sampled in the field were relatively consistent with what was identified in the desktop review. The habitat types show close associations with specific vegetation types and systems (see section 2.3), many of which are suitable for supporting various SRE Groups. Most sites sampled were attributed to the sandplain habitat (Table 2), which defines over 65% of the sampled area (Figure 5); three sites were sampled in Drainage sandplain habitat; and three sites were selected for their respective occurrence on the least abundant habitat types, so that each habitat was represented by at least one sample site.

The distributions of vegetation system associations (VSAs) defined previously (Umwelt-Australia 2022); section 2.3) almost entirely align with the distributions of habitats characterised during the field surveys. Most of the Project area is composed of sand plains (Figure 5) covered by hummock grasslands with shrub steppes and soft spinifex (Umwelt-Australia 2022). A small section (0.86%) of the survey area is composed of creek drainage habitat, which host more diverse floras. This habitat was typically dominated by river gum woodlands with tall shrublands or acacias, often associated with fringing communities of eucalypts with grasses or spinifex (Umwelt-Australia 2022). The remaining habitat types (outcrop/stony hills, and drainage sandplain) together represent 28.48% of the study area and have various associations of spinifex and shrubs, with occasional *Acacia* spp. and ephemerals. The last habitat, the sand dune habitat, is probably the most notable. Typically the sand dunes are dominated by *Acacia* spp. overlying tussock rather than hummock grasses, and appear to host assemblages of shrubs unique to the Project area (Umwelt-Australia 2022). It is important to mention that sand dune habitat is not found inside the development envelope and has rather been excluded intentionally given its ecological significance.

Based on the five habitat types and the vegetation associations recognised by Umwelt-Australia (2022), the Hemi mining area appears to host few habitats suitable for SRE Groups. Sandplain soils are generally ideal for burrowing groups such as mygalomorph spiders and urodacid scorpions, and although they might provide suitable habitat for some vegetation types such as shrubs and occasional wooded areas, they tend to hold low diversity values when it comes to SRE Groups. On the other hand, creek drainage, along with the higher number of vegetation types they host, represent habitats capable of holding rich SRE diversity values. Drainage lines provide an open microhabitat with almost no vegetation cover on the riverbed, while at the same time allowing for a covered microhabitat within the riverbank shade and leaf litter ideal for several SRE Groups such as millipedes, slaters, and land snails.

5.4. Survey results

In total, 685 specimens representing at least 28 species belonging to SRE Groups were collected during the two rounds (November 2021 and April 2022) of the field survey at the Hemi mining area (Table 3). This number is low to moderate compared to the 50 species recovered in the desktop review. A small

number of specimens were immature or belonged to the nondiagnostic sex, so could not be identified to a sufficient level to align them with other recorded species; such specimens were therefore not considered distinct taxa.

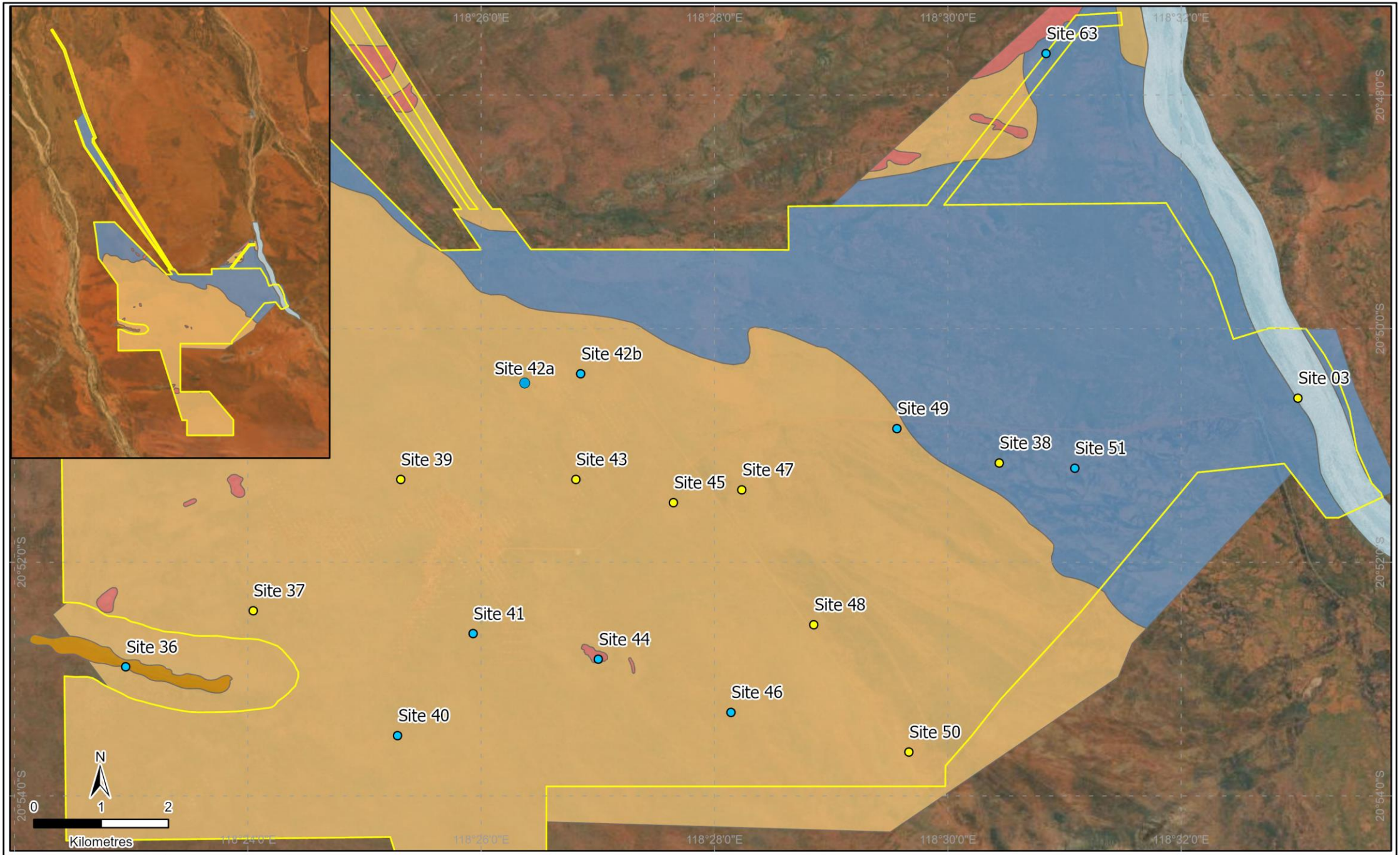
One species of mygalomorph spider was collected in the survey, a low number when compared with the nine species recovered in the desktop review (Appendix 1). The desktop assessment reported the confirmed SRE mygalomorph species *Aname mcalpinei* in the search area just outside (18 km south-southwest) of Port Hedland (Castalanelli *et al.* 2020). This species was not recorded at Hemi during the two rounds of sampling. Existing records suggest Aname *mcalpine* occurs in plains hosting low mulga woodlands, making it unlikely that the species is found within the Hemi mining area. The survey also recorded one species of harvestman, at least eleven different species of pseudoscorpions, three species of scorpions, at least five species of centipede (Chilopoda), two species of polyxenid millipede (Diplopoda), and at least five species of slaters (Isopoda; Table 3).

Overall, most species collected in the survey are known to be widespread or are considered unlikely to have restricted ranges. Only six species collected – the mygalomorph *Synothele* `BMYG195`, the harvestman *Dampetrus* `BOP017`, and the pseudoscorpions *Afrostenophorus* `BPS436`, *Austrohorus* `BPS411`, and *Oratemnus* `BPS437`, and the isopod *Laevophiloscia* `BIS546`– are considered Potential SRE species (Table 3).

Table 2. Summary of habitats sampled for SRE invertebrates at Hemi between both sampling rounds.

Habitat	Vegetation	Sun Exposure	Soil/geology	Extended area (ha)	Extended area %	Area within DE (ha)	Percentage represented	Survey sites
Sand plain	Spinifex dominated landscape with *Acacia* and *Eucalyptus* trees	Very high, some protection around bushes and trees (variable density amongst sites)	Red sandy clay topsoil	17,439.83	65.09%	15,781.94	71.10%	Sites 37, 39, 40, 41, 43, 45, 46, 47, 48, 49, 50, 42*
Drainage sandplain	*Acacia* shrubland over scattered spinifex	Very high, some protection under trees and in litter	Red clay to clayey sand	8,106.35	30.25%	6,031.38	27.17%	Site 38, 51, 63
Outcrop/stony hills	*Acacia* shrubland	High, some protection under trees	Red clay	378.63	1.41%	201.90	0.91%	Site 44
Sand dunes	Spinifex dominated, with *Acacia* and salt bushes	Moderate, cover provided by bush, under spinifex and leaf litter	Red sand to clayey sand	64.84**	0.24%	NA**	NA**	Site 36
Creek drainage	Associations of *Eucalyptus* and *Acacia* trees	High, some protection under trees	Brown sand	804.59	3.00%	181.28	0.82%	Site 03
TOTAL				**26,794.23**	**100%**	**22,196.51**	**100%**	

*Site 42 was burned during round 1 and shifted slightly to a similar habitat close by for round 2; identified here as 42a and 42b, respectively, they represent a single sampling site, i.e., 18 sites per sampling round.
**Sand dunes habitat have been excluded from the development envelope.



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Author: K. Sagastume
Date: 4/08/2023

Legend

Hemi Development Envelope

Sampling type
- Hand foraging
- Trapping

SRE Habitat
- Creek drainage
- Drainage sandplain
- Outcrop/Stony hills
- Sand dune
- Sandplain

Figure 5. Sampling sites mapped over SRE habitats.

Inset shows full extent of the Development Envelope.

Table 3. Species from SRE Groups collected during the two rounds of field survey, November 2021 and April 2022.
Asterisks denote higher order identifications (may align with other taxa). Species representing Potential SREs are highlighted in orange. †Lodged at WAM.

Lowest Identification	Site 03		Site 36		Site 37		Site 38		Site 39		Site 40		Site 41		Site 42a*		Site 43		Site 44		Site 45		Site 46		Site 47		Site 48		Site 49		Site 50		Site 51		Site 63		Site 42b*		Total	Comments
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2		
Araneae: Mygalomorphae																																						
Synothele `BMYG195` †						1																															1	Undescribed species recognised only from molecular markers. It matches genetically with specimens collected from Toweranna. Considered an **Unlikely Potential SRE**.
Opiliones																																						
Dampetrus `BOP017` †															2																						2	Undescribed species which has been collected also from Mt. Berghaus and Toweranna. Linear range extends up to 65 km and therefore considered here an **Unlikely Potential SRE**.
Pseudoscorpiones																																						
Afrosternophorus `BPS436` †																																	1				1	Currently known only for two localities at the Mallina Gold Project: Greater Hemi and Mt. Berghaus. Considered an **Unlikely Potential SRE.**
Afrosternophorus sp.*																							2															2	Likely to be the above species.
Austrohorus `BPS411` †			1																																		1	Known from a single specimen, but the genus is widely distributed in the Pilbara. Considered here an **Unlikely Potential SRE**.
Beierolpium 8/2 `BPS417` †				1															1																			2	Recorded across the four tenements for the Mallina Gold Project. Not an SRE.
Beierolpium 8/4 `BPS407` †													4	5				1	1				4												17			32	Also recorded outside of the Hemi area. Not an SRE.

Lowest Identification	Site 03		Site 36		Site 37		Site 38		Site 39		Site 40		Site 41		Site 42a*		Site 43		Site 44		Site 45		Site 46		Site 47		Site 48		Site 49		Site 50		Site 51		Site 63		Site 42b*		Total	Comments
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2		
Beierolpium 8/4 `BPS413` †											2			5										14					3				2			3	28	Known from seven different localities (two of them outside of Hemi) and in moderately high numbers. Not an SRE.
Beierolpium sp.*				1									4	5										1									2	4		2	19	Likely to be the above species.
Indolpium `BPS404` †			4	1	3			1	2		47		3	2	3						2		2	3	1				35				14						123	Recorded in high densities both inside and outside of the Hemi mining area. Not an SRE
Indolpium `BPS406` †	2																																					2	Recorded from outside of the Hemi mining area in high densities. Not an SRE.
Indolpium `BPS408` †																											4												5	Has also been recorded at Withnell and Toweranna. Not an SRE.
Indolpium sp.*			2											5										1						5								18	Likely to be one of the above species.
Oratemnus `BPS437` †		3																																				3	Recorded only from paperbark peel at the Turner River sampling site. Considered an **Unlikely Potential SRE.**
Xenolpium `BPS409` †																														1								1	Also recorded at Withnell and Toweranna. Unlikely to be an SRE.
Synsphyronus xynus											2	1	2										3						3	4	1							16	Molecular data matched to *Synsphyronus* `PSE093` codes on GenBank, a molecular species which was recently described by Cullen and Harvey (2021) as *S. xynus*. The species is considered widespread.
Scorpiones																																							
Lychas `BSCO048` (cf. harveyi/JPP)				13	1	1							3				5		3				1					1				8						30	Molecular data matched the specimens from Hemi to one previously recorded from Broome. Widespread species.

Lowest Identification	Site 03		Site 36		Site 37		Site 38		Site 39		Site 40		Site 41		Site 42a*		Site 43		Site 44		Site 45		Site 46		Site 47		Site 48		Site 49		Site 50		Site 51		Site 63		Site 42b*		Total	Comments
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2		
Lychas `SCO039` (annulatus complex)				1										2																							3	Molecular data matched the specimens from Hemi to a species recorded previously from the Western Range. Considered a widespread species.
Urodacus ?butleri															1														1								2	Widespread species. Likely part of a species group.
Chilopoda																																						
Ethmostigmus curtipes			1																				1						5								7	Widespread species.
Cryptops `BSCOL093`																													1						4		5	Collected also from other tenements of the Mallina Gold Project. Not an SRE.
Scolopendra laeta			2		1				1						1			2						1						1					2		6	17	Widespread species.
Scolopendra mortisans			12	5										2									3		2	1		5		6		3		3	2			44	Widespread species.
Scolopendra sp.*			1	1							3		3	2					1								2			1							14	Likely to be one of the above species.
Scutigeridae sp.				2							2	1	1						1							1		9		3		2					22	High order identification. Unlikely it belongs to an SRE.
Diplopoda																																						
Unixenus sp.			2																								1							3			6	Unidentified species but considered unlikely to be an SRE.
Phryssonotus novaehollandiae												1	4	12						1			8			4		35					25	70		6	166	Widespread species.
Isopoda																																						
Buddelundia `BIS477` †													1	29												6											36	Abundant on tenements around the Hemi mining area. Not an SRE.
Buddelundia `BIS478` †			6											3		2		1		1		3				1		3		1				1		1	23	Also recorded from outside the Hemi area. Considered unlikely to be an SRE.
Buddelundia `BIS479` †			2	2								3		3									21						3		8				4			46	Highly abundant species distributed both inside and outside the Hemi area. Not an SRE.
Buddelundia `BIS481` †																												1		1							2	Although less abundant than the other species, it has also been found from outside of the Hemi mining area, making it unlikely to be an SRE.

Lowest Identification	Site 03		Site 36		Site 37		Site 38		Site 39		Site 40		Site 41		Site 42a*		Site 43		Site 44		Site 45		Site 46		Site 47		Site 48		Site 49		Site 50		Site 51		Site 63		Site 42b*		Total	Comments
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2		
Buddelindia sp.*																											2						2			1	5	Likely to be one of the above species. Unable to identify further given specimens were juvenile or damaged.
Laevophiloscia `BIS546` †		1																																			1	Unidentified species recorded from a single specimen. However, none of the described species within the family show SRE distribution patterns. Considered here a **Data Deficient Potential SRE.**
Total count																																					**685**	

5.4.1. Species Accounts

More information about the distributions and SRE status of recorded species within each target group is given below.

Mygalomorph spiders

A single species of mygalomorph spider was collected from the Hemi mining area, which after molecular analysis was identified as *Synothele* `BMYG195` (Barychelidae) from site 37. Molecular species cut-off for separating between species followed the 9.5% genetic similarity boundary proposed by Castalanelli *et al.* (2014) for mygalomorph spiders.

Synothele `BMYG195` (Barychelidae) was collected as a mature female from a burrow in site 37, a sandplain site dominated by *Acacia* (Appendix 4). The genus *Synothele* comprises 24 described species endemic to Western and South Australia (World Spider Catalog 2023). However, there are probably many undescribed species in the Pilbara region, among which molecular work is often required to differentiate. The undescribed species *Synothele* `BMYG195` was recorded from a single specimen at the Hemi mine site (Figure 6); but genetic sequencing matches it with specimens of the same genus recorded from the Toweranna tenement (over 50 linear km away). Given its current distribution range and the fact it has been collected from widespread habitat, it is considered here as an Unlikely Potential SRE.

Wishbone spiders from the family Anamidae (previously in the family Nemesiidae and recently reclassified by Opatova *et al.* 2020) were not found at the Hemi mining area although members of the family were recorded from the other tenements.

Opiliones

Recent taxonomic framework suggests species of Laniatores include taxa with low dispersal ability and high microhabitat specificity (Derkarabetian *et al.* 2021), and the EPA (2016b) Technical Guidance suggests that several harvestmen species possess small ranges, although often larger than the SRE threshold of 10,000 km^2.

One species of opilionid was found in the Hemi area: *Dampetrus* `BOP017` (Figure 6). Morphological inspection of specimens collected from Mt Berghaus and Toweranna match with *D.* `BOP017` and suggests the species is not restricted to the Hemi Project area. Based on the collection records at Mt. Berghaus, Greater Hemi and Toweranna, the species has a linear range of more than 65 km and is therefore considered here an Unlikely Potential SRE. In addition to comparisons made previously between specimens collected from Withnell, genetic sequencing and comparisons between specimens collected at Toweranna and Greater Hemi will be conducted in early 2024 to confirm morphological identifications and linear ranges.

Pseudoscorpions

Epigean pseudoscorpions species are generally considered to have widespread distributions and it has been suggested that few species are SREs (Harvey 2002). Notably, however, some species have limited distributions and are normally restricted to specialist habitats including granite outcrops (Harvey 2010, 2012; Harvey 2018; Harvey *et al.* 2015a). While phoresy (dispersal by means of attachment to a host organism; White *et al.* (2017) has been documented for many families of pseudoscorpions (Jhasser Martínez *et al.* 2018b; Lira and Tizo-Pedroso 2017; Muchmore 1972), pseudoscorpion taxonomy is poorly resolved, largely due to high diversity; as a result, range determination can be difficult.

Eleven species were recorded in the Hemi mining area. Most were recorded in several localities and in moderately high density; for this reason, these taxa are considered unlikely to have confined distributions. However, three of the eleven species were recorded at one or few localities, *Afrosternophorus* `BPS436`, *Austrohorus* `BPS411`, and *Oratemnus* `BPS437` (Table 3; Figure 6).

None of the four Australian described species of *Afrosternophorus* have restricted distributions (ALA 2023). However, the undescribed species reported here has been found from *Eucalyptus* bark peel at only two localities (Mt. Berghaus and Hemi), less than 8 linear km apart, and is known from a single specimen taken at each site. Given that the habitat where the species was recorded is spread broadly around the Hemi area and given that none of the currently described species have a restricted distribution, we consider *Afrosternophorus* `BPS436` an Unlikely Potential SRE.

There is only one known species of *Austrohorus*, *A. exsul*, described from a single locality 350 km outside of Perth (Beier 1966). The species reported here, *Austrohorus* `BPS411`, comes from a single specimen and locality, but the genus has been recorded at many different localities in the Pilbara and Gascoyne regions. The taxonomy of the genus is poorly known, and possibly the records represent a single species., It is not expected that the species will be found to be an SRE in the future and is therefore considered here as an Unlikely Potential SRE.

Although *Beierolpium* 8/2 `BPS417` was recorded at only two sites within the Hemi mining area (Table 3), it has also been recorded at Mt. Berghaus, Withnell, and Toweranna (over 60 linear km apart). Similarly, *Indolpium* `BPS408` and *Xenolpium* `BPS409` were recorded only from a single site within the Hemi mining area, but they were both also collected at Withnell and Toweranna. It is likely the distributions of these species are not limited to the Hemi area, so they are considered unlikely to be SRE species.

The genus *Oratemnus* has four described Australian species (Harvey 2013), none of them with a restricted distribution. Our surveys recovered three 3 specimens from the undescribed species *Oratemnus* `BPS437` from a single locality on the Turner River, in the vicinity of the proposed dewatering bore outfall (Figure 6). Although our records might suggest the species has a restricted distribution, the habitat where the species was found (paperbark trees) is not restricted, and the genus does not show a limited distribution pattern. The species reported here is considered as an Unlikely Potential SRE.

The Australasian endemic genus *Synsphyronus* was recently revised by Cullen and Harvey (2021), where the authors described new species and discussed the potential conservation implications for some of them. Many of the species described recently have been collected at single localities, and due to their small ranges, they are often considered to be SREs. Molecular analysis shows that the two suspected morphological species found at the Hemi mining area belong to the recently described species *Synsphyronus xynus,* a widespread species within the Pilbara region of Western.

Scorpions

The framework for scorpion identification in Australia needs revision; accordingly, determining the distribution of morphospecies of the genera *Lychas* and *Urodacus* requires comparison with a range of specimens from the region. Molecular information may also assist in clarifying morphological identifications.

One species of the genus *Urodacus* (burrowing scorpions) was collected at the Hemi mining area, *Urodacus ?butleri*. This species was collected from wet traps at sites 42 and 50 (a single specimen at each site). It is identified under *U. ?butleri* given it resembles the description of the species holotype, albeit with minor differences, and it is expected to be part of a species group that needs further revision. It is considered a widespread species distributed abundantly throughout the Pilbara. Two other species of *Urodacus* have been found for the other tenements, but it is unlikely any of them represents an SRE species.

At least two species of the genus *Lychas* have been recorded at Hemi: *Lychas* `BSCO048` (cf. harveyi/JPP) and *Lychas* `SCO039` (annulatus complex). Molecular analysis found that *Lychas* `BSCO048` (cf. harveyi/JPP) matched records from a species previously recorded from Broome, approximately 500 linear kilometres from Hemi. The second species, *L.* `SCO039` (annulatus complex), matched specimens recorded by the WAM from the locality of the Western Range, approximately 300 linear kilometres from

Hemi. Given the extent of geographical distributions shown by the species, they are both considered to be widespread.

Myriapods

The species *Cryptops* `BSCOL093` was recorded at a single locality in the Hemi mining area, but it was also recorded in other tenements of the Mallina Gold Project and is therefore considered not to be an SRE. The species *Scolopendra laeta, S. mortisans,* and *Ethmostigmus curtipes* are widespread, and without conservation significance for the Hemi development area. One unidentified species of the family Scutigeridae was also recorded extensively inside the Hemi area. However, given the higher-level identification of the species, it is difficult to assess its SRE status. On balance, it is unlikely that the sample represents an SRE species.

The millipedes recorded, *Unixenus* sp. and *Phryssonatus novaehollandiae*, belong to a group of millipedes (Polyxenida) whose Western Australian species are considered widespread (e.g. (Short and Huynh 2011, 2013). It has been suggested that the genus *Unixenus* is speciose and that further new species will be found within it. Both *U. mjoebergi* and *U. karajinensis* (neither considered SRE) occur close to the Hemi mining area (Short and Huynh 2013), and it is possible that the unidentified species reported here belongs to one of them.

No evidence was found during the survey for the occurrence of classic SRE genus *Antichiropus* (Car and Harvey 2014; Car *et al.* 2013), nor of other genera of millipede known to contain geographically confined species (e.g. *Atelomastix*, species of which are known from further south; (Edward and Harvey 2010).

Slaters

Two families of slaters were represented in the survey. In the family Armadillidae, at least 4 species of the genus *Buddelundia* were found from thirteen sites and were usually collected from leaf litter or tree digs (Table 3). None of the morphologically recognised species are considered potential SREs given they have been recorded on high numbers and from widespread habitats both inside and outside of the Hemi mining area.

The single Philosciidae slater specimen collected from the Project area was identified morphologically as belonging to an undescribed species of *Laevophiloscia*, identified by the code name *Laevophiloscia* `BIS546`. This species was found only from a single specimen at the Turner River sampling site. Although it comes from a single specimen, the higher-level taxonomy makes SRE status assessment difficult. It is important to note that specimens from this group are harder to collect than other isopods and seem less abundant. The only known species to occur in the Pilbara is *Laevophiloscia yalgoensis* which has a widespread distribution extending throughout WA, from the south west to the Pilbara (ABRS 2023; ALA 2023). It is not expected that this species will be an SRE as it has been suggested that species within the genus show widespread distributions (Judd 2004). However, based on the single specimen collected from the Hemi mining area the lack of records from adjacent tenements, it is here considered a Data Deficient Potential SRE (Table 3; Figure 6).

General species discussion

Pseudoscorpions comprise the majority of records from the Hemi mining area, with over 36% of the samples belonging to this group. Millipedes, slaters, and centipedes, comprise the next most abundant groups, leaving mygalomorph spiders and opilionids as the least abundant groups (Figure 7). It is important to point out that sandplains accounted for the vast majority of the survey area (over 65%), on which most sample sites were also located (12 out 18 sites; see Table 2; Figure 5; Appendix 2). Although locally widespread, sandplains are a habitat type not suitable for many prospective SRE Groups, such as some mygalomorph spiders and snails; and although sandplains may host high densities of other groups such as scorpions, slaters or myriapods, these are generally restricted to a few locally abundant species.

Mygalomorphs require suitable soil conditions for creating their burrows, which help them regulate humidity, provide protection from predators, and allow them to ambush their prey. Sandy soils collapse easily, so are generally not ideal for most mygalomorph spider families; hence, it is unlikely to find many mygalomorph species in such substrates, possibly explaining the low number of specimens collected during the field survey. The single mygalomorph species collected from the Project area, *Synothele* `BMYG195` was also collected from Towerrana, approximately 55 linear km apart, suggesting the species is not restricted to the Hemi Project area. It is possible that other species of trapdoor spiders, particularly from the family Anamidae, occur within the Hemi area considering the adjacent tenements resulted in high number of records from the genus *Aname*; however, no specimens were recorded for the Hemi area.

Although recent phylogenomic revision of some harvestman groups suggest that Laniatores are likely to include examples of SRE taxa (Derkarabetian *et al.* 2021), our findings suggest it is unlikely that is the case for the only harvestman species identified as occurring in the Hemi Project area, *Dampetrus* `BOP017`. This species was recovered from the Hemi Project are from 2 specimens at a single site and, after closer revision and morphological inspection, specimens of this species were able to be identified as occurring at Mt. Berghaus and Toweranna, extending over 65 linear km. While this is no proof of a range over 10,000 km^2, it shows clear evidence that the species is not restricted to the Project area and suggests it is unlikely the species will represent an SRE and is therefore categorised as an Unlikely Potential SRE.

Contrary to trapdoor spiders, scorpions thrive on sandy substrates. Scorpions are adapted to life in dryer habitats and have a higher lethal temperature tolerance compared to other arthropods, due to a waterproof wax coating the external cuticle which prevents desiccation by reducing water loss to a rate of 0.01%, considered the lowest for desert animals (Hadley 1974). In addition to these metabolic adaptations, buthid scorpions (e.g. *Lychas, Isometroides*) tend to find refuge during the day beneath bark, leaf litter, or fallen logs, and do not require burrows, instead wandering generally through vast sections of habitat by night, making them locally abundant during night surveys. The burrowing scorpion *Urodacus*, on the other hand, is a fossorial obligate burrower with elongate, elliptical, or spiral burrows reaching up to 1 m deep, either on open ground or at the base of bushes on clay to clay-sand substrates, although sandy soils have also been reported for some species (Koch 1978). Most of the sites were situated on loose sandy substrates, probably not favourable for burrowing scorpions, a situation which correlates with our finding only two specimens from a single species.

Pseudoscorpions were the most abundant group recorded from the Hemi mining area (Figure 7), with a total of 247 records, of which 123 corresponded to a single species (*Indolpium* `BPS404`). Some of the samples were obtained by foraging through leaf litter or through bark peeling or litter sieves, all considered suitable habitats for pseudoscorpions. However, most samples came from wet traps and show that one species is particularly locally abundant. It is suspected that phoresy could drive the high number of samples retrieved from on wet traps, as pseudoscorpions show associations with other animals that act as dispersive aids (Harvey *et al.* 2012), (Aguiar and Bührnheim 1998), including various beetles, a group that was abundant among wet trap by-catch. Although not all species recorded from Hemi appear to show this same pattern, it is likely that the most abundant species (*Indolpium* `BPS404`) is highly phoretic.

Three species are considered as Unlikely Potential SREs: *Afrosternophorus* `BPS436`, *Austrohorus* `BPS411`, and *Oratemnus* `BPS437`. *Afrosternophorus* `BPS436` has also been recorded from the Mt. Berghaus tenement, suggesting its distribution might be wider than is currently known. The other two pseudoscorpion species, *Austrohorus* 'BPS411' and *Oratemnus* `BPS437`, were recorded from single localities within the Hemi mining area. Although both species are represented by few specimens, none of the already described species within both genera show restricted distributions. The habitats where they have been collected, drainage sandplain and creek drainage, respectively, are considered abundant outside of the proposed Development Envelope, and they are considered Unlikely Potential SREs. The

three species were only collected by hand foraging, primarily from *Eucalyptus* bark which appears to be their preferred micro-habitat and is a plant species widely distributed throughout the sandplain and drainage sandplain habitats in the Hemi Mining Area (Figure 6).

6. POTENTIAL IMPACTS

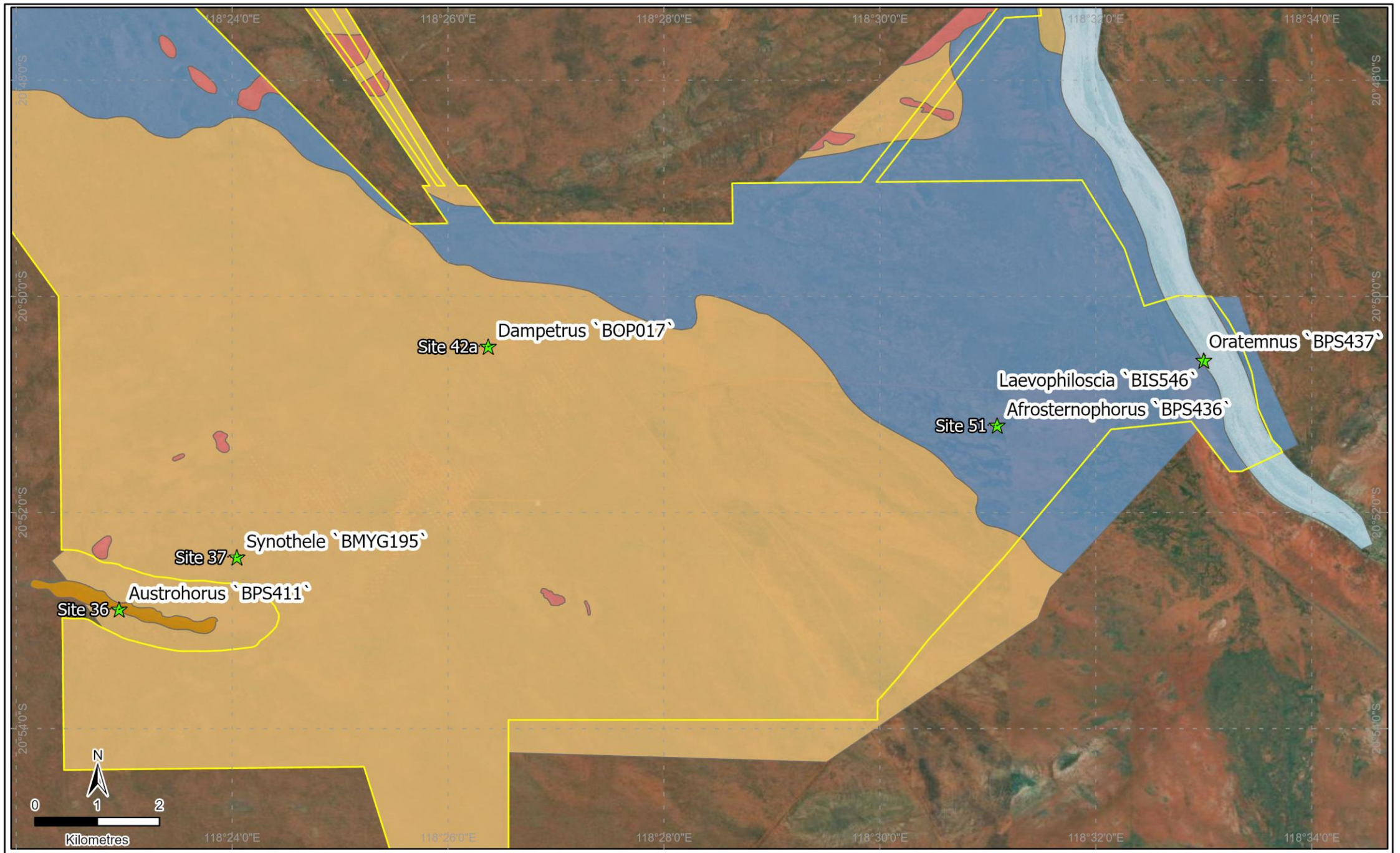
The potential impacts of the Hemi mining area on terrestrial invertebrate species can be divided into direct impacts from clearing and indirect impacts from changes in habitat connectivity.

6.1.1. Clearing

Within the development envelope, most of the impact sites were found in broad sandplains dominated by *Acacia* bushes where the impact of vegetation clearing on habitat availability is considered small. Given the majority of the recorded species appear to have broad distributions over habitats that are not restricted to the Hemi mining area, we consider clearing will have little to no impact on any of the species present in the Hemi area.

6.1.2. Habitat connectivity

The proposed development of the Hemi mining area is likely to affect habitat connectivity for some species by causing isolation or fragmentation among their populations. However, these potential impacts are expected to be low for most species, as they have been identified from habitats widespread within the region (Figure 6). Some species, however, appear to have habitat specificity. The species most susceptible to habitat connectivity interruptions are the three Potential SRE pseudoscorpion species recorded from bark peels: *Afrosternophorus* `BPS436`, *Austrohorus* `BPS411`, and *Oratemnus* `BPS437` (Table 3). Extensive interruption of the species' connectivity could result in a decline in populations in the area, which at the time of this report, are restricted to the Hemi mining area and the adjacent tenement of Mt. Berghaus.



Bennelongia Environmental Consultants

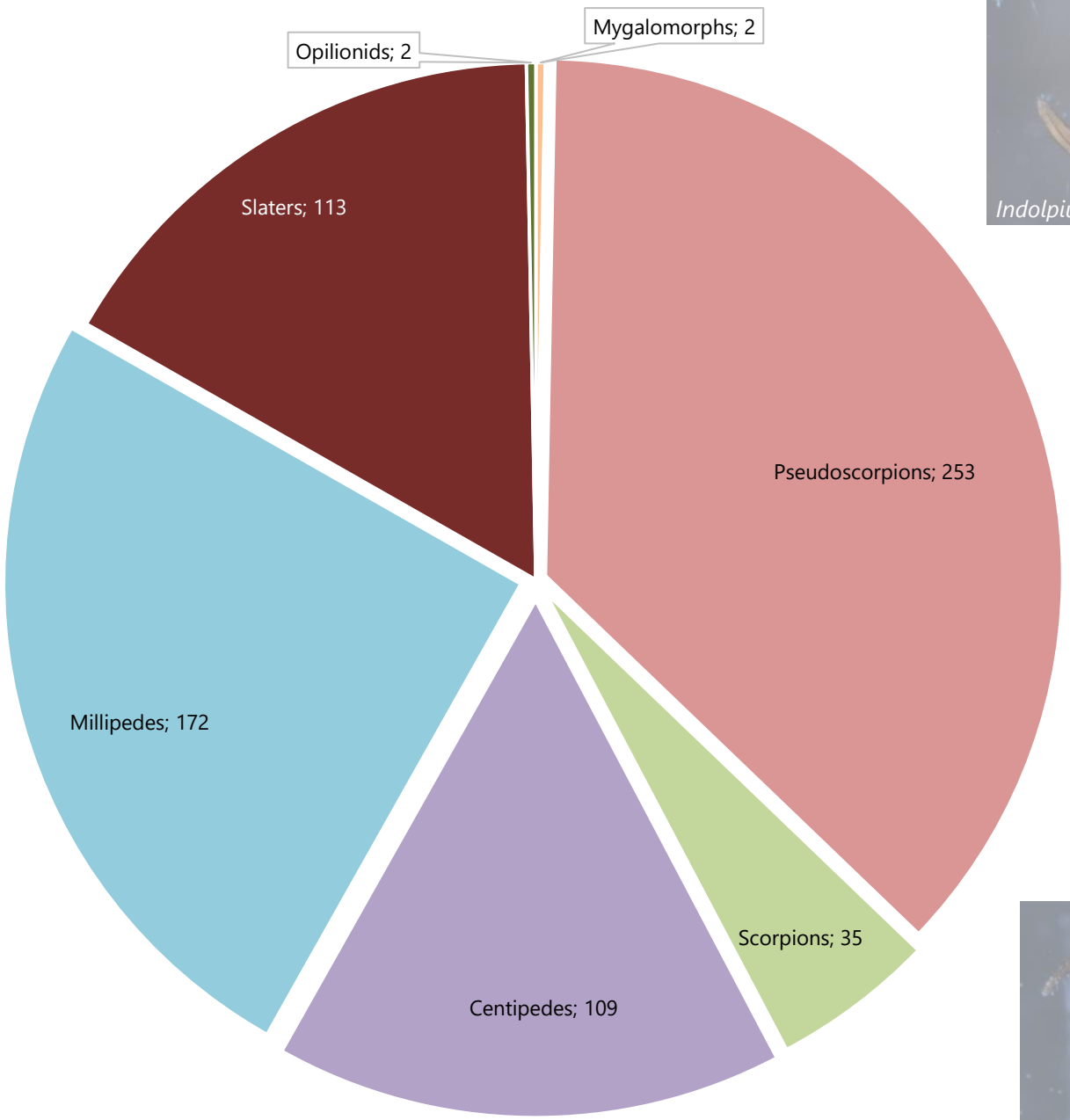
GCS GDA 1994
Author: K. Sagastume
Date: 13/12/2023

Legend

- Hemi Development Envelope
- SRE Habitat
  - Creek drainage
  - Drainage sandplain
  - Outcrop/Stony hills
  - Sand dune
  - Sandplain

Figure 6. Potential SRE species mapped over the identified habitats at the Hemi mining area.

Figure 7. Density of SRE groups collected for the Hemi Mining Area



7. CONCLUSIONS

The current survey assessed the values of short range endemic invertebrate species in and around the Hemi mining area. Based on a desktop review, the area appears suitable for hosting many species from groups that contain confirmed SREs; however, two rounds of field surveys did not find any Confirmed SRE species. The surveys did document at least 28 species belonging to target SRE groups, including one mygalomorph spider species; one species of harvestman; at least eleven species of pseudoscorpions; at least three species of scorpions; at least five species of centipedes; two species of millipedes; and five species of slaters.

The majority of the species collected are considered widespread as they have been found from outside the Hemi area and come from widespread habitats. Similarly, most of the sample sites corresponded to the abundant and wide-ranging sandplain habitat, which hosts a variety of vegetation associations. However, some sites targeted specific habitats, such as site 36 and site 44, which corresponded to isolated sand dune and the patchy outcrop/stony hills, respectively (Figure 5).

Based on their distributions within and outside of the Hemi mining area, the number of specimens collected, and the habitat from which they were collected, five species are categorised as Unlikely Potential SREs and one as a Data Deficient Potential SRE. Three Unlikely Potential SRE species are pseudoscorpions collected primarily from tree bark, considered to be the most susceptible to any potential changes in habitat connectivity. The mygalomorph spider species *Synothele* `BMYG195` is also categorised as an Unlikely Potential SRE as it is known from two localities separated approximately 55 km apart (site 37 at Greater Hemi and site 11 at Toweranna). Although this is not proof of a range over 10,000 km2, it shows that the species is not restricted to the development envelope and suggests that it is unlikely the species will represent an SRE. The genus *Synothele* is widespread throughout WA and SA, and the lack of known specimens from certain localities reflects only poor collections from those regions and not necessarily absence of species (Raven 1994).
Further inspection of the harvestman species collected within the Project area confirmed that the species *Dampetrus* `BOP017` is not restricted to Hemi as it was able to be morphologically matched with specimens collected from Mt. Berghaus and Toweranna. These findings suggest the linear range of the species is over 65 km and the species is therefore categorised as an Unlikely Potential SRE.

The single Philosciidae slater species collected from the Project area, *Laevophiloscia* `BIS546`, is known from a singleton specimen collected from paperbark tree dig. The only described species of the genus occurring in the Pilbara has a widespread distribution and it is expected *L.* `BIS546` will share a similar pattern. It has also been shown members of the genus have high tolerance to bark humidity levels and are the most common isopod taxa inside logs, with most species showing broad regional patterns (Judd 2004). However, given the lack of sufficient knowledge about *L.* `BIS546`'s biology and its actual distribution it is categorised here as a Data Deficient Potential SRE species.

Between the two low-extent habitats recognised for the survey area (sand dunes and outcrop/stony hills), only one Potential SRE species, *Austrohorus* `BPS411`, was found in the sand dune habitat. However, the sand dune habitat falls outside the development envelope, and there are no potential impacts expected to arise relevant to any of the SRE species found there.

It appears that the Turner River, along with its more diverse vegetation types, is the area most likely to host any susceptible SRE species. Where possible, excessive clearing of woodland areas should be avoided during the development of the Hemi site, to prevent extensive disruptions to species with potentially restricted populations. Nevertheless, overall, none of the recognized SRE species are considered likely to be impacted upon by the Hemi mining area development.

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Appendix 1- Species of SRE invertebrate groups found within the Desktop assessment for the Hemi Mining area and its vicinity.

Grey highlight represents higher level identification likely to belong to another species listed.

Higher Classification	Lowest Identification	Specimen records	SRE Status	Minimum Known Linear Range	Location of Occurrences
ARTHROPODA					
ARACHNIDA					
Araneae					
Araneomorphae					
Selenopidae	*Karaops* `*aurizon*`	3	**Potential SRE**	Approximately 13 km	82-95 km south of Porth Headland
	Karaops kariyarra	2	**Confirmed SRE** (Crews 2013)	57 km (only two locations)	Wodgina area, and approximately 12 km East of the Project.
Mygalomorphae					
Anamidae	*Aname* `MYG372`	2	**Potential SRE**	Single location	15 km NE of Wodgina
	Aname `MYG682`	1	**Potential SRE**	Single location	5 km NNE of Wodgina
	Aname mcalpinei	1	**Confirmed SRE** (Castalanelli *et al.* 2020)	Single location	18 km SSW of Port Hedland
	Aname mellosa	4	Widespread	Relatively widespread in the Pilbara (> 300 km)	33 km SE of the Project Area
	Kwonkan `MYG089`	2	**Potential SRE**	Single location	48 km NNW of the Project area.
	Kwonkan `MYG209`	1	**Potential SRE**	Single location	31 km N of the Project area.
Barychelidae	*Aurecocrypta* sp. B01	1	**Potential SRE**	45 km (only two locations)	39 km SE of the Project area.
	Synothele sp. B02	1	**Potential SRE**	Single location	39 km SE of the Project area.
Idiopidae	*Idiosoma* `MYG084`	1	Unlikely SRE	160 km (three locations)	Dixon Island; a site 5km N of Lake Poongkaliyarra; and a site 57 km SSE of Port Hedland.
Opiliones					
	Opiliones sp.	2	Uncertain ID		34 km SE of the Project.
Pseudoscorpiones					

Higher Classification	Lowest Identification	Specimen records	SRE Status	Minimum Known Linear Range	Location of Occurrences
Atemnidae	*Oratemnus* `PSE060`	1	Unlikely SRE	93 km (only two locations)	80 km SSE and 170 km SSE of Port Hedland.
Chernetidae	*Austrochernes* `sp. nov. 001`	5	**Potential SRE**	106 m (only two locations)	Locations within the abandoned pit of Mount Dove mine.
	Sundochernes `PSE021`	1	Widespread	254 km	Near Wodgina mine and Turee Creek in the Hamersley range.
Garypidae	*Synsphyronus* `PSE008`	1	**Potential SRE**	Single location	38 km SE of the Project.
	Synsphyronus `PSE012`	1	**Potential SRE**	42 km (three locations)	130 km SSE. of Port Hedland (BHP Mainline rail) and Wodgina mine (31 km SSE of the Project).
	Synsphyronus `PSE094` ('long chelal hand`)	8	Widespread	281 km	Woodie Woodie mine and 55 km S of Port Headland (23 km from the Project).
	Synsphyronus `PSE128`	16	**Potential SRE**	25 km	10 km S of the Project and near Wodgina mine.
	Synsphyronus sp. B01	1	**Potential SRE**	Single location	34 km SE of the Project.
Olpiidae	*Austrohorus* sp.	6	Uncertain ID		34 km SE of the Project.
	Beierolpium sp.	4	Uncertain ID		Within and outside the Project's development envelope.
	Indolpium `long chelal hand`	1	Widespread	234 km (only two locations)	Near Wodgina airport (28 km SE of the Project) and 64 km E of Paraburdoo
	Indolpium sp. B01	8	Widespread	193 km	34 km SE of the Project, and in many locations towards Roy Hill Station.
Chthoniidae	*Tyrannochthonius* `sp. nov. near aridus`	1	Unlikely SRE	71 km	Mt Dove and Abydos, approximately 71 km ESE.
	Tyrannochthonius sp.	2	Uncertain ID		Possibly juveniles of records above.
	Pseudoscorpiones sp.	1	Uncertain ID		Possibly juveniles of records above.
Scorpiones					
Urodacidae	*Urodacus* cf. *butleri*	1	Widespread	>500 km	From Barrow Island to the Chichester Range. If confirmed as *U. butleri* (currently "cf."), this record represents a widespread species.
	Urodacus `SCO035` / `pilbara 2`	8	Widespread	~ 350 km	From near Whim Creek hotel to 78 km E of Meentheena Outcamp.

Higher Classification	Lowest Identification	Specimen records	SRE Status	Minimum Known Linear Range	Location of Occurrences
	Urodacus `sp. 7`	1	Highly unlikely SRE	210 km (only two locations)	45 km NNE. of Whim Creek Hotel and 2 km SW. of Marda Pool.
CHILOPODA					
Scolopendrida					
Cryptopidae	*Cryptops* sp.	5	**Potential SRE**		33 km SE of the Project.
	Scolopendrida sp.	2	Uncertain ID		Possibly juveniles of records above.
Scutigeromorpha					
Unknown family	Scutigeromorpha sp.	13	Uncertain ID		33 km SE of the Project.
DIPLOPODA					
Polydesmida					
Paradoxosomatidae	*Antichiropus* `DIP033` / `wodgina`	3	**Potential SRE**	6 km (three locations)	Near Wodgina Mine.
	Antichiropus sp.	8	Uncertain ID		Possibly juveniles of records above.
SYMPHYLA					
Unknown order					
Unknown family	Symphyla sp.	1	Uncertain ID		33 km SE of the Project.
MALACOSTRACA					
Isopoda					
Armadillidae	?*Hybodillo* sp. B01	1	**Potential SRE**	50 km	38 km SE of the Project.
	Acanthodillo sp. B01	1	**Potential SRE**	55 km	38 km SE of the Project.
	Acanthodillo sp.	5	Uncertain ID		Possibly juveniles of records above.
	Buddelundia `sp. 10`	10	Widespread	190 km	From around Coolawanyah Airport to South Hedland.
	Buddelundia `sp. 13`	5	Widespread	175 km	From around Coolawanyah Airport on the west to Wodgina mine.
	Buddelundia `sp. 14`	46	Widespread	140 km	From South Hedland to the south for approximately 140 km.
	Buddelundia `sp. 14re`	6	**Potential SRE**	Single location	14 km east of the Project.
	Buddelundia `sp. 17`	11	Unlikely SRE	99 km	From South Hedland to Wodgina mine area.

Higher Classification	Lowest Identification	Specimen records	SRE Status	Minimum Known Linear Range	Location of Occurrences
	Buddelundia `sp. 18`	1	Unlikely SRE	55 km	45 km SE of the Project.
	Buddelundia `sp. 19`	6	Widespread	115 km	From South Hedland to the SSE for approximately 140 km.
	Buddelundia `sp. 21`	48	**Potential SRE**	38 km	Mount Dove and Wodgina Airport area
	Buddelundia `sp. 31`	9	**Potential SRE**	52 km	Wodgina Airport area, 15 km E of the Project, and Abydos.
	Buddelundia `sp. 36`	14	**Potential SRE**	23 km	12 to 35 km south of the Project.
	Buddelundia sp. B10	6	Widespread	>900 km	Pilbara (39 km SE of the Project) and Ularring.
	Buddelundia sp. B11	3	**Potential SRE**	5 km (only two locations)	34 km SE of the Project.
	Buddelundia sp. B18	3	**Potential SRE**	55 km	From a location 39 km SE of the project to locations up to 55 km south.
	Buddelundia sp.	17	Uncertain ID		Possibly juveniles of records above.
	Buddelundiinae sp.	15	Uncertain ID		Possibly juveniles of records above.
	Spherillo wodgina	7	**Potential SRE**	53 km	From Port Hedland to Wodgina.
	Spherillo sp.	2	Uncertain ID		Possibly juveniles of records above.
Philosciidae	*Laevophiloscia* sp.	4	Uncertain ID		27 km SSE of the Project.
MOLLUSCA					
GASTROPODA					
Stylommatophora					
Camaenidae	*Gen. nov. cf. `Z` n.sp.*	5	Widespread	~ 250 km	31 km SSE of the Project, Abydos area and 22km N of Skull Springs.
	Quistrachia turneri	15	Widespread	~ 280 km	Shaw River Airport to Karratha.

Appendix 2. Sampling details of Hemi Mining Area sites for round 1 & 2.

Site Code	Sample method Round 1 & 2	Habitat	Site type	Latitude	Longitude	Days opened (Round 1; Round 2)	Comments
03	Hand forage	Creek drainage	Impact	-20.843241	118.550002	NA	
36	Trapping	Sand dune	Reference	-20.884495	118.395423	42; 41	
37	Hand forage	Sandplain	Impact	-20.875580	118.400702	NA	
38	Hand forage	Drainage sandplain	Reference	-20.886071	118.413238	NA	
39	Hand forage	Sandplain	Impact	-20.850719	118.418674	NA	
40	Trapping	Sandplain	Impact	-20.893741	118.424926	41; 42	
41	Trapping	Sand Plain	Impact	-20.877157	118.432120	41; 42	
42a	Trapping	Sandplain	Impact	-20.841088	118.439546	42; NA	Burned in fire after round 1; moved during round 2 and assigned new code: Site 42b
43	Hand forage	Sandplain	Impact	-20.854274	118.448245	NA	
44	Hand forage/trapping	Outcrop/Stony hills	Impact	-20.880524	118.450055	NA; 42	Swapped with site 48 sampling method for round 2.
45	Hand forage	Sandplain	Reference	-20.863047	118.464803	NA	
46	Hand forage	Sandplain	Impact	-20.889030	118.468315	NA	
47	Hand forage	Sandplain	Reference	-20.854800	118.473668	NA	
48	Trapping/hand forage	Sandplain	Reference	-20.874327	118.483079	41; NA	Changed from trapping to hand forage on round 2 as it is found along the pipeline; swapped with site 44 sampling method.
49	Trapping	Sandplain	Reference	-20.864643	118.498045	40; 42	
50	Trapping	Sandplain	Reference	-20.890609	118.499414	41; 42	
51	Trapping	Drainage sandplain	Reference	-20.854732	118.518330	41; 43	
63	Trapping	Drainage sandplain	Reference	-20.794114	118.514029	40; 40	
42b	Trapping	Sandplain	Impact	-20.839790	118.447560	NA; 41	In lieu of site 42a which got burned on fire after round 1. Since it moved considerably got assigned a new site code.

Appendix 3. Photographs of SRE Impact collection sites at Hemi Mining Area in November 2021 and April 2022.

Site 37

Site 37

Site 39

Site 39

Site 40

Site 40

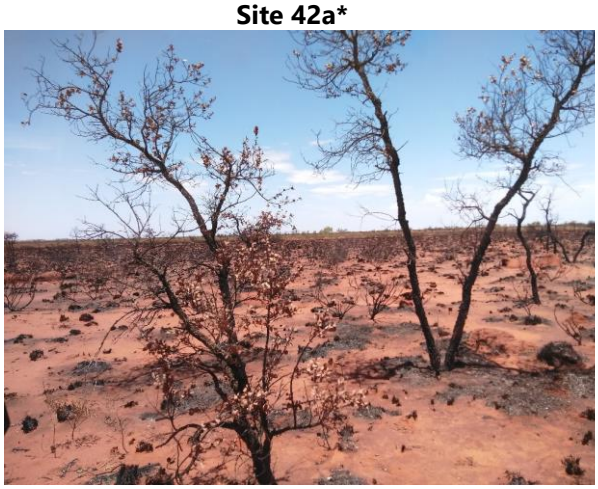
Site 41

Site 41

Site 42a*

Site 42a*

Site 42a*



Site 42a*

***Site 42a was burned after round 1 of sampling and two traps were completely destroyed. It was moved outsite of the fire scar for round 2, and assigned new code (Site 42b).

Site 42b*

Site 42b*

*Site 42b replaces site 42a for round 2 due to fire during round 1.

Site 43

Site 43

Site 44

Site 44

Site 46

Site 46

Appendix 4. Photographs of SRE Reference collection sites at Hemi Mining Area in November 2021 and April 2022.

Site 03

Site 03

Site 36

Site 36

Site 38

Site 38

Site 45

Site 45

Site 47

Site 47

Site 48

Site 48

Site 49

Site 49

Site 50

Site 50

Site 51

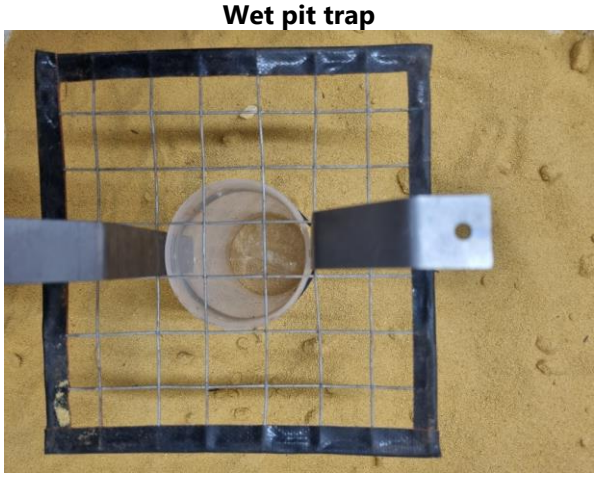
Site 51

Site 63

Site 63

Appendix 5. Sampling techniques photo album

Wet pit trap



Wet pit trap

Wet pit trap (mounted)

Wet pit trap (covered)

Leaf blowing

Leaf blowing (uncovered burrow)

Litter sieve

Litter sieve

Burrow dig

Burrow dig