Bennelongia Environmental Consultants

Beharra Silica Short-Range Endemic Invertebrate Desktop and Survey Report

Prepared for:

Tetris Environmental Pty Ltd

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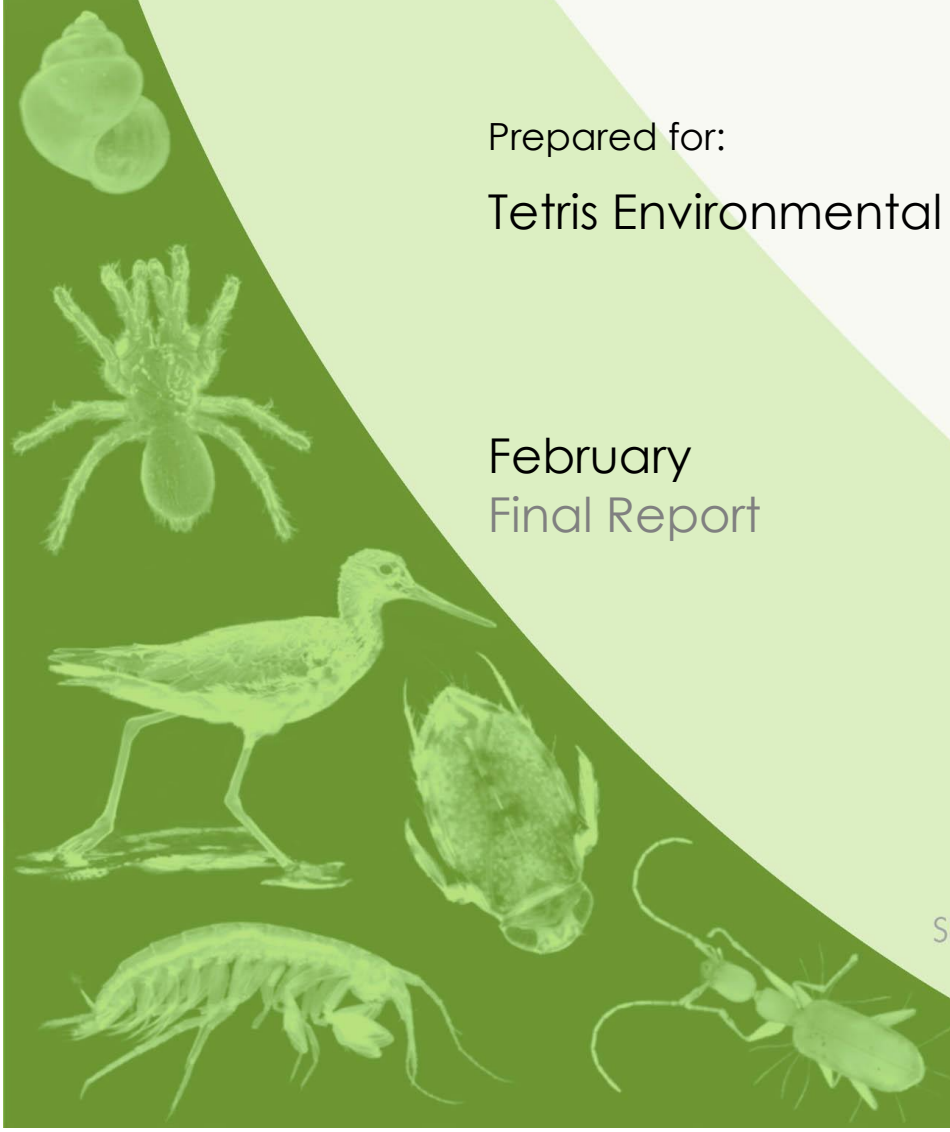
Final Report



Short-Range Endemics I Subterranean Fauna

Waterbirds I Wetlands

Beharra Silica Short-Range Endemic Invertebrate Desktop and Survey Report

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EXECUTIVE SUMMARY

The Beharra Silica Project (the Project) is located approximately 26 km southeast of Dongara, Western Australia. The Project involves the mining of silica sands from a section of predominately Kwongan Heath located on Mount Adams Road. This report assesses the presence of, and potential impacts on, short-range endemic (SRE) invertebrate species at the Project.

SRE species are broadly defined as having an overall range of less than 10,000 km^2. They are usually characterised by patchy or fragmented distributions within their range, slow growth, low fecundity and poor dispersal capabilities. Assessment of environmental impacts on SREs focuses on several taxonomic groups (the SRE Groups) that are known to contain high proportions of species with these characteristics. In southwestern Australia, SRE Groups are land snails (Gastropoda); millipedes (Diplopoda); centipedes (Chilopoda); pseudoscorpions (Pseudoscorpiones); scorpions (Scorpiones); spiders [Araneae, mainly Mygalomorphae (trapdoor spiders), but also some modern spiders within Araneomorphae]; slaters (Isopoda), harvestmen (Opiliones), velvet worms (Onychophora) and earthworms (Oligochaeta).

This report consists of both a desktop review of SRE values and the results of a survey designed to collect SRE species at the Project. Previous records of terrestrial invertebrate species were collated from Western Australian Museum (WAM) and Bennelongia databases, along with published taxonomic literature, from a search area that extended 50 km north, east and south of the Project (decimal degrees search area, top left: -29.0°S:114.8°E, bottom right -30.0°S:115.6°E). The western border was the Indian Ocean.

Subsequently, field survey of SRE invertebrate fauna was undertaken in July 2021 accordance with the Environment Protection Authority's *Technical Guidance: Sampling of Short Range Endemic Invertebrate Fauna*. A total of 169 specimens belonging to at least 21 species of SRE groups were collected. Groups represented include trapdoor spiders (six species), isopods (four species), pseudoscorpions (three species), scorpions (three species), centipedes (three species), and snails (two species).

The survey resulted in the collection of nine likely potential SRE species, seven unlikely potential SRE and five widespread species. Two of the species are listed as P1 species, namely *Idiosoma kwongan* and the snail *Bothriembryon perobesus*, which is widespread.

Four likely potential SRE species are currently known only from the Project area. These are the mygalomorph spiders *Idiosoma* 'BMYG192` and *Idiosoma* 'BMYG193`, the pseudoscorpion *Austrohorus* `BPS381` and the centipede Chilenophilidae`BGE056`. Based on available habitat in the surrounding region, it is considered likely that all of these species have ranges extending outside the Project. The ranges of the two P1 species extend beyond the Project. It is unlikely that Project development will affect the conservation status of any SRE Group or listed species.

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1. INTRODUCTION

Bennelongia Environmental Consultants (Bennelongia) have been engaged to conduct a Short-Range Endemic (SRE) invertebrate desktop assessment and field survey at the Beharra Silica Project (the Project), located approximately 26 km southeast of Dongara, Western Australia (Figure 1). The Project involves the mining of silica sands from vegetation dominated by Kwongan Heath, located on Mount Adams Road. Mining of this resource has the potential to impact SRE conservation values through the direct removal of habitat. This examines the likelihood of SRE species occurring in the vicinity of the Project, provides the results of field survey for SREs within the Project area, and discusses potential threats to the SRE species from Project development.

1.1. Conservation Framework

The listing of species for special protection is governed at the federal level by the *Environment Protection and Biodiversity Conservation Act 1999*, and at the state level by the *Biodiversity Conservation Act 2016* (BC Act). The state listing of Threatened species (Critically Endangered, Endangered and Vulnerable species; Appendix 1) under the BC Act is maintained by the Department of Biodiversity, Conservation and Attractions (DBCA); additionally, the DBCA maintains a list of Priority species that potentially require protection but do not currently meet survey or data requirements for formal Threatened status (see Appendix 1 for definitions of Priority categories).

1.2. Terrestrial SRE Invertebrates

In addition to formal listing of Threatened and Priority fauna, assessment of the impacts of development on SRE invertebrates in Western Australia is prescribed by the Environmental Protection Authority (EPA 2016a, b)., SRE species are broadly defined as those ground-dwelling invertebrate species having an overall range of less than 10,000 km^2 (Harvey 2002). They are usually characterised by patchy or fragmented distributions within their range, slow growth, low fecundity and poor dispersal capabilities. Assessment of environmental impacts on SREs focuses on several taxonomic groups (the SRE Groups) that are known to contain high proportions of species with these characteristics. In southwestern Australia, the groups are land snails (Gastropoda); millipedes (Diplopoda); centipedes (Chilopoda); pseudoscorpions (Pseudoscorpiones); scorpions (Scorpiones); spiders [Araneae, mainly Mygalomorphae (trapdoor spiders), but also some modern spiders within Araneomorphae]; slaters (Isopoda), harvestmen (Opiliones), velvet worms (Onychophora) and earthworms (Oligochaeta).

The SRE Groups listed above provide a practical framework for identifying potentially restricted species, but it is important to note two further points. First, species with small ranges can also occur in groups where most species are widespread, due to high vagility, ecological plasticity or xeric adaptation (Framenau *et al.* 2008; Rix *et al.* 2015). Such small-range species are not picked up by the SRE framework, although they may be covered by the listing process for Threatened and Priority species. Second, and importantly, many species belonging to SRE Groups are in fact widespread. Therefore, determining whether a species has a significantly restricted range (notionally <10,000 km^2) is more difficult than simply identifying them as belonging to an SRE Group.

One factor that helps determine whether species in SRE Groups are restricted is that many true SRE species are confined to single habitats. Therefore, if a species has been collected from only one habitat and this is restricted or patchy, the species is likely to have a smaller range than species found in multiple or widespread habitats. Nevertheless, there is sometimes species turnover in widespread habitats (e.g. due to climatic gradients) that results in a species occupying only part of a widespread habitat and, therefore, being an SRE with a range that is much smaller than the extent of its apparently suitable habitat (Rix *et al.* 2015).

In this report, the SRE status of each species was determined using a modified version of the Western Australian Museum's (WAM) SRE classification system (Appendix 2). The modifications used by

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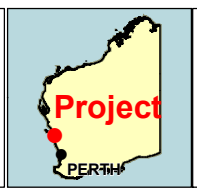

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Mine Development Envelope

Dongara

Roads

Figure 1: Mine Development Envelope associated with the Project.

Bennelongia aim to account for the fact that many recorded species have limited available data on their taxonomy, range, habitat preferences, and/or natural history.

When using the classification, SRE Group species were assigned to the following categories: *widespread (not an SRE), unlikely potential SRE, likely potential SRE, or confirmed SRE*. Species were considered *widespread* if they have a known distribution >10,000 km^2. Species were considered *confirmed SREs* if they have a well-known taxonomy from well represented collections and a known range of <10,000 km^2.

Assignment to the two categories of potential SRE was more uncertain. Species that are likely to have been under-sampled or have uncertain species status (e.g. undescribed or belong to a species complex) and have currently been recorded from areas <10,000 km^2 classified as *likely* or *unlikely potential SREs* based on the following information (if available):

- Degree of ecological specialisation and extent of habitat (e.g. occur in one or multiple habitats, these are restricted or widespread);
- Expert opinion or information available for related species; and/or
- Molecular evidence regarding the genetic variability within known populations (this provides information about dispersal capability).

For species that are data deficient in all criteria, the precautionary approach was taken of assigning them *likely potential SREs*. We highlight these species in our results and note the lack of available data.

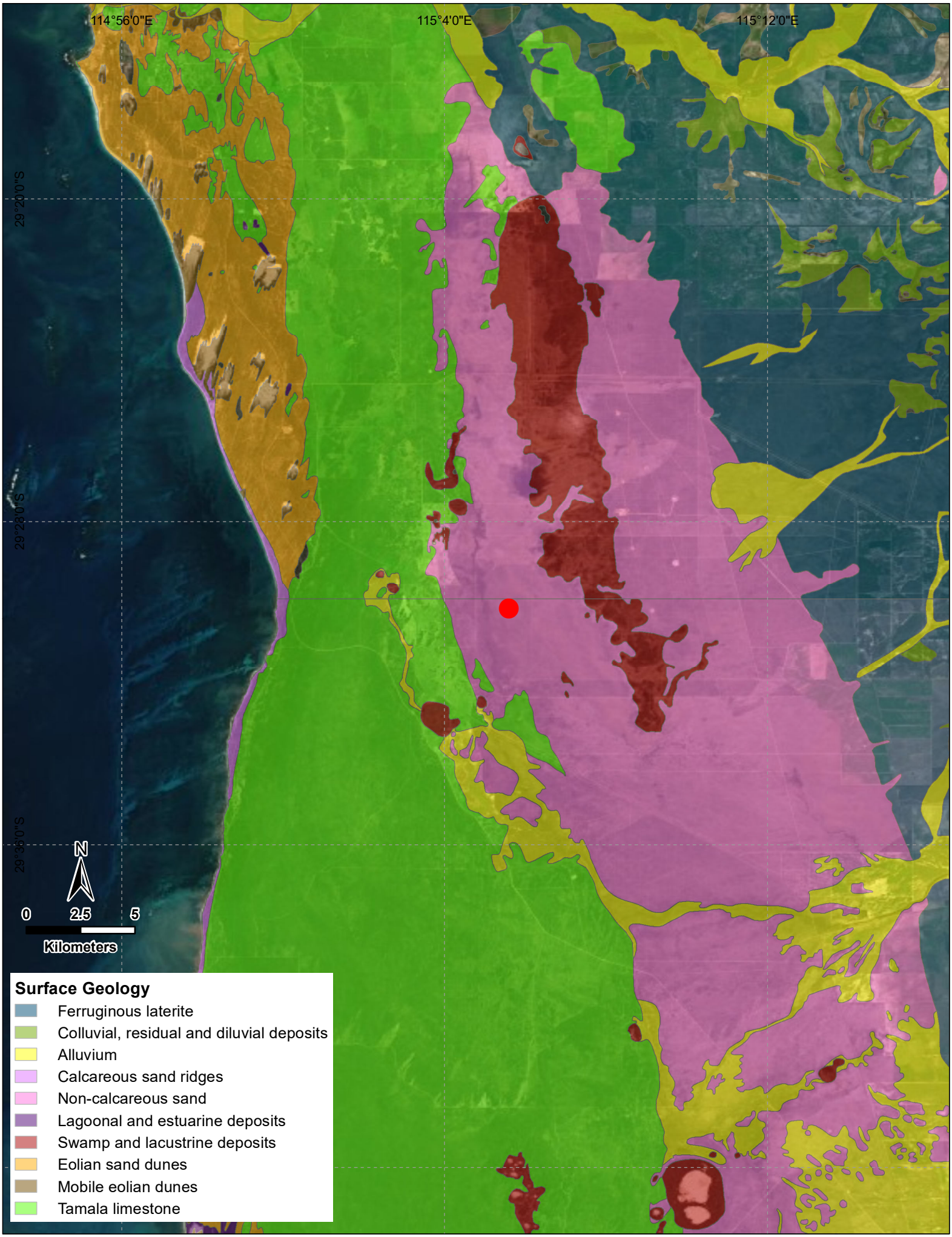
2. HABITAT ASSESSMENT

2.1. Regional Setting

The Project is located within the Lesueur Sandplains, a sub-region in the Interim Biogeographic Regionalisation of Australia (IBRA; http://www.environment.gov.au/land/nrs/science/ibra/australias-bioregions-maps). The Lesueur Sandplains comprise the southern half of the Geraldton Sandplain Region, covering coastal areas south of Geraldton to Jurien Bay. The underlying geology is characterised by Permian to Cretaceous sedimentary basins, with extensive undulating sandplains at the surface that include limestone, siltstone, sandstone and drainage-associated alluvials (Figure 2) (Desmond and Chant 2002). The region has a dry, warm Mediterranean climate with the majority of precipitation falling in the winter months. Flora communities of the Lesueur Sandplains support of Kwongan vegetation (Mucina *et al.* 2014), comprising mainly proteaceous scrub-heath of *Banksia*, *Melaleuca*, *Eucalyptus* and *Acacia*. The sub-region is notable, by both national and international standards for its high levels of floristic species richness and endemism (Desmond and Chant 2002).

2.2. Habitats in the Project Area

Mineral sands deposits occur mainly in areas of former beach, where mineral sand has been concentrated by wave action that removes lighter quartz and calcareous sand. The broad landscape around the Project is dominated by calcareous sand (Figure 2). The more prospective deposits lie mostly in areas of swampy and lacustrine soils dominated by clay, silt and diatomite (Mory 1995). Beard (1975) described the vegetation of the Project area as belonging to the Eridoon system (Figure 3), which mostly occurs on flat coastal plain where longitudinal sandy ridges have formed after deposition by small rivers and creeks. Surface sands are bleached white and, at depths of up to one metre below ground, clay loams are present. Vegetation is characterised by scattered small trees, an open layer of tall shrubs and a closed layer of heath like shrubs. There are some damplands scattered throughout this system where heavier clay-like soils occur.



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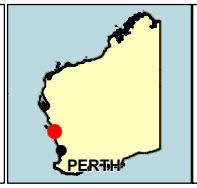

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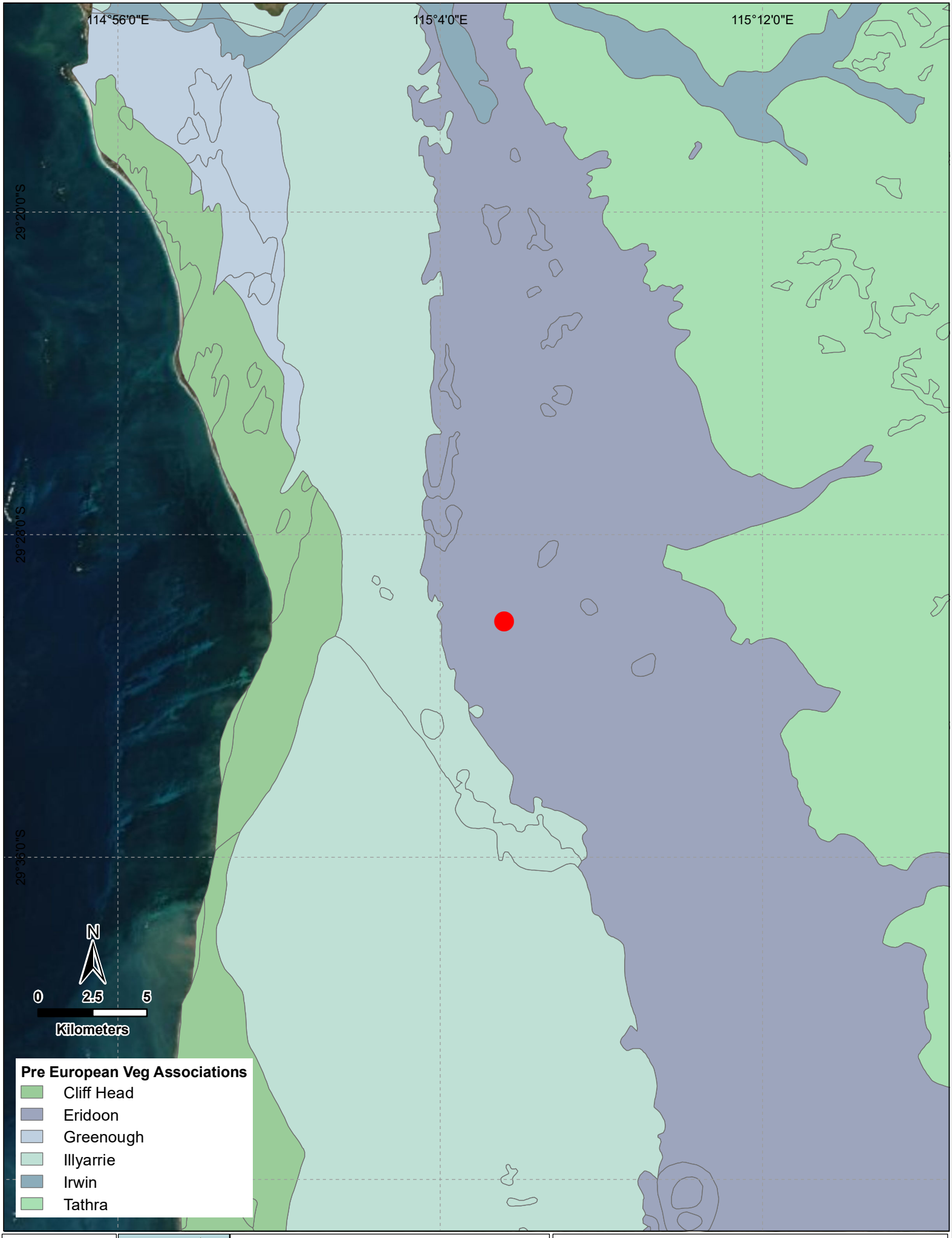
The Project

Figure 2: Surface geology in the vicinity of the Project as per the Western Australia Geological Survey 1:100,000 series.



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The Project

Figure 3: Pre-European vegetation systems as defined by Beard (1975).

Woodman Environmental (2011) conducted detailed vegetation mapping in the Project and surrounding areas. This identified five vegetation types within the Project area (Figure 4 and Table 1). They were:

- Low woodland to thicket of *Banksia attenuata* and *Banksia menziesii* over mixed shrubs dominated by myrtaceous species.
- Pockets of vegetation classified as heath to thicket dominated by *Allocasuarina campestris* and/or *Banksia leptophylla var. leptophylla* that are predominately to the north with a few scattered pockets to the south.
- Two pockets of thicket dominated by *Actinostrobus pyramidalis* and *Banksia leptophylla* var. *leptophylla* to the south-east that extend outside the project area to the east.
- An area characterised as species rich woodlands and heaths on the western edge of the Project that extends substantially further west.
- A small pocket of thicket dominated by *Banksia hookeriana* and/or *Banksia attenuata*, with emergent *Banksia prionotes* that also extends well beyond the boundary of the Project area westwards (Figure 4 and Table 1).

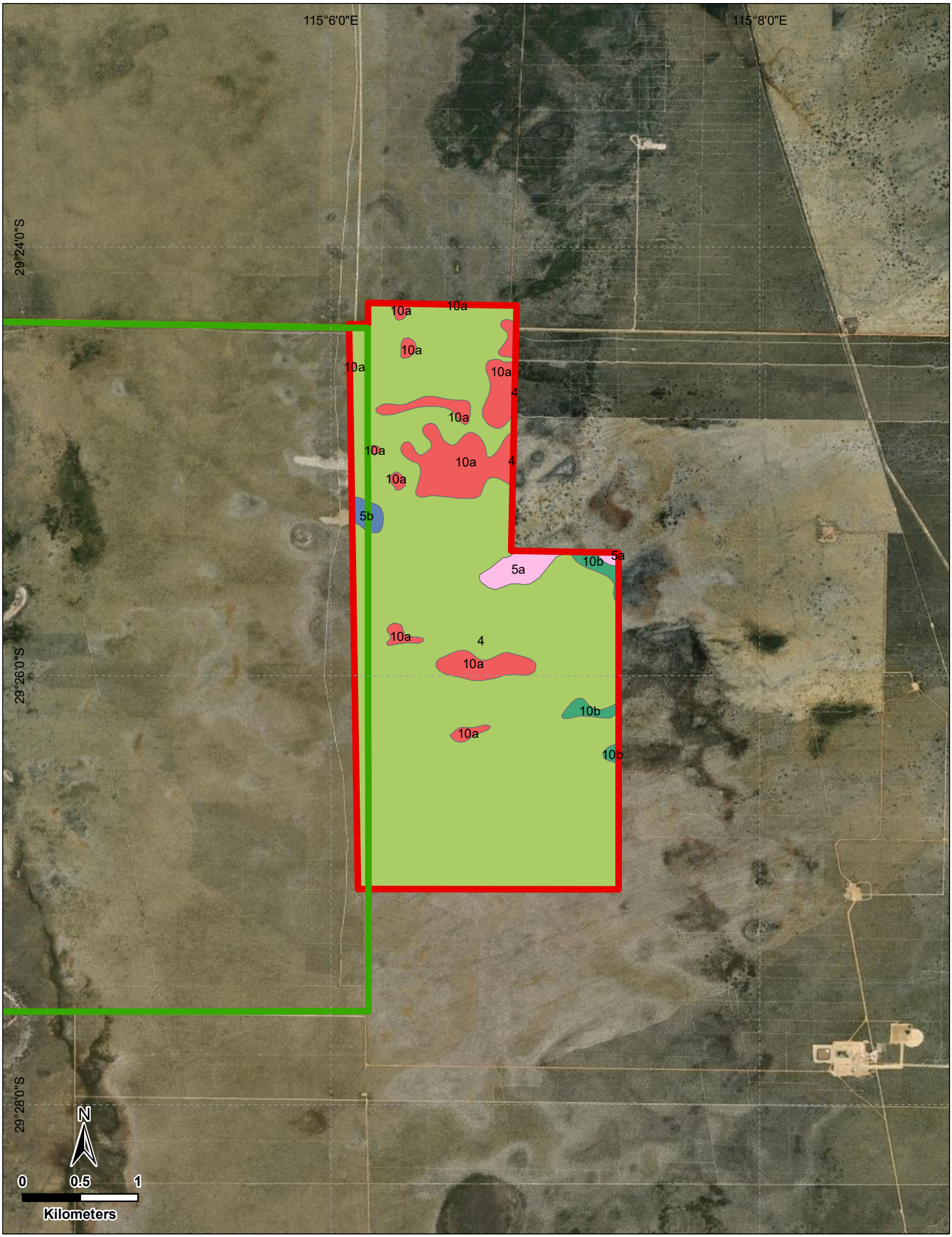
The soils and ground cover of the Project area and, to a lesser extent, the vegetation communities have the potential to harbour SRE species, particularly in microhabitats that have higher local moisture content than surrounding areas, such as bark, leaf litter beds, soil humus, and large debris. Such microhabitats within areas of remnant vegetation on the Geraldton Sandplains are likely to have provided refuges for many relictual invertebrate taxa, as the region has undergone long-term aridification and more recent clearing for agriculture (ecologia 2010). It is possible that the taller and/or thicker vegetation communities, such as woodlands, shrubs and closed heaths, are likely to contain a higher proportion of prospective microhabitats than more open communities within the Project. However, appropriate microhabitats may potentially be found within any of the Project area vegetation communities.

Despite a lack of dedicated sampling effort in the Geraldton Sandplains, species from numerous SRE Groups have been recorded from habitats in the bioregion that resemble those of the Project area. The groups collected include mygalomorph spiders, scorpions, pseudoscorpions, isopods, millipedes and snails (Bennelongia 2021a; ecologia 2010; Harvey *et al.* 2000). Mygalomorph spiders appear to be diverse in coastal sandplains of the bioregion; for example, many species of the family Idiopidae are endemic to the Geraldton Sandplains (Rix *et al.* 2018a; Rix *et al.* 2018b; Rix *et al.* 2019).

Regular fire has the potential to impact collections of SRE specimens through the removal of habitat such as leaf litter and bark on trees. Aerial imagery shows large sections of the northern half of the Project area had large fire scars from recent burns. Some stray cattle were present and the soil compaction and general disturbance they caused had potential to detrimentally affect occurrence of SREs, especially burrowing species.

Table 1: Vegetation units found in the Project as define by Woodman Environmental (2011).

Veg type Code	Description
4	Low Woodland to Thicket of *Banksia attenuata* and *Banksia menziesii* over mixed shrubs dominated by myrtaceous species on brown or yellow sand
5a	Species rich Woodlands and Heaths on grey sand in the eastern portion of the Eneabba sandplain
5b	Thicket dominated by *Banksia hookeriana* and/or *Banksia attenuata*, with emergent *Banksia prionotes* on yellow sand on upper slopes and dune crests
10a	Heath to Thicket dominated by *Allocasuarina campestris* and/or *Banksia leptophylla* var. *leptophylla* on grey or brown sandy clay in drainage lines
10b	Thicket dominated by *Actinostrobus pyramidalis* and *Banksia leptophylla* var. *leptophylla* on grey diatomaceous earth or sandy clays on lower slopes



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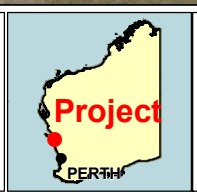

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- The Project
- Mine Development Envelope
- Yardanogo Nature Reserve

Figure 4: Vegetation communities in the Project survey area (Woodman 2011).

3. DESKTOP ASSESSMENT

3.1. Methods

Previous records of terrestrial invertebrate species were collated from the Western Australian (WAM) and Bennelongia databases, including records from recent surveys in tenements held by VRX Silica that are adjacent to the Project (Bennelongia 2021a, b), along with records in published taxonomic literature. This was done for a search area extending 50 km north, east and south of the Project and bordered to the west by the Indian Ocean (decimal degree coordinates of search area, top left: -29.0°S:114.8°E, bottom right -30.0°S:115.6°E).

In processing records, it was first determined whether any species in the search were listed as Threatened or Priority species. We then applied the criteria listed in section 1.2 to evaluate the SRE status of species. Many of the records from the databases were higher order identifications for which the species had not been determined; these were retained in the final species list only if there were no other species-level identifications within the same taxonomic group.

3.2. Results

3.2.1. Listed and Threatened Species

The database searches returned records of three Priority species (Table 2, Figure 5); the land snail *Bothriembryon perobesus,* the trapdoor spider *Idiosoma kwongan* and the bee *Hylaeus globuliferus*. The most commonly recorded of these species within the search area was *B. perobesus*, which has been collected from several locations surrounding the Project (Figure 5). The other species were collected from locations between 20 and 50 km south-east of the Project, with *I. kwongan* collected from one location and *H. globuliferus* collected from three locations in the search area (Figure 5). More information about these species is provided below.

Bothriembryon perobesus

The Priority 1 snail *Bothriembryon perobesus* has currently been recorded as far south as Gingin (approximately 200 km south of the Project) and as far north as Geraldton (approximately 90 km north of the Project). Within the desktop search area, it has been collected from locations surrounding the Project, with the nearest collection approximately 5 km west on the coast (Figure 5). Many of the previous collections are associated with *Banksia* woodlands and low shrubland on white sandy soils, similar to the Project area vegetation (Whisson 2019). While most species in the genus are typically collected only in leaf litter, *B. perobesus* has been found on bare sand and the branches of shrubs (Whisson 2019). The desktop search resulted in *B. perobesus* being considered likely to occur within the Project area, which was confirmed by the field survey (see section 4.4).

Idiosoma kwongan

The Priority 1 shield-backed trapdoor spider, *Idiosoma kwongan* it appears to be restricted to the southern Geraldton Sandplains bioregion (i.e. the Lesueur Sandplains, Rix *et al.* 2018a). The records within the search area are among the most northerly records of the species and reach to within 20 km of the Project (Figure 5). However, the northern collection was from Kwongan vegetation at the Eneabba Mineral Sands mine site, which is similar to the Project area (Iluka 2012). It was therefore considered possible that the species also occurs in habitats at the Project.

Hylaeus globuliferus

The Priority 3 bee *Hylaeus globuliferus* occurs throughout southwestern Australia, with the records in the search area occurring in remnants vegetation near Eneabba, as well as in Kwongan vegetation of Tathra National Park (Figure 5). This species appears to be a Proteaceae specialist (Houston 2018) and the collections in the search area were all associated with flowers and foliage of the woollybush

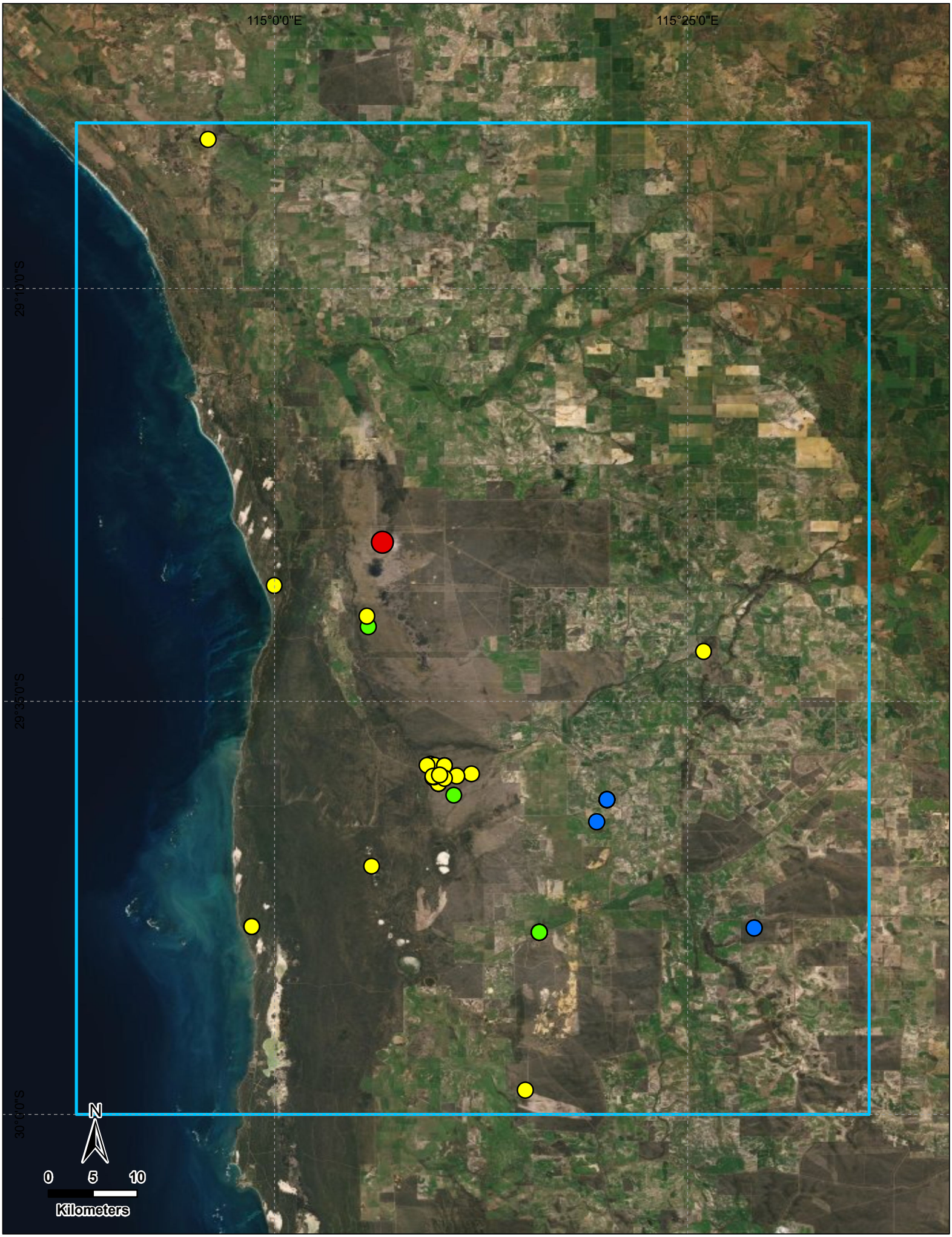
Table 2: Listed Threatened and Priority terrestrial invertebrates in the search area.

Higher Classification	Lowest Identification	BCA (2016) Status	EPBC (1999) Status	Habitat Preference	Presence of habitat at the Project	Likelihood of occurrence at the Project
Mollusca						
Gastropoda						
Stylommatophora						
Bothriembryontidae	*Bothriembryon perobesus*	P1	-	Bare sand in low vegetation under *Banksia* and *Eucalyptus* woodland (Whisson 2019)	Yes	High
Arthropoda						
Chelicerata						
Arachnida						
Araneae						
Mygalomorphae						
Idiopidae	*Idiosoma kwongan*	P1	-	Kwongan *Banksia* heathland (Rix *et al.* 2018a)	Yes	Low-Moderate
Hexapoda						
Insecta						
Hymenoptera						
Colletidae	*Hylaeus globuliferus*	P3	-	Proteaceae specialist requiring *Adenanthos cygnorum* in kwongan heathland (Houston 2018)	Yes	Moderate

Adenanthos cygnorum. The vegetation mapping within the Project did not note *A. cygnorum* as a dominant species in any communities; however, *H. globuliferus* is also known to frequent flowers of other Proteaceae species such as *Banksia*, which do occur within the Project.

3.2.2. SRE Invertebrate Groups in the Area

Using the WAM and Bennelongia databases, we recognised 15 species from SRE Groups recorded within the search area that have known or potential ranges of <10,000 km^2 (Table 3). These species included trapdoor spiders, pseudoscorpions, scorpions, centipedes, millipedes and slaters. None of the species had sufficient taxonomic certainty and representation in collections to be categorised as confirmed SREs.



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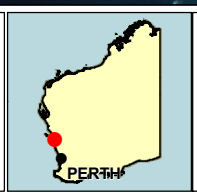

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- Search area
- The Project
- Bothriembryon perobesus
- Idiosoma kwongan
- Hylaeus globuliferus

Figure 5: Records of listed invertebrates within the search area.

Table 3: Confirmed and potential SREs species from SRE Groups in the search area.
*Species marked with an asterisk under the SRE category column were data deficient.

Higher Classification	Lowest Identification	SRE Category
Arthropoda		
Arachnida		
Araneae		
Mygalomorphae		
Actinopodidae	*Missulena* `bisevac sp. 1`	Likely potential SRE
	Missulena `bisevac sp. 2`	Likely potential SRE
Barychelidae	*Synothele* `howi?`	Unlikely potential SRE
Idiopidae	*Bungulla banksia*	Likely potential SRE
	Euoplos mcmillani	Likely potential SRE
Pseudoscorpiones		
Panctenata		
Olpiidae	*Beierolpium* sp.	Likely potential SRE*
Scorpiones		
Urodacidae	*Urodacus* `SCO016, Mingenew`	Likely potential SRE*
Chilopoda		
Lithobiida		
Henicopidae	*Lamyctes* sp.	Unlikely potential SRE*
Diplopoda		
Polydesmida		
Paradoxosomatidae	*Antichiropus* `DIP057, cooljarloo`	Likely potential SRE
	Antichiropus `DIP076, ensiculus`	Likely potential SRE
	Antichiropus `DIP076, houstoni`	Likely potential SRE
	Antichiropus `DIP078, Eneabba 1`	Likely potential SRE
	Antichiropus sulcatus	Likely potential SRE
Spirostreptida		
Iulomorphidae	*Podykipus* sp.	Likely potential SRE*
Crustacea		
Malacostraca		
Isopoda		
Ligiamorpha		
Armadillidae	*Buddelundia lateralis*	Likely potential SRE*

However, based on available information regarding habitat specialisation, biology and ecology of the species or their close relatives, nine of the species are considered likely potential SREs. A further five species were data deficient and assigned as likely potential SREs by default (these species are marked with an asterisk in Table 3). One species with uncertain identification, the barychelid trapdoor spider *Synothele* `howi?' is considered an unlikely potential SRE. If this record represents *S. howi*, then a polygon around current records of the species extends slightly beyond 10,000 km^2.

4. FIELD SURVEY

A single season Level 1 field survey of SRE invertebrate fauna was undertaken in accordance with the *Technical Guidance: Sampling of Short Range Endemic Invertebrate Fauna* (EPA 2016b). The survey was designed to target species from invertebrate groups known to contain a high proportion of range-restricted species: land snails (Gastropoda), millipedes (Diplopoda), centipedes (Chilopoda),

pseudoscorpions (Pseudoscorpiones), scorpions (Scorpiones), spiders (Mygalomorphae and Selenopidae), harvestmen (Opiliones) and slaters (Isopoda). Earthworms (Megadrilacea) and velvet worms (Onychophora) were not targeted because they are restricted to high-rainfall areas (Blakemore 2000; Reid 2002). The specific aims of the survey were to:

1. Characterise the SRE community in the Project area;
2. Provide information about the potential SRE habitats of the Project area and its surrounds; and
3. Assess the SRE status of species and the likelihood of their confinement to disturbance areas at the Proposal.

4.1. Conditions during Survey

The survey was conducted over four days from 26-29 July 2021. The regional weather and climate guide for the Northern Agricultural Region describes the area as having reliable winter rain but unreliable summer rain (BOM 2020). Rain was present in the months leading up to the survey (observed personally by the survey team), making conditions suitable for SRE surveys. The nearest Bureau of Meteorology weather stations (Geraldton and Carnamah) recorded where approximately 62 mm and 77 mm, respectively, of rain in the two weeks prior to the survey. Sporadic showers were occurred in the Project area throughout the four days of survey.

4.2. Survey Effort

A total of 18 sites were sampled across the Project area (Figure 6). They were distributed across each of the habitats present based on vegetation mapping conducted by Woodman Environmental (2011) and with minor adjustments to the pre-selected locations when in the field to focus on sampling isolated vegetation patches likely to harbour SRE species. Photos of sites are shown in Appendix 3.

4.3. Survey Methods

Two sampling methods were used at each site – active foraging and litter collection. Detailed information on habitat characteristics was also collected at each site as a means of characterising the habitat requirements of all species. The metrics included extent of shade and litter cover, fire and stock impact, soil types, landscape forms and dominant vegetation.

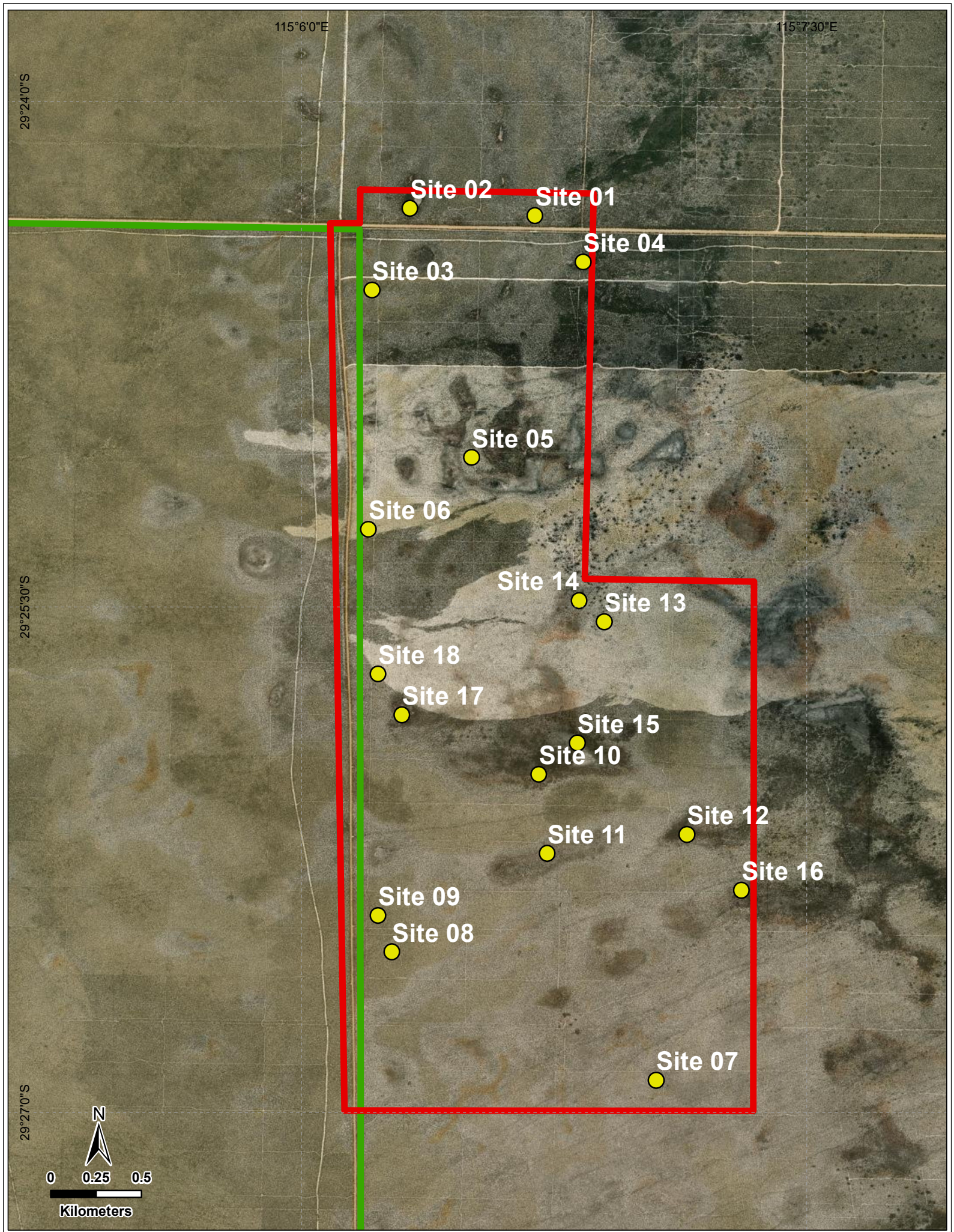
While walking to, from and between sites, any SRE group species observed were collected as opportunistic samples as a means of maximising specimen collection and increasing knowledge on species habitat requirements and distribution around the Project.

4.3.1. Foraging

Active searches of all prospective microhabitats present, including leaf litter, under logs, in the soil and bark at the base of large trees and under rocks were conducted at each site for 1-2 hours by two staff. Proportion of time spent on different searching techniques varied between sites depending on the presence of microhabitats suitable to SREs but detecting the presence of burrows was consistently prioritised.

Leaf blowers were used to uncover trapdoor spider burrows which were subsequently excavated to collect the specimen. *Urodacus* scorpions were collected in cup traps and occasionally through burrow excavations. Comprehensive light and UV spotlighting was undertaken at 10 sites by two people at night to collect nocturnally active species, e.g. night hunting spiders of the family Selenopidae, or animals that fluoresce under ultraviolet light making them easily detectable (scorpions and opilionids).

All animals collected by foraging were preserved directly in 100% ethanol.



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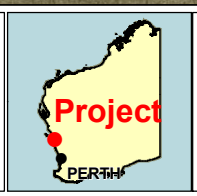
Author: vmarques
Date: 21/03/2022



Legend

- Mine Development Envelope
- Yardanogo Nature Reserve
- The Project
- Sites

Figure 6: Beharra development envelope and SRE survey sites

Table 4. Characterisation of sites (locations shown in Figure 6) where SRE groups were surveyed.

Site	Bark Peel	Log Turn	Burrow Dig	Litter Sieve (number)	Leaf Blow	UV Spotlighting	Scorpion cup traps	Shade	< 1 cm litter (%)	1 - 5 cm litter (%)	> 5 cm litter (%)	Soil Type	Landform	Habitat Description	Slope	Moisture	Fire Impact score (0 = no fire, 3 = recent intense fire intense fire)	Stock Impact score (0 = no stock damage, 3 = intensive stock damage)
Site 01		✓	1	2	✓	✓	4	Low 5-20%	20	05	0	White Sand	Sand Plain	*Allocasuarina, Acacia, Eucalyptus* and *Banksia* shrubland	Flat	Damp Topsoil	0	0
Site 02	✓	✓	3	2	✓	✓	1	Med to High 60-80%	50	20	0	Brown Sandy Clay	Damplands	*Allocasuarina* woodland	Flat	Dry	0	0
Site 03		✓		2	✓	✓	3	Low 5-20%	15	05	0	White Sand	Sand Plain	*Acacia* and *Banksia* shrubland	Flat	Damp Topsoil	2	0
Site 04	✓	✓	2	2	✓	✓		Medium 40-60%	60	20	0	Brown Sandy Clay	Sand Plain	*Acacia* shrubland	Flat	Damp Topsoil/Pooling water	2	0
Site 05		✓		2	✓			Negligible <5%	10	0	0	White Sand	Sand Plain	*Acacia* and *Casuarina* shrubland	Flat	Damp Topsoil	2	0
Site 06	✓		2	2	✓			Negligible <5%	10	0	0	White Sand	Sand Plain	*Acacia* and *Banksia* Shrubland	Low	Damp Topsoil	0	0
Site 07	✓	✓		2	✓	✓	1	Low 5-20%	20	10	0	White Sand	Sand Plain	*Allocasuarina, Acacia, Eucalyptus* and *Banksia* shrubland	Flat	Damp Topsoil	0	0
Site 08	✓	✓		2	✓	✓	3	Low 5-20%	15	5	0	White Sand	Sand Plain	*Allocasuarina* and *Banksia* shrubland	Flat	Damp Topsoil	0	0
Site 09			1	2	✓			Low 5-20%	20	5	0	White Sand	Sand Plain	*Acacia* and *Banksia* shrubland	Flat	Damp Topsoil	1	0
Site 10				2	✓	✓	3	Medium 40-60%	40	10	0	Brown Sandy Clay	Damplands	*Acacia* shrubland	Flat	Damp Topsoil	0	0

Site	Bark Peel	Log Turn	Burrow Dig	Litter Sieve (number)	Leaf Blow	UV Spotlighting	Scorpion cup traps	Shade	< 1 cm litter (%)	1 - 5 cm litter (%)	> 5 cm litter (%)	Soil Type	Landform	Habitat Description	Slope	Moisture	Fire Impact score (0 = no fire, 3 = recent intense fire intense fire)	Stock Impact score (0 = no stock damage, 3 = intensive stock damage)
Site 11				2	✓	✓	1	Low to Med 20-40%	20	05	0	Brown Sandy Clay	Sand Plain	*Acacia* and *Allocasuarina* shrubland	Low	Damp Topsoil	0	0
Site 12			1	2	✓	✓		Low to Med 20-40%	40	10	0	Brown Sandy Clay	Sand Plain	*Acacia* and *Allocasuarina* shrubland	Flat	Damp Topsoil	0	0
Site 13	✓	✓	1	2	✓	X		Low 5-20%	10	0	0	White Sand	Sand Plain	*Banksia* shrubland with *Eucalyptus* copse	Flat	Damp Topsoil	2	0
Site 14		✓	1	2	✓	X		Low 5-20%	10	0	0	White Sand	Sand Plain	*Banksia* shrubland	Flat	Damp Topsoil	2	0
Site 15		✓		2	✓	X		Negligible <5%	5	0	0	Brown Sandy Clay	Damplands	*Acacia* grassland	Flat	Damp Topsoil	1	0
Site 16				2	✓	✓	5	Low to Med 20-40%	40	10	0	White Sand	Sand Plain	*Acacia* and *Allocasuarina* shrubland	Flat	Damp Topsoil	0	0
Site 17		✓	2	2	✓	X		Low 5-20%	30	15	0	Brown Sandy Clay	Damplands	*Acacia* and *Allocasuarina* shrubland	Flat	Damp Topsoil	0	0
Site 18				2	✓	X	5	Negligible <5%	05	0	0	White Sand	Sand Plain	*Acacia* and *Banksia* shrubland	Flat	Damp Topsoil	1	0

4.3.2. Soil and Leaf Litter Collection

Two composite samples of approximately 1 L of leaf litter and underlying soil were collected from all 18 sites and placed in calico bags. The samples were kept cool and out of direct light, transported back to the laboratory and placed in Tullgren funnels to collect invertebrates using absolute ethanol as a preservative. Subsequently, the substrate was also sorted under dissecting microscopes to collect any remaining specimens.

4.3.3. Morphological Species Identification

All animals collected by foraging, and the species belonging to SRE groups in the Tullgren funnels, were identified morphologically to species level unless the material was unsuitable for identification. This was done using dissecting and compound microscopes and the available taxonomic literature, unpublished keys, and reference collections. The identifications were made by Bruno Buzatto (spiders, scorpions, myriapods), Huon Clark (slaters, snails) and Jane McRae (pseudoscorpions) at the Bennelongia laboratory.

4.3.4. Molecular Species Identification

DNA sequencing was attempted on several specimens from the study area to provide or confirm species identifications. Depending on the size of the specimens, legs or whole animals were used for DNA extractions using a Qiagen DNeasy Blood & Tissue kit (Qiagen 2006). Elute volumes varied from 40 µL to 200 µL depending on the quantity of material. Primer combinations used for PCR amplifications were LCO1490:HCO2198 and C1J1718:HC02198 for the MT-CO1 gene (Folmer *et al.* 1994; Simon *et al.* 1994), as well as SRJ14197:SRN14745 for the 12S gene (Simon *et al.* 2006). Next, dual-direction, sanger sequencing was undertaken for PCR products by the Australian Genome Research Facility (AGRF). Sequences returned were aligned in Geneious (Kearse *et al.* 2012) and neighbour-joining phylogenetic trees were estimated using 1,000 bootstraps. Genetic distances (using the Tamura-Nei method) between sequences were measured as uncorrected p-distances (total percentage of nucleotide differences between sequences). Sequences on GenBank and in the grey literature were included in phylogenetic analysis to provide a framework for assessing intra- and interspecific variation, as well as to document the levels of intraspecific differentiation in described species across their geographic ranges.

4.4. Survey Results

4.4.1. On-site Assessment of Habitats

During the survey, two main landforms were identified, 1) sandy plain which, generally speaking had *Banksia* species and heath shrubland and 2) low lying damplands which contained soils with a higher clay content that supported thicker copses of *Allocasuarina* and *Acacia* (Figure 7). It is these small pockets of vegetation/habitat that maybe expected to harbour SREs due to the isolated nature of them throughout the landscape. It was also noticed that one area in the centre of the Project that had originally been assessed as dominated by *Allocasuarina* was, in fact, primarily dominated by *Acacia* species although *Allocasuarina* was present (labelled as 10c in Figure 7).

4.4.2. Animal Collection and Records

A total of 169 specimens belonging to at least 21 SRE Group species were collected during the July 2021 field survey (Table 5). The SRE Groups recorded included trapdoor spiders (six species), isopods (four species), pseudoscorpions (three species), scorpions (three species), centipedes (three species), and snails (two species). Table 5 provides a list of the species and an assessment of their SRE status. Detailed comments about the results of genetic analysis, taxonomy and SRE status are provided below for some species. Not all species are discussed and the reader should refer to Table 5 for a comprehensive listing of species and status.

Bennelongia Environmental Consultants

GCS GDA 1994
Author: vmarques
Date: 21/03/2022

Legend

- Mine Development Envelope
- Yardanogo Nature Reserve
- Damplands
- Sandy plain

Figure 7: Landforms and updated vegetation based on onsite survey

Table 5. SRE Group species collected with an assessment of likely SRE status.

Higher Order Taxonomy	Lowest Identification	No of Specimens	Sites	Known only from the Project	Distribution and SRE status
Arthropoda					
Arachnida					
Araneae					
Mygalomorphae					
Idiopidae	*Euoplos* sp.	1	9	Not known	Data deficient likely potential SRE; failed to return a sequence. Could be same as an individual from Arrowsmith
	Idiosoma `MYG222`	1	6	No	Widespread, linear range of 141 km
	Idiosoma kwongan	2	1, 2	No	P1 listed; likely potential SRE; also known from Arrowsmith (21 km SSE) and Mt Lesueur, 83 km to the south.
	Idiosoma 'BMYG191`	2	4, 14,	No	Widespread; Matched WAM T132757 from Perth suburbs approx. 290 km south of project
	Idiosoma 'BMYG192`	1	12	Yes	Data deficient likely potential SRE; singleton
	Idiosoma 'BMYG193`	1	13	Yes	Data deficient likely potential SRE; singleton
	Idiosoma sp.	4	2, 6, 17	Uncertain	Could be either *Idiosoma* 'BMYG191` or *Idiosoma* 'BMYG190` from Arrowsmith
Pseudoscorpiones					
Chthoniidae	*Austrochthonius* `BPS376`	17	1, 2, 4, 13, 14	No	Data deficient unlikely potential SRE; also known from Arrowsmith; known linear range of 30 km, multiple habitats
	Chthoniidae sp.	4	2, 12	Uncertain	Possible further records of *Austrochthonius* `BPS376`
Olpiidae	*Beierolpium* 8/4 `BPS380`	5	4, 7, 11, 14	Yes	Data deficient unlikely potential SRE; known from four sites up to 5.3 km apart, multiple habitats
	Austrohorus `BPS381`	1	6	Yes	Data deficient likely potential SRE; singleton
Scorpiones					
Bothriuridae	*Cercophonius granulosus*	19	2, 3, 4, 5, 12	No	Widespread

Higher Order Taxonomy	Lowest Identification	No of Specimens	Sites	Known only from the Project	Distribution and SRE status
Urodacidae	*Urodacus* `BSCO072`	4	7, 16 and two opportunistic collections	No	Unlikely potential SRE; also known from Arrowsmith; confirmed linear range of 13 km but likely range of 300 km
	Urodacus `BSCO071`	6	1, 4, 8	No	Data deficient likely potential SRE; also known from Arrowsmith; known linear range of 30 km
Chilopoda					
Geophilida					
Chilenophilidae	Chilenophilidae`BGE056`	1	7	Yes	Data deficient likely potential SRE; singleton
Schendylidae	*Australoschendyla* `BGE054`	1	3	No	Data deficient likely potential SRE; also known from Arrowsmith; known linear range of 31 km
Lithobiomorpha					
	Lithobiomorpha sp.	22	2, 10, 12, 15, 16, 17	Uncertain	Data deficient unlikely potential SRE; Could be the species of *Lamyctes* (family Henicopidae) from the Desktop results
Malacostraca					
Isopoda					
Armadillidae	*Buddelundia* `BIS449`	8	1, 7, 10, 14	No	Data deficient unlikely potential SRE; also known from Arrowsmith; known linear range of 29 km, multiple habitats
	Buddelundia `BIS451`	1	2	No	Data deficient likely potential SRE; also known from Arrowsmith; known linear range of 15 km
Philosciidae	*Laevophiloscia* `BIS445`	29	1, 2, 10, 11, 15, 17	No	Data deficient unlikely potential SRE; also known from Arrowsmith; known linear range of 30 km, multiplr habitats
	Philosciidae `BIS446`	9	1, 5, 15, and one opportunistic collection	No	Data deficient unlikely potential SRE; also known from Arrowsmith; known linear range of 29 km, multiple habitats
Mollusca					

Higher Order Taxonomy	Lowest Identification	No of Specimens	Sites	Known only from the Project	Distribution and SRE status
Gastropoda					
Bothriembryontidae	*Bothriembryon perobesus*	28	3, 5, 6, 7, 8, 9, 13, 14, 18 and one opportunistic collection	No	P1 listed; Widespread (records extending 290 km North to South)
Punctidae	*Westralaoma aprica*	2	2	No	Widespread, southwest WA

Mygalomorph (trapdoor) spiders

Figure 8: *Idiosoma kwongan* from the Project

The majority of mygalomorph spiders construct burrows (Main 1985), often close to their maternal burrow due to their poor dispersal ability (Buzatto *et al.* 2021). Burrow morphology can be highly variable between species (Mason *et al.* 2012) and can consist of open holes (Castalanelli *et al.* 2020), or those covered with a trap door (Main 1985). Those that build trapdoors often incorporate specific vegetation into the lids (Rix *et al.* 2018a) highlighting the importance of habitat and species associations for these species.

The desktop search identified five species of trapdoor spiders in the search area that were considered potential SREs, representing the families Actinopodidae (two species), Barychelidae (one species) and Idiopidae (two species). The two species within Actinopodidae were undescribed species of the mouse spider known from heathland at a mineral sands mine south of Eneabba, similar to the Project area. However, no specimens of this genus were collected during the field survey, which detected at least six species of mygalomorph spider from the family Idiopidae. All collected mygalomorph spiders were females or juveniles dug from burrows, so identification to species level relied on genetic work.

Spiny trapdoor spiders (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.* 2018a). The desktop search detected the described species *Bungulla banksia* and *Euoplos mcmillani* near the Project. Like many species in the family Idiopidae, *B. banksia* and *E. mcmillani* are restricted to the Geraldton Sandplains region, where they prefer Kwongan heathland on sandy soils such as the habitat of the Project area (Rix *et al.* 2018b; Rix *et al.* 2019). The field survey did not detect the presence of the genus *Bungulla* in the survey area. Regarding the genus *Euoplos*, one adult female was collected from her burrow in site 9. This genus is represented by three different groups in Western Australia, *the Euoplos inornatus*-group, the *Euoplos hoggi*-group and the *Euoplos mcmillani*-group (Rix *et al.* 2019). Despite the fact that the desktop search identified the species *Euoplos mcmillani* from the search area, the individual collected was

morphologically more consistent with the *Euoplos hoggi*-group. Unfortunately, the specimen failed to return a sequence, so its identification to species level was not possible. The detection of a species from the *Euoplos hoggi*-group in the Project would represent a slight range extension for the *Euoplos hoggi*-group. Under the precautionary approach, this species is here considered a **likely potential SRE**, but it is an uncertain assignment.

At least five species of *Idiosoma* species were collected during the field survey at Beharra. This includes the **Priority 1 listed species** *Idiosoma kwongan* (Figure 1), which is treated here as a **likely potential SRE**. It belongs to a group with a high proportion of SRE species and, while considered data deficient by Rix *et al.* 2018a), has known distribution from existing records of about 500 km^2. Owing to the conservation significance of this species, DNA analysis was conducted which resulted in a genetic match to species sequences from both Genbank and specimens from VRX Silica tenements (divergences of 4.6% and 4.2-4.5%, respectively). This is below the minimum interspecific divergence of 7% and an average intraspecific divergence of 5.4% for the group of animals including *I. kwongan* presented by Rix *et al.* (2018a), in their study on the systematics of the shield-backed trapdoor spiders. This collection resulted in a range extension for this species.

A further nine specimens of *Idiosoma* were also collected and divided into three morphospecies with an additional two determined as too juvenile to ascertain morphospecies identification. As a result, one of each morphospecies, each consistent with specimens collected in tenements neighbouring the Project and both juvenile specimens were sequenced. This resulted in the identification of four species, none of which matched the anticipated morphospecies identified from the surrounding area. Two individuals (one juvenile and one adult) from Beharra matched genetically with a divergence of 0.0% in Mt-COI. These individuals have been assigned as *Idiosoma* `BMYG191` (Figure 9). These specimens were both 13.3% divergent in Mt-COI from its closest morphospecies in the surrounding area. They did, however, match a specimen lodged at the Western Australian Museum (WAM) (Reg No T132757) with Mt-COI divergences of 6.9 and 7.0% respectively. This specimen was collected from Shenton Bushland only 5 km west of the Perth CBD resulting in a known linear distribution of approximately 290 km. As a result, this species is considered **not an SRE** (i.e. it is relatively widespread).

A third individual has been assigned to *Idiosoma* `BMYG192`. This individual was expected to be a match to an individual collected close by, however it was divergent in Mt-COI by 11.6%. No other sequences could be found that matched, resulting in this individual being considered a new species known only from one site at the Project (Figure 9). Similarly, *Idiosoma* `BMYG193` was 15.9% divergent when using Mt-COI from its nearest relative and is therefore again considered to be a new species known only from one site at the Project (Figure 9). Both of these species are considered to be data deficient **likely potential SREs**.

The final individual, Idiosoma 'MYG222', was a juvenile with a sequence matching at least two other individuals. One sequence was from an animal collected 141 km south with a divergence of 2.7% in Mt-COI and the other sequence was on GenBank with a divergence of 2.9% in Mt-COI (Figure 9). Idiosoma 'MYG222' has a linear sequence of at least 141 km and is considered **not an SRE**.

An additional four specimens of trapdoor spider were collected during vertebrate surveys at the Project from 1-9 December by Bamford Consulting Ecologists. This included three males and a female. Locational data and habitat information were not provided with these specimens. Each of them is a member of the Anamidae family. The males were able to be taken to genus and each of them is *Kwonkan* sp. while the female could not be taken past family based on morphology and therefore remains as Anamidae sp.

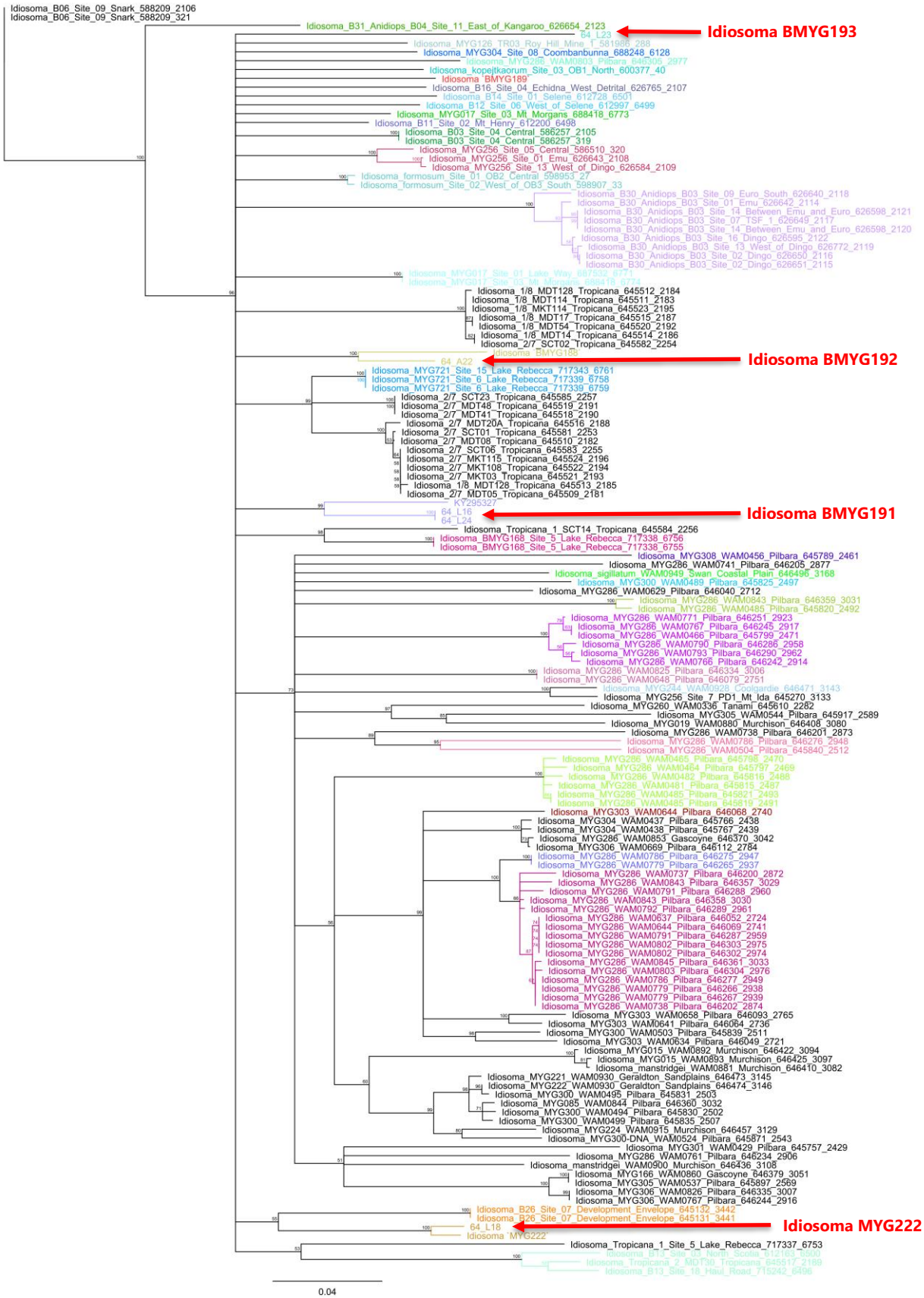


Figure 9: Maximum likelihood tree based on barcoding analyses of sequences of the family Idiopidae. The species sequenced from the current survey are highlighted with red arrows.

Four individuals that were assigned into a morphospecies with *Idiosoma* `BMYG193` could not be assigned to species, as morphologically, they match both *Idiosoma* `BMYG193` and *Idiosoma* `BMYG190` from the surrounding area. As a result, they are reported as *Idiosoma* sp. and would require further sequencing to determine the species level identification.

Pseudoscorpions

Epigean pseudoscorpion species are mostly considered to have widespread distributions and it has been suggested that few species are SREs (Harvey 2002). Phoresy (dispersal by means of attachment to a host organism) has been documented for many families of pseudoscorpion (Jhasser Martínez *et al.* 2018; 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 Furthermore, some species are restricted to specialist habitats including granite outcrops and have limited distributions (Harvey 2010, 2012; Harvey 2018; Harvey *et al.* 2015).

The desktop only detected one pseudoscorpion in the search area that was considered to be a Potential SRE and it was a genus level identification (*Beierolpium* sp.). The taxonomy of this group is poorly defined and there has been no formal review of the genus *Beierolpium* in Western Australia. Consequently, *Beierolpium* sp. was considered data deficient and listed as a likely potential SRE by default. The field survey identified at least three species of pseudoscorpion in the Project, representing the families Chthoniidae and Olpiidae.

Seven individuals of *Austrochthonius* `BPS376` (family Chthoniidae) were collected from five sites (1, 2, 4, 13, 14). This species is also known from 30 km south of the Project and is restricted to the Project area. However, because of its relatively small known range, it is conservatively listed as an **unlikely potential SRE**. A further four specimens of Chthoniidae sp. were collected; they were juveniles and could not be determined to species level through morphology, although they are probably further representatives of *Austrochthonius* `BPS376`.

Two species of Olpiidae were collected, both of which are known only from the Project aera. Five specimens of *Beierolpium* 8/4 `BPS380` were collected from four sites (4, 7, 11, and 14) within the Project with a known linear distribution of 5.3 km. It is possible that this species is the *Beierolpium* sp. from the desktop search but that could not be confirmed. *Beierolpium* 8/4 `BPS380` is considered to be an **unlikely potential SRE** based on occurrence *Austrohorus* `BPS381` was collected once at site 6 and is therefore considered to be a singleton and a data deficient **likely potential SRE**. Due to the unique morphology of these species, no genetic sequencing was required.

Scorpions

A single scorpion (and undescribed species of *Urodacus*) in the desktop search area was considered a potential SRE. The record in the search area was from near Mingenew, approximately 50 km north-east of the Project, in habitat that is likely to be quite different to the Project area. The survey did not detect any specimens consistent with that morphospecies, but three other species of scorpion were collected: the described and widespread *Cercophonius granulosus* (family Bothriuridae) and two species of *Urodacus* that, based on the available keys and taxonomic literature, best fit *Urodacus hartmeyeri*.

The framework for formal scorpion identification in Australia needs revision. *Urodacus* is endemic to Australia, with 20 described species and many undescribed species are known from the WAM collection (Koch 1977; Volschenk *et al.* 2010; Volschenk *et al.* 2012; Volschenk *et al.* 2000). 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, so that undescribed *Urodacus* are usually considered potential SREs. More specifically, the description of *U. hartmeyeri* is very old (Kraepelin 1908), and the only key available for the genus (Koch 1977) does not cover the multiple undescribed species that are known to occur in WA.

Two species of *Urodacus* (*U.* 'BSCO071' and 'BSCO072') were recognised morphologically. Three specimens were sequenced, and morphological comparisons of all specimens with made with specimens at WAM, including *U. hartmeyeri* and an undescribed species known as *U.* `Eneabba`. Small morphological differences suggested that neither of the species collected represented *U. hartmeyeri* and this was confirmed genetically. However, *Urodacus* `BSCO071` (Figure 10) was 0.1%-0.4% divergent in the Mt-COI gene from animals at Arrowsmith (Figure 11), giving it a known linear range of approximately 30 km and has been collected outside of the Project area. It is treated as a data deficient **likely potential SRE** because matches the current understanding of *Urodacus* biology.

The second species, *U.* `BSCO072`, was 0.1-0.9% divergent in the Mt-COI gene from animals approximately 13 km southwest of the Project, which represent the same species (Figure 11). *U.* `BSCO072` was ten compared morphologically to animals at WAM known as *U.* `Eneabba`. Morphologically, these species are extremely similar and may well be the same but genetic data are not available for the WAM individual. Subsequent surveys by Bennelongia have also resulted in a very similar morphospecies being collected near Gingin, north of Perth (yet so be sequenced). Based on the current information, *U.* `BSCO072` is considered an **unlikely potential SRE** (with a possible linear range of at least 300 km).

Figure 10: *Urodacus* `BSCO071` collected from Project.

Chilopoda (centipedes)

Only one centipede species from the desktop search area was considered a potential SRE. This was an unidentified species of *Lamyctes* (family Henicopidae). *Lamyctes* is a highly diverse Gondwanan genus, with species from a range of temperate and tropical habitats in the Southern Hemisphere (Edgecombe and Giribet 2003). This genus has yet to receive detailed phylogenetic study, but they are called rock centipedes in Australia, and are known to contain SRE. The species sp, which was collected from a mineral

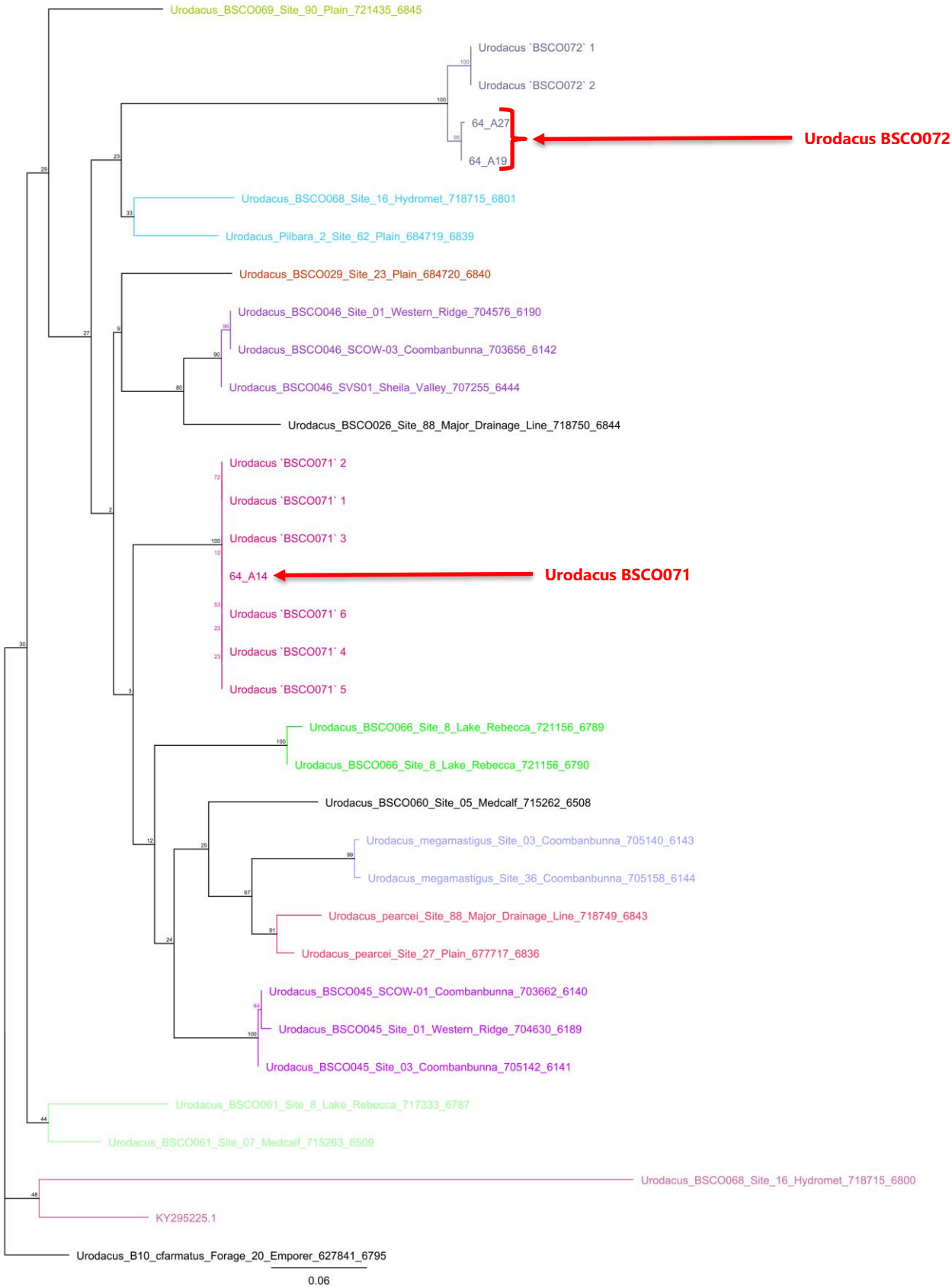


Figure 11: Maximum likelihood tree based on barcoding analyses of sequences of the genus *Urodacus*. The species sequenced from the current survey are highlighted with red arrows.

sands mine at Eneabba. was therefore considered data deficient but classified as an unlikely potential SRE on the basis on the biology of the genus as a whole *Lamyctes*. The field survey at Beharra collected 22 specimens of the order Lithobiomorpha, which includes the genus *Lamyctes,* from six sites (2, 10, 12, 15, 16, and 17). Given the similarity of habitat these could represent the genus *Lamyctes*. On this basis, combined with abundant occurrence, Lithobiomorph asp. is treated as an **unlikely potential SRE**.

Within the order Geophilida, two data deficient **likely potential SRE** species, representing two different families, were recorded. *Australoschendyla* `BGE054` (family Schendylidae) was recorded at site 3 and is also known from areas outside the Project with a known linear range of approximately 30 km. One specimen of Chilenophilidae`BGE056` from the family Chilenophilidae was collected from site 7. This is the only known record of this species.

Isopoda (slaters)

In Australia, the order Isopoda contains a largely undescribed and diverse group of terrestrial epigean crustaceans (suborder Oniscidae) that, owing to poor dispersal capabilities and specific habitat preferences, are often SREs (Judd 2004; Judd and Horwitz 2003; Judd and Tati 2011). The desktop search recorded one species of slater in the search area, *Buddelundia lateralis*. Several species in the genus *Buddelundia* have restricted distributions (Judd 2004) but there is very little published information on *B. lateralis*, and it is considered data deficient likely potential SRE. The records in the search area are from the Mingenew area, nearly 50 km from the Project and likely to be in very different habitat. Thus, *Buddelundia lateralis* was not expected to occur at Beharra.

The field survey recorded four different species of isopods, from the families Armadillidae (*Buddelundia* `BIS449` and *Buddelundia* `BIS451`) and Philosciidae (*Laevophiloscia* `BIS445` and Philosciidae `BIS446`). Both species of *Buddelundia* are known from sites outside the project, so that *B*. `BIS449` has a known linear range of 28 km and is considered to be a data deficient **unlikely potential SRE** because of its abundance and occurrence in multiple habitats. Unfortunately, the attempted sequencing for *B*. `BIS449` failed so comparisons could not be made to specimens further afield. *Buddelundia* `BIS451` has a known linear range of 15 km but is known from a single habitat in the Project and so is treated as a data deficient **likely potential SRE**. The different conclusions regarding the status of these similar species highlights the often very arbitrary nature of decisions about SRE status when few surveys have occurred in areas of potential habitat.

Laevophiloscia `BIS445` and Philosciidae `BIS446` are also known from outside the Project, each with a known linear ranges of 29-30 km. One specimen of Philosciidae `BIS446` was sequenced, which confirming it was conspecific with animals 29 km away (divergence 4.4-5% in the Mt-COI gene) (Figure 13). The sequence for *Laevophiloscia* `BIS445` failed but morphology strongly indicated animals in the Project and 30 km away are conspecific. Both species are treated as data deficient **unlikely potential SREs**.

Gastropoda (land snails)

A total of 28 specimens of the **Priority 1 listed species** *Bothriembryon perobesus* (Figure 12) were collected at nine sites at Beharra (sites 3, 5, 6, 7, 8, 9, 13, 14, and 18). A majority of these were collected as live specimens, adding significantly to the known collection of this species. This species was detected in the desktop search and these collections fall within the known of the species. Similar specimens were collected in neighbouring tenements and genetic analysis confirmed them as conspecifics with a divergence of 2.5% in the Mt-COI gene. The identification of this species was also confirmed by experts at WAM. No other potential SRE snail species were collected during the survey. The species is considered to be **not an SRE**.

Figure 12: *Bothriembryon perobesus* collected from Project.

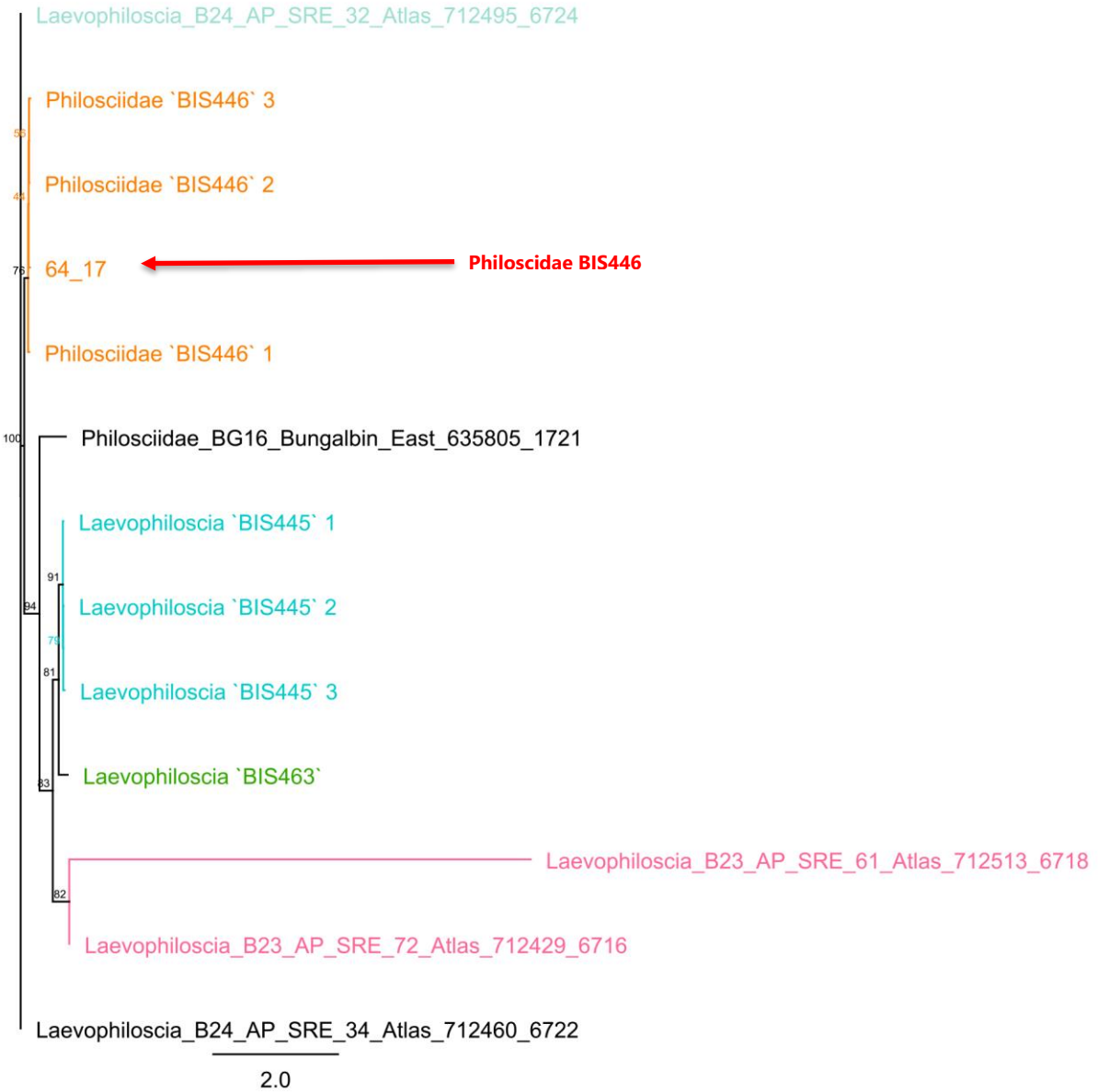


Figure 13: Maximum likelihood tree based on barcoding analyses of sequences of the isopod family Philoscidae. The species sequenced from the current survey are highlighted with red arrows.

5. DISCUSSION AND CONCLUSIONS

The field survey sampled 18 sites for species in SRE Groups. The sites were located throughout the Project area. Site selection was based on vegetation mapping conducted by Woodman Environmental (2011). The vegetation overlay two main landforms: 1) sandy plain which, generally speaking had *Banksia* species and heath shrubland, and 2) low lying damplands which contained soils with a higher clay content that supported thicker copses of *Allocasuarina* and *Acacia*. These small pockets of vegetation/habitat would conventionally be expected more likely to harbour SREs due to their isolated nature.

5.1. SRE Species

The field survey collected a total of 169 specimens belonging to at least 21 species. We classify nine species as likely potential SRE species many of these are default assignments because of lack of data and all are short of data for decision-making. One species is classified as an unlikely potential SRE based on moderately informative data and another six are classified as unlikely potential SREs based on inadequate data. Five of the species collected are widespread and are unambiguously not SREs (Table 5).

Five of the 16 species with some potential to be SREs are currently only known from the Project area. These are the mygalomorph spiders *Idiosoma* 'BMYG192` and *Idiosoma* 'BMYG193`, the pseudoscorpions *Beierolpium* 8/4 `BPS380` and *Austrohorus* `BPS381` and the centipede Chilenophilidae`BGE056`. All are likely potential SREs other than *Beierolpium* 8/4 `BPS380`, which is treated as an unlikely potential SRE because of its occurrence in multiple habitats. The difference between the desktop and field survey classification of *Beierolpium* highlights the importance of adequate data in reaching consistent conclusions about species status.

Of the four likely potential SREs, *Idiosoma* 'BMYG192` was collected at site 16 within a low lying dampland dominated by *Acacia* and *Allocasuarina* shrubland (Figure 14). This is one of the patchier habitat types within the Project area. This habitat type is present within Project on its very eastern edge but it continues outside to the east where the habitat will not be impacted by any development of the Project. Similarly, *Idiosoma* 'BMYG193` was collected in a small patch of *Banksia* shrubland with *Eucalyptus* copse at site 13 (Figure 14). While this vegetation unit is limited within the Project area, mapping by Woodman Environmental (2011) shows extensive continuous areas of this habitat extending to the east. As a result, it is considered likely that the ranges of both species extend beyond the boundaries of the Project area.

Only one individual of *Austrohorus* `BPS381` was collected in *Acacia* leaf litter at site 6 (Figure 15). This habitat type extends well beyond the Project area into the neighbouring Yardanogo Nature Reserve (Woodman Environmental 2011) and as a result it is likely the range of this species extends outside the Project area.

Chilenophilidae`BGE056` was collected as a single individual while hand foraging at site 7 (Figure 16). This site is located close to the southern boundary of the Project area in the most widespread habitat type. Woodman Environmental (2011) described this habitat type as Low Woodland to Thicket of *Banksia attenuata* and *Banksia menziesii* over mixed shrubs dominated by myrtaceous species on brown or yellow sand. Not only is this vegetation common throughout the Project, it extends continuously, north and south as well as into the neighbouring Yardanogo Nature Reserve, well beyond the boundaries of the Project (Woodman Environmental 2011). The range of Chilenophilidae`BGE056` is also likely to extend well beyond the Project area.

5.2. Listed Species

The desktop assessment identified three Priority listed terrestrial invertebrate species within the search area, the land snail *Bothriembryon perobesus,* the trapdoor spider *Idiosoma kwongan* and the bee *Hylaeus*

globuliferus. Two of these were collected during field survey. Twenty-eight specimens of *B. perobesus* were collected from nine sites (3, 5, 6, 7, 8, 9, 13, 14, and 18) from a variety of habitats (Figure 14). This snail is a widespread species with a north-south range of approximately 300 km (Figure 17). The extent of disturbance of the Project will cover less than 0.1% of the species' range.

Two specimens of *I. kwongan* were collected at Beharra, one female and one juvenile. The specimens were collected from two habitat types (Figure 14). One specimen was from an isolated dampland patch dominated by *Allocasuarina* while the other was from the widespread *Banksia attenuata* and *B. menziesii* woodland habitat, albeit the animal was collected in association with an *Allocasuarina*. *I. kwongan* has previously been collected in Kwongan habitats between 20 and 50 km south of the Project (Figure 17). This survey along with others in VRX silica tenements has extended the known range of the species and supports the conclusion by Rix *et al.* (2018a) that the known distribution of this species was, and probably still is, underestimated. Based on known range information, it can confidently be stated that the extent of Project disturbance will cover less than 2% of *I. kwongan*'s range.

The bee, *H. globuliferus,* was not observed during the survey but it has also been collected in similar habitat types between 20 and 50 km south of the Project. *H. globuliferus* is a specialist of Proteaceae flowers and is considered to have a moderate likelihood of occurring at the Project. We note that the timing of the survey (in July) did not coincide with flowering of the host plants that would have allowed detection of *H. globuliferus*.

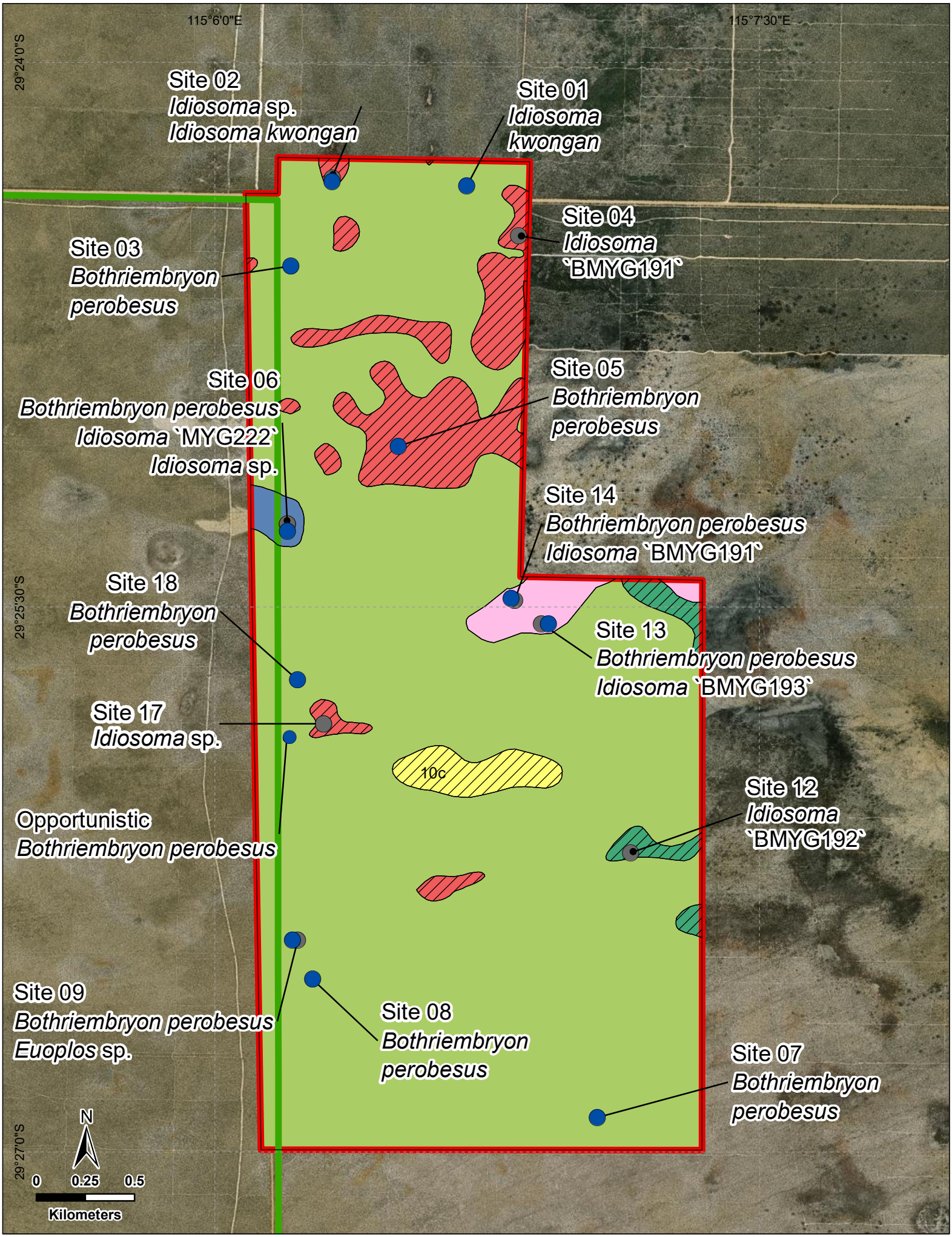
5.3. Summary

This desktop and field survey assessment indicates that a diverse community of SRE invertebrates occurs in, and around, the Project. Twenty-one species belonging to SRE Groups were collected during field survey in late July 2021. Animals were collected primarily by hand foraging.

While 16 of the 21 species cannot be regarded as widespread on the basis of existing information, and therefore were classified as potential SREs, the classification of individual species was often somewhat arbitrary because of few animals had been collected and a limited ecological framework for interpreting these records. This difficulty assigning SRE status, however, did not extend to assessing the likelihood of species having ranges beyond the Project area.

Five species are currently known only from the Project area, being the mygalomorph spiders *Idiosoma* 'BMYG192` and *Idiosoma* 'BMYG193`, the pseudoscorpions *Beierolpium* 8/4 `BPS380` and *Austrohorus* `BPS381` and the centipede Chilenophilidae`BGE056`. Based on the size of the Project area and the continuous connections of habitat inside the Project area with similar habitat outside, combined with what is known of the biology of the groups, it is likely that all five species have ranges extending beyond the proposed area of Project disturbance. Their conservation status will not be impacted by Project development.

In addition, two listed Priority species were collected at the Project, the trapdoor *Idiosoma kwongan* (which is also a likely potential SRE species) and the snail *Bothriembryon perobesus* (which has a more widespread distribution). Both species have large ranges relative to the size of the Project area and their conservation status will not be threatened by Project development.



Bennelongia Environmental Consultants

GCS GDA 1994
Author: Vmarques
Date: 21/03/2022

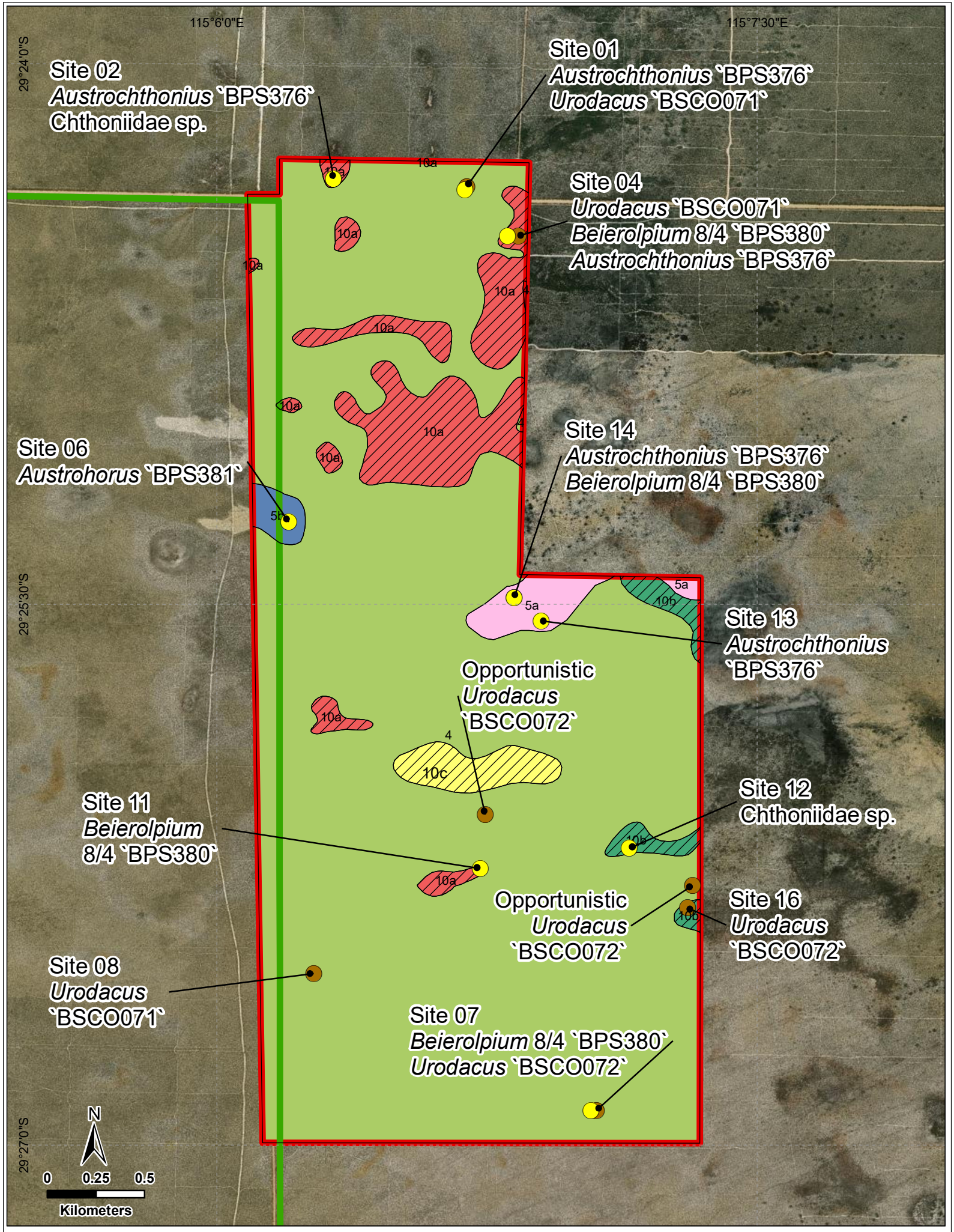
Project
PERTH

Legend

- Mine Development Envelope
- Yardanogo Nature Reserve
- Damplands
- Sandy plain
- Potential SRE spiders
- Priority 1 Species

Figure 14: Potential SRE spiders at Beharra.

(Idiosoma kwongan and Bothriembryon perobesus are Priority 1 species).



Bennelongia Environmental Consultants

GCS GDA 1994
Author: vmarques
Date: 21/03/2022

Project
PERTH

Legend

- Mine Development Envelope
- Yardanogo Nature Reserve
- Damplands
- Sandy plain
- Potential SRE scorpions
- Potential SRE pseudoscorpions

Figure 15: Potential SRE pseudoscorpions and scorpions at Beharra.

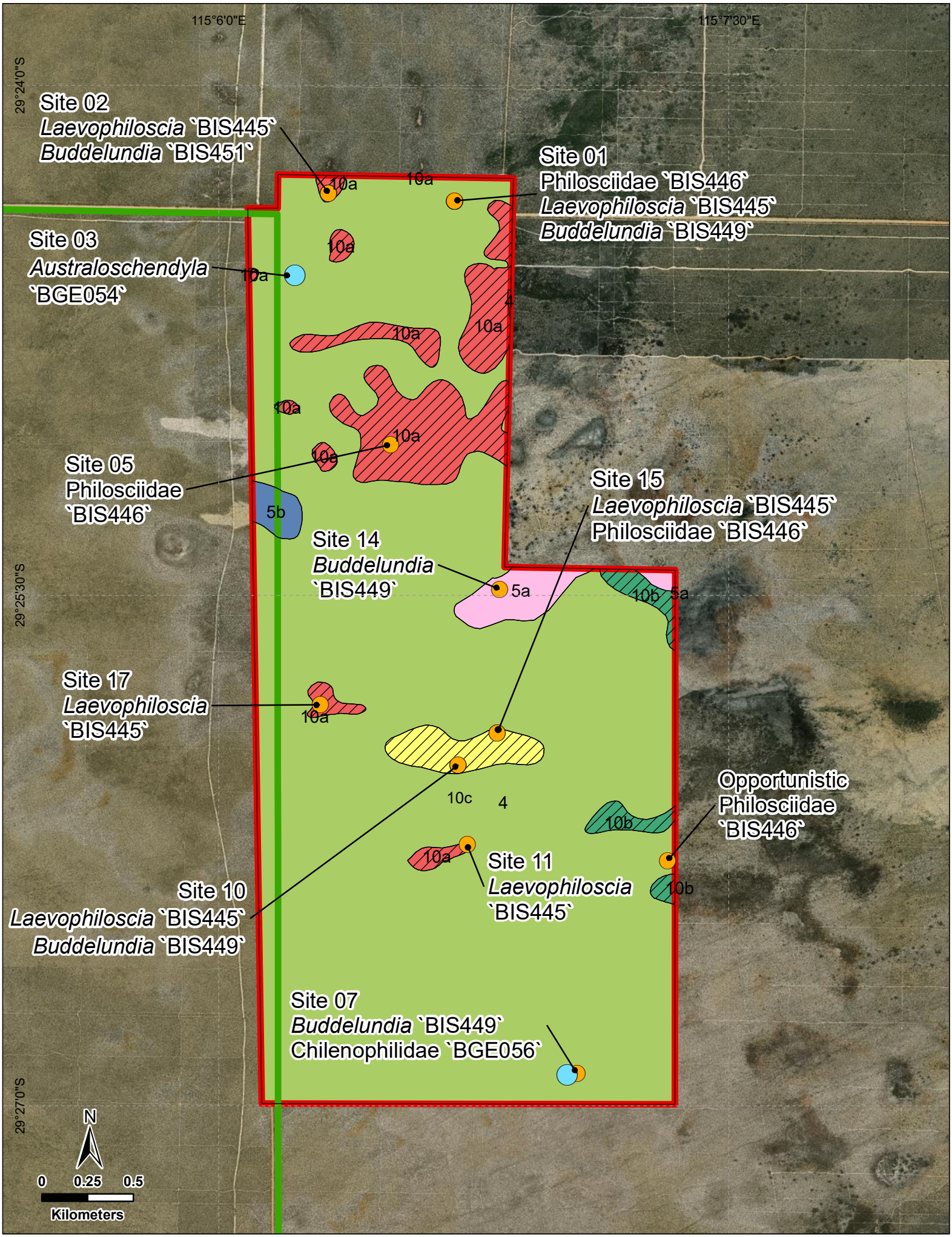
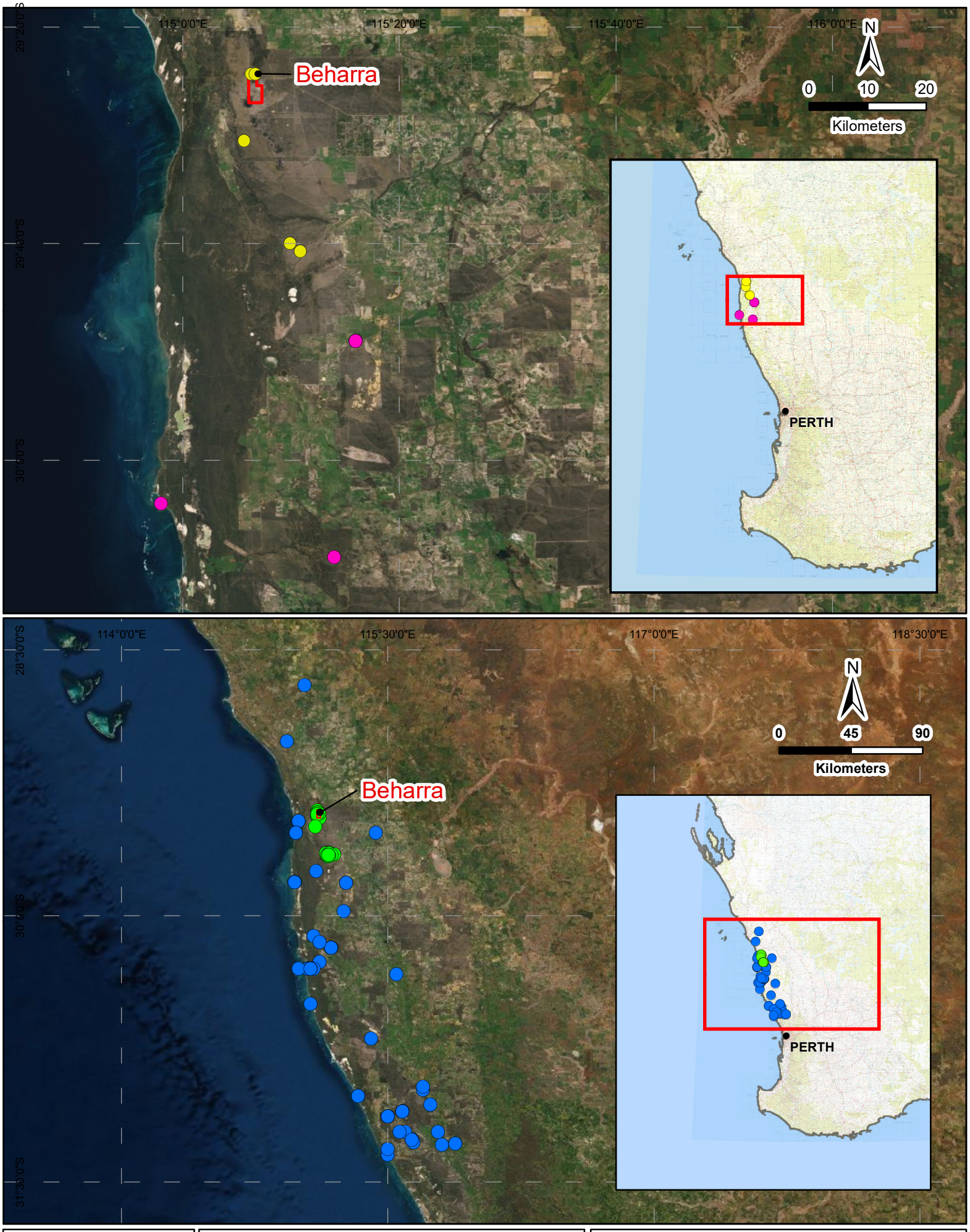


Figure 16: Potential SRE myriapods and isopods at Beharra.



Bennelongia Environmental Consultants

GCS GDA 1994
Author: vmarques
Date: 21/03/2022

Legend

- I. kwongan (Bennelongia)
- I. kwongan (WAM)
- B. perobesus (Bennelongia)
- B. perobesus (WAM)
- Mine Development Envelope

Figure 17: All known records of the two P1 listed species at Beharra, Idiosoma kwongan (upper panel) and Bothriembryon perobesus (lower panel).

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Appendix 1 – Threatened and Priority Species Categories

Western Australia – Biodiversity Conservation Act (2016)

The following is reproduced from:

Department of Biodiversity, Conservation and Attractions. *Conservation Codes for Western Australian Flora and Fauna*. Available at: https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/Conservation%20code%20definitions.pdf (Accessed 14 October 2020).

Threatened species

Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as threatened species under section 26(2) of the Biodiversity Conservation Act 2016 (BC Act). Threatened fauna is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for Threatened Fauna.

- CR, Critically Endangered: Threatened species considered to be "facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines".
- EN, Endangered: Threatened species considered to be "facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines".
- VU, Vulnerable: Threatened species considered to be "facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines.

Priority species

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna or flora. Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

- P1: Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
- P2: Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
- P3: Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not

meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.

- P4: (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Australia – Environmental Protection and Biodiversity Conservation Act 1999

Listing of species under the EPBCA 1999 is based on the IUCN Red List categories and criteria for threatened species listing. In addition to the categories Extinct (EX) and Extinct in the Wild (EW), these include:

- CR, Critically Endangered: Considered to be facing an extremely high risk of extinction in the wild
- EN, Endangered: Considered to be facing a very high risk of extinction in the wild.
- VU, Vulnerable: Considered to be facing a high risk of extinction in the wild.

These considerations are based on the criteria set out in:
IUCN (2000) *IUCN Red List and Criteria, V 3.1*. Available at http://s3.amazonaws.com/iucnredlist-newcms/staging/public/attachments/3097/redlist_cats_crit_en.pdf (Accessed 14 October 2020).

Additionally, under the EPBCA 1999 species in Australia can be listed under the category Conservation Dependent, if:

(a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming Vulnerable, Endangered or Critically Endangered; or
(b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory; (iv) cessation of the plan of management would adversely affect the conservation status of the species.

For more information, see:
Threatened Species Scientific Committee (2014) *Guidelines for assessing the conservation status of a native species*. Available at https://www.environment.gov.au/system/files/pages/d72dfd1a-f0d8-4699-8d43-5d95bbb02428/files/tssc-guidelines-assessing-species-2020.pdf (Accessed 14 October 2020).

Appendix 2 – Western Australian Museum SRE Classification System

Confirmed SREs are species with well understood taxonomy that are well represented in collections or come from areas that have been well sampled and have a known distribution range <10,000 km2.
Potential SREs are species that belong to genus or other taxonomic grouping for which there are gaps in our knowledge, either because the taxon is not well represented in collections, taxonomic knowledge is incomplete, or species distributions are imperfectly understood because sampling has been patchy.
Widespread (not SRE) species have a known distribution range >10,000 km2. The taxonomy of the species is well understood and it is well represented in collections.

The WAM uses five further sub-categories if a species is determined to be a "Potential SRE". These relate to the reasons for treating a species as a Potential SRE:
1. Data deficient: This is a precautionary sub-category because classification because the species is treated as a Potential SRE because there are insufficient data available to determine SRE status, either because there is a lack of geographic and taxonomic information, or because the individuals sampled cannot be identified to species level (e.g. wrong sex, juvenile, damaged);

2. Habitat Indicators: Here and in the following sub-categories, there is some evidence available from which the likely SRE status of the species may be inferred. For example, habitat indicators may suggest a species is likely to be an SRE because of its association with a particular habitat;

3. Morphological Indicators: The likely SRE status of a species may be determined through its morphological characteristics;

4. Molecular Evidence: DNA sequence data reveal patterns congruent with the species being an SRE; and

5. Research & Expertise: Available research data and/or WAM expertise may provide the basis for considering a species likely to be an SRE.

Appendix 3 – Photographs of the SRE collection sites in the Project area.

Site 1

Site 2

Site 3

Site 4

Site 5

Site 6

Site 7

Site 8

Site 9

Site 10

Site 11

Site 12

Site 13

Site 14

Site 15

Site 16

Site 17

Site 18