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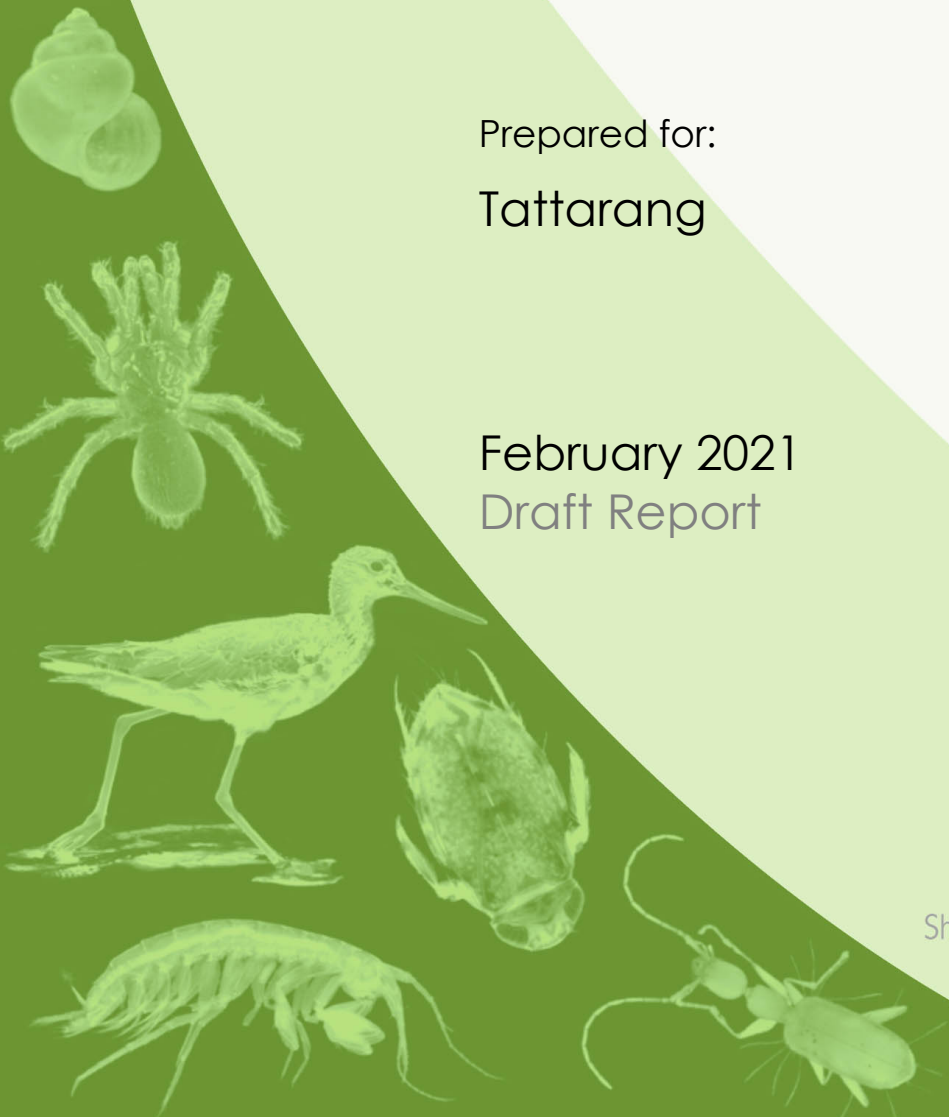
## Ningaloo Lighthouse Resort: Short Range Endemic Invertebrates Desktop Assessment

Prepared for:  
Tattarang

February 2021  
Draft Report

Short-Range Endemics | Subterranean Fauna

Waterbirds | Wetlands





# Ningaloo Lighthouse Resort: Short Range Endemic Invertebrates Desktop Assessment

Bennelongia Pty Ltd  
5 Bishop Street  
Jolimont WA 6014

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

ABN: 55 124 110 167

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Report Version	Prepared by	Reviewed by	Submitted to Client	
			Method	Date
Draft	Bruno Alves Buzatto	Stuart Halse	email	19 November 2021
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## EXECUTIVE SUMMARY

The Ningaloo Lighthouse Resort is located near the Cape Vlamingh Lighthouse at the north-western tip of Exmouth Peninsula in Western Australia. The facility was formerly called the Lighthouse Holiday Park, and after acquiring it in 2018, Tattarang Pty Ltd plans to redevelop the holiday park with a greater range of accommodation and facilities. Redevelopment of the holiday park and adjacent freehold land as Ningaloo Lighthouse Resort is referred to as the 'Project' and will require very minor land clearing to expand the original Holiday Park area.

The Project is located on Yardie Creek Road, approximately 22 km north of Cape Range National Park and 16 km north of Exmouth. The ocean to the west of the Project lies within the inshore State and more offshore Commonwealth Ningaloo Marine Parks that form the bulk of the Ningaloo Coast World Heritage Area, while the beach lies within Jurabi Coastal Park, which is also part of the World Heritage area. A proposed borefield to supply the Project with additional water lies in the extensive area of Unallocated Crown Land at the northern end of Exmouth Peninsula. The planned borefield will begin approximately 700 m south of the Project and run 1.1 km south along the eastern side of Cape Range. Additional monitoring bores will be placed up to 700 m south of the borefield itself. Production bores will be located at the base of the foothills of the eastern side of the range or in the swale between the foothills and the first red sand dune parallel to the range. The existing wastewater treatment plant (WWTP) for the holiday park is located on freehold land about 400 m south of the Project and almost 300 m east of the nearest production bore. It lies within an interdunal swale.

The Exmouth Peninsula has high diversity of species belonging to SRE groups. These are groups of terrestrial invertebrate species that tend to have highly restricted ranges and may be threatened by individual development projects. Despite the small size of the Project, development may have potential to negatively affect populations of some short-range endemic invertebrate (SRE) species.

Previous survey records of terrestrial invertebrate species from SRE Groups in a search area of nearly 7,000 km<sup>2</sup>, encompassing all North West Cape peninsula, were compiled by searching the databases of the Western Australian Museum and Bennelongia, as well as relevant publications. This type of desktop search gives only an indication of the level of species richness that can be expected in an area, rather than a precise number of species that exists.

Based on the desktop search, at least 24 species from SRE groups have been recorded in the search area, including four species of spider, one species of pseudoscorpion, one species of harvestman, two species of scorpion, three species of millipede, two species of slater, and 11 species of land snail. Of the records with no taxonomic uncertainty, 14 species are described and a further seven species are recognised as new species that have not yet been formally described. Effort to collect terrestrial invertebrates (particularly targeting SRE Groups) in the vicinity of the Project has occurred predominantly within Cape Range National Park.

In terms of their distributions, 21 of the 24 species are potential or confirmed SREs (i.e., species with ranges <10,000 km<sup>2</sup>), and 11 of the species either occur at the Project or are moderately likely to do so and would be expected to face elevated risk from development. The land snail *Promonturconchum superbum* and the millipede *Boreoheperus capensis*, despite being confirmed SREs, are common and very widespread in the North West Cape peninsula, and these species are unlikely to be under threat from the proposed development, which only represents a small fraction of their known distribution. The millipede *Antichropus humphreysi*, which is also a confirmed SRE, has a smaller range. It is known from only seven locations 24 km apart, with occurrences only 11 km south from the Project. It most likely occurs in the Project area. However, its distribution is also probably multiple times larger than the area of the Ningaloo Lighthouse Resort, meaning persistence of the species will not be affected.

While this desktop review presents information of the types of species in SRE Groups that occur on the North West Cape peninsula, it does not give a list of the particular species present. This level of inventory cannot be achieved without survey of the area. Nevertheless, it can be stated that the likely level of threat to SRE species is low because of the small spatial extent of the Project area.

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## 1. INTRODUCTION

The Ningaloo Lighthouse Resort is located near the Cape Vlamingh Lighthouse at the north-western tip of Exmouth Peninsula in Western Australia. The facility was formerly called the Lighthouse Holiday Park, and after acquiring it in 2018, Tattarang Pty Ltd plans to redevelop the holiday park with a greater range of accommodation and facilities. Redevelopment of the holiday park and adjacent freehold land as Ningaloo Lighthouse Resort is referred to as the 'Project' and will require very minor land clearing to expand the original Holiday Park area.

The Exmouth Peninsula is considered likely to contain high richness of short-range endemic (SRE) invertebrates. These are mostly ground-dwelling invertebrates that have overall ranges of less than 10,000 km<sup>2</sup> (Harvey 2002). This makes them susceptible to spatially extensive habitat changes, especially if anthropogenic. While most SRE species have larger ranges than the scale of the Project, development of the Project has the potential to negatively affect populations (at least) of some of SRE species.

The objectives of this report are to:

1. Compile and evaluate records of SRE species, as well as listed species and ecological communities, in the vicinity of the Project.
2. Assess ranges of SRE species, as well as any listed species, and incorporate this information into an assessment of the likelihood conservation significant species occurrence in the Project area.
3. Outline the potential impacts to SRE and any listed species from proposed developments.

### 1.1. Project Description

The Project is located on Yardie Creek Road, approximately 22 km north of Cape Range National Park and 16 km north of Exmouth (Figure 1). The ocean to the west of the Project lies within the inshore State and more offshore Commonwealth Ningaloo Marine Parks that form the bulk of the Ningaloo Coast World Heritage Area, while the beach lies within Jurabi Coastal Park, which is also part of the World Heritage area.

A proposed borefield to supply the Project with additional water lies in the extensive area of Unallocated Crown Land at the northern end of Exmouth Peninsula. The planned borefield will begin approximately 700 m south of the Project and run 1.1 km south along the eastern side of Cape Range. Additional monitoring bores will be placed up to 700 m south of the borefield itself. Production bores will be located at the base of the foothills of the eastern side of the range or in the swale between the foothills and the first red sand dune parallel to the range.

The existing wastewater treatment plant (WWTP) for the holiday park is located on freehold land about 400 m south of the Project and almost 300 m east of the nearest production bore. It lies within an interdunal swale.

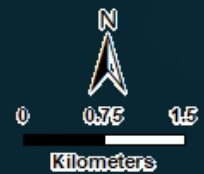
## 2. LEGISLATION

An ecological community comprising a naturally occurring biological assemblage in a particular habitat type may be listed by the Minister for the Environment, under the *Biodiversity Conservation Act 2016*, as a Threatened Ecological Community (TEC) if it presumed to be totally destroyed, critically endangered, endangered or vulnerable. A community that is threatened but does not meet these criteria, is rare but not threatened, is near threatened, has recently been removed from the TEC list, or is conservation-dependent, may be listed informally by the Department of Biodiversity, Conservation and Attractions (DBCA) as a Priority Ecological Community (PEC). There are no PECs or TECs in the vicinity of the search area listed on a basis of terrestrial SRE taxa. There are also no terrestrial invertebrate species listed as Threatened by the Minister under the *Biodiversity Conservation Act 2016* or as Priority species by DBCA in the vicinity of the Project.





**EXMOUTH**



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**Figure 1: Location of the Ningaloo Lighthouse Resort area with respect to Perth and Exmouth.**

Borefield
  North West Resorts - Section 18 Area & DPLH 1038

### 3. SRE FRAMEWORK

SRE species tend to exhibit patchy distributions within their small range, and to have slow growth, low fecundity, and poor dispersal capabilities. Guidelines for the assessment of impacts to SRE invertebrates in Western Australia are provided in *Environmental Factor Guideline: Terrestrial fauna* (EPA 2016b) and *Technical Guidance: Sampling of short range endemic invertebrate fauna* (EPA 2016a). Assessment is restricted to a number of taxonomic groups (the SRE Groups) that are known to contain at least some, but more commonly moderate to high proportions of, SRE species. The groups include land snails (Gastropoda); millipedes (Diplopoda); centipedes (Chilopoda); pseudoscorpions (Pseudoscorpiones); scorpions (Scorpiones); spiders [Araneae, mainly Mygalomorphae (trapdoor spiders)]; slaters (Isopoda); and harvestmen (Opiliones). Some other groups, such as velvet worms (Onychophora) and earthworms (Oligochaeta), are SRE Groups but are restricted to mesic landscapes.

Groups containing species that are mostly widespread due to high vagility, ecological plasticity or xeric adaptation, may also have species with restricted ranges (e.g., Framenau *et al.* 2008; López-López *et al.* 2016; Rix *et al.* 2015) and, conversely, some species belonging to SRE Groups are in fact widespread. Determining whether a species belonging to an SRE Group really has a significantly restricted range (estimated as less than 10,000 km<sup>2</sup>) is often difficult. However, species distributions usually reflect the distribution of their preferred habitats. Most SRE species prefer restricted or patchy habitats and hence have smaller ranges than species found in widespread habitats. Additional causes of species having small ranges include life history and ecological interactions; these sometimes lead to species occupying only small extent of a widespread habitat (Harvey 2002; Rix *et al.* 2015).

Here we followed the classification used for SRE species by the Western Australian Museum (WAM), where a species can be classified into one of the following categories:

1. **Confirmed SREs** have a known distribution range smaller than 10,000 km<sup>2</sup>. The taxonomy is well known, and the group well represented in collections and/or via comprehensive sampling.
2. **Potential SREs** 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<sup>2</sup>. The taxonomy is well known, and the group well represented in collections via comprehensive sampling.

The factors considered when evaluating the SRE status of each species in this report were the known range of the species, habitat(s) at the collection location(s) and the spatial extent and connectivity of these habitats, as well as the distribution patterns of phylogenetically related surrogate species (ideally members of the same genus).

When considering potential impacts on a species, it is recognised that even SRE species may be locally widespread around a project area, so that identifying potential SRE species is only the first part of a filtering process used to determine whether species may be threatened by a proposed development. The actual level of threat to an SRE species depends on its distribution relative to the development footprint, rather than SRE status alone. Determining the likely level of threat to a species requires consideration of the extent of the species' preferred habitat, both within and outside the area of disturbance.



## 4. DESKTOP REVIEW

Existing records of terrestrial invertebrates and associated habitat information were examined to appraise the likelihood of SRE or listed invertebrate species occurring in the vicinity of the Project.

### 4.1. Previous records

Existing survey records in the WAM and Bennelongia databases of species in SRE Groups were compiled for a search area of nearly 7,000 km<sup>2</sup>, encompassing all North West Cape peninsula (Figure 2, Figure 3). This type of desktop search gives only an indication of the level of species richness that can be expected, in the Project area rather than a species list. Appendix 1 provides a tabulated list of species recorded in the search area. It was not practicable to determine the exact number of species that has been collected even in the search area because of incomplete or inconsistent taxonomy for some records. Some recorded species may represent multiple taxa and, conversely, some specimens assigned to different taxa may in reality represent the same species.

Based on the desktop search, 943 individuals from at least 24 species belonging to SRE groups have been recorded in the search area. This includes the higher-level identification *Philosciidae* sp., which must represent at least one unique species (potentially several) because no other species from that family were recorded in the search area. The 24 species included four species of spider, one species of pseudoscorpion, one species of harvestman (order Opiliones), two species of scorpion, three species of millipede, two species of slater, and eleven species of land snail (Appendix 1).

Fourteen species of the 24 species are described. Seven others are recognised as new species but have not been formally described yet and so have provisional names (such as *Aname* 'Learmonth sp. 1' and *Euoplos* 'MYG672').

Other records in Appendix 1 include five additional taxa as a result of animals being identified only to higher level than species, two additional taxa as a result of animals being assigned to species already in the list but with reservations noted about the identification, and one additional taxon that was probably a mis-identification.

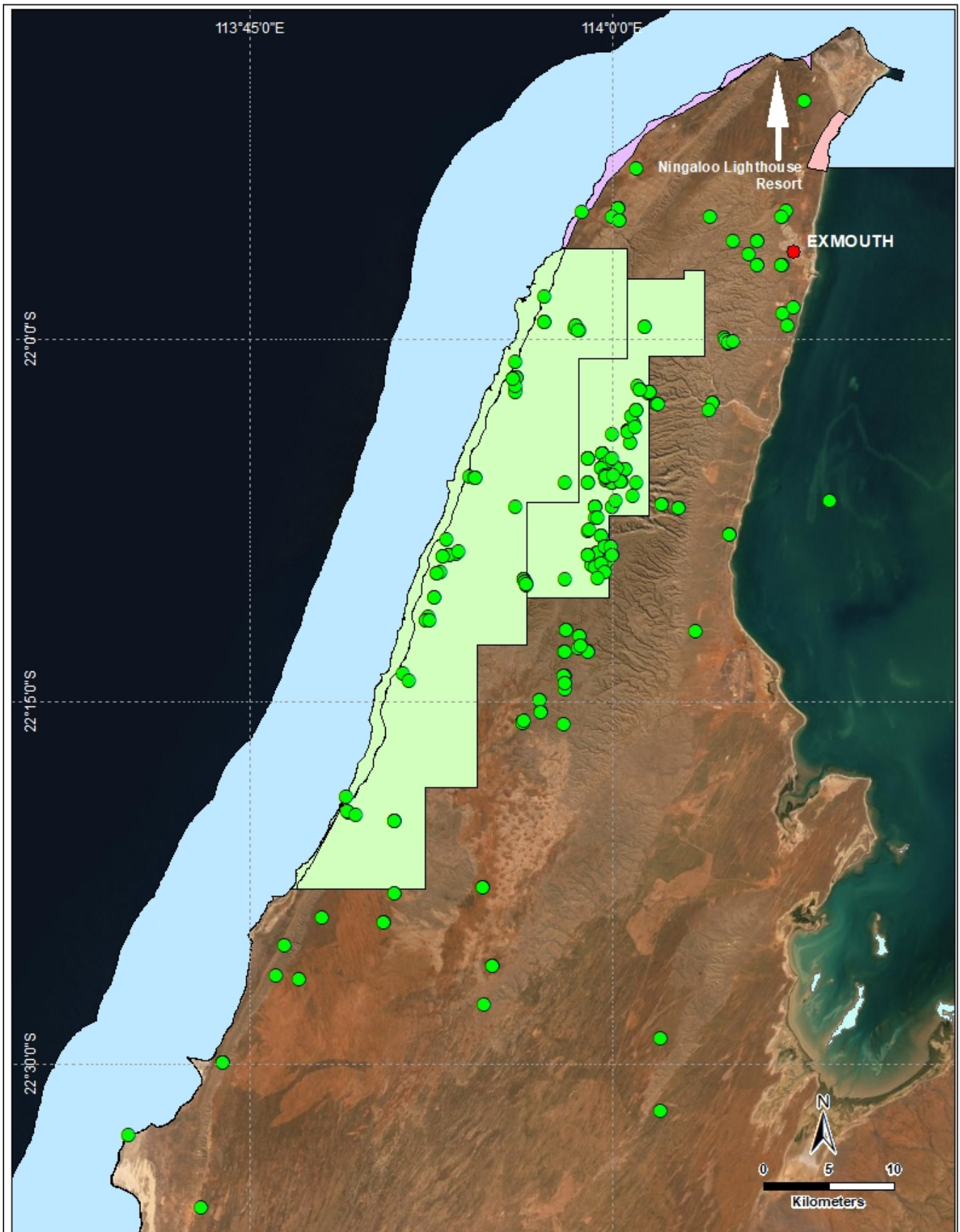
The two taxa with reservations about the identifications were (*'Euoplos?'* 'MYG672' and *Boreohesperus* 'capensis?') are most likely synonyms with species already in the table. Moreover, the records of *Isometroides* 'aitkeni' probably represent a mis-identification of specimens of *Lychas* 'aitkeni spp. grp', which represent a species complex (similarly to *Urodacus* 'yaschenkoi spp. grp') that might contain multiple undescribed species.

Using species records as a proxy for sampling coverage, effort to collect terrestrial invertebrates (particularly SRE Groups) in the vicinity of the Project has occurred predominantly within Cape Range National Park (Figure 2). Further information on species collected is provided below.

### 4.2. SRE groups in the Search Area

#### Trapdoor spiders (Araneae: Mygalomorphae)

At least four species of trap door spiders were collected in the search area, from three different families. The family of open-holed trapdoor spiders (Anamidae) was represented by two species, both collected between 3 and 7 km south of the southern limit of Cape Range National Park. *Aname* 'Learmonth sp. 1' is known from three locations up to 8.8 km apart, whereas *Aname* 'Learmonth sp. 2' is only known from one location, and they are both considered data deficient potential SREs. Both species are, however, unlikely to occur in the Ningaloo Lighthouse Resort. The genus *Aname* contains large diversity of described and undescribed species, and whereas the Pilbara fauna is well studied (Castalanelli *et al.* 2020), some species from North West Cape remain undescribed.



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**Figure 2: SRE records around the Ningaloo Lighthouse Resort**

- SRE records
- Whitmore, Roberts, Doole Islands and Sandalwood Landing Nature Reserve
- Bundegi Coastal Park
- Jurabi Coastal Park
- Cape Range National Park
- Ningaloo Marine Park

*Conothele* `MYG673` (Halonoproctidae) was collected from two different locations approximately 8.5 km apart, one within the northern end of Cape Range National Park, and the other one just outside its north-eastern border. Both locations are about 24 km south of the Project, and this species is also considered a data deficient potential SRE, moderately likely to occur in the Ningaloo Lighthouse Resort. Several new genetic lineages of this genus were recently detected by Huey *et al.* (2019), but none of these were recorded from North West Cape.

Finally, the spiny trapdoor spider *Euoplos* `MYG672` (Idiopidae; Wilson *et al.* 2020) was collected from three different locations up to 24 km apart, all of them at least 24.7 kms south of the Project Area. These spiders were also collected both within and outside Cape Range National Park, in the northern and central part of the park. This species is a data deficient potential SRE, moderately likely to occur in the Ningaloo Lighthouse Resort.

### **Pseudoscorpions**

The pseudoscorpion fauna of North West Cape is diverse, but mostly comprised of subterranean species. On the surface, only one species of potential SRE pseudoscorpion was recorded in the surface area, *Synsphyronus* `PSE164` (Garypidae). This species was only recorded in one location, immediately east of the north-eastern border of Cape Range National Park, and approximately 27.5 km south of the Project. *S.* `PSE164` is one of many new undescribed species of the genus from the Pilbara and Gascoyne regions, and some of the described species are considered SREs (Harvey *et al.* 2015). *S.* `PSE164` is a potential SRE, moderately likely to occur in the Ningaloo Lighthouse Resort.

### **Harvestmen (order Opiliones)**

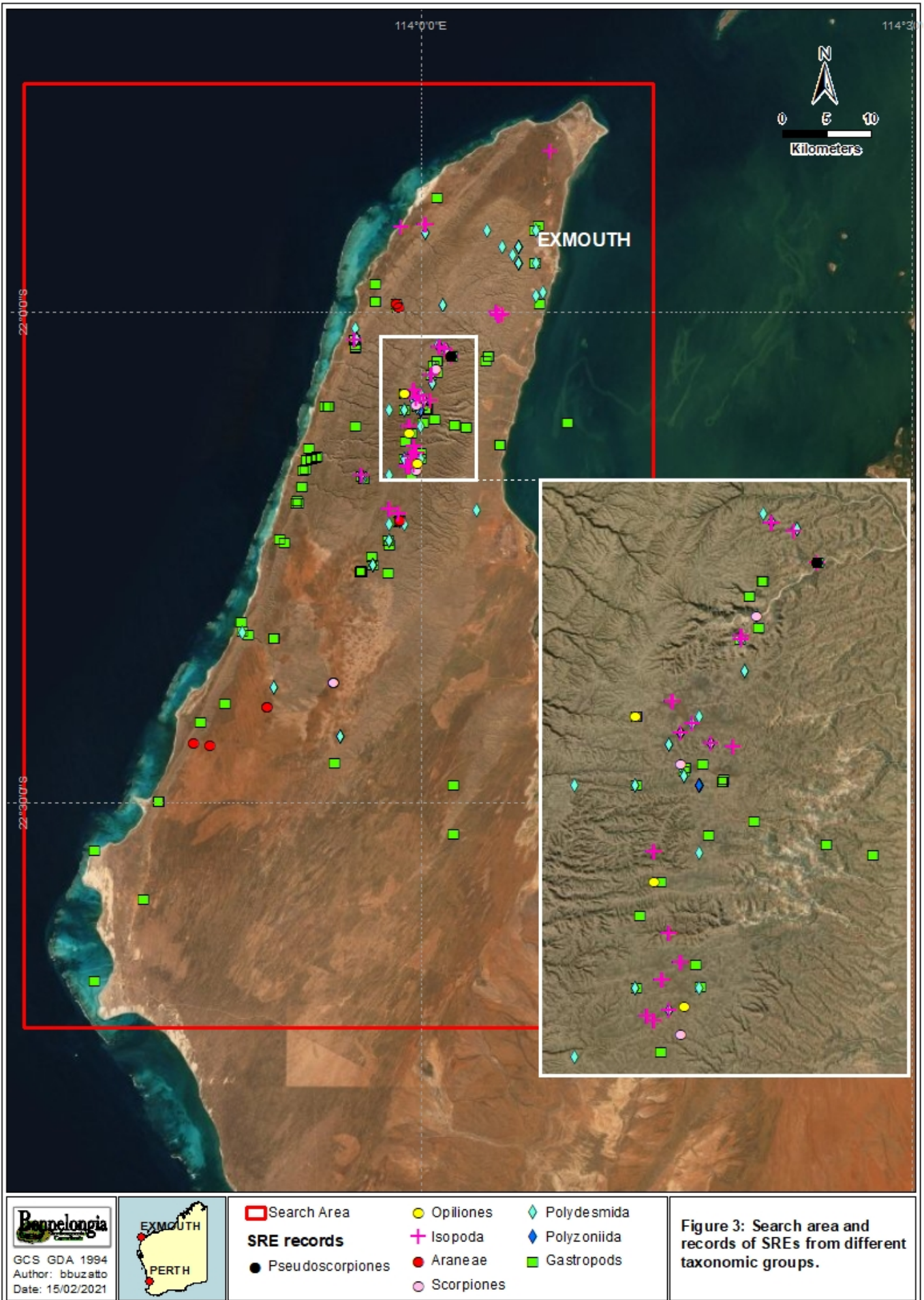
The species *Dampetrus isolatus* (Assamiidae) was originally described from several caves in the North West Cape. Despite having reduced eyes, it is not especially troglomorphic (Shear 2001) and the species might also inhabit epigeal environments. The species is currently known from at least three different locations that are approximately 8 km apart, all within Cape Range National Park (central eastern part) and at least 32 km from the Project. This species is therefore a potential SRE, moderately likely to occur in the Ningaloo Lighthouse Resort.

### **Scorpions**

Two species of potential SRE scorpions, from two different families, were recorded in the Search Area. In the family Buthidae, *Lychas* `aitkeni spp. grp` was collected from two different locations approximately 4.5 km apart, both within the north-eastern end of Cape Range National Park. These locations are about 29 km south of the Project, and this species is considered a data deficient potential SRE, moderately likely to occur in the Ningaloo Lighthouse Resort.

In the family *Urodacidae* (burrowing scorpions), there are three records of *Urodacus* `yaschenkoi spp. grp` from one single location, approximately 4 km east of the southern boundary of Cape Range National Park. The framework for formal scorpion identification in Western Australia needs significant revisions, and whereas *Urodacus yaschenkoi* is a seemingly widespread described species, it is known to represent a species complex that hides cryptic diversity (Luna-Ramirez *et al.* 2017), and the specimens from North West Cape probably represent a new undescribed species that is here considered a data deficient potential SRE. Due to its occurrence more than 60 km south of the Project, it is considered unlikely to occur near the Ningaloo Lighthouse Resort.





## Millipedes

At least three different species of potential SRE millipedes from two families were recorded in the search area. In the family Siphonotidae (Polyzoniida), the species *Megalosiphon` humphreysi`* is known from two different locations approximately 1.3 km apart, both within the north-eastern end of Cape Range National Park. The name *Megalosiphon` humphreysi`* is an unpublished name from the PhD thesis by Dennis Black, and might become a valid published species in the future. The locations from which this species was collected are about 33 km south of the Project, and this species is considered a potential SRE that is moderately likely to be present in the Ningaloo Lighthouse Resort area.

Two species of the family Paradoxosomatidae (Polydesmida) were found in the search area. *Antichiropus humphreysi* was originally described from a cave in Cape Range National Park (Shear 1992), but it has since been collected in epigeal environments as well, and is currently known from seven locations just over 24 km apart, some of these in the central-eastern part of the National Park, and some around the town of Exmouth (approximately 11 km from the Project). This genus has been well studied morphologically and genetically, and the group has also been extensively collected across the Pilbara (Car *et al.* 2019). *A. humphreysi* is therefore considered a **confirmed SRE** that is likely to occur in the Ningaloo Lighthouse Resort.

Similarly to *A. humphreysi*, the other species of Paradoxosomatidae recorded, *Boreoheperus capensis*, was also originally described from caves (Shear 1992). Both species have been commonly found in caves, (near the entrance), but also on the surface, and their lack of troglobitic adaptations suggests that their presence in caves result from cave entrances presenting attractive refuges in the dry environment of the North West Cape. All described species of *Boreoheperus* are also SREs (Car and Harvey 2017), and *B. capensis* is therefore considered a **confirmed SRE** that is likely to occur in the Ningaloo Lighthouse Resort. This species is, however, fairly common and widespread in the North West Cape peninsula, known so far from 41 locations up to 60 km apart and, therefore, it is very unlikely to be under threat from the proposed development.

## Slaters (Isopoda)

Isopods from the species *Buddelundia` sp. BBCR01`* (Armadillidae) were collected from seven locations 28.3 km apart, mostly in the eastern part of Cape Range National Park, but also just outside the park to the north and east of its borders. The records are at least 17.8 km from the Project, and the species is considered moderately likely to occur in the Ningaloo Lighthouse Resort. Species of this genus can vary widely in the size of their distributions, and some are SREs (Judd 2004). Given that *B. `sp. BBCR01`* is not a valid described species, it is currently considered a data deficient potential SRE.

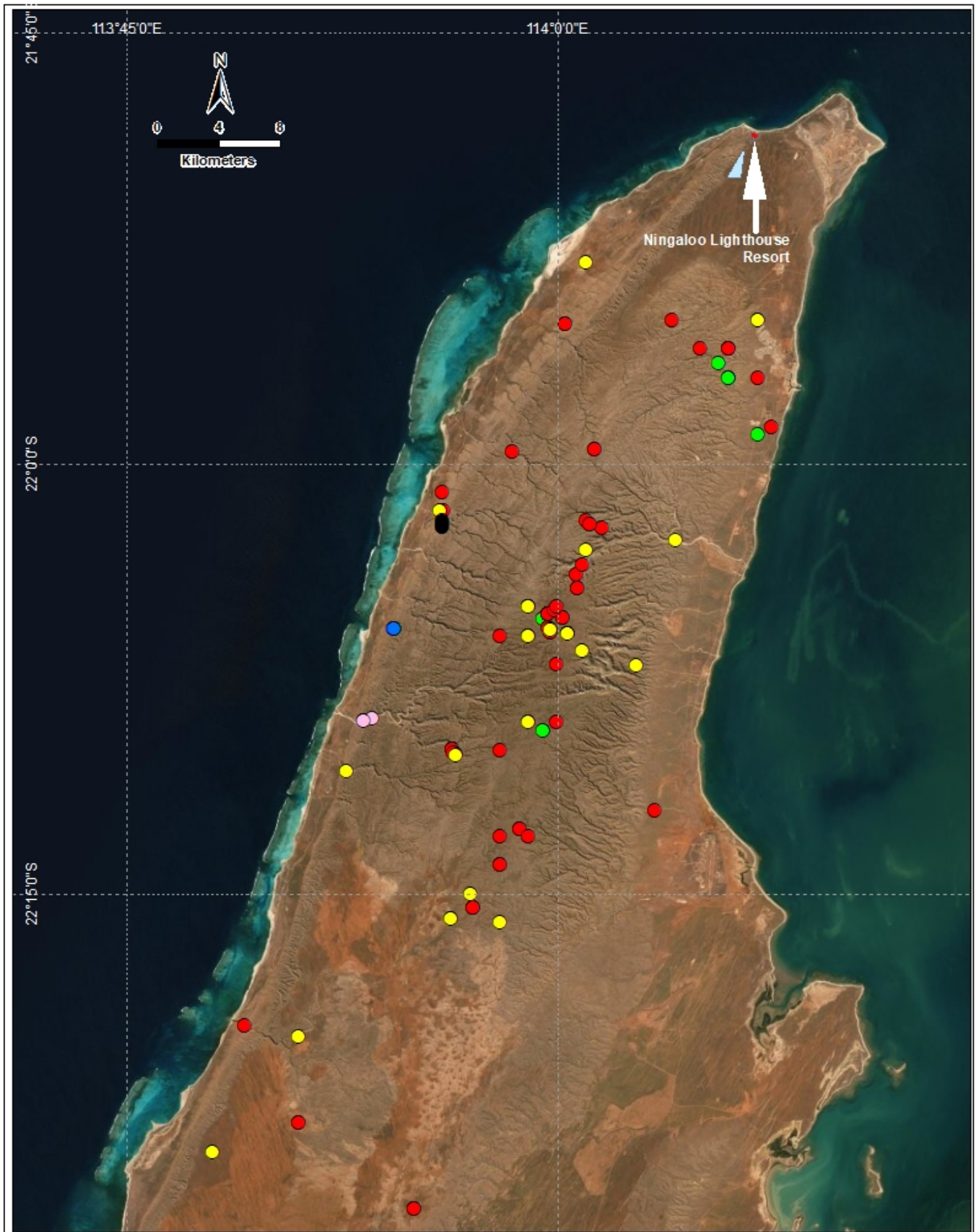
The family Philosciidae was represented by 42 specimens recorded from seven different locations. Unfortunately, given the uncertain identification (to family level) of these records, even though they are known to represent new species (not the same as any other record in Appendix 1), these records could represent several species, and an SRE status assessments is not possible at present.

## Land snails (Gastropoda: Camaenidae)

The family Camaenidae represent the dominant group of land snails in the North West Cape (Taylor *et al.* 2015), and 11 species of this family were recorded in the search area.

The genera *Plectorhagada* and *Strepsitaurus* are morphological similar and present mutually exclusive ranges near Cape Range (Taylor *et al.* 2015). *Plectorhagada teres* is a potential SRE, known from three locations 18.5 km apart, two of these in the north-western part of Cape Range National Park, and the other just north of Exmouth and 11 km south from the Project. It is considered likely to occur in the Ningaloo Lighthouse Resort area. Meanwhile, *Plectorhagada scolythyra* is also a potential SRE, but known from only one location, 22 km south of Exmouth on the Eastern coast of North West Cape. This location is 35.5 km south of the Project, and therefore the species is less likely to occur in the Ningaloo Lighthouse Resort area.





**Figure 4: Confirmed SREs in the Desktop Search Area.**

- |  |                                  |
|--|----------------------------------|
| North West Resorts - Section 18 Area & DPLH 1038 | <i>Promonturconchum superbum</i> |
| Borefield  | <i>Strepsitaurus manduensis</i>  |
| <i>Antichiropus humphreysi</i>                   | <i>Strepsitaurus milyeringus</i> |
| <i>Boreohes perus capensis</i>                   | <i>Strepsitaurus susieae</i>     |



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Five species of the genus *Strepsitaurus* are known from the Search Area, and three of them are **confirmed SREs**. *S. manduensis* is only known from the Mandu Mandu Gorge at two sites 560 m apart; *S. susieae* is only known from one small unnamed gorge (approximately 1.2 km long), south of Tulki Gorge, on the west side of Cape Range; and *S. milyeringus* is only known from two sites (< 500 m apart) in the Milyering Gorge (Taylor *et al.* 2015). These three species are, however, unlikely to occur in the vicinity of the Ningaloo Lighthouse Resort. Meanwhile, the other two species are known from multiple locations, and their ranges span at least 50 km (*Strepsitaurus ningaloo*), and 60 km (*Strepsitaurus williami*). Whereas the records of *S. ningaloo* are at least 43 km south of the project (unlikely to occur in the area), *S. williami* occurs just south of Exmouth (15 km south of the Project) and it is considered likely to moderately likely to occur in the Ningaloo Lighthouse Resort.

*Caperantrum polygyrum* is the only species in its genus, and represents a rare and endemic species in Cape Range. It is a potential SRE known from only eight locations that are 27.2 km apart and include areas in the south and east parts of Cape Range National Park, as well as a location outside of the park, to the southeast. The closest record of this species to the Project is 37 km to the south, and the species is hence considered moderately likely to occur in the area.

*Promonturconchum superbum* is common and very widespread in the North West Cape peninsula, known so far from more than 20 locations up to 66.5 km apart. Due to the geography of the peninsula, however, the known area of distribution of this species is still less than 1,000 km<sup>2</sup>, so it is still considered a **confirmed SRE**. The species is likely to occur in the Project area, but it is unlikely to be under threat from the proposed development, given that it only represents a small fraction of its known distribution.

The species *Quistrachia warroorana* is widespread, known from multiple locations outside the Search Area, up to 260 km south (south of Lake Mcleod). The specimens recorded in the Search Area, however, were only found in one location and identified to *Quistrachia cf. warroorana*, meaning that the alignment with *Quistrachia warroorana* is not certain. Even if the species is new and only closely related to *Quistrachia cf. warroorana*, it was recorded more than 38 km to the south of the Project, in the middle of the Cape Range National Park and is unlikely to occur in the Ningaloo Lighthouse Resort.

*Rhagada capensis* is a relatively widespread species, recorded up to 150 km south of the Project, near the northern end of Lake Mcleod. Some of the specimens recorded in the search area, however, were identified as *Rhagada cf. capensis*, which means that the alignment with *R. capensis* is not certain. It is possible that this is a new species and potential SRE, only known from three locations up to 5.5 km apart, in the north-eastern part of Cape Range National Park. These locations are 28.6 km south of the Project, so this species is relatively unlikely to be in the Ningaloo Lighthouse Resort.

### 4.3. SRE Habitats

SRE habitat prospectivity was assessed by reviewing recent vegetation and landform mapping (Ecoscape 2018), as well as observations from a brief recognisance trip by Bennelongia between the 12<sup>th</sup> and 14<sup>th</sup> of January, 2021. Emphasis was placed on identifying relict, isolated, sheltered, or moist habitats, such as rocky outcrops, that are generally considered to be more prospective for SRE species.

The Project area hosts seven vegetation types, including a total of 169 vascular flora species (Ecoscape 2018) that cover three different major vegetation habitat types: coastal zone, limestone hills and red Pindan dunes. Regarding fauna, five habitat types were recorded by that survey:

- Red Pindan dune crests,
- Red Pindan dune swales,
- Rocky hills and slopes,
- Sheltered gullies and minor caves associated with limestone,
- Coastal dunes.

There is certainly some overlap between these habitat types, in terms of their function as habitat for terrestrial invertebrates in general, and for SRE groups. Coastal dunes are not expected to be prospective

to SREs, whereas the red Pindan dunes (especially the swales) should be prospective to SRE scorpions and centipedes mostly, and less prospective to other SRE groups. Meanwhile, the rocky hills and slopes, especially when south facing, should be prospective to a wide range of SRE taxa, including millipedes, land snails and spiders. Finally, the sheltered gullies and minor caves have the highest potential to hold moisture, and are also the most isolated and patchy habitats, and therefore have the highest SRE conservation significance.

Despite the detection of the five habitats described above by the Ecoscape (2018) survey, the footprint area (Figure 1) of the Project only overlaps dune swales and rocky hills and slopes. The former represents approximately 80% of the new impact area, whereas the latter represent the remaining 20%. These two habitats should be prospective to SREs, but their connectivity outside the development envelope, as well as the small area of impact footprint, suggests the Project will have a negligible impact on SRE species in the area. Moreover, the SRE species captured in the desktop search most likely to occur in the Project (Appendix 1, Figure 3) were found in rocky hills and slopes, with the exception of the northern most record of an isopod, collected on red Pindan dunes, but only identified as *Isopoda* sp.

Finally, an important caveat of this assessment is that the habitats discussed above were originally categorized based on their suitability as habitats for terrestrial vertebrates, and they have limited suitability as indicators for SRE invertebrates, as these animals are distributed at the microhabitat scale.

#### 4.4. Preliminary SRE observations

While on site for a subterranean fauna survey, between the 12<sup>th</sup> and 14<sup>th</sup> of January 2021, Bennelongia staff conducted a brief reconnaissance for SRE species within the project area. This included the borefield and resort development footprint. The reconnaissance consisted of looking for evidence of SRE species and assessing possible habitat of SRE species. Two broad habitat types were observed on site: 1) the Red Pindan dunes with *Triodia* hummock grassland, mallee and *Banksia* (photos 1 and 2 in Appendix 2), and 2) rocky hills (limestone outcropping) with little or no topsoil (photo 5 in Appendix 2).

Searches within the sand dunes identified the presence of burrows from the scorpion genus *Urodacus* (photo 4 in Appendix 2). This was further confirmed with the sighting of a *Urodacus* specimen (photo 3 in Appendix 2). At one location, a circular, web lined hole indicative of open-holed trap door spiders (family Anamidae) was also observed (photo 6 in Appendix), however the presence of this group cannot be confirmed, as no spiders were observed and some wolf spiders (family Lycosidae, not typically considered SRE species) are known to build similar burrows. Additionally, numerous snail shells were observed on the surface of the sand dunes. Table 1 outlines the snail species observed on site. Leaf litter accumulation under mallee (top right of photo 2 in Appendix 2) and *Banksia* may provide habitat for other SRE groups/species, such as millipedes, pseudoscorpions, and slaters, however a more thorough search would be required for this.

The limestone outcropping also revealed the presence of members from SRE groups. Under rocks and in cracks and crevices, we located the exuvia of a millipede from the family Paradoxosomatidae, from the genus *Antichiropus* or *Boreoheperus*. This was a broken exuvia of a partial animal, so further identification is not possible. Snail shells were also collected from under rocks and in cracks and crevices and are outlined in Table 1. All snail identifications are preliminary since only dead shells were used, and in some cases, only damaged shells were available.

**Table 1:** Snail species observed in the recognisance trip, their broad habitats and notes on taxonomy.

Species	Habitat		Taxonomic Notes and Literature Reviewed
	Sand Dune	Limestone Outcrop	
<i>Quistrachia</i> c.f. <i>warroorana</i>	16	11	Closest morphological match based on shell and distribution (Stanisic <i>et al.</i> 2017, O'Neill <i>et al.</i> 2014) Shell shape, pattern and umbilicus match.
<i>Plectorhagada</i> <i>scolythyra</i> or <i>Plectorhagada</i> <i>teres</i>	2	0	Closest morphological match based on shell and distribution. Umbilicum morphology matches <i>P. scolothyra</i> , while upper spire morphology matches <i>P. teres</i> (Stanisic <i>et al.</i> 2017; Taylor <i>et al.</i> 2015). Old shell may be worn, influencing morphological traits.
<i>Pupoides</i> <i>contrarius</i>	1	1	Certain ID (Stanisic <i>et al.</i> 2017)
<i>Rhagada</i> c.f. <i>globosa</i>	3	1	Closest match based on shell morphology and distribution (Stanisic <i>et al.</i> 2017)
Camaenidae sp. or ? <i>Rhagada</i> sp.	0	1	Juvenile and broken shell. Very difficult to identify. Very angular, but <i>Rhagada</i> species known to have variable intra species shell morphology (Johnson and Stankowski 2018; Johnson <i>et al.</i> 2016; Stanisic <i>et al.</i> 2017).

## 5. CONCLUSIONS

This desktop assessment indicates that there is a community of potential SRE invertebrates (11 species) with likelihoods of occurring at the Project that range from moderate to high. The species include trapdoor spiders, pseudoscorpions, harvestmen, scorpions, millipedes, isopods, and snails. Six species of confirmed SREs were recorded in the search area, but only three of these are likely to occur in the Project.

The land snail *Promonturconchum superbum* and the millipede *Boreoheperus capensis*, despite being confirmed SREs, are common and very widespread in the North West Cape peninsula, and these species are unlikely to be under threat from the proposed development, which only represents a small fraction of their known distribution. On the other hand, the millipede *Antichiropus humphreysi* is only known from seven locations just over 24 km apart, and some of these are approximately 11 km south of the Project. This confirmed SRE species is the most likely to occur in the Project, but its distribution is also probably multiple times larger than the area of the Ningaloo Lighthouse Resort.

Importantly, the exact species that will be found at the Project cannot be identified without survey within the area. Additional species of short-range endemic invertebrates that were not captured by this desktop assessment might occur in the Project and nearby borefield area. This is especially likely given that SRE targeted sampling in the North West Cape has focused on Cape Range National Park and surroundings, whereas we have no evidence of previous sampling in habitats similar to those of the Project area. Moreover, habitat evaluation produces uncertain inference about the occurrence of SREs, and even the SRE taxa considered likely to be in the Project area have not been confirmed to occur there.

During Bennelongia's recognisance trip, suitable SRE habitat in dune swales (for scorpions and centipedes) was observed in the impact footprint (Appendix 2), and an unidentified species of burrowing scorpion (*Urodacus* sp.) was recorded in that area. Five species of snails and one species of millipede were also observed, but the identifications are mostly preliminary. Rocky slopes, suitable for a range of SRE groups, were observed near the borefield, where potential open-holed trapdoor spider burrows were also observed (Appendix 2). A field survey would be needed to confirm the presence of these species and provide a species identification for them, but the negligible impact footprint on rocky hills and very small footprint on red Pindan dune swales, suggests that the Project is very unlikely to represent any significant impact on SRE fauna.



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## Appendix 1 – Species of SRE invertebrate groups recorded in the Project area and its vicinity.

Described species known to be widespread (non-SRE, with ranges larger than 10,000 Km<sup>2</sup>) were removed from the table. Grey denotes higher order identifications that might belong to other listed species (not viewed as unique species); blue represents species complexes.

Higher Classification	Lowest Identification	Specimen records	SRE Status
<b>ARTHROPODA</b>			
<b>Arachnida</b>			
<b>Araneae</b>			
Anamidae	<i>Aname`Learmonth sp. 1`</i>	3	<b>Potential SRE</b> , only known from 3 locations 8.8 kms apart.
	<i>Aname`Learmonth sp. 2`</i>	1	<b>Potential SRE</b> only known from 1 location.
Halonoproctidae	<i>Conothele`MYG673`</i>	2	<b>Potential SRE</b> , only known from 2 locations 8.5 kms apart.
Idiopidae	<i>Euoplos`MYG672`</i>	2	<b>Potential SRE</b> , only known from 3 locations up to 24 kms apart.
	<i>`Euoplos?`MYG672`</i>	1	Most likely the same species as the record above.
<b>Pseudoscorpiones</b>			
Garypidae	<i>Synsphyronus`PSE164`</i>	4	<b>Potential SRE</b> only known from 1 location.
<b>Opiliones</b>			
Assamiidae	<i>Dampetrus isolatus</i>	3	<b>Potential SRE</b> , associated to caves and only known from 3 locations 8.5 kms apart.
<b>Scorpiones</b>			
Buthidae	<i>Lychas`aitkeni spp. grp`</i>	2	<b>Potential SRE</b> from a species complex, only known from 2 locations 4.5 kms apart.
	<i>Isometroides`aitkeni`</i>	1	Probably a miss-identification of a specimen of the species above, wrongly attributed to the genus <i>Isometroides</i> .
Urodacidae	<i>Urodacus`yaschenkoi spp. grp`</i>	3	<b>Potential SRE</b> from a species complex, only known from 1 location.
<b>Diplopoda</b>			
<b>Polyzoniida</b>			
Siphonotidae	<i>`Megalosiphon`humphreysi`</i>	10	<b>Potential SRE</b> , only known from 2 locations 1.3 km apart.
<b>Polydesmida</b>			
Paradoxosomatidae	<i>Antichiropus humphreysi</i>	20	<b>Confirmed SRE</b> , known from 7 locations 29.4 kms apart.
	<i>Boreohesperus capensis</i>	93	<b>Confirmed SRE</b> , known from 41 locations up to 60 kms apart.
	<i>Boreohesperus`capensis?`</i>	4	Most likely the same species as the record above.

<b>Malacostraca</b>			
<b>Isopoda</b>			
Armadillidae	<i>Buddelundia</i> `sp. BBCR01`	23	<b>Potential SRE</b> , known from 7 locations 28.3 kms apart.
	<i>Buddelundia</i> sp.	4	Uncertain ID, potentially the same species as the record above.
	Armadillidae sp.	5	Uncertain ID, possibly the same species as the record above.
Philosciidae	Philosciidae sp.	42	Uncertain ID, but not consistent with any of the other taxa. Could represent several species.
Family unknown	Isopoda sp.	74	Uncertain ID, possibly the same species as one of the above.
<b>MOLLUSCA</b>			
<b>Gastropoda</b>			
<b>z</b>			
Camaenidae	<i>Caperantrum polygyrum</i>	47	<b>Potential SRE</b> , known from 8 locations 27.2 kms apart.
	<i>Caperantrum</i> sp.	11	Uncertain ID, potentially the same species as the record above.
	<i>Plectorhagada teres</i>	16	<b>Potential SRE</b> , known from 3 locations 18.5 kms apart.
	cf. <i>Plectorhagada scolythyra</i>	4	<b>Potential SRE</b> , known from only 1 location.
	<i>Promonturconchum superbum</i>	170	<b>Confirmed SRE</b> , known from >20 locations up to 66.5 kms apart, but still endemic to North West Cape.
	<i>Quistrachia</i> cf. <i>warroorana</i>	10	Widespread (if confirmed as <i>Q. warroorana</i> ), from multiple locations, up to 260 kms south.
	<i>Rhagada</i> cf. <i>capensis</i>	5	Widespread (if confirmed as <i>R. capensis</i> ), from multiple locations, up to 150 kms south.
	<i>Strepsitaurus manduensis</i>	15	<b>Confirmed SRE</b> , only known from the Mandu Mandu Gorge, at two sites 560 m apart.
	<i>Strepsitaurus milyeringus</i>	3	<b>Confirmed SRE</b> , only known two sites (< 500 m apart) in the Milyering Gorge.
	<i>Strepsitaurus ningaloo</i>	145	<b>Potential SRE</b> , known from multiple locations up to 50 kms apart.
	<i>Strepsitaurus susieae</i>	15	<b>Confirmed SRE</b> , only known from one unnamed gorge (1.2 km long), south of Tulki Gorge.
	<i>Strepsitaurus williami</i>	84	<b>Potential SRE</b> , known from multiple locations up to 60 kms apart.
	<i>Strepsitaurus</i> sp.	121	Uncertain ID, potentially the same species as the record above.



## Appendix 2: Potential SRE habitats recorded in the Project area.

**Dune swale within impact footprint**



**Dune swale in borefield**



***Urodacus* sp. scorpion from the impact area**



**Burrowing scorpion (*Urodacus* sp.) burrows**



**Rocky slopes near borefield**



**Potential open-holed trapdoor spider burrow**





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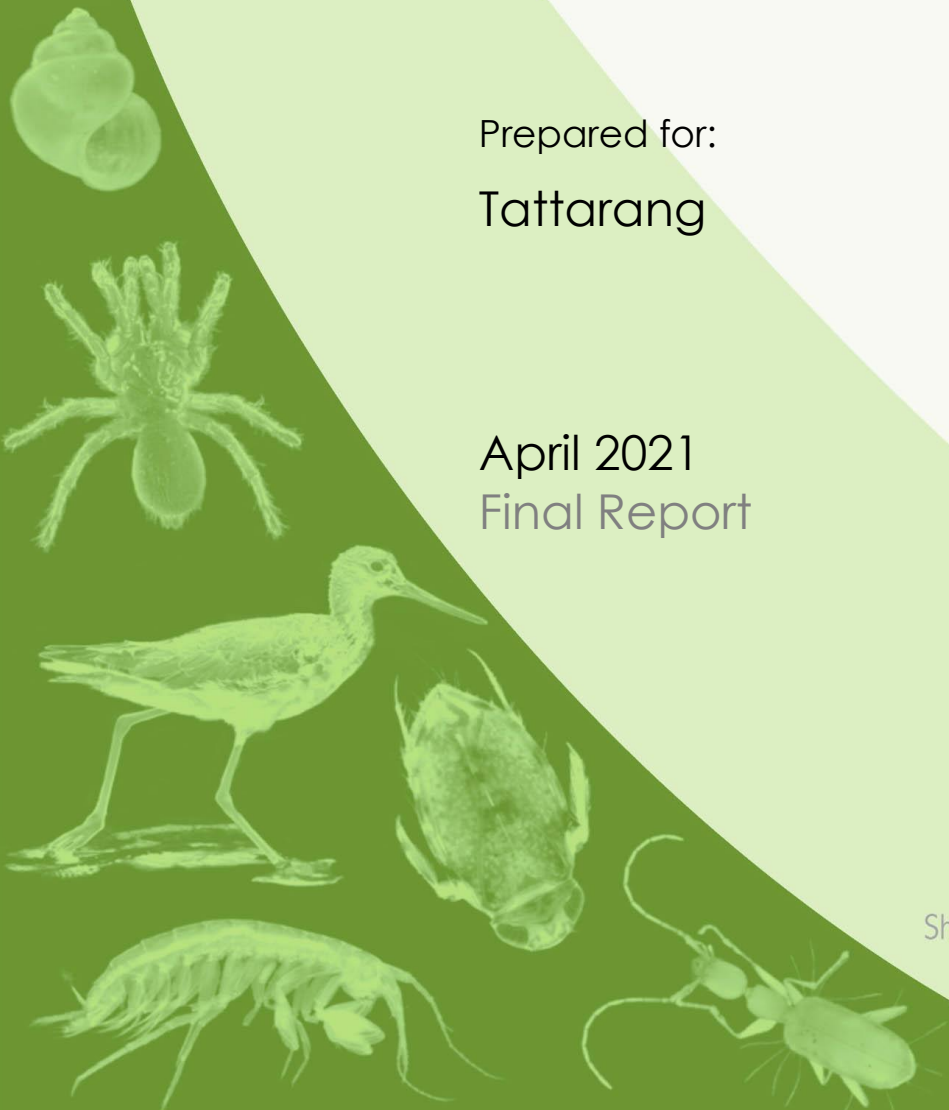
## Ningaloo Lighthouse Resort: Short Range Endemic Invertebrates Survey

Prepared for:  
Tattarang

April 2021  
Final Report

Short-Range Endemics | Subterranean Fauna

Waterbirds | Wetlands







# Ningaloo Lighthouse Resort: Short Range Endemic Invertebrates Survey

Bennelongia Pty Ltd  
5 Bishop Street  
Jolimont WA 6014

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

ABN: 55 124 110 167

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			Method	Date
Final	Bruno Alves Buzatto	Stuart Halse	email	23 April 2021

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## EXECUTIVE SUMMARY

The Ningaloo Lighthouse Resort is located near the Cape Vlamingh Lighthouse at the north-western tip of Exmouth Peninsula in Western Australia. The facility was formerly called the Lighthouse Holiday Park and, after acquiring it in 2018, Tattarang Pty Ltd plans to redevelop the holiday park with a greater range of accommodation and facilities. Redevelopment of the holiday park and adjacent freehold land as Ningaloo Lighthouse Resort is referred to as the 'Project' and will require very minor land clearing to expand the original holiday park area.

The Project is located on Yardie Creek Road, approximately 22 km north of Cape Range National Park and 16 km north of Exmouth. The ocean to the west of the Project lies within the inshore State and more offshore Commonwealth Ningaloo Marine Parks that form the bulk of the Ningaloo Coast World Heritage Area, while the beach lies within Jurabi Coastal Park which is also part of the World Heritage area. A proposed borefield to supply the Project with additional water lies in the extensive area of Unallocated Crown Land at the northern end of Exmouth Peninsula. The planned borefield will begin approximately 700 m south of the Project and run 1.1 km south along the eastern side of Cape Range. Additional monitoring bores will be placed up to 700 m south of the borefield itself. Production bores will be located at the base of the foothills of the eastern side of the range or in the swale between the foothills and the first red sand dune parallel to the range. The existing wastewater treatment plant (WWTP) for the holiday park is located on freehold land about 400 m south of the Project and almost 300 m east of the nearest production bore. It lies within an interdunal swale.

The Exmouth Peninsula has high diversity of species belonging to SRE Groups. These are groups of terrestrial invertebrate species that tend to have highly restricted ranges and may be threatened by individual development projects. Despite the small size of the Project, development may have potential to negatively affect populations of some short-range endemic invertebrate (SRE) species.

Previous survey records of terrestrial invertebrate species from SRE Groups in a search area of nearly 7,000 km<sup>2</sup>, encompassing all Exmouth Peninsula, were compiled by searching the databases of the Western Australian Museum and Bennelongia, as well as relevant publications. This type of desktop search gives only an indication of the level of species richness that can be expected in an area, rather than a precise number of species that exists.

The conclusion of the desktop review was that at least 24 species from SRE Groups have been recorded in the search area, including four species of spider, one species of pseudoscorpion, one species of harvestman, two species of scorpion, three species of millipede, two species of slater, and 11 species of land snail. Of the records with no taxonomic uncertainty, 14 species are described and a further seven species are recognised as new species that have not yet been formally described. Effort to collect terrestrial invertebrates (particularly targeting SRE Groups) in the vicinity of the Project has occurred predominantly within Cape Range National Park.

In terms of their distributions, 21 of the 24 species reported in the desktop review are potential or confirmed SREs (i.e., species with ranges <10,000 km<sup>2</sup>), and 11 of the species either occur at the Project or are moderately likely to do so and would be expected to face elevated risk from development. The land snail *Promonturconchum superbum* and the millipede *Boreoheperus capensis*, despite being confirmed SREs, are common and very widespread on the Exmouth Peninsula, and these species are unlikely to be under threat from the proposed development, which only represents a small fraction of their known distribution. The millipede *Antichiropus humphreysi*, which is also a confirmed SRE, has a smaller range. It is known from only seven locations 24 km apart, with occurrences only 11 km south from the Project. It most likely occurs in the Project area. However, its distribution is also probably multiple times larger than the area of the Ningaloo Lighthouse Resort, meaning persistence of the species will not be affected.

A field survey was undertaken in March 2021 to provide additional information to that in the desktop review and the confirm (or otherwise) the conclusions of the review. The survey documented 38 species belonging to SRE Groups, including two species of mygalomorph spider; one species of 'flattie' spider

(Selenopidae); 9 species of pseudoscorpion; five species of scorpion; three species of centipede, five species of millipede; one species of dipluran; six species of slater and six species of land snail. Out of these species, 16 were potential SREs, two were confirmed SREs (the millipedes *Antichiropus humphreysi* and *Boreoesperus capensis*), and the remaining 20 species were unlikely SREs or widespread species. Only the pseudoscorpion *Austrohorus* 'BPS342' and the scorpion *Lychas* 'BSCO065' are potential SREs currently only known from the Project impact footprint and, therefore, of conservation significance. These two species are potential SREs because of deficient data and further studies might align them genetically with species outside the Project area.

Despite the presence of a rich SRE fauna in the Project area, the small size of the impact footprint of the Project on rocky hills and very small footprint on red Pindan dune swales suggest that the Project is very unlikely to have conservation significant impact on any SRE fauna.



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## 1. INTRODUCTION

The Ningaloo Lighthouse Resort is located near the Cape Vlamingh Lighthouse at the north-western tip of Exmouth Peninsula in Western Australia. The facility was formerly called the Lighthouse Holiday Park, and after acquiring it in 2018, Tattarang Pty Ltd plans to redevelop the holiday park with a greater range of accommodation and facilities. Redevelopment of the holiday park and adjacent freehold land as Ningaloo Lighthouse Resort is referred to as the 'Project' and will require very minor land clearing to expand the original holiday park area.

The Exmouth Peninsula is considered likely to contain high richness of short-range endemic (SRE) invertebrates. These are mostly ground-dwelling invertebrates that have overall ranges of less than 10,000 km<sup>2</sup> (Harvey 2002). This makes them susceptible to spatially extensive habitat changes, especially if anthropogenic. While most SRE species have larger ranges than the scale of the Project, development of the Project may have the potential to negatively affect populations of some SRE species.

The objectives of this report are to:

1. Compile and evaluate records of SRE species, as well as listed species and ecological communities, in the vicinity of the Project.
2. Assess ranges of SRE species, as well as any listed species, and incorporate this information into an assessment of the likelihood conservation significant species occurrence in the Project area.
3. Report the results of a targeted SRE field survey, compiling and mapping the detected species in the Project area and associated borefield.
4. Outline potential impacts to SRE invertebrate fauna from proposed developments.

### 1.1. Project Description

The Project is located on Yardie Creek Road, approximately 22 km north of Cape Range National Park and 16 km north of Exmouth (Figure 1). The ocean to the west of the Project lies within the inshore State and more offshore Commonwealth Ningaloo Marine Parks that form the bulk of the Ningaloo Coast World Heritage Area, while the beach lies within Jurabi Coastal Park, which is also part of the World Heritage area.

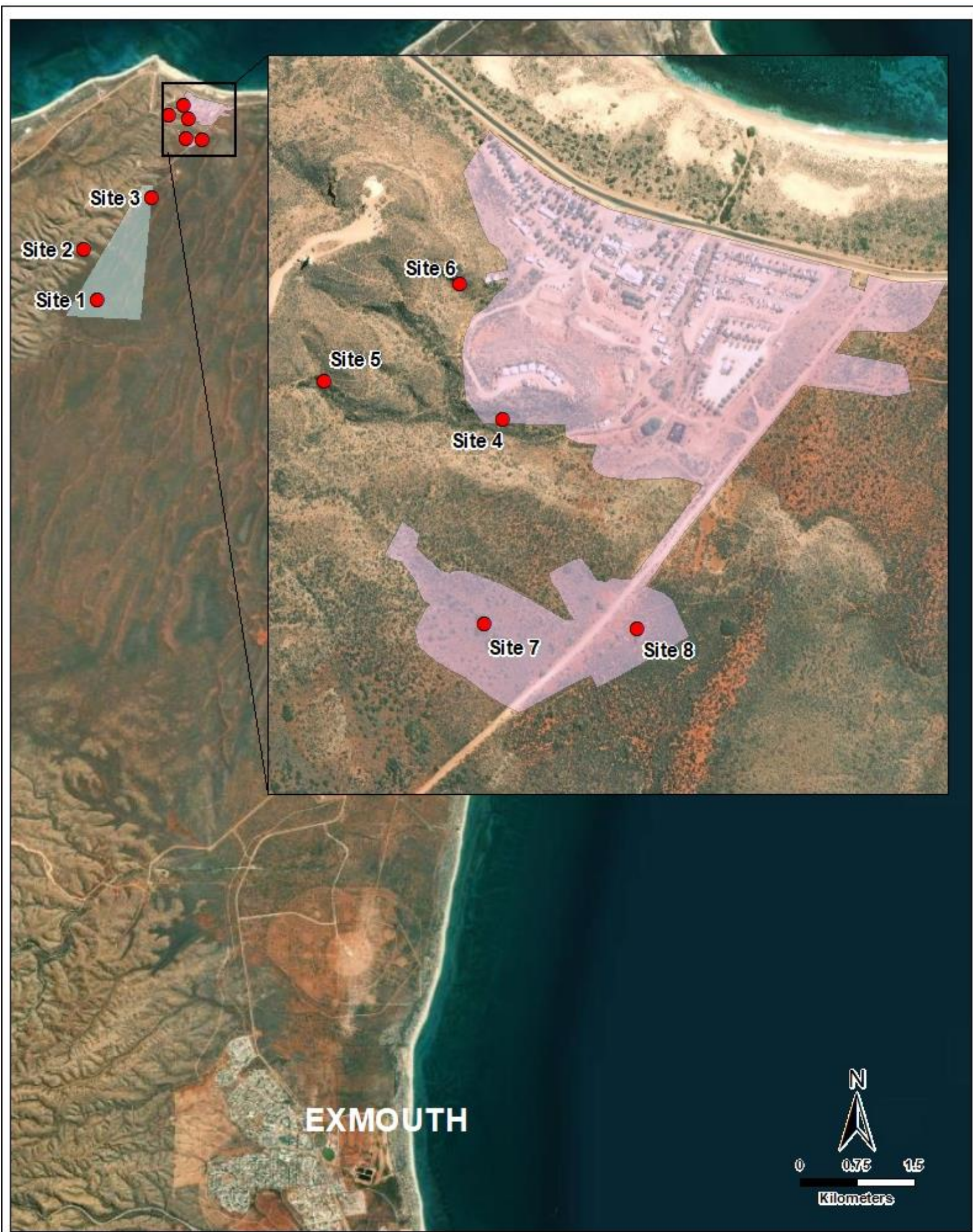
A proposed borefield to supply the Project with additional water lies in the extensive area of Unallocated Crown Land at the northern end of Exmouth Peninsula. The planned borefield will begin approximately 700 m south of the Project and run 1.1 km south along the eastern side of Cape Range. Additional monitoring bores will be placed up to 700 m south of the borefield itself. Production bores will be located at the base of the foothills of the eastern side of the range or in the swale between the foothills and the first red sand dune parallel to the range.

The existing wastewater treatment plant (WWTP) for the holiday park is located on freehold land about 400 m south of the Project and almost 300 m east of the nearest production bore. It lies within an interdunal swale.

## 2. LEGISLATION

An ecological community that comprises a naturally occurring biological assemblage in a particular habitat type may be listed by the Minister for the Environment, under the *Biodiversity Conservation Act 2016*, as a Threatened Ecological Community (TEC) if it presumed to be totally destroyed, critically endangered, endangered or vulnerable. A community that is threatened but does not meet these criteria, is rare but not threatened, is near threatened, has recently been removed from the TEC list, or is conservation-dependent, may be listed informally by the Department of Biodiversity, Conservation and Attractions (DBCA) as a Priority Ecological Community (PEC). There are no PECs or TECs in the vicinity of the search area listed on the basis of terrestrial SRE taxa. There are also no terrestrial invertebrate species listed as Threatened by the Minister under the *Biodiversity Conservation Act 2016* or as Priority species by DBCA in the vicinity of the Project.





**Figure 1: Location of the Ningaloo Lighthouse Resort area (with respect to Perth and Exmouth), and SRE sampling sites.**

- SRE sampling sites
- Borefield
- North West Resorts - Section 18 Area & DPLH 1038



GCS GDA 1994  
 Author: BBuzatto  
 Date: 23/04/2021





### 3. SRE FRAMEWORK

SRE species tend to exhibit patchy distributions within their small range, and to have slow growth, low fecundity, and poor dispersal capabilities. Guidelines for the assessment of impacts to SRE invertebrates in Western Australia are provided in *Environmental Factor Guideline: Terrestrial fauna* (EPA 2016b) and *Technical Guidance: Sampling of short range endemic invertebrate fauna* (EPA 2016a). Assessment is restricted to a number of taxonomic groups (the SRE Groups) that are known to contain at least some, but more commonly moderate to high proportions of, SRE species. The groups include land snails (Gastropoda); millipedes (Diplopoda); centipedes (Chilopoda); pseudoscorpions (Pseudoscorpiones); scorpions (Scorpiones); spiders [Araneae, mainly Mygalomorphae (trapdoor spiders)]; slaters (Isopoda); and harvestmen (Opiliones). Some other groups, such as velvet worms (Onychophora) and earthworms (Oligochaeta), are SRE Groups but are restricted to mesic landscapes.

Groups containing species that are mostly widespread due to high vagility, ecological plasticity or xeric adaptation, may also have species with restricted ranges (e.g., Framenau *et al.* 2008; López-López *et al.* 2016; Rix *et al.* 2015) and, conversely, some species belonging to SRE Groups are in fact widespread. Determining whether a species belonging to an SRE Group really has a significantly restricted range (estimated as less than 10,000 km<sup>2</sup>) is often difficult. However, species distributions usually reflect the distribution of their preferred habitats. Most SRE species prefer restricted or patchy habitats and hence have smaller ranges than species found in widespread habitats. Additional causes of species having small ranges include life history and ecological interactions; these sometimes lead to species occupying only small extent of a widespread habitat (Harvey 2002; Rix *et al.* 2015).

Here we followed the classification used for SRE species by the Western Australian Museum (WAM), where a species can be classified into one of the following categories:

1. **Confirmed SREs** have a known distribution range smaller than 10,000 km<sup>2</sup>. The taxonomy is well known, and the group well represented in collections and/or via comprehensive sampling.
2. **Potential SREs** 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<sup>2</sup>. The taxonomy is well known, and the group well represented in collections via comprehensive sampling.

The factors considered when evaluating the SRE status of each species in this report were the known range of the species, habitat(s) at the collection location(s) and the spatial extent and connectivity of these habitats, as well as the distribution patterns of phylogenetically related surrogate species (ideally members of the same genus). **Potential SREs** can be separated into species that treated as SREs as a precautionary measure because of insufficient information to determine whether they are widespread (**data deficient Potential SREs**), species that are unlikely to be SREs although the information suggesting this is not definitive (**Unlikely SREs**), and species that existing information suggest are quite likely SREs (**Potential SREs**).

When considering potential impacts on a species, it is recognised that even SRE species may be locally widespread around a project area, so that identifying potential SRE species is only the first part of a filtering process used to determine whether species may be threatened by a proposed development. The actual level of threat to an SRE species depends on its distribution relative to the development footprint, rather than SRE status alone. Determining the likely level of threat to a species requires consideration of the extent of the species' preferred habitat, both within and outside the area of disturbance.



## 4. DESKTOP REVIEW

Existing records of terrestrial invertebrates and associated habitat information were examined to appraise the likelihood of SRE or listed invertebrate species occurring in the vicinity of the Project.

Existing survey records in the WAM and Bennelongia databases of species in SRE Groups were compiled for a search area of nearly 7,000 km<sup>2</sup>, encompassing all North West Cape peninsula (Figure 2, Figure 3). This type of desktop search gives only an indication of the level of species richness that can be expected, in the Project area rather than a species list. Appendix 1 provides a tabulated list of species recorded in the search area. It was not practicable to determine the exact number of species that has been collected even in the search area because of incomplete or inconsistent taxonomy for some records. Some recorded species may represent multiple taxa and, conversely, some specimens assigned to different taxa may in reality represent the same species.

Based on the desktop search, 943 individuals from at least 24 species belonging to SRE groups have been recorded in the search area. This includes the higher-level identification Philosciidae sp., which must represent at least one unique species (potentially several) because no other species from that family were recorded in the search area. The 24 species included four species of spider, one species of pseudoscorpion, one species of harvestman (order Opiliones), two species of scorpion, three species of millipede, two species of slater, and eleven species of land snail (Appendix 1).

Fourteen of the 24 species are described. Seven others are recognised as new species but have not been formally described and so have provisional names (such as *Aname* `Learmonth sp. 1` and *Euoplos* `MYG672`).

Records in Appendix 1 include five additional taxa as a result of animals being identified only to higher level than species, two additional taxa as a result of animals being assigned to species already in the list but with reservations noted about the identification, and one additional taxon that was probably a mis-identification.

The two taxa with reservations about the identifications were (*Euoplos?* `MYG672` and *Boreoheperus* `capensis?`) are most likely synonyms of species already in the table. Moreover, the records of *Isometroides* `aitkeni` probably represent a mis-identification of specimens of *Lychas* `aitkeni spp. grp`, which represent a species complex (similarly to *Urodacus* `yaschenkoii spp. grp`) that might contain multiple undescribed species.

Using species records as a proxy for sampling coverage, the effort to collect terrestrial invertebrates (particularly SRE Groups) in the vicinity of the Project has occurred predominantly within Cape Range National Park (Figure 2). Further information on species detected in the desktop review is provided in section 5.3, alongside the results of the recent SRE survey in the project area.

### 4.1. SRE Habitats

The prospectivity of areas for SREs was assessed by reviewing recent vegetation and landform mapping (Ecoscape 2018), as well as through observations made during a brief recognisance trip by Bennelongia from 12-14 January 2021. Emphasis was placed on identifying relict, isolated, sheltered, or moist habitats, such as rocky outcrops, that are generally considered to be more prospective for SRE species.

The Project area hosts seven vegetation types, including a total of 169 vascular flora species (Ecoscape 2018) that cover three different major vegetation habitat types: coastal zone, limestone hills and red Pindan dunes. Regarding fauna, five habitat types were recorded by that survey:

- Red Pindan dune crests,
- Red Pindan dune swales,
- Rocky hills and slopes,
- Sheltered gullies and minor caves associated with limestone,
- Coastal dunes.

There is certainly some overlap between these habitat types, in terms of their function as habitat for terrestrial invertebrates in general, and for SRE groups. Coastal dunes are not expected to be prospective to SREs, whereas the red Pindan dunes (especially the swales) should be prospective to SRE scorpions and centipedes mostly, and less prospective to other SRE groups. Meanwhile, the rocky hills and slopes, especially when south facing, should be prospective to a wide range of SRE taxa, including millipedes, land snails and spiders. Finally, the sheltered gullies and minor caves have the highest potential to hold moisture, and are also the most isolated and patchy habitats, and therefore have the highest SRE conservation significance.

Despite the detection of the five habitats described above by the Ecoscape (2018) survey, the footprint area (Figure 1) of the Project only overlaps dune swales and rocky hills and slopes. The former represents approximately 80% of the new impact area, whereas the latter represents the remaining 20%. These two habitats should be prospective to SREs, but their connectivity outside the development envelope, as well as the small area of impact footprint, suggests the Project will have a negligible impact on SRE species in the area. Moreover, the SRE species captured in the desktop search that are most likely to occur in the Project (Appendix 1, Figure 3) were found in rocky hills and slopes, with the exception of the northernmost record of an isopod, collected on red Pindan dunes, but only identified as *Isopoda* sp.

Finally, an important caveat of this assessment is that the habitats discussed above were originally categorized based on their suitability as habitats for terrestrial vertebrates, and they have limited suitability as indicators for SRE invertebrates, as these animals are distributed at the microhabitat scale.

## 4.2. Preliminary SRE observations

While on site for a subterranean fauna survey, from 12-14 January 2021, Bennelongia staff conducted a brief reconnaissance for SRE species within the project area. This included the borefield and resort development footprint. The reconnaissance consisted of looking for evidence of SRE species and assessing possible habitat of SRE species. Two broad habitat types were observed on site: 1) the Red Pindan dunes with *Triodia* hummock grassland, mallee and *Banksia* (photos 1 and 2 in Appendix 2), and 2) rocky hills (limestone outcropping) with little or no topsoil (photo 5 in Appendix 2).

Searches within the sand dunes identified the presence of burrows from the scorpion genus *Urodacus* (photo 4 in Appendix 2). This was further confirmed with the sighting of a *Urodacus* specimen (photo 3 in Appendix 2). At one location, a circular, web lined hole indicative of open-holed trap door spiders (family Anamidae) was also observed (photo 6 in Appendix), however the presence of this group cannot be confirmed, as no spiders were observed and some wolf spiders (family Lycosidae, not typically considered SRE species) are known to build similar burrows. Additionally, numerous snail shells were observed on the surface of the sand dunes. Table 1 outlines the snail species observed on site. Leaf litter accumulation under mallee (top right of photo 2 in Appendix 2) and *Banksia* may provide habitat for other SRE groups/species, such as millipedes, pseudoscorpions, and slaters, however a more thorough search would be required for this.

The limestone outcropping also revealed the presence of members from SRE groups. Under rocks and in cracks and crevices, we located the exuvia of a millipede from the family Paradoxosomatidae, from the genus *Antichiropus* or *Boreoheperus*. This was a broken exuvia of a partial animal, so further identification is not possible. Snail shells were also collected from under rocks and in cracks and crevices and are outlined in Table 1. All snail identifications are preliminary since only dead shells were used, and in some cases, only damaged shells were available.

**Table 1:** Snail species observed in the recognisance trip, their broad habitats and notes on taxonomy.

Species	Habitat		Taxonomic Notes and Literature Reviewed
	Sand Dune	Limestone Outcrop	
<i>Quistrachia</i> c.f. <i>warroorana</i>	16	11	Closest morphological match based on shell and distribution (Stanisic <i>et al.</i> 2017, O'Neill <i>et al.</i> 2014) Shell shape, pattern and umbilicus match.
<i>Plectorhagada</i> <i>scolothyra</i> or <i>Plectorhagada</i> <i>teres</i>	2	0	Closest morphological match based on shell and distribution. Umbilicum morphology matches <i>P. scolothyra</i> , while upper spire morphology matches <i>P. teres</i> (Stanisic <i>et al.</i> 2017; Taylor <i>et al.</i> 2015). Old shell may be worn, influencing morphological traits.
<i>Pupoides</i> <i>contrarius</i>	1	1	Certain ID (Stanisic <i>et al.</i> 2017)
<i>Rhagada</i> c.f. <i>globosa</i>	3	1	Closest match based on shell morphology and distribution (Stanisic <i>et al.</i> 2017)
Camaenidae sp. or ? <i>Rhagada</i> sp.	0	1	Juvenile and broken shell. Very difficult to identify. Very angular, but <i>Rhagada</i> species known to have variable intra species shell morphology (Johnson and Stankowski 2018; Johnson <i>et al.</i> 2016; Stanisic <i>et al.</i> 2017).

## 5. FIELD SURVEY

In order to test the conclusions of the desktop study, a field survey targeting SRE groups in the particular habitats mentioned above, both in the Project Area and the associated borefield (Figure 1), was conducted to clarify the conservation values of SRE invertebrates in the Ningaloo Lighthouse Resort area. The survey was carried out from 15-19 March 2021 by Vitor Marques and Bruno Buzatto. The aim of the surveys was to collect species from recognised SRE groups in representative habitats types at the Project area and associated borefield.

### 5.1. Survey timing

Many SRE Groups are most active, and therefore likely to be collected, during and immediately following substantial rainfall. A very significant amount of rain fell 13 days before the start of the survey: the weather station at Exmouth town recorded a total of 123 mm rainfall from 1-3 March 2021. Unfortunately, no more rain was recorded in the survey area during the remainder of March, with the exception of 0.2 mm on 15 March, the first day of the survey.

### 5.2. Sampling effort and methods

A total of eight sites were sampled using a range of active search methods (Table 2) that varied at each site according to habitat, knowledge of the biology of certain taxa and visual observations of burrows or other signs of target species. These sites were distributed across each of the habitats present (red Pindan dune crests, red Pindan dune swales, rocky hills and slopes, and sheltered gullies and minor caves associated with limestone). The distribution of sampling sites is shown in Figure 1. Site selection was also based on recent vegetation and landform mapping (Ecoscape 2018), as well as observations from the brief recognisance trip by Bennelongia.

In addition to habitat characterisation/mapping, two collection techniques were used:

1. **Habitat characterisation** consisted of recording the dominant vegetation type; land formation, and slope of terrain; the depth of leaf litter and estimated proportion of the site area covered by three depth categories (< 1mm, between 1mm and 5mm and > 5mm); and the estimated extent of fire and stock impact on the site (both in categories of 1 to 4).
2. **Active foraging** consisted of visual searching for evidence of SRE species and included searching under boulders and bark, counting spider burrows and digging up representative burrows to confirm species identifications, using UV torch searches at night to find scorpions and selenopids (spiders commonly known as flatties), setting of cup traps to catch scorpions, digging through litter and around roots, and sieving litter. Foraging was conducted in all relevant microhabitats present at a survey site, such as under logs, rocks, tree bark or in the shade of south facing slopes. Active foraging was always performed for at least 2 h by two people, equating a total of 4 h of sampling effort per site.
3. **Litter and soil sampling** were performed by collecting up to 0.0037 m<sup>3</sup> of litter and soil from each site to capture small SRE species, such as pseudoscorpions, small snails, scorpions, centipedes and millipedes. The litter/soil samples were sorted in the laboratory using Tullgren funnels to separate the animals from the litter/soil.

The survey targeted seven SRE Groups: spiders (Araneae), pseudoscorpions (Pseudoscorpiones), scorpions (Scorpiones), centipedes (Chilopoda), millipedes (Diplopoda), slaters (Isopoda) and snails (Gastropoda). Even though earthworms (Oligochaeta) and velvet worms (Onychophora) are known to contain SREs, these groups were not targeted as they are restricted to high-rainfall areas (Blakemore 2000; Reid 2002). When foraging, the individuals of all target SRE Groups were preserved in 100% ethanol and returned to the laboratory for full identification. Morphological species identifications were undertaken by Bruno Buzatto (scorpions, spiders and millipedes), Huon Clark (snails and isopods) and Jane McRae (pseudoscorpions and centipedes).

**Table 2.** Summary of the distribution of SRE sampling sites in the Project Area. NLRA refers to the Ningaloo Lighthouse Resort Area, whereas BF refers to the associated borefield to the SSW.

Method	NLRA	BF	Total
F + L	2	2	4
T + F + UV	3	1	4
<b>Total</b>	<b>5</b>	<b>3</b>	<b>8</b>

F, forage; L, litter; UV, nocturnal spotlighting with ultraviolet light.

### 5.3. SREs known from the Desktop Search and collected in the survey

#### Trapdoor spiders (Araneae: Mygalomorphae)

At least four species of trap door spiders, from three different families, were recorded in the desktop search area. The family of open-holed trapdoor spiders (Anamidae) was represented by two species, both collected between 3 and 7 km south of the southern limit of Cape Range National Park. *Aname* 'Learmonth sp. 1' is known from three locations up to 8.8 km apart, whereas *Aname* 'Learmonth sp. 2' is only known from one location, and they are both considered data deficient potential SREs. Both species are, however, unlikely to occur in the Ningaloo Lighthouse Resort. Despite sighting burrows similar to those of this genus during Bennelongia's recognisance trip (see section 4.2), no spiders from the family Anamidae were found in the Project Area during the SRE field survey. The genus *Aname* contains large diversity of described and undescribed species, and whereas the Pilbara fauna is well studied (Castalanelli *et al.* 2020), some species from North West Cape remain undescribed.



**Table 3:** Species of SRE invertebrate groups recorded in the Project area and its vicinity.

Grey denotes higher order identifications that might belong to other listed species (not viewed as unique species); blue represents species complexes; red denotes sites within the Project’s development footprint, as well as potential SRE species only collected in these sites.

Higher Classification	Lowest Identification	Subterranean fauna bycatch				SRE sampling sites								Distribution comments
		LH04P	LH06P	LH07P	LH10P	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	
<b>ARTHROPODA</b>														
ARACHNIDA														
<b>Araneae</b>														
Actinopodidae	<i>Missulena</i> sp.									1				Likely <i>Missulena insignis</i> species complex. Found outside the project footprint. <b>Unlikely SRE.</b>
Idiopidae	<i>Euoplos</i> sp.									1				Likely <i>Euoplos</i> ‘MYG672’. Found outside the project footprint. <b>Potential SRE.</b>
Selenopidae	<i>Karaops burbidgei</i>										1			Known from Barrow Island and found outside the project footprint. <b>Not SRE.</b>
<b>Pseudoscorpiones</b>														
Cheiridiidae	Cheiridiidae ‘BPS339’											2	13	New species, only found within the project footprint. <b>Unlikely SRE.</b>
Chernetidae	Chernetidae ‘BPS338’												4	New species, only found within the project footprint. <b>Unlikely SRE.</b>
Chthoniidae	<i>Austrochthonius</i> ‘BPS341’						7				1			New species, only found outside the project footprint. <b>Unlikely SRE.</b>
	<i>Tyrannochthonius brooksi</i>						2				1			Minimum known linear range of 54 Km and only found outside the project footprint. <b>Unlikely SRE.</b>
	Chthoniidae sp.						8				1			Likely one of above species.

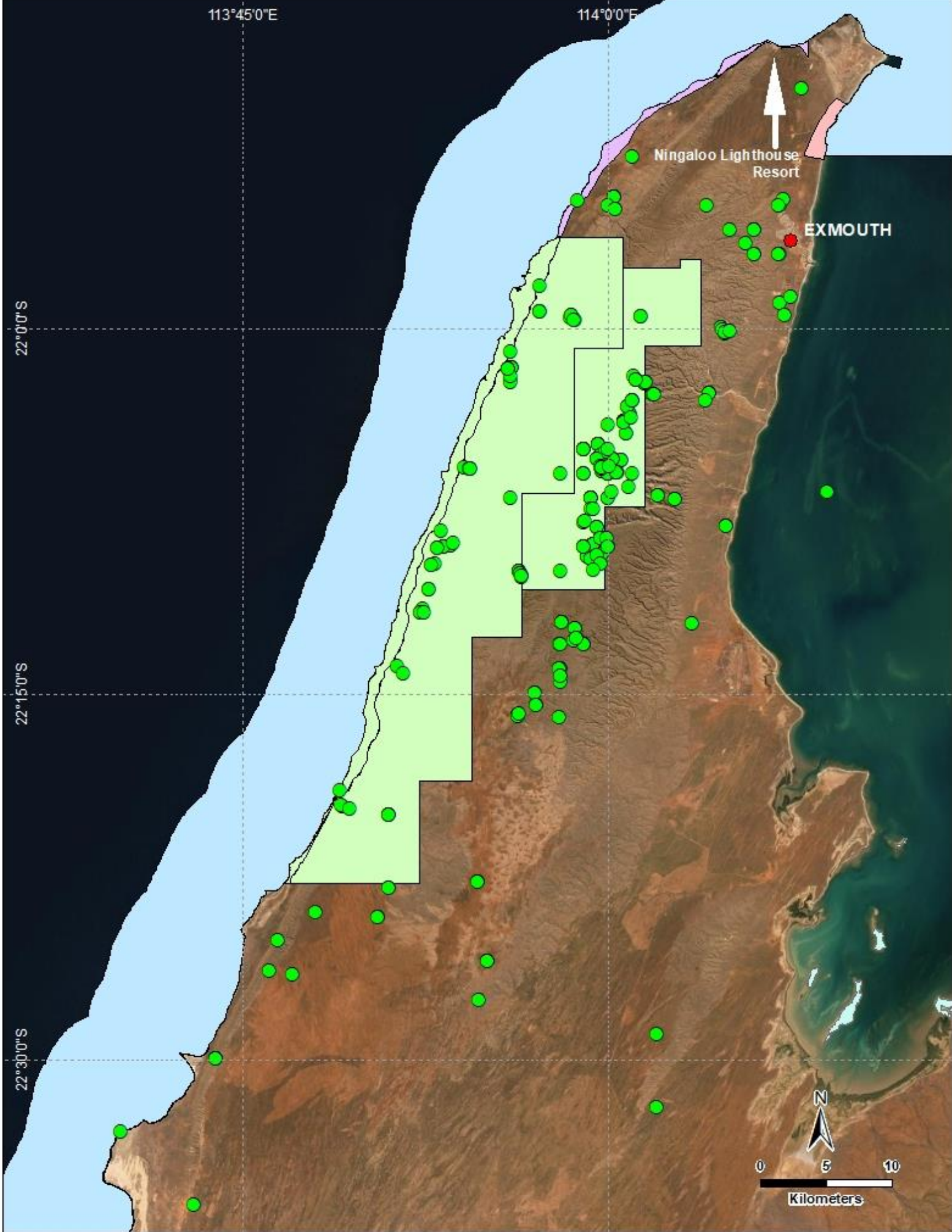
Higher Classification	Lowest Identification	Subterranean fauna bycatch				SRE sampling sites								Distribution comments
		LH04P	LH06P	LH07P	LH10P	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	
Geogarypidae	<i>Geogarypus taylori</i>								1					Widespread species. <b>Not SRE.</b>
Olpiidae	<i>Austrohorus</i> `BPS340`						2			3	1			New species only known from the Project Area, but from sites outside the project footprint. <b>Potential SRE.</b>
	<i>Austrohorus</i> `BPS342`											1		New species only known from the Project Area, from a site within the project footprint. <b>Potential SRE.</b>
	<i>Beierolpium</i> sp.	2												Uncertain ID, only collected as subterranean fauna bycatch in the borefield. <b>Unlikely SRE.</b>
	<i>Euryolpium</i> sp.				2									Uncertain ID, only collected as subterranean fauna bycatch in the borefield. <b>Unlikely SRE.</b>
	Olpiidae sp.		2	2			5	1	2	1	2			Likely one of above species.
Family unknown	Pseudoscorpiones sp.		2											Likely one of above species.
<b>Scorpiones</b>														
Buthidae	<i>Lychas</i> 'BSCO064'					1								Singleton, collected outside the Project footprint. <b>Potential SRE.</b>
	<i>Lychas</i> 'BSCO065'								1					Singleton, collected from within the Project footprint. <b>Potential SRE.</b>
	<i>Lychas</i> sp.									1				Likely one of above species.
	<i>Lychas variatus</i> s.l.					2		1				2		Potentially a species complex, but found within and outside the Project footprint. <b>Unlikely SRE.</b>

Higher Classification	Lowest Identification	Subterranean fauna bycatch				SRE sampling sites								Distribution comments
		LH04P	LH06P	LH07P	LH10P	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	
Urodacidae	<i>Urodacus</i> `BSCO062`						1					3	3	New species from the <i>Urodacus yaschenkoi</i> species complex, from within and outside the Project footprint. <b>Unlikely SRE.</b>
	<i>Urodacus</i> `BSCO063`								1					Potentially conspecific of species above, with minor morphological differences. <b>Unlikely SRE.</b>
	<i>Urodacus</i> sp.					1	1							Likely one of above species.
CHILOPODA														
<b>Geophilida</b>														
Mecistocephalidae	<i>Mecistocephalus</i> sp.									1				Uncertain ID. <b>Potential SRE.</b>
Oryidae	<i>Orphnaeus</i> sp.										1			Uncertain ID. <b>Unlikely SRE.</b>
<b>Scolopendrida</b>														
Scolopendridae	<i>Scolopendra</i> sp.						1							Uncertain ID. <b>Not SRE.</b>
DIPLOPODA														
<b>Polydesmida</b>														
Paradoxosomatidae	<i>Antichiropus humphreysi</i>								1		1			Known from locations 40 Km to the south. <b>Confirmed SRE.</b>
	<i>Boreoesperus capensis</i>						1				1			Known from locations 72 Km to the south. <b>Confirmed SRE.</b>
	Paradoxosomatidae sp.*						9		5	2	1			Very likely one of above species.
<b>Polyxenida</b>														
Polyxenidae	<i>Unixenus</i> sp.								22	4	6			Uncertain ID. <b>Unlikely SRE</b> (Short and Huynh 2013)

Higher Classification	Lowest Identification	Subterranean fauna bycatch				SRE sampling sites								Distribution comments
		LH04P	LH06P	LH07P	LH10P	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	
Synxenidae	<i>Phryssonotus novaehollandiae</i>						13		2	2	11			Widespread species. <b>Not SRE.</b>
<b>Polyzoniida</b>														
Siphonotidae	Siphonotidae `BDI072`						1		5	15	1			Most likely the undescribed species ' <i>Megalosiphon humphreysi</i> '. <b>Potential SRE.</b>
ENTOGNATHA														
<b>Diplura</b>														
Parajapygidae	Parajapygidae sp.						1							Uncertain ID. <b>Not SRE.</b>
MALACOSTRACA														
<b>Isopoda</b>														
Armadillidae	<i>Buddelundia</i> `BIS427`								4		1			New species only known from the Project, from sites within and outside the project footprint. <b>Potential SRE.</b>
	<i>Buddelundia</i> `BIS428`						1							Singleton only known from one site outside the footprint of the Project. <b>Potential SRE.</b>
	<i>Buddelundia</i> `BIS429`									3				New species only known from one site outside the footprint of the Project. <b>Potential SRE.</b>
	<i>Buddelundia</i> `BIS430`								1	1				New species only known from the Project, from sites within and outside the project footprint. <b>Potential SRE.</b>
	<i>Troglarmadillo</i> `BIS431`						3							New species only known from one site outside the footprint of the Project. <b>Potential SRE.</b>



Higher Classification	Lowest Identification	Subterranean fauna bycatch				SRE sampling sites								Distribution comments	
		LH04P	LH06P	LH07P	LH10P	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8		
Paraplatyarthridae	<i>Paraplatyarthrus</i> `BIS432`						1								New species only known from one site outside the footprint of the Project. <b>Potential SRE.</b>
Family unknown	Isopoda sp.						1								Uncertain ID, likely one of the above species.
<b>MOLLUSCA</b>															
GASTROPODA															
<b>Stylommatophora</b>															
Camaenidae	<i>Plectorhagada</i> cf. <i>scolythera</i>						3			4	3				Also known from 35.5 Km south. <b>Potential SRE.</b>
	<i>Quistrachia</i> cf. <i>warroorana</i>						23		47	46	14				Also known from 38 Km south. <b>Potential SRE.</b>
	<i>Rhagada</i> cf. <i>globosa</i>					1	17		18	28	40				Also known from 150 Km south. <b>Potential SRE</b> (if alignment with <i>Rhagada globosa</i> not confirmed).
	Camaenidae sp.											50			Uncertain ID, likely one of the above species.
Pupillidae	<i>Gastrocopta larapinta</i>									5		1			Widespread species. <b>Not SRE.</b>
	<i>Pupisoma</i> cf. <i>orcula</i>									2		1			Widespread species. <b>Not SRE</b> (however species alignment with <i>Pupisoma orcula</i> not confirmed yet).
	<i>Pupoides contrarius</i>								2	3					Widespread species. <b>Not SRE.</b>
<b>Order unknown</b>	Gastropoda sp.								1	5		1			Likely one of above species.
CLASS UNKNOWN	Mollusca sp.									4					Likely one of above species.



113°45'0"E

114°0'0"E

22°0'0"S

22°15'0"S

22°30'0"S

Ningaloo Lighthouse  
Resort

EXMOUTH



GCS GDA 1994  
Author: BBuzato  
Date: 15/02/2021



**Figure 2: SRE records around the Ningaloo Lighthouse Resort**

- SRE records
- Bundegi Coastal Park
- Cape Range National Park
- Whitmore, Roberts, Doole Islands and Sandalwood Landing Nature Reserve
- Jurabi Coastal Park
- Ningaloo Marine Park

*Conothele* `MYG673` (Halonoproctidae) is known from two different locations approximately 8.5 km apart, one within the northern end of Cape Range National Park, and the other one just outside its north-eastern border. Both locations are about 24 km south of the Project, and this species is also considered a data deficient potential SRE, moderately likely to occur in the Ningaloo Lighthouse Resort. Several new genetic lineages of this genus were recently detected by Huey *et al.* (2019), but none of these were recorded from North West Cape. No species of this genus were found during the SRE survey.

The spiny trapdoor spider *Euoplos* `MYG672` (Idiopidae; Wilson *et al.* 2020) is known from three different locations up to 24 km apart, all of them at least 24.7 kms south of the Project Area. This species is a data deficient potential SRE, and it was initially considered moderately likely to occur in the Ningaloo Lighthouse Resort. In fact, a mature female of this genus was collected during Bennelongia's SRE survey in site 5, in a south facing rocky slope that is out of the project's development envelope. This female is likely conspecific with *Euoplos* `MYG672`, but this can only be confirmed with future sequencing work. Even if this is a new species, however, it should not be under threat from the proposed development, given its occurrence outside the project footprint.

Finally, a juvenile mouse spider (Actinopodidae: *Missulena*) was collected during the field survey, from the same south facing rocky slope found in site 5. This genus currently has 17 described species in Australia, most of these occurring in Western Australia, where seven species are endemic to the state (Framenau and Harms 2017). It is also clear that the diversity of this genus is underrepresented by the current taxonomy (Harms and Framenau 2013; Miglio *et al.* 2014), which represents a fraction of the actual species diversity in this region (Framenau and Harms 2017). The only species from that genus that had previously been collected from the Exmouth Peninsula was *Missulena occatoria*, which is a widespread species. However, Miglio *et al.* (2014) highlighted that *Missulena insignis* and *Missulena occatoria* cannot be distinguished based on the original description, and Main (1985) suggested that Western Australian specimens are *M. insignis*, whereas eastern Australian specimens are the real *M. occatoria*. Therefore, the new *Missulena* specimen probably represent *M. insignis*, which in itself could represent a species complex, and whether the new specimen is a new genetic lineage can only be determined with future molecular work. Regardless of whether this specimen represents a new and restricted genetic lineage, or a widespread lineage of *M. insignis*, it should not be under threat from the proposed development, given its occurrence outside the project footprint.

#### **'Wall crab spiders' or 'flatties' (Araneomorphae: Selenopidae)**

Spiders of the family Selenopidae are dorsoventrally flattened and very fast, and the genus *Karaops* is restricted to Australia and widespread throughout the continent. The elusiveness of the genus probably explains low numbers in museum collections, where many species are known only from one sex, and several species from only a single specimen, leading Crews and Harvey (2011) to suggest that with more collecting, as well as morphometric and molecular data, some species of the genus will be considered SREs in the future. One mature female of *Karaops burbidgei* was collected in site 6, a south facing rocky slope that is out of the project's development envelope. This species was originally described from Barrow Island (Crews and Harvey 2011; Crews 2013), and has since been detected in Cape Range National Park, suggesting that the species is relatively widespread in the northwest corner of the Pilbara.

#### **Pseudoscorpions**

The pseudoscorpion fauna of North West Cape is diverse, but mostly comprised of subterranean species. On the surface, only one species of potential SRE pseudoscorpion is known from the desktop search area, *Synsphyronus* `PSE164` (Garypidae). This species was only recorded in one location, immediately east of the north-eastern border of Cape Range National Park, and approximately 27.5 km south of the Project. *S.* `PSE164` is one of many new undescribed species of the genus from the Pilbara and Gascoyne regions, and some of the described species are considered SREs (Harvey *et al.* 2015). *S.* `PSE164` is a potential SRE, moderately likely to occur in the Ningaloo Lighthouse Resort. Bennelongia's SRE survey detected a total of 68 pseudoscorpions from at least nine different species that are surface dwellers, even though two of these species (*Beierolpium* sp. and *Euryolpium* sp.) were only collected as bycatch

from Bennelongia's stygofauna survey. No individuals of the genus *Synsphyronus*, or even the family Garypidae, were collected in the survey.

#### *Family Chthoniidae*

Two species of the pseudoscorpion family Chthoniidae were collected. Eight individuals of *Austrochthonius* `BPS341` were found in two sites outside the project footprint. Epigeal members of this genus in Australia can be common in leaf litter, but the only species known from the Northwest Cape peninsula is the troglobitic *Austrochthonius easti* (Harvey and Mould 2006). Therefore, *A.* `BPS341` probably represents an undescribed species that is unlikely to be an SRE. Meanwhile, three specimens of *Tyrannochthonius brooksi* were collected from the same two sites mentioned above, outside the project footprint. This species was previously known from three different sites in the Northwest Cape peninsula, and the new record from the project area extends its minimum known linear range to approximately 54 Km. Neither chthoniid collected is under threat from the proposed development.

#### *Family Cheiridiidae*

This family is very poorly known in Australia, with only one species described, and no records from the Northwest Cape peninsula. Cheiridiidae `BPS339` is probably a new species, and it was found abundantly in sites 7 and 8, within the project development footprint. The family is known to have phoretic associations with insects (Jhasser Martínez *et al.* 2018), and therefore its species are not normally considered SREs. However, confidently inferring the SRE status for Cheiridiidae `BPS339` is currently not possible, so this species remains an unlikely SRE.

#### *Family Chernetidae*

This cosmopolitan family is poorly defined, and there is no taxonomic framework to allow assigning this species to a particular genus. Four individuals of Chernetidae `BPS338` were collected from site 8, within the project's footprint. However, this family is also known for phoresy, so it is very likely that Chernetidae `BPS338` is phoretic on flies and beetles. Considering these pseudoscorpions tendency to be widely dispersed, Chernetidae `BPS338` is unlikely to be of conservation significance, but its SRE status cannot be fully ruled out, and it is here considered an unlikely SRE.

#### *Family Geogarypidae*

*Geogarypus taylori* was only collected from within the project footprint, but this species is widespread in Australia, with multiple records from Western Australia, as well as the Northern Territory, South Australia, New South Wales and Victoria.

#### *Family Olpiidae*

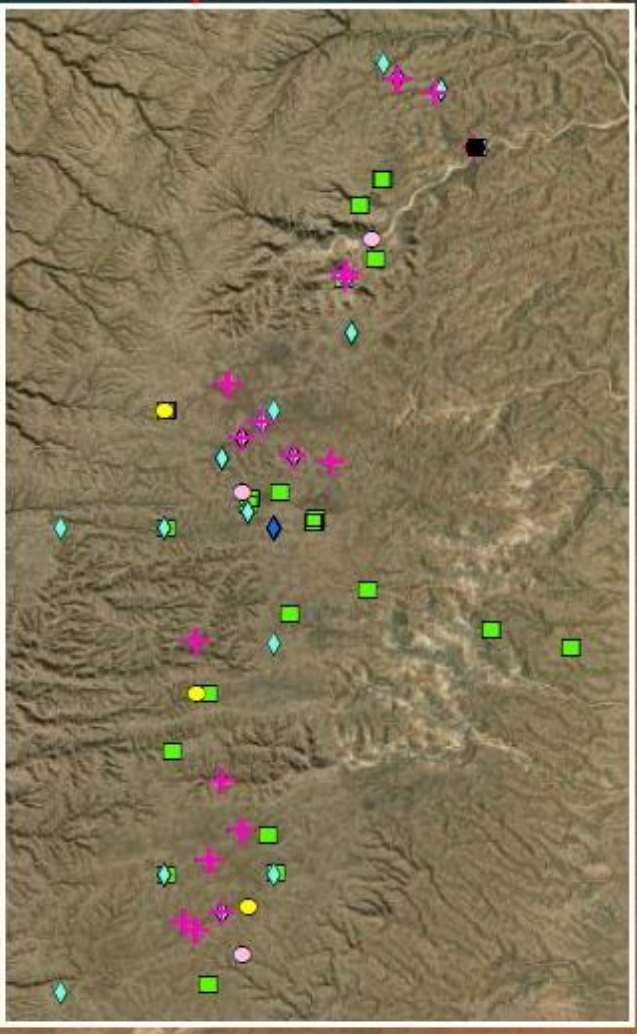
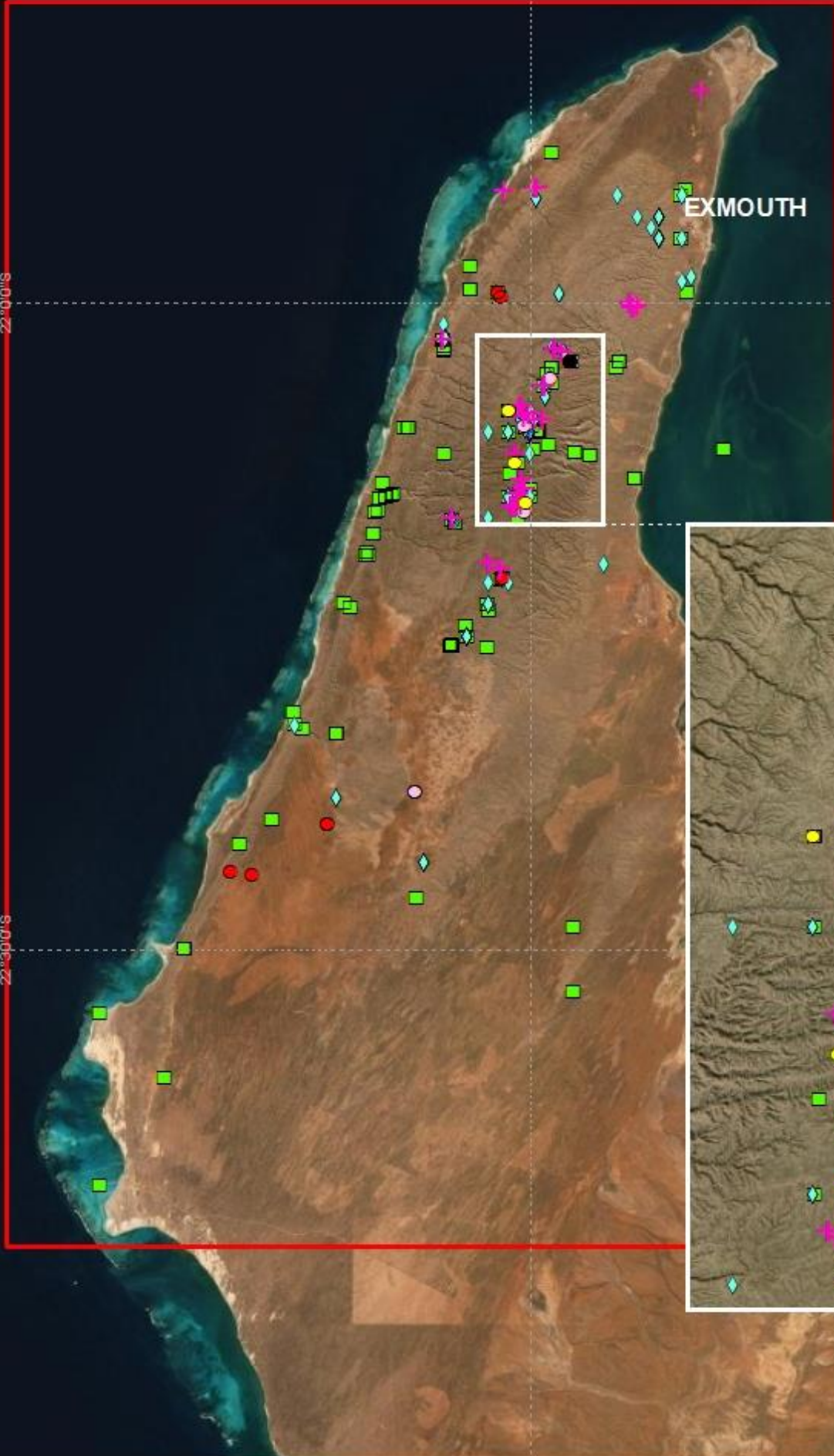
The genus *Austrohorus* only has one described species in Australia, and only four records from the Exmouth Peninsula, all from the eastern part of Cape Range National Park, and all only identified to genus. *Austrohorus* `BPS340` was collected from three different sites, all outside of the project footprint, whereas *Austrohorus* `BPS342` was only collected from one site, within the project development footprint. The current knowledge of this genus is insufficient to accurately determine species distributions, and this group is believed to contain potentially range restricted species. Therefore, *A.* `BPS340` and *A.* `BPS342` are potential SREs, but only the former is of conservation significance, given that it is only known from the Project footprint area.

Finally, the species *Beierolpium* sp. and *Euryolpium* sp. were represented by four individuals collected as bycatch from the stygofauna sampling in the borefield. These individuals could not be identified to species level, but their occurrence in the borefield, which is not considered an impact area for SREs, suggests they are not of conservation significance.



114°0'0"E

114°3'



**Figure 3: Search area and records of SREs from different taxonomic groups.**

### Harvestmen (order Opiliones)

The species *Dampetrus isolatus* (Assamiidae) was originally described from several caves in the North West Cape. Despite having reduced eyes, it is not especially troglomorphic (Shear 2001) and the species may also inhabit epigeal environments. The species is currently known from at least three different locations that are approximately 8 km apart, all within Cape Range National Park (central eastern part) and at least 32 km from the Project. This species is therefore a potential SRE, moderately likely to occur in the Ningaloo Lighthouse Resort. However, this species was not recorded during the SRE survey.

### Scorpions

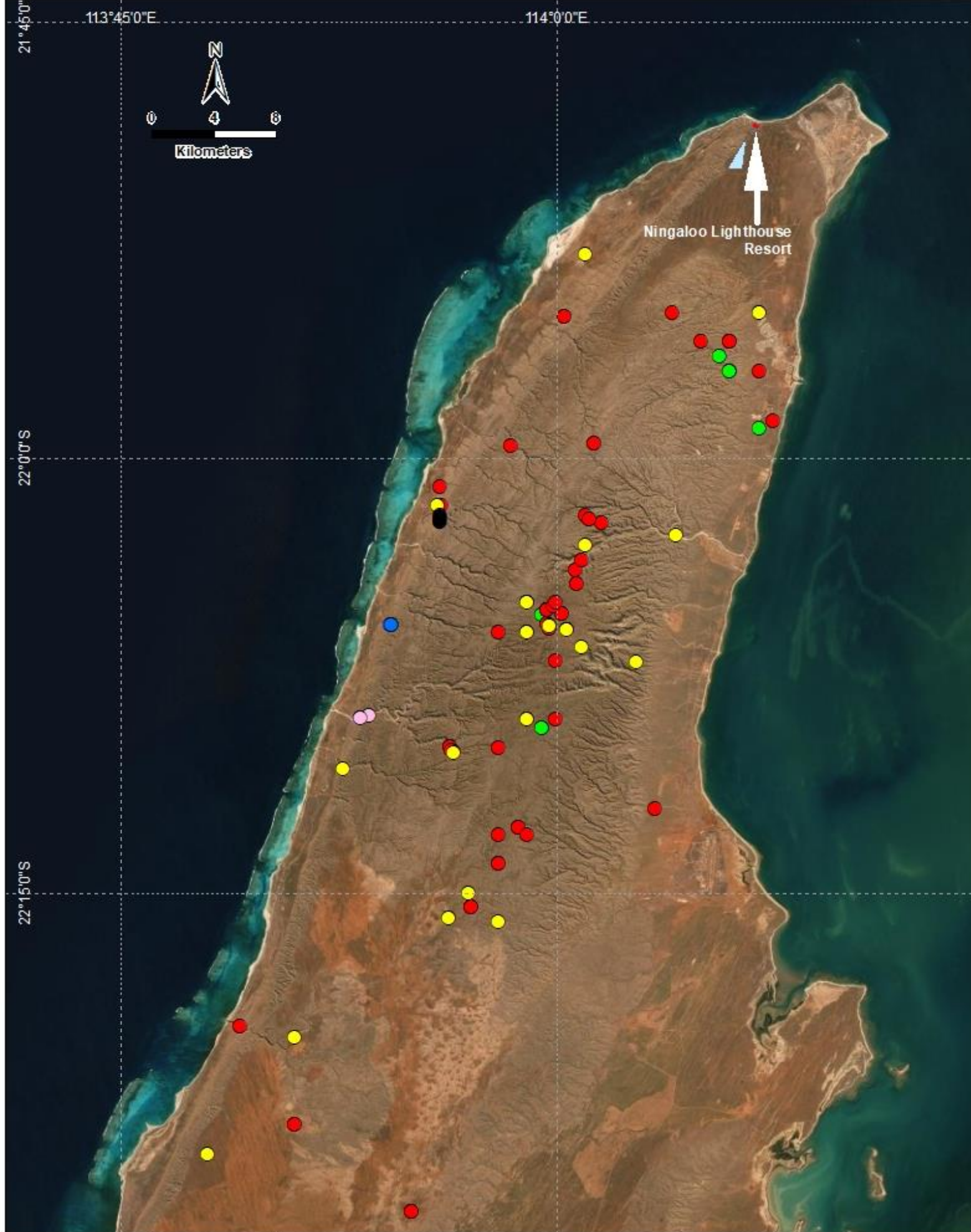
Two species of potential SRE scorpions, from two different families, are known from the desktop search area. In the family Buthidae, *Lychas aitkeni* spp. grp` was collected from two different locations approximately 4.5 km apart, both within the north-eastern end of Cape Range National Park. These locations are about 29 km south of the Project, and this species is considered a data deficient potential SRE, moderately likely to occur in the Ningaloo Lighthouse Resort. During the survey, three species of the genus *Lychas* were collected, *Lychas variatus* s.l., *Lychas* 'BSCO064' and *Lychas* 'BSCO065'. The first species probably represent a species complex, but its abundance and occurrence in diverse habitats suggests it is unlikely to be an SRE. *Lychas* 'BSCO064' and *Lychas* 'BSCO065', on the other hand, are both new species that are only known from the project area. And whereas the former is only known from outside the project impact footprint, the latter is only known from a site within that footprint. Both species are potential SREs, and *Lychas* 'BSCO065' is of conservation significance. The alignment of these species with *Lychas aitkeni* spp. grp`, and a more detailed assessment of their potential distribution, requires comparisons with museum material and/or molecular work.

In the family *Urodacidae* (burrowing scorpions), there were three records of *Urodacus yaschenko* spp. grp` from a location, approximately 4 km east of the southern boundary of Cape Range National Park. The framework for formal scorpion identification in Western Australia needs significant revisions, and whereas *Urodacus yaschenko* is a seemingly widespread species, it is known to represent a species complex that hides cryptic diversity (Luna-Ramirez *et al.* 2017), and the specimens from Exmouth Peninsula probably represent a new undescribed species that is here considered a data deficient potential SRE. Due to its occurrence more than 60 km south of the Project, this species was originally considered unlikely to occur near the Ningaloo Lighthouse Resort, but seven specimens of the species complex were collected during the survey. They were found both within and outside the project impact footprint, in the red sand dunes habitat. We here refer to this species as *Urodacus* `BSCO062`, and its occurrence more than 60 km to the south indicates it is unlikely to be an SRE. Importantly, one specimen of *Urodacus* had slight differences in the pedipalp manus and metasoma V, and therefore is treated as *Urodacus* `BSCO063`. This specimen might be a conspecific with *Urodacus* `BSCO062`, but this can only be confirmed with molecular work.



### Centipedes

No SRE centipedes were detected in the desktop search area, but three individuals were collected from reference sites in the Project area. The identification of *Mecistocephalus* sp., *Orphnaeus* sp. and *Scolopendra* sp. could not be made at the species level, but all three specimens were collected outside the project impact footprint, and they are therefore considered not to be of conservation significance. Based on their taxonomy, *Mecistocephalus* sp. is considered a potential SRE, whereas *Orphnaeus* sp. is an unlikely SRE, and *Scolopendra* sp. is not an SRE, although these are preliminary assessments, and genetic work is necessary for a full assessment.





**Figure 4: Confirmed SREs in the Desktop Search Area.**

- |   |  |   |                                   |
|---|--|---|-----------------------------------|
|  | North West Resorts - Section 18 Area & DPLH 1038 |  | <i>Promonturconchum superbum</i>  |
|  | Borefield  |  | <i>Streps itaurus manduens is</i> |
|  | <i>Antichiropus humphreysi</i>                   |  | <i>Streps itaurus milyeringus</i> |
|  | <i>Boreohes perus capens is</i>                  |  | <i>Streps itaurus s usieae</i>    |



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 Date: 15/02/2021



## Millipedes

At least three different species of potential SRE millipedes from two families were known from the desktop Search area. In the family Siphonotidae (Polyzoniida), the species *Megalosiphon humphreysi* is known from two different locations approximately 1.3 km apart, both within the north-eastern end of Cape Range National Park. The name *Megalosiphon humphreysi* is an unpublished name from the PhD thesis by Dennis Black, and might become a valid published species in the future. The 22 specimens of siphonotids were collected from four different locations in the Project area during survey are referred to as Siphonotidae `BDI072` but may well be *Megalosiphon humphreysi*. The original locations from which this species was collected are about 33 km south of the Project, and Siphonotidae `BDI072` is therefore considered a potential SRE that is not under threat from the proposed development.

Two species of the family Paradoxosomatidae (Polydesmida) were known from the search area. *Antichiropus humphreysi* was originally described from a cave in Cape Range National Park (Shear 1992), but it has since been collected in epigeal environments as well, and is currently known from seven locations just over 24 km apart, some of these in the central-eastern part of the National Park, and some around the town of Exmouth (approximately 11 km from the Project). This genus has been well studied morphologically and genetically, and the group has also been extensively collected across the Pilbara (Car *et al.* 2019), so *A. humphreysi* is considered a confirmed SRE. Bennelongia's survey collected at least two males of this species in the Ningaloo Lighthouse Resort area, from sites both within and outside the project's development footprint. These new records extend the known linear range of this species to approximately 40 km, and it is not considered to be under threat from the proposed development.

Similarly to *A. humphreysi*, the other species of Paradoxosomatidae known from the desktop search area, *Boreoheperus capensis*, was also originally described from caves (Shear 1992). This species has commonly been found on the surface as well, and its lack of troglobitic adaptations suggests that its presence in caves results from cave entrances presenting attractive refuges in the dry environment of Exmouth Peninsula. All described species of *Boreoheperus* are SREs (Car and Harvey 2017), and *B. capensis* is therefore considered a confirmed SRE. The species was found in at least two sites in the project area, both outside the project's footprint. This survey extends the species known linear distribution to 72 km, and despite being a well-studied confirmed SRE, the species is fairly common and widespread in the Exmouth Peninsula, and is hence not under threat from the proposed development.

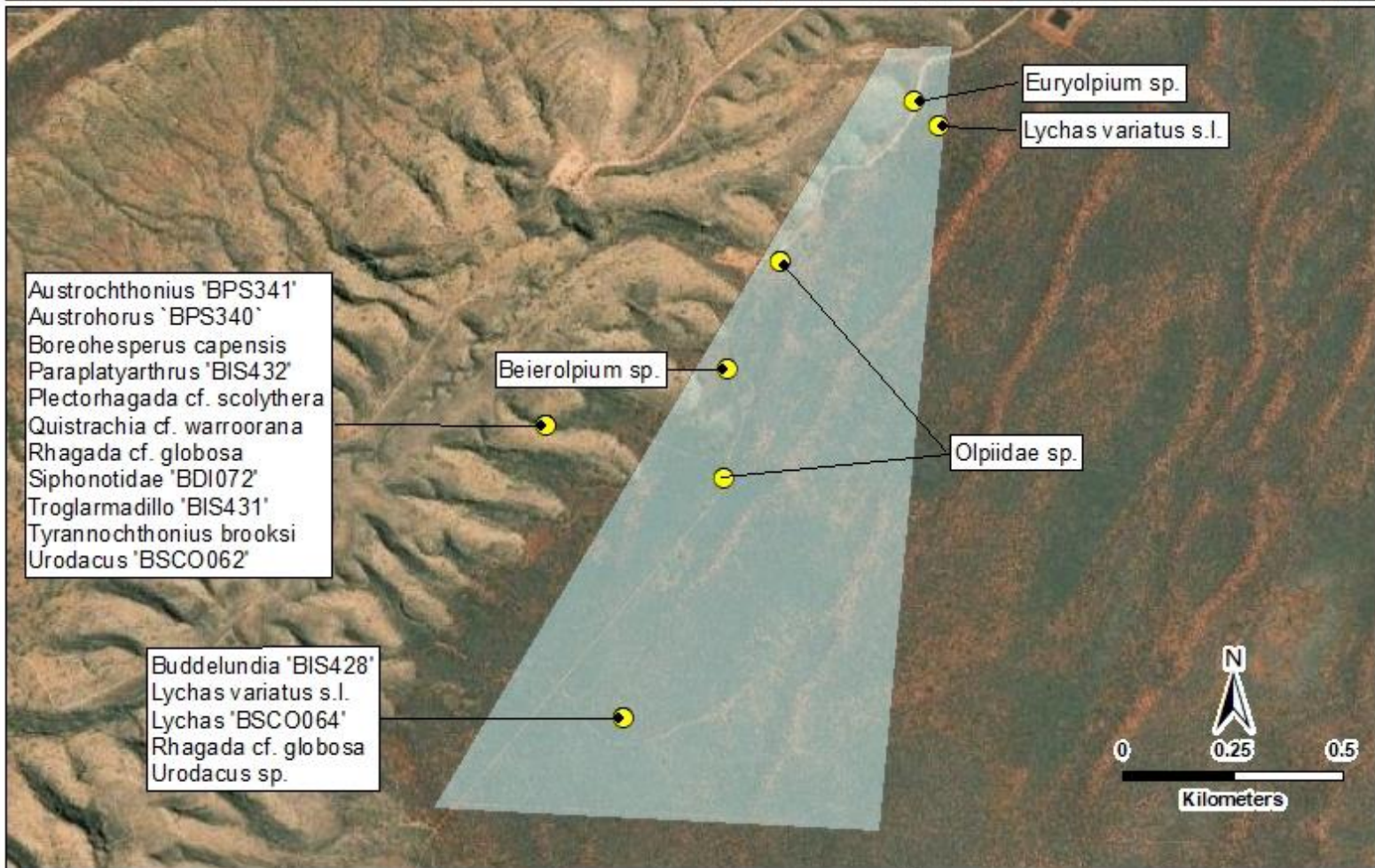
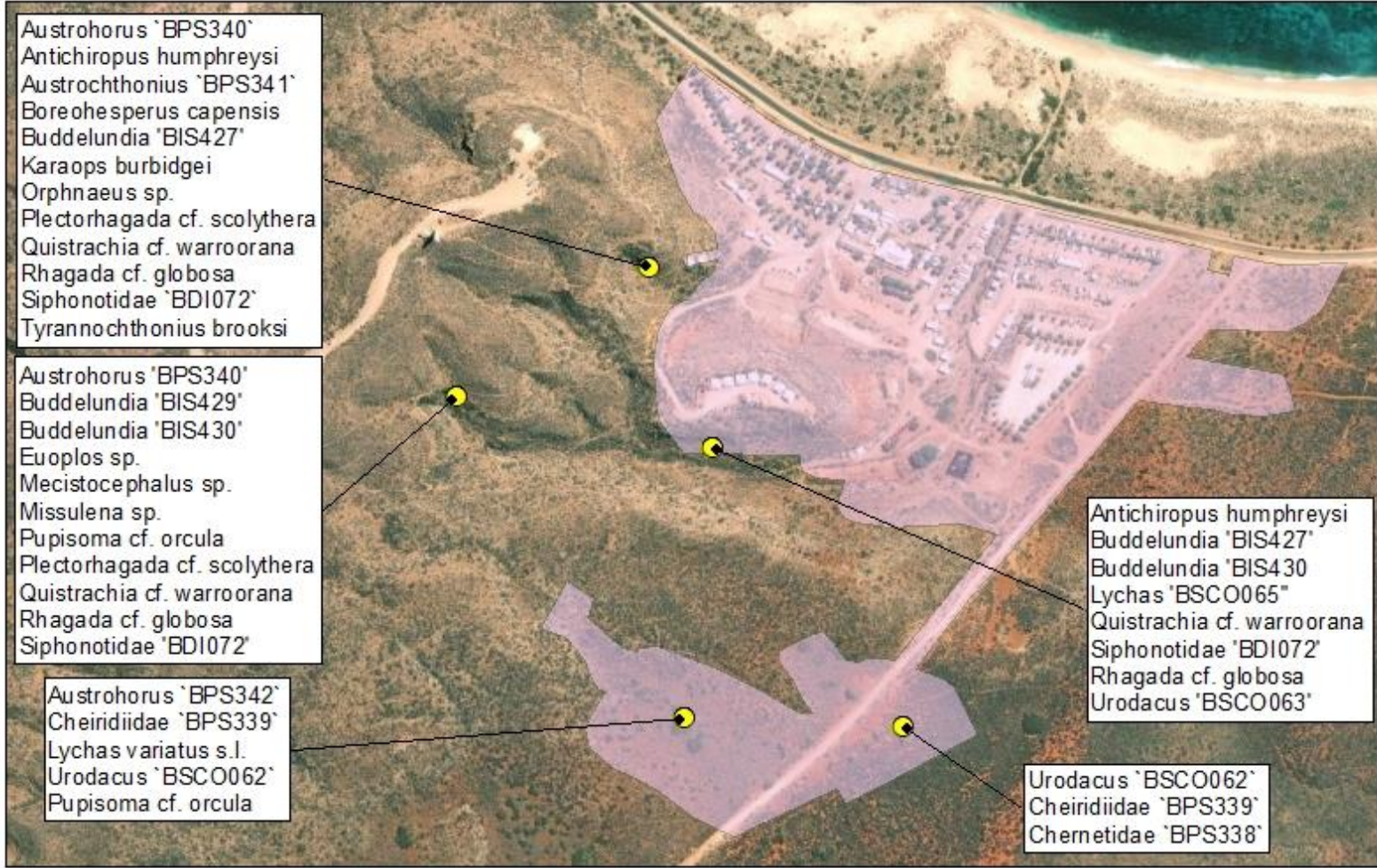
## Slaters (Isopoda)

### Family Armadillidae

Isopods from the species *Buddelundia* `sp. BBCR01` (Armadillidae) were known from seven locations 28 km apart, mostly in the eastern part of Cape Range National Park, but also just outside the park to the north and east of its borders. The records are at least 18 km from the Project, and the species is considered moderately likely to occur in the Ningaloo Lighthouse Resort. Species of this genus can vary widely in the size of their distributions, and some are SREs (Judd 2004). Given that *B. sp. BBCR01* is not a valid described species, it is currently considered a data deficient potential SRE. During the survey, four species of the genus *Buddelundia* were collected. These are currently all considered new species and potential SREs, but one of them could be aligned to *Buddelundia* `sp. BBCR01` in the future. All of these species were collected from at least one site outside the project footprint, and therefore none of them is considered to be under threat from the proposed development.

The genus *Troglarmadillo* was absent from the desktop Search area, but three individuals of *Troglarmadillo* `BIS431` were collected during the survey, from site 2 outside the Project footprint. This new species is considered a potential SRE, but it is not under threat from the proposed development.







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**Legend**

	North West Resorts - Section 18 Area & DPLH 1038		Borefield
	SRE records		

**Figure 5. SRE groups collected in the Project Area.**



#### *Family Paraplathyarthridae*

The genus *Paraplathyarthrus* was absent from the desktop search area, but one individual of *Paraplathyarthrus* 'BIS432' were collected during the survey from site 2 outside the Project footprint. This new species is considered a potential SRE, but it is not under threat from the proposed development.

#### *Family Philosciidae*

This family was represented by 42 specimens in the desktop search, recorded from seven different locations. Unfortunately, given the uncertain identification (to family level) of these records, even though they are known to represent new species (not the same as any other record in Appendix 1), these records could represent several species, and an SRE status assessments is not possible at present. No species from this family were collected during the survey.

#### **Land snails (Gastropoda: Camaenidae)**

The family Camaenidae represent the dominant group of land snails on Exmouth Peninsula Cape (Taylor *et al.* 2015), and 11 species of this family were known from the desktop search area. The SRE survey collected 319 specimens of land snails, but the vast majority of these records consist of empty shells, so the identifications are often preliminary, indicated by 'cf.'

*Caperantrum polygyrum* is the only species in its genus, and represents a rare and endemic species in Cape Range. It is a potential SRE known from only eight locations that are 27.2 km apart and include areas in the south and east parts of Cape Range National Park, as well as a location outside of the park, to the southeast. The closest record of this species to the Project is 37 km to the south, and the species was hence considered moderately likely to occur in the area. No specimens of this species were collected during the survey.

The genera *Plectorhagada* and *Strepsitaurus* are morphological similar and have mutually exclusive ranges near Cape Range (Taylor *et al.* 2015). *Plectorhagada teres* is a potential SRE, known from three locations 18.5 km apart, two of these in the north-western part of Cape Range National Park, and the other just north of Exmouth and 11 km south from the Project. It was initially considered likely to occur in the Ningaloo Lighthouse Resort area. Meanwhile, *Plectorhagada scolythyra* is also a potential SRE, but known from only one location, 22 km south of Exmouth on the eastern coast of the peninsula. This location is 35.5 km south of the Project, and therefore the species was initially considered less likely to occur in the Ningaloo Lighthouse Resort area. However, whereas *Plectorhagada teres* was not collected during the survey, 10 individuals of *Plectorhagada cf. scolythyra* were collected from three different sites, all outside the project impact footprint.

Five species of the genus *Strepsitaurus* are known from the desktop search area, and three of them are confirmed SREs. *S. manduensis* is only known from the Mandu Mandu Gorge at two sites 560 m apart; *S. susieae* is only known from one small unnamed gorge (approximately 1.2 km long), south of Tulki Gorge, on the west side of Cape Range; and *S. milyeringus* is only known from two sites (< 500 m apart) in the Milyering Gorge (Taylor *et al.* 2015). These three species are, however, unlikely to occur in the vicinity of the Ningaloo Lighthouse Resort. Meanwhile, the other two species are known from multiple locations, and their ranges span at least 50 km (*Strepsitaurus ningaloo*), and 60 km (*Strepsitaurus williami*). Whereas the records of *S. ningaloo* are at least 43 km south of the project (unlikely to occur in the area), *S. williami* occurs just south of Exmouth (15 km south of the Project) and it is considered likely to moderately likely to occur in the Ningaloo Lighthouse Resort. However, no species of the genus *Strepsitaurus* were collected during the survey.

The species *Quistrachia warroorana* is widespread, known from multiple locations outside the search area, up to 260 km south (south of Lake Mcleod). The specimens recorded in the search area, however, were only found in one location 38 km to the south of the Project, in the middle of the Cape Range National Park, and were identified as *Quistrachia cf. warroorana*, meaning that the alignment with *Quistrachia warroorana* is not certain. Thus, *Quistrachia warroorana* was considered unlikely to occur at the Project but 130 individuals of this species were collected from four different sites, both within and

outside the project impact footprint. This species is therefore considered a potential SRE that is not under threat from the proposed development.

*Rhagada capensis* is a relatively widespread species, recorded up to 150 km south of the Project, near the northern end of Lake Mcleod. Some of the specimens recorded in the search area, however, were identified as *Rhagada cf. capensis*, which means that the alignment with *R. capensis* is not certain. It is possible that this is a new species and potential SRE, only known from three locations up to 5.5 km apart, in the north-eastern part of Cape Range National Park. These locations are 28.6 km south of the Project, so this species is relatively unlikely to be in the Ningaloo Lighthouse Resort. In fact, the only species of this genus collected during the survey was *Rhagada cf. globosa*, of which 104 individuals were collected from five different sites, both within and outside the Project impact footprint. *Rhagada globosa* is known from Coral Bay, 150 km to the south, so if the collected individuals are confirmed to be that species, it would not be considered an SRE. However, given that only dead shells were collected, the alignment cannot be confirmed. Even if *Rhagada cf. globosa* is a new species only known from the Project Area, its abundance and distribution outside the project footprint suggest it is not under threat from the proposed development.

*Promonturconchum superbum* is common and very widespread in the Exmouth Peninsula, known so far from more than 20 locations up to 66.5 km apart. Due to the geography of the peninsula, however, the known area of distribution of this species is still less than 1,000 km<sup>2</sup>, so it is still considered a confirmed SRE. The species is likely to occur in the Project area, but it is unlikely to be under threat from the proposed development, given that it only represents a small fraction of its known distribution. This species was not collected during the survey.

## 6. CONCLUSIONS

This desktop assessment indicates that there is a community of potential SRE invertebrates (11 species) with likelihoods of occurring at the Project that range from moderate to high. The species include trapdoor spiders, pseudoscorpions, harvestmen, scorpions, millipedes, isopods, and snails. Six species of confirmed SREs were recorded in the search area, but only three of these were initially considered likely to occur in the Project.

Based on a desktop review, it was concluded that the land snail *Promonturconchum superbum* and the millipede *Boreoesperus capensis*, despite being confirmed SREs, are common and very widespread on the Exmouth Peninsula, and these species are unlikely to be under threat from the proposed development, which only represents a small fraction of their known distribution. On the other hand, the millipede *Antichiropus humphreysi* was originally only known from seven locations just over 24 km apart, and some of these are approximately 11 km south of the Project. This confirmed SRE species is the most likely to occur in the Project, but its distribution is also probably multiple times larger than the area of the Ningaloo Lighthouse Resort.

During Bennelongia's recognisance trip associated with the desktop review, suitable SRE habitat in dune swales (for scorpions and centipedes) was observed in the impact footprint (Appendix 2), and an unidentified species of burrowing scorpion (*Urodacus* sp.) was recorded in that area. Five species of snails and one species of millipede were also observed, but the identifications are mostly preliminary. Rocky slopes, suitable for a range of SRE groups, were observed near the borefield, where potential open-holed trapdoor spider burrows were also observed.

A field survey undertaken in March 2021 in the Project and close surrounds collected 38 species belonging to target groups, including two species of mygalomorph spider; one species of 'flattie' spider (Selenopidae); 9 species of pseudoscorpion; five species of scorpion; three species of centipede, five species of millipede; one species of dipluran; six species of slater and six species of land snail. Out of these species, 16 were potential SREs, two were confirmed SREs (the millipedes *Antichiropus humphreysi* and *Boreoesperus capensis*), and the remaining 20 species were unlikely SREs or widespread species.

Among the species collected, only the pseudoscorpion *Austrohorus* 'BPS342' and the scorpion *Lychas* 'BSCO065' are potential SREs that are currently only known from the Project impact footprint, and therefore are of conservation significance. These species are, however, data deficient Potential SREs and assigning them as potential SREs is precautionary. Further studies may align them genetically with species outside the project area.

Despite the presence of a rich SRE fauna in the Project Area, the negligible impact footprint of the Project on rocky hills and very small footprint on red Pindan dune swales suggest that the Project is very unlikely to have significant impact on any SRE fauna.

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## Appendix 1 – Species of SRE invertebrate groups recorded in the Project area and its vicinity.

Described species known to be widespread (non-SRE, with ranges larger than 10,000 Km<sup>2</sup>) were removed from the table. Grey denotes higher order identifications that might belong to other listed species (not viewed as unique species); blue represents species complexes.

Higher Classification	Lowest Identification	Specimen records	SRE Status
<b>ARTHROPODA</b>			
<b>Arachnida</b>			
<b>Araneae</b>			
Anamidae	<i>Aname`Learmonth sp. 1`</i>	3	<b>Potential SRE</b> , only known from 3 locations 8.8 kms apart.
	<i>Aname`Learmonth sp. 2`</i>	1	<b>Potential SRE</b> only known from 1 location.
Halonoproctidae	<i>Conothele`MYG673`</i>	2	<b>Potential SRE</b> , only known from 2 locations 8.5 kms apart.
Idiopidae	<i>Euoplos`MYG672`</i>	2	<b>Potential SRE</b> , only known from 3 locations up to 24 kms apart.
	<i>`Euoplos?`MYG672`</i>	1	Most likely the same species as the record above.
<b>Pseudoscorpiones</b>			
Garypidae	<i>Synsphyronus`PSE164`</i>	4	<b>Potential SRE</b> only known from 1 location.
<b>Opiliones</b>			
Assamiidae	<i>Dampetrus isolatus</i>	3	<b>Potential SRE</b> , associated to caves and only known from 3 locations 8.5 kms apart.
<b>Scorpiones</b>			
Buthidae	<i>Lychas`aitkeni spp. grp`</i>	2	<b>Potential SRE</b> from a species complex, only known from 2 locations 4.5 kms apart.
	<i>Isometroides`aitkeni`</i>	1	Probably a miss-identification of a specimen of the species above, wrongly attributed to the genus <i>Isometroides</i> .
Urodacidae	<i>Urodacus`yaschenkoi spp. grp`</i>	3	<b>Potential SRE</b> from a species complex, only known from 1 location.
<b>Diplopoda</b>			
<b>Polyzoniida</b>			
Siphonotidae	<i>`Megalosiphon`humphreysi`</i>	10	<b>Potential SRE</b> , only known from 2 locations 1.3 km apart.
<b>Polydesmida</b>			
Paradoxosomatidae	<i>Antichiropus humphreysi</i>	20	<b>Confirmed SRE</b> , known from 7 locations 29.4 kms apart.
	<i>Boreoesperus capensis</i>	93	<b>Confirmed SRE</b> , known from 41 locations up to 60 kms apart.
	<i>Boreoesperus`capensis?`</i>	4	Most likely the same species as the record above.

<b>Malacostraca</b>			
<b>Isopoda</b>			
Armadillidae	<i>Buddelundia</i> `sp. BBCR01`	23	<b>Potential SRE</b> , known from 7 locations 28.3 kms apart.
	<i>Buddelundia</i> sp.	4	Uncertain ID, potentially the same species as the record above.
	Armadillidae sp.	5	Uncertain ID, possibly the same species as the record above.
Philosciidae	Philosciidae sp.	42	Uncertain ID, but not consistent with any of the other taxa. Could represent several species.
Family unknown	Isopoda sp.	74	Uncertain ID, possibly the same species as one of the above.
<b>MOLLUSCA</b>			
<b>Gastropoda</b>			
<b>Stylommatophora</b>			
Camaenidae	<i>Caperantrum polygyrum</i>	47	<b>Potential SRE</b> , known from 8 locations 27.2 kms apart.
	<i>Caperantrum</i> sp.	11	Uncertain ID, potentially the same species as the record above.
	<i>Plectorhagada teres</i>	16	<b>Potential SRE</b> , known from 3 locations 18.5 kms apart.
	cf. <i>Plectorhagada scolythyra</i>	4	<b>Potential SRE</b> , known from only 1 location.
	<i>Promonturconchum superbum</i>	170	<b>Confirmed SRE</b> , known from >20 locations up to 66.5 kms apart, but still endemic to North West Cape.
	<i>Quistrachia</i> cf. <i>warroorana</i>	10	Widespread (if confirmed as <i>Q. warroorana</i> ), from multiple locations, up to 260 kms south.
	<i>Rhagada</i> cf. <i>capensis</i>	5	Widespread (if confirmed as <i>R. capensis</i> ), from multiple locations, up to 150 kms south.
	<i>Strepsitaurus manduensis</i>	15	<b>Confirmed SRE</b> , only known from the Mandu Mandu Gorge, at two sites 560 m apart.
	<i>Strepsitaurus milyeringus</i>	3	<b>Confirmed SRE</b> , only known two sites (< 500 m apart) in the Milyering Gorge.
	<i>Strepsitaurus ningaloo</i>	145	<b>Potential SRE</b> , known from multiple locations up to 50 kms apart.
	<i>Strepsitaurus susieae</i>	15	<b>Confirmed SRE</b> , only known from one unnamed gorge (1.2 km long), south of Tulki Gorge.
	<i>Strepsitaurus williami</i>	84	<b>Potential SRE</b> , known from multiple locations up to 60 kms apart.
	<i>Strepsitaurus</i> sp.	121	Uncertain ID, potentially the same species as the record above.



**Appendix 2: Potential SRE habitats recorded in the Project area.**

**Dune swale within impact footprint**



**Dune swale in borefield**



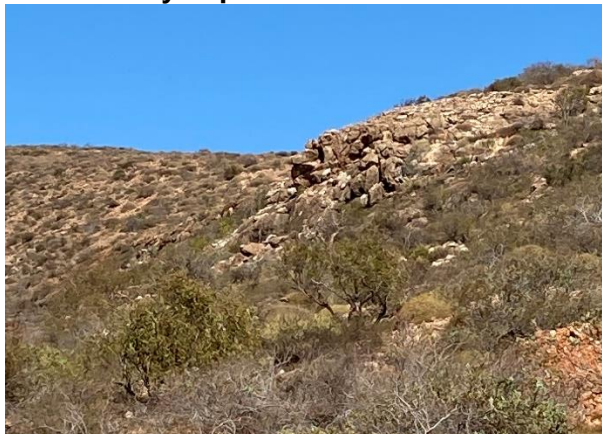
***Urodacus* sp. scorpion from the impact area**



**Burrowing scorpion (*Urodacus* sp.) burrows**



**Rocky slopes near borefield**



**Potential open-holed trapdoor spider burrow**

