Bennelongia Environmental Consultants

Beharra Silica Sand Project

Subterranean Fauna Desktop Assessment

Prepared for:

Tetris Environmental Pty Ltd

March 2022

Final Report

Short-Range Endemics I Subterranean Fauna

Waterbirds I Wetlands

Beharra Silica Sand Project Subterranean Fauna Desktop Assessment

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EXECUTIVE SUMMARY

Tetris Environmental Pty Ltd commissioned Bennelongia Environmental Consultants to conduct a subterranean fauna desktop assessment at the Beharra Silica Sand Project (the Project), located approximately 26 km southeast of Dongara, Western Australia. The Project involves the mining of silica sand from vegetation dominated by Kwongan Heath, located on Mount Adams Road. This report presents the results of a desktop review of habitat information and relevant biological records to appraise the conservation values of subterranean fauna in the Project and surrounds and to assess the level of possible threat to subterranean fauna.

The term subterranean fauna includes two groups of underground animals: aquatic stygofauna and air-breathing troglofauna. Subterranean fauna species characteristically have reduced or absent eyes and are poorly pigmented due to lack of light. All subterranean species require access to subterranean habitat for persistence; many spend their entire life cycles below ground (stygobites and troglobites), while others also have a life-stage in surface habitats (stygophiles and troglophiles).

Geology influences the presence, richness and distribution of subterranean fauna through the different types of habitats it provides. Karstic geologies with an extensive network of internal spaces support larger assemblages of subterranean fauna, both in terms of abundance and diversity, than consolidated geologies. The fine non-calcareous sand of the superficial formations in the Project area are unlikely to provide voids, or even interstitial spaces, large enough to support troglofauna. However, aquifers within the Quaternary Bassendean Sands geologies of the sub-region have been found to be transmissive and therefore may hold appropriate spaces for stygofauna.

A database and literature search found records of 716 subterranean fauna specimens from within a 100 km x 100 km search area around the Project. This includes 443 stygofauna specimens belonging to 17-20 species and 273 troglofauna specimens belonging to 25-27 species. The troglofauna specimens were associated with cave systems while the stygofauna records were mostly from the Dongara Mineral Sands Project directly adjacent to the east of the Project. The geology of the Dongara Mineral Sands project is different to the Project as there are reported to be small outcrops of limestone in the centre of the area. The geology and soils of the Project area are not associated with cave systems or limestone and are unlikely to provide sufficient spaces large enough to support troglofauna.

It is concluded that the Project is unlikely to significantly impact subterranean fauna values because:

- there is lack of suitable troglofauna habitat present within the Project area,
- stygofauna species present are likely to be widespread at the sub-regional level and
- the groundwater drawdown (≤1.8 m, most likely 1.35m) will result in minimal reduction in the volume of stygofauna habitat.

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1. INTRODUCTION

Perpetual Resources Ltd is proposing to mine silica sand from an area adjacent Mt Adams Road approximately 26 km southeast of Dongara, Western Australia (Figure 1). Environmental approvals for the proposal, known as the Beharra Silica Sand Project (and hereafter referred to as the Project), are being managed by Tetris Environmental Pty Ltd (Tetris Environmental). The Project proposes to mine silica sand to a depth of less than 10 m and will be above the water table requiring no dewatering. Subterranean fauna is a term used to describe species of animals (mostly invertebrates) that must have access to underground habitats for persistence. There are two types of subterranean species: stygofauna live in groundwater and troglofauna live between the lower levels of surface soil and the water table.

Tetris Environmental has commissioned Bennelongia Environmental Consultants to conduct a desktop assessment of the likelihood of subterranean fauna occurrence at the Project and the likelihood of the Project affecting subterranean fauna conservation values.

The specific aims of this assessment are to:

1. Review available geological information to assess the prospectivity of habitats in the vicinity of the Project for subterranean fauna.
2. Compile and evaluate records of subterranean fauna within the vicinity of the Project (including any listed species and ecological communities) and review ranges and other available information about recorded species to characterise the likely subterranean fauna communities in the Project area.

2. SUBTERRANEAN FAUNA AND LEGISLATIVE FRAMEWORK

Subterranean species characteristically have reduced or absent eyes and are poorly pigmented due to lack of light. They have often developed vermiform bodies and elongate sensory structures, as well as physiological adaptations such as the loss or reduction of wings, increased lifespan, a shift towards K-selection breeding strategy and lower metabolic rate (Gibert and Deharveng 2002). Except for a few species of fish and snakes, all subterranean fauna species in Western Australia are invertebrates.

Although inconspicuous, subterranean fauna contributes markedly to the overall biodiversity of Australia. The Pilbara, Yilgarn and neighbouring regions of Western Australia are globally important for subterranean fauna, with an estimated 4,500 or more subterranean species likely to occur (Guzik *et al.* 2010; Halse 2018), the majority of which remain undescribed. Most subterranean species satisfy Harvey's (2002) criteria for short-range endemism (SRE), having total range size of less than 10,000 km^2 and occupying discontinuous or fragmented habitats.

Many subterranean fauna species (stygobites and troglobites) spend their entire life cycles below ground. Other species (stygophiles and troglophiles) may have a surface life-stage, often when they mate, but spend the remainder of their life cycle below ground. Just like stygobites and troglobites, they require also access to subterranean habitat for persistence. In most cases, species that come to the surface at some stage have larger ranges than entirely subterranean species because of greater opportunity for dispersal when on the surface. Some troglofauna species found in caves make relatively limited use of the subterranean environment are referred to as troglophiles.

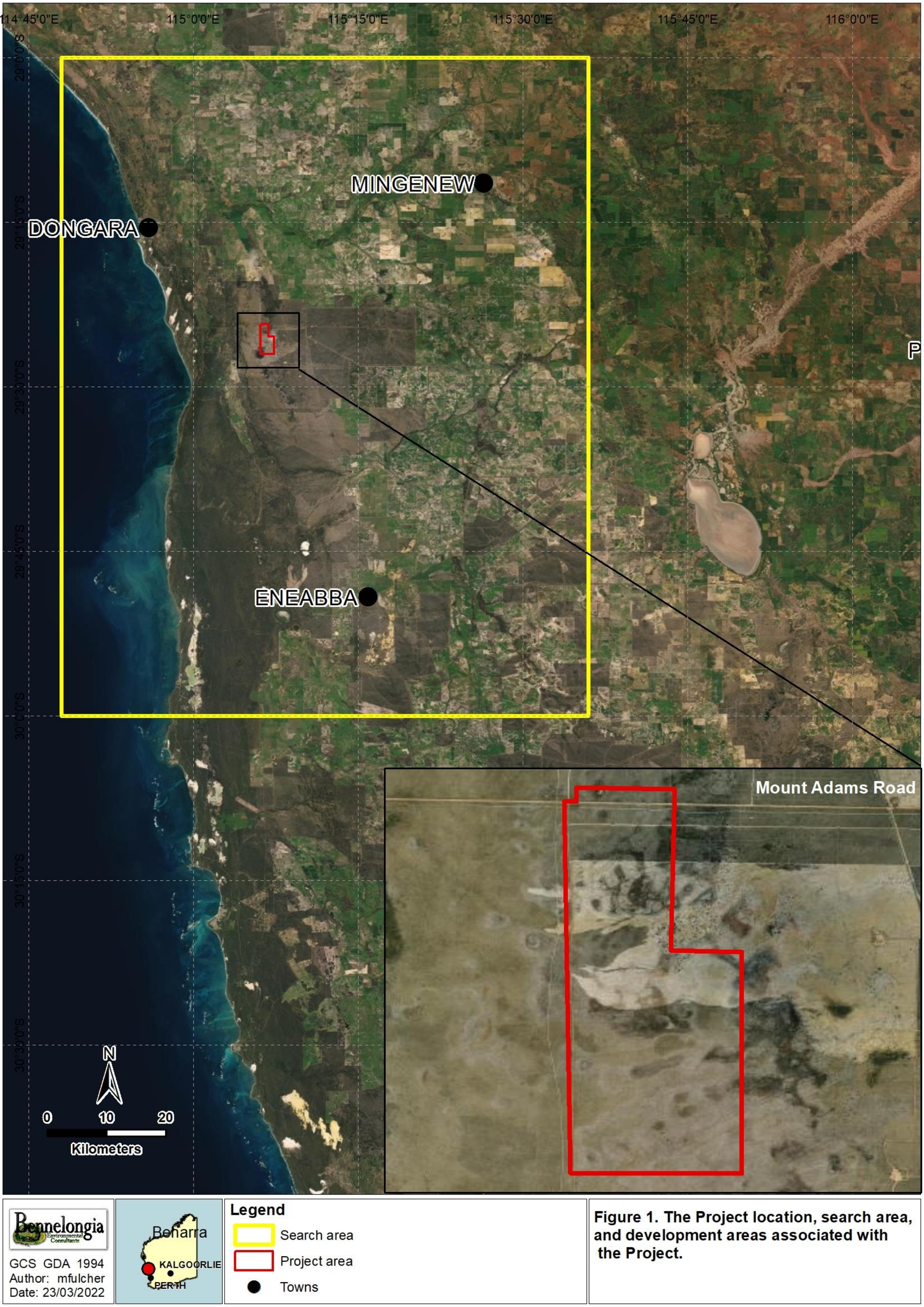


Figure 1. The Project location, search area, and development areas associated with the Project.

Given that species with small ranges are more vulnerable to extinction following habitat degradation than wider ranging species (Ponder and Colgan 2002), it follows that many subterranean species are highly susceptible to anthropogenic threats.

2.1. Legislation

Recognising that subterranean fauna is vulnerable to large-scale developments, the Environmental Protection Authority (EPA) in Western Australia requires consideration of subterranean fauna as part of environmental impact assessments (EPA 2016, 2021). The legislation providing more specific protection for species is contained in the Western Australian *Biodiversity Conservation Act 2016* (BC Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1996* (EPBC Act).

The BC Act covers general protection for all species in Western Australia and the listing of threatened species and communities by the Minister of the Environment for special protection. Some other species and communities that are considered to be at risk are informally listed by the Department of Biodiversity, Conservation and Attractions (DBCA) as priority species and communities. The EPBC Act supports slightly smaller lists of threatened species and communities, with slightly smaller lists of Western Australian species and communities, especially in relation to subterranean habitats.

2.2. Threats

Two broad categories of impact on subterranean fauna are recognised in this report:

- *Primary Impacts (direct impacts)* are those that directly remove habitat, such as mine pit excavation and borefield operations that lower the water table. These have obvious potential to threaten the persistence of subterranean species if the area of impact is large.
- *Secondary Impacts (indirect impacts)* are those that affect habitat quality but the physical structure remains intact. This type of impact may adversely affect subterranean fauna through reducing population densities but not threaten species persistence, and may include nutrient enrichment, small-scale petroleum spills and some surface alteration that reduces or changes transfer or carbon below-ground.

This report focusses on potential primary impacts on subterranean fauna when considering the possible effects of sand mining. Excavation of mine pits is considered the most significant potential primary impact on troglofauna, which are very unlikely to occur at the Project.

Significant water abstraction to enable mining and processing can threaten the persistence of stygofauna species with a range restricted to the area of groundwater drawdown, although it may be possible for species to persist in the residual aquifer if habitat and water chemistry do not change with depth. It should be noted that, although this report considers all potential primary impacts, no mine pit dewatering is proposed for the Project.

3. POTENTIAL HABITAT

3.1. Habitat Requirements

Geology influences the presence, richness and distribution of subterranean fauna by providing different types of habitat (Hose *et al.* 2015). Geologies with an extensive network of internal spaces support larger assemblages of subterranean fauna, both in terms of abundance and diversity, than consolidated geologies. Early records of subterranean fauna were centred around cave environments (Holthuis 1960; Schneider and Culver 2004; Skubała *et al.* 2013; Whitley 1945), however more recently, it has become clear that subterranean species inhabit voids in geologies throughout the landscape matrix beyond the boundaries of cave systems (Eberhard *et al.* 2005a; Guzik *et al.* 2010). The focus of environmental impact assessments for subterranean fauna in Western Australia is the occurrence of these animals in the broad landscape matrix.

Troglofauna is outcompeted by surface soil species in the uppermost soil layers but can be abundant at depth, where relative humidity is high (Halse 2018). Troglofauna species are common in vuggy (e.g. weathered iron ore) or those karstic (e.g. calcrete) geologies but are also found various detritals, including colluvium. Some species of stygofauna occur in streambeds and in springs but, at least in the Pilbara and Yilgarn, most species occur in groundwater aquifers that are not directly connected to the surface. Stygofauna is common in karstic as well as detrital geologies, especially alluvium. The extent of subterranean fauna occurrence on the northern Swan Coastal Plain and Mid-West coast is still being evaluated. Some stygofauna have been collected from the Yarragadee aquifer and superficial aquifers near the Project (Rockwater 2011).

3.2. Project Geology and Hydrogeology

Superficial formations (Allen, 1976) are an informal name for a group of Quaternary-Tertiary age sediments on the Swan Coastal Plain. These extend from the coast east to the Gingin and Darling Scarp. The local geology of the Beharra project comprises Quaternary Bassendean Sands (0.3 to 1.0Ma) overlying Late Jurassic Yarragadee Formation sediments (circa 150Ma). The Bassendean Sands also referred to as Bassendean Dunes consists of grey to white, fine to medium grained non calcareous silica sands worked by aeolian processes and contains in part lower lying areas of swamp and lacustrine deposits of clay, silt, and scarce diatomaceous earth. These sands are indicated as sand plains formations in Figure 2.

Aquifers within the Quaternary Bassendean Sands geologies of the sub-region have been found to be transmissive and therefore may hold appropriate spaces for stygofauna (Gibert and Deharveng 2002). Adjacent and to the west lie the Spearwood Dunes which have been derived from the underlying Quaternary Tamala Limestone. The Spearwood Sands consists of a yellow-coloured quartz carbonaceous sands which locally can overly Bassendean Sand. The underlying Yarragadee Formation is a sequence of continental sandstones, siltstones, and conglomerates. The Yarrendean Formation locally has a thickness exceeding 2 kms and conformably overlies the Cadda Formation that comprises paralic sequences and marine sequences of shale and sandstone. There are two aquifers in the Project area: the unconfined to semi-confined superficial aquifer and the semi-confined to confined Yarragadee aquifer (Nidigal, 1995). Within the Project area, the shallow unconfined superficial aquifer sits in lenticular deposits of sand, silt, and clay that typically extend 30-55 m below ground level. The deeper Yarragadee aquifer is a semi-confined bedrock aquifer comprised of sand, silt, clay successions based on sand proportions (Advisian Hydrogeological Assessment 2022).

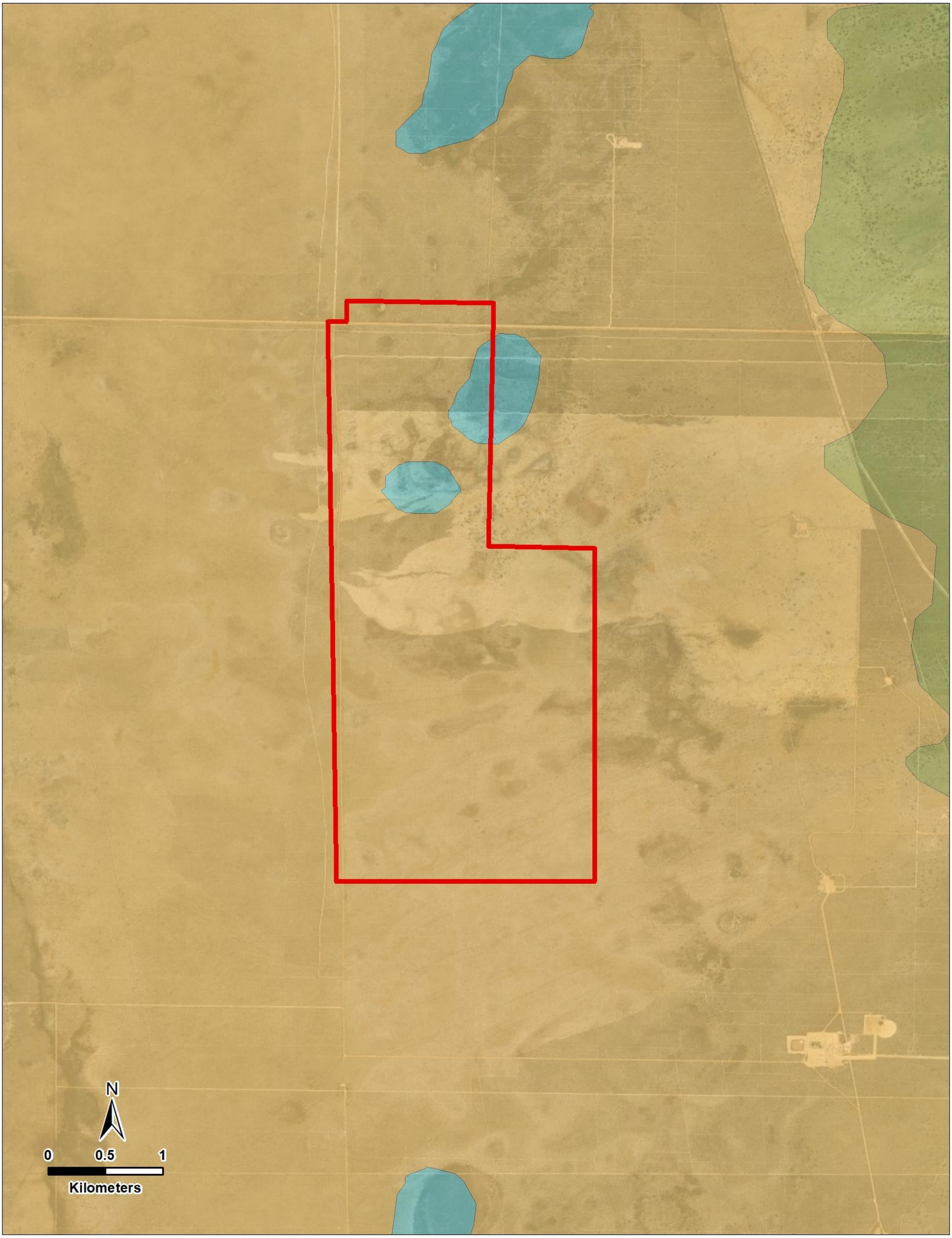
3.3. Habitat Prospectivity

More generally, troglofauna are most commonly collected across the broad landscape from weathered or mineralised iron formations and karstic calcrete, none of which is present with the Project area. Many of the features hosting subterranean fauna in south-western Australia do not occur within the Project area. This includes caves (English *et al.* 2003; Knott *et al.* 2007; Knott *et al.* 2008; Knott *et al.* 2009), karst (Moulds 2007) and specific groundwater environments such as those containing eucalypt root mats (Tang and Knott 2009). Troglofauna has also been found in alluvium in the Yilgarn (Barranco and Harvey 2008), and in sand habitats on the Swan Coastal Plain (Biota 2005). Nevertheless, the fine sands of the superficial formations in the Project appear unlikely to contain interstitial spaces capable of supporting a troglofauna community. Water quality parameters at the Project are well within the tolerances of stygofauna and will not be a limiting factor on their occurrence. The water table is sufficiently shallow for groundwater to harbour many stygofauna. In addition, groundwater movement has maintained interstitial spaces below the water table in the aquifer in the Project area, suggesting the physical structure of habitat may be suitable for stygofauna (Gibert and Deharveng 2002).

4. MINE PLAN

A series of four drawdown scenarios have been modelled by Advisian (2022) to address the potential variability in hydraulic conductivity between the Yarragadee and Superficial aquifers in the Project area. In the most likely of these (the base case scenario), the predicted maximum drawdown is approximately 1.35 m at the production bore, and 0.2 m at a distance of 1.2 km after continuous pumping up to 560 ML per annum for a period of 10 years. The predictions of the remaining three, less likely scenarios are 1.1-1.8m drawdowns near the production bores and 0.2 m drawdown at distances of 1.2-5 km after over 10 years.

The mine area has been split into four mining panels based on a grouping sequence aimed at accessing higher grade material first, whilst minimising haul distance and road development. Each mining panel is further subdivided into 24 mine cells, each of which is approximately 4-5 ha in size. Systematic mining within small mine cells will ensure that only discrete pockets of sand are extracted at one time and rehabilitation is progressive, following the completion of each small mine cell. Each year the company plans to mine and progressively rehabilitate four mine cells, representing up to 20 ha of open mine pit, with all previous mined cells under varying stages of rehabilitation (PEC 2021).



Bennelongia Environmental Consultants

GCS GDA 1994
Author: mfulcher
Date: 24/03/2022

Legend

Formations (ESRI online sources)

- Alluvium
- Lacustrine
- Sandplain
- Project area

Figure 2. Regolith of the Project development envelope and surrounding area.

5. PROJECT AREA SUBTERRANEAN FAUNA

Some of the justification for assessing environmental impacts on subterranean fauna in Western Australia is based on the Pilbara and Yilgarn regions of the State being internationally recognised as supporting globally important radiations of subterranean fauna. The relatively limited work to date in near coastal areas of south-western Australia has revealed a significantly decreased species richness.

Information about the likely stygofauna and troglofauna communities at the Project area was gathered by collating records of fauna in a search area of 100 km x 100 km centred on the Project (decimal degree coordinates of search area, top left: -29.0°S:114.8°E, bottom right -30.0°S:115.6°E). The Dongara Mineral Sands project directly adjacent to this Project provides the majority of data used in this desktop study. A total of 44 samples were taken between March and September of 2009, with 31 of these from within the Dongara Mineral Sands project area and 13 from regional sites that are within the desktop search area. No subfauna species collected during this sampling was found to be restricted. The remaining data are from Kadathinni 50 km SE from the Project and Leeman 60 km SW from the Project.

The information was used mainly to provide an indication of the level of subterranean species richness that could be expected within the Project area, rather than being an attempt to document the communities in the Project area. It is also important to note that due to incomplete or inconsistent taxonomy associated with some records, it was not possible to determine the exact number of species recorded in the search area. Some recorded species may contain multiple taxa and, conversely, some specimens assigned to different taxa may actually represent the same species. It is likely that the majority of subfauna in the search area was collected from habitats that are not specific to the Project area.

5.1. Stygofauna

The search area contains records of 443 individuals belonging to 17-20 species. These include at least two species of amphipod, three species of syncarid, six species of copepod, four species of annelid worm, one species of ostracod, and one higher order rotifer identification (Table 1). Of 17 or more potential species, only two are undescribed and seven are higher order identifications. Numerous records of nematodes are also present, although due to a lack of ecological knowledge and unresolved taxonomy, this group is not assessed within the environmental impact assessment process and these animals are excluded from Table 1.

5.1.1. Evaluation

Almost all of the stygofauna records come from sampling directly adjacent to the Project area (Rockwater 2011).. The Project could be expected to support a similar taxonomic composition to that at the Dongara Mineral Sands Project. It is important to note that bore LS31C, located on the Project area southern boundary, was sampled on three separate occasions using both pumping and haul netting techniques and yielded no stygofauna.

Analysis by Rockwater (2011) concluded that no stygofauna species were restricted to the Dongara Mineral Sands Project. There is also little evidence to suggest that the lithologies of the superficial formations in the vicinity of both projects are unique, so that species which could occur at the Project would also be expected to extend more widely and, probably, within the surrounding sub-region.

Project development is unlikely to threaten stygofauna species in the Project area. In addition to being likely to be widespread, there is no mine pit dewatering associated with the project, with the predicted drawdown of the water table from local groundwater abstraction considered minor (maximum of 1.8 m, most likely scenario 1.35 m), allowing stygofauna species to persist in situ with that level of drawdown.

Table 1: Stygofauna records from the search area.

Species Lowest Identification	Group	Location	Subterranean Affinity
Antarctodrilus sp. WA3	Oligochaeta	Kadathinni	Stygobite
Bathynella sp.	Syncarida	Dongara Mineral Sands Project	Stygobite
Bdelloidea sp.	Rotifera	Dongara Mineral Sands Project	Stygobite
Candonopsis tenuis	Ostracoda	Dongara Mineral Sands Project	Stygobite
Diacyclops humpreysi humpreysi	Copepoda	Dongara Mineral Sands Project	Stygobite
Enchytraeidae sp. (nr sp WAM 2)	Oligochaeta	Dongara Mineral Sands Project	Stygobite
Fierscyclops sp. B1	Copepoda	Dongara Mineral Sands Project	Stygobite
Harpacticoida sp.	Copepoda	Dongara Mineral Sands Project	Stygobite
Hexabathynella sp.	Syncarida	Dongara Mineral Sands Project	Stygobite
Hexabathynella sp. B2	Syncarida	Dongara Mineral Sands Project	Stygobite
Insulodrilus nr *nudus*	Oligochaeta	Dongara Mineral Sands Project	Stygobite
nr *Nitocrella* sp. B1	Copepoda	Dongara Mineral Sands Project	Stygobite
Paramelitidae (n gen) *Protocrangonyix*	Amphipoda	Dongara Mineral Sands Project	Stygobite
Paramesochridae sp. B1	Copepoda	Dongara Mineral Sands Project	Stygobite
Parastenocaris sp.	Copepoda	Dongara Mineral Sands Project	Stygobite
Parastenocaris sp. B4	Copepoda	Dongara Mineral Sands Project	Stygobite
Parastenocaris sp. B5	Copepoda	Dongara Mineral Sands Project	Stygobite
Phreaochiltonia sp. B1	Amphipoda	Dongara Mineral Sands Project	Stygobite
Tubificidae sp.	Oligochaeta	Dongara Mineral Sands Project	Stygobite

5.2. Troglofauna

The search area contains 273 individuals from 25-27 species of troglofauna. This includes at least eight species of spider, one species of cockroach, one species of centipede, four species of beetle, one species of hemiptera, five species of isopoda, one species of lepidoptera, two species of pseudoscorpion, and two species of silverfish (Table 2). Of the 25-27 species, eight have been described and two others are probably undescribed species. All but one of the troglofauna records came from caves near Eneabba (Moulds 2007) approximately 50 km south of the Project. The remaining record came from Leeman (60 km SW from the Project). Almost all of the species collected are classified as troglophiles.

5.2.1. Evaluation

There has been little sampling for troglofauna within the 100 km x 100 km search area other than in caves approximately 10 km to 50 km from the Project which support a moderately rich troglofaunal assemblage. The relatively small amount of troglofauna sampling in the area can in part be explained by the lack of prospective troglofauna habitat (Rockwater 2011). No cave systems occur within or close to the boundary of the Project area.

Habitat information (i.e., inspection of drill logs Rockwater 2011 and BEC 2022) strongly suggests that troglofauna species are unlikely to be present in the Project area. While the fine mineral sands in the Project area are unlikely to have large enough interstitial spaces to support troglofauna, if some troglofauna species do occur they are likely to have comparatively large ranges (tens of kilometres) because of the uniform and widespread geology around the Project. The Project area is about 8.2 km^2.

Table 2: Troglofauna records from the search area.

Species Lowest Identification	Group	Location	Subterranean Affinity
Armadillidae sp. 2	Isopoda	Eneabba Karst	Trogloxene
Achaearanea sp.	Araneae	Eneabba Karst	Troglophile
Allothereua lesueurii	Chilopoda	Eneabba Karst	Troglophile
Araneae sp. 10	Araneae	Eneabba Karst	Troglophile
Araneae sp. 7	Araneae	Eneabba Karst	Troglophile
Araneae sp. 8	Araneae	Eneabba Karst	Troglophile
Araneae sp. 9	Araneae	Eneabba Karst	Troglophile
Baiami tegenarioides	Araneae	Eneabba Karst	Troglophile
Baiami volucripes	Araneae	Eneabba Karst	Troglophile
Brises acuticornis duboulayi	Coleoptera	Eneabba Karst	Troglophile
Laevophiloscia ?richardsae	Isopoda	Eneabba Karst	Troglophile
Laevophiloscia sp. 1	Isopoda	Eneabba Karst	Troglophile
Laevophiloscia sp. 2	Isopoda	Eneabba Karst	Troglophile
Laevophiloscia sp. 3	Isopoda	Eneabba Karst	Troglophile
Monopis ?crocicapitella	Lepidoptera	Eneabba Karst	Troglophile
Neotemnopteryx douglasi	Blattodea	Eneabba Karst	Troglophile
Trinemura ?novaehollandiae	Zygentoma	Eneabba Karst	Troglophile
Opilionida sp. 1	Araneae	Eneabba Karst	Troglophile
Philosciidae sp. 1	Isopoda	Eneabba Karst	Troglophile
Protochelifer cavernarum	Pseudoscorpion	Eneabba Karst	Troglophile
Ptinus exulans	Coleoptera	Eneabba Karst	Troglophile
Speotarus lucifugus	Coleoptera	Eneabba Karst	Troglophile
Trinemura sp. 1	Zygentoma	Eneabba Karst	Troglobite?
Carabidae `sp.`	Coleoptera	Eneabba	Troglobite/phile
Coleoptera `sp.`	Coleoptera	Eneabba	Troglobite/phile
Hemiptera `sp.`	Hemiptera	Leeman	Troglobite/phile
Protochelifer `sp.`	Pseudoscorpion	Eneabba Karst	Troglobite/phile

6. CONCLUSION

A search of records of subterranean fauna surrounding the Project area and an examination of the local geology and its surrounds suggests that the Project area is likely to support a stygofauna community that is widespread at a sub-regional level and is unlikely to support troglofauna species given the lack of suitable habitat. Therefore, it is considered that the Project is unlikely to significantly impact subterranean fauna values.

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