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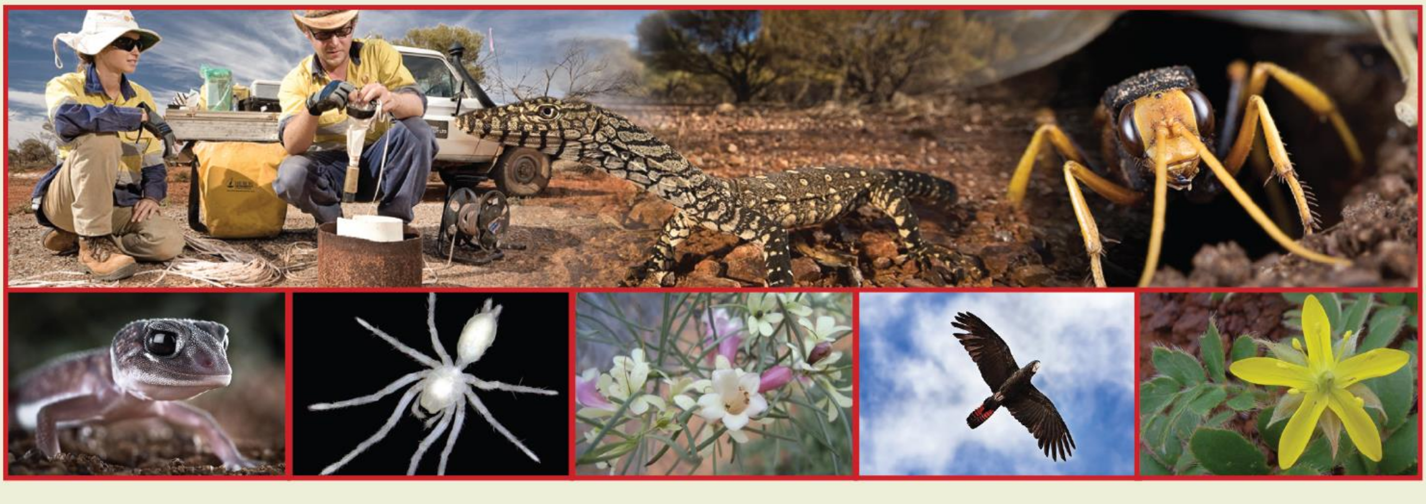
Level 2 stygofauna assessment for the Beyondie Sulphate of Potash Project

Prepared for Kalium Lakes Potash Pty Ltd

May 2018

Final Report



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Final Report

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Contents

List of Figures

List of Tables

List of Appendices

EXECUTIVE SUMMARY

Kalium Lakes Potash Pty Ltd (Kalium) proposes to develop the Beyondie Sulphate of Potash Project ('the Project'), located approximately 160 km south east of Newman with access to the Great Northern Highway at Kumarina approximately 75 km to the west. The Project spans the border between the Little Sandy Desert and Gascoyne bioregions. Kalium proposes to produce Sulphate of Potash through extraction of hypersaline groundwater and use of solar evaporation to concentrate and sequentially harvest the different salts.

Approximately 1.5 GL/annum of freshwater is required for processing, which was the focus of this assessment. This component of the Project is referred to as the Freshwater Development Envelope (FDE), which comprises four proposed water supply areas (Kumarina, Beyondie West, Ten Mile South and Vango), located between the Project and Kumarina.

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned to conduct a Level 2 stygofauna survey of the FDE, supplementary to a subterranean fauna desktop review and Level 1 subterranean fauna survey conducted for the Project.

The initial desktop review identified seven stygofauna species within approximately 100 km of the study area, three of which areonly known from single localities, *Billibathynella ilgarariensis*, *Brevisomabathynella magna* and *Pilbaracyclops frustratio*. The remaining four are widespread species.

The Level 1 survey was conducted in March 2017 and recorded stygofauna in the alluvial aquifers of the Beyondie West and Ten Mile South FDE areas. None of the species identified in the desktop review were recorded. This result triggered the need for a Level 2 stygofauna survey for the FDE component of the Project consistent with Environmental Protection Authority (EPA) guidelines for subterranean fauna.

The Level 1 survey returned two stygofaunal taxa, a Syncarid Parabathynellidae (BAP028) and an amphipod, Paramelitidae sp. indet. (AMP036). Neither of these have been recorded elsewhere. Two unresolved taxa were also collected (*Mesocyclops* sp. indet. and Oligochaeta sp. indet.) of which both groups are known to contain both widespread species (e.g. *Mesocyclops brooksi*, which was also recorded) and short-range endemic (SRE) stygofaunal species.

The objective of the Level 2 stygofauna survey was to further investigate the presence and distribution of stygofauna in the FDE. The survey was undertaken in February 2018 and entailed net hauls of 48 bores and recording bore and water quality data. The study area encompassed the FDE and nearby bores, although the Vango FDE area was not sampled as this area will provide water via dewatering of the Plutonic gold mine pits, currently being operated by Vango Mining Ltd. The survey methodology complied the EPA's guidelines for subterranean fauna surveys.

The Project is located just off the north-western edge of the Yilgarn Craton and just off the south-western edge of the North-west Officer Basin. Four main aquifers exist in the study area, including upper unconsolidated alluvial and colluvial sediments (<15 m deep), areas of saturated calcrete, basal palaeochannel sands and areas of weathered or fractured bedrock.

Ten distinct stygofauna taxa were collected from the survey of which eight could be identified to species level either by morphologic or molecular identification methods (mitochondrial DNA). An additional two taxa were indeterminate and may represent taxa already recorded. Taxa collected include two amphipods, two syncarids, three cyclopoid copepods, two ostracods and one oligochaete. An indeterminate amphipod and copepod were also collected.

Seven species collected in the survey have not been collected anywhere else. One species was known to be widespread previously and another, *Dussartcyclops* sp. B13, was found to be widespread. Four

taxa were not able to be identified to a sufficient level to state if they are potential SREs but come from groups known to have SRE representatives. Only one was synonymous with taxa collected in the Level 1 survey (Oligochaeta sp. indet.).

The amphipods (spp. indet. AMP039 and AMP040) were both from the family Paramelitidae, and syncarids (spp. indet. BAP018 and BAP019) were both from the family Parabathynellidae. Each of these four species represented distinct genetic lineages (based on molecular analysis), i.e. distinct species, and were also genetically distinct from those collected in the Level 1 survey. These species have not previously been recorded in WA.

There appears to be distinct differences in stygofauna assemblages between each of the three FDE areas sampled, with one exception. The copepod *Dussartcyclops* sp. B13 was common to both the Kumarina and Ten Mile South FDE areas, up to 75 km away from each other. Three species were found only in the Kumarina FDE area in bores KMB01 and KPB01: Parabathynellidae sp. indet. (BAP019), Paramelitidae sp. indet. (AMP040) and *Candonopsis* sp. indet. Three species were collected only in Ten Mile South FDE area: Paramelitidae sp. indet. (AMP039), Parabathynellidae sp. indet. (BAP019) (one specimen from KPB01 was indeterminate) and Nr. *Fierscyclops* (New Genus) sp. B01.

In the Beyondie West FDE area, Parabathynellidae sp. indet. (BAP018) was recorded outside of the FDE boundary in the current survey within an area of massive calcrete (Czk). In the Level 1 survey, the amphipod Paramelitidae sp. indet. (AMP036) was recorded both inside and outside (15 km north) the Beyondie West FDE. The widespread *Fierscyclops fiersi* and representatives of the typically widespread oligochaete were also recorded in this area.

The amphipod Paramelitidae sp. indet. (AMP036) and syncarid Parabathynellidae sp. indet. (BAP028) collected from the Level 1 survey (essentially from the Beyondie West FDE area) were not collected in the current survey despite being located between the species collected in the eastern and western parts of the current study area.

A different stygobitic community in each FDE area was not unexpected as each aquifer is unconnected, but occur in relatively similar geologies (except for the Vango FDE). The surface geology data and more localised drill log data suggest that the stygofauna community within each FDE area is likely to be more widespread than the sampled extent. This is particularly the case for the Kumarina and Beyondie West FDE areas. There, the dominant surface geologies are alluvial and extend well beyond the FDE boundaries. The drill logs for Kumarina demonstrate that Paramelitidae sp. indet. (AMP040) and *Dussartcyclops* sp. B13 occur within at least two 'habitat types' (e.g. gravel/sand and 'voids' at KMB01 and calcrete/alluvium at KPB01). While limited drill log data is available with respect to Beyondie West bores that yielded stygofauna, Paramelitidae sp. indet. (AMP036) was found 15 km north in the Level 1 survey, well outside that FDE area. The massive calcrete formation (Czk) east of Beyondie West may contain more restricted species, but this area is not currently being targeted.

The Ten Mile South FDE taxa included those from typically restricted groups (e.g. amphipods and ostracods) and widespread groups (Oligochaeta and Cyclopoida). The taxa from restricted groups were constained to the southern half of the 'massive calcrete' formation that comprises less than 20% of the FDE. Their absence from the northern half of the formation closer to Ten Mile Lake coincides with significantly higher groundwater salinity and lacustrine sediments. However, to the south, drill logs from the bores in the alluvial flood plain that feeds the calcrete (from which the widespread Oligochaeta sp. indet., *Mesocycplos brooksi* and *Mesocyclops* sp. indet. were recorded) were not unlike those of the calcrete formation. Further, the groups these taxa represent were also recorded within the Kumarina and Beyondie West FDE's, both of which occur in alluvial geologies. Therefore, it is considered possible that the taxa currently restricted to the calcrete formation component of the Ten Mile South FDE, may in fact be found to the southwest within the alluvial aquifer.

Despite these local observations however, sample effort has been greatest within the Ten Mile South FDE. And further, calcrete formations (within the Yilgarn Craton in particular) are known to support restricted subterranean fauna species/assemblages in WA. Therefore, at this stage, a precautionary approach to abstraction of water from bores within the southern half of the Ten Mile South calcrete formation is considered prudent until further distributional information is available for several taxa.

1 INTRODUCTION

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Kalium Lakes Potash Pty Ltd (Kalium) to conduct a Level 2 stygofauna assessment for the Beyondie Sulphate of Potash Project ('the Project').

The Project is located approximately 160 km south east of Newman, with access to the Great Northern Highway at Kumarina approximately 75 km to the west, with several proposed water supply areas collectively comprising the Freshwater Development Envelope (FDE); including Kumarina FDE, Beyondie West FDE, Ten Mile South FDE and Vango FDE (Figure 1-1). The Project area spans the border between the Great Sandy Desert and Gascoyne bioregions.

This survey was conducted in follow up to a Level 1 subterranean fauna assessment completed in March 2017 (Phoenix 2018) which recorded stygofauna from a small number of bores within the FDE. As the water supply requirements for the Project will result in aquifer drawdown associated with the FDE, further stygofauna sampling was required to gain additional knowledge concerning the species presence and distribution in this area.

1.1 BACKGROUND

The Project encompasses three lake systems, the Beyondie Lakes, Ten Mile Lake and Lake Sunshine (Figure 1-1). The Beyondie Lakes consist of a western freshwater marsh connected to a circular salt playa in the east (outside the study area and not to be impacted). Ten Mile Lake is a large salt playa located about 6 km to the south. The Beyondie Lakes salt playas connect with Ten Mile Lake during extreme inundation events. Lake Sunshine is located approximately 22 km ENE of Beyondie Lakes and Ten Mile Lake. Several fresh-brackish claypans are located around and between the lakes. Together, Ten Mile Lake and Lake Sunshine comprise the Salt Lake Development Envelope (SLDE; Figure 1-1).

Kalium is seeking to develop a sub-surface brine deposit within the SLDE to produce 150 ktpa Sulphate of Potash (SOP) product via an evaporation and processing operation. The Project will entail the extraction of hypersaline groundwater that will be pumped to ponds where the salts will be concentrated via solar evaporation, and different salts extracted and purified sequentially.

The process will particularly target the basal palaeochannel aquifers of Ten Mile Lake and Lake Sunshine that have a significantly lower hydraulic conductivity with the overlying, less permeable layers, but a much greater yield. Brine abstraction by superficial channels on Ten Mile Lake and Lake Sunshine also form part of the Project (Advisian 2017a).

These aquifers were considered in Phoenix (2018) and determined, via a desktop review and subsequent Level 1 survey, to be unsuitable for subterranean fauna due to the hypersaline groundwater and low porosity lacustrine sediments present. No further sampling of these aquifers (i.e. within the Sale Lake Development Envelope) was therefore undertaken.

The Project also requires freshwater for processing purposes. Two alluvial aquifers (Kumarina and Beyondie West), one alluvial/calcrete aquifer (Ten Mile South) and a series of gold mine pits (Vango) are proposed to be utilised within the FDE. These unconfined alluvial aquifers occur to the west of Beyondie Lakes and south and southwest (old Plutonic gold mine pits) of Ten Mile Lake (Figure 1-1).

Small pockets of calcrete occur in the alluvial aquifers and there is a large calcrete formation that commences at the south end of Ten Mile Lake, extending for several kilometres. This large calcrete formation contains hypersaline water close to Ten Mile Lake and gets fresher further away from the lake, to the southwest. The calcrete is typically thin (<10 m) and in many places is not inundated (Advisian 2017a). Accordingly, yields are typically low, so the formation will likely contribute only a minor proportion of the processing requirements. The majority of the freshwater processing requirements will likely be supplied by the most western alluvial aquifer (Kumarina FDE area; which to date has returned the greatest yields via pump tests), from bores on the headwaters of the Gascoyne River, close to Kumarina (Figure 1-1).

The Level 1 survey conducted in March 2017 (Phoenix 2018) recorded six taxa of stygofauna from the FDE target aquifers, two of which have not been recorded elsewhere, an amphipod Paramelitidae sp. indet. (AMP036) and a bathynellid syncarid (Parabathynellidae sp. indet. BAP028). The subsequent Level 2 stygofauna survey reported here therefore focussed on aquifers within the FDE.

1.2 SURVEY OBJECTIVES AND SCOPE OF WORKS

The objective of the Level 2 stygofauna assessment was to investigate the presence and distribution of stygofauna associated with the proposed freshwater supply aquifers within the FDE.

The scope of work was as follows:

- conduct a field survey for stygofauna
- undertake data analyses, sample processing and species identifications for samples collected
- prepare maps showing species records
- prepare a technical report, that builds on the existing subterranean fauna desktop review and Level 1 survey study (Phoenix 2015, 2018), outlining survey methods, results, assessment of significant species and habitats.

Where practicable, survey design, methodology and report writing will adhere to relevant principles and guidelines, including:

- Environmental Protection Authority (EPA) Environmental Factor Guideline. Subterranean fauna (EPA 2016a)
- EPA Technical Guidance. Sampling methods for subterranean fauna (EPA 2016b).

1.3 STUDY AREA

The study area for the Level 2 stygofauna assessment encompassed the four components of the FDE and nearby bores. It included Project tenements E69/3347 and E69/3309 (Figure 1-1).

The FDE collectively comprises four distinct target areas: Kumarina, Beyondie West, Ten Mile South and Vango (Figure 1-1). The Vango component of the study area was not sampled as no bores were available at the time of the survey. At Vango, Kalium is considering drawing water from abandoned mine pits and so there are no plans to drill bores and therefore sample this area.

Figure 1–1
Project location and study area

- Freshwater Development Envelope
- Tenement E69/3309
- Tenement E69/3346
- Tenement E69/3347
- Tenement E69/3351
- Tenement E69/3352
- Road
- Minor road
- Major creeks and rivers
- Lake

0 12.5 25 50
Kilometres
1:1,250,000

Client: Kalium Lakes Ltd
Project: Beyondie Sulphate of Potash Project

Author: AL
Date: 04-May-18

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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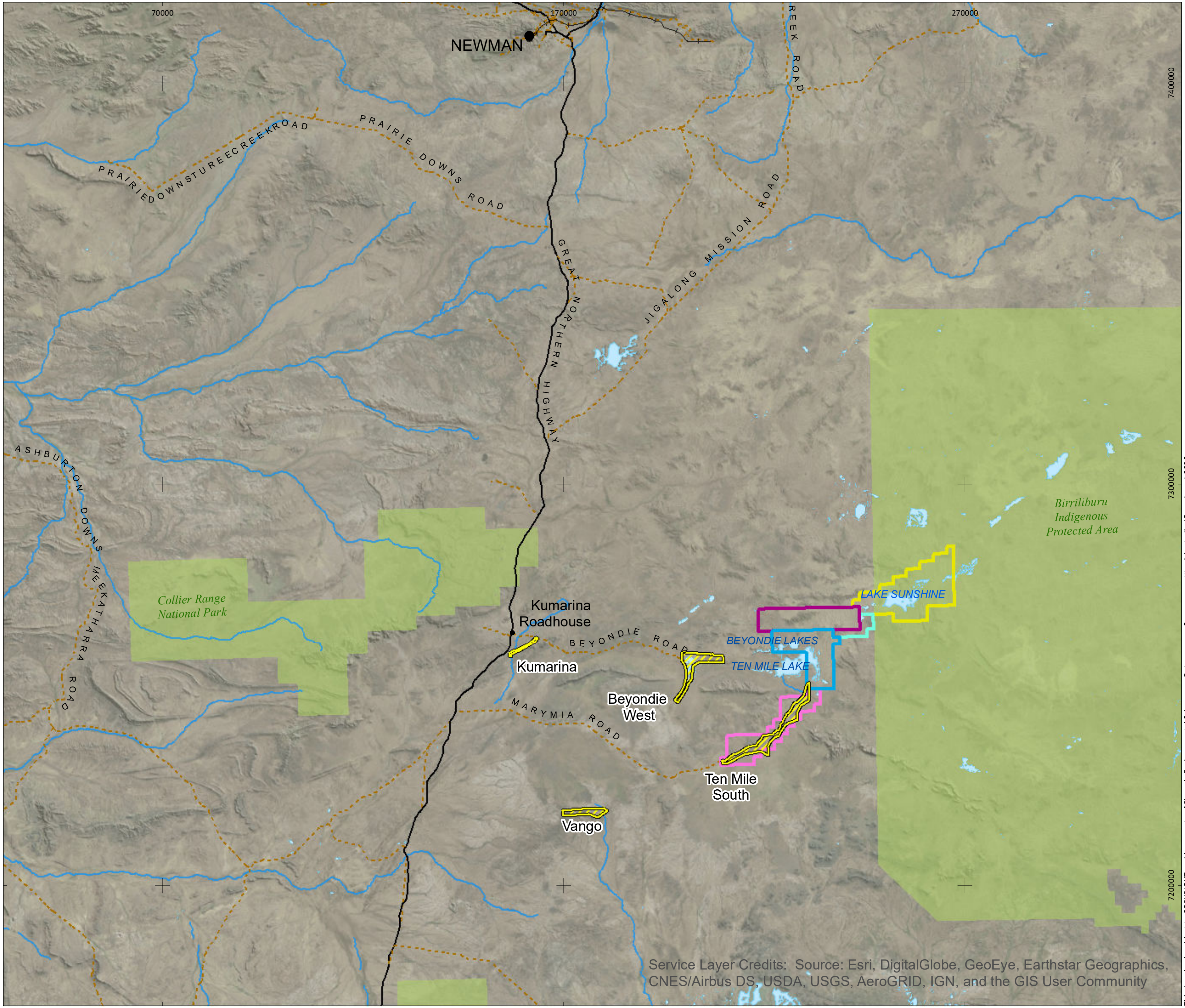


2 LEGISLATIVE CONTEXT

For the purposes of environmental impact assessment (EIA), the EPA (2016a) defines subterranean fauna as: *fauna which live their entire lives (obligate) below the surface of the earth*. They include stygofauna (aquatic and living in groundwater) and troglofauna (air-breathing and living in caves and voids). The EPA's objective with respect to subterranean fauna is *its protection so that biological diversity and ecological integrity are maintained*.

The obligate underground existence of subterranean fauna greatly increases the likelihood of short-range endemism and the possibility that a species' conservation status may be impacted as a result of the implementation of a proposal. Subterranean fauna species may therefore be considered to be significant due to being identified as Threatened or Priority species, locally endemic, potentially new species, occupying restricted habitats and/or forming part of a Threatened Ecological Community (TEC) or Priority Ecological Community (PEC) (EPA 2016a).

Very few subterranean fauna species or communities are listed as Threatened Fauna or TECs, and therefore are matters of national environmental significance (MNES), under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Cape Range Remipede (*Kumonga exleyi*) and a blind cave eel (*Ophisternon candidum*) from the Cape Range peninsula in WA are two species exceptions and Aquatic Root Mat Community 3 in Caves of the Leeuwin Naturaliste Ridge.

At the State level however, many subterranean communities are listed as TECs or PECs. TECs at the State level are ecological communities which are at risk of becoming destroyed as 'Threatened'[1], and are listed by the Minister for Environment. PECs are non-statutory communities listed by DBCA that are also considered to be of conservation significance. Many subterranean species in WA are listed as Threatened (Protected) species[2] under the *Wildlife Conservation Act 1950* (WC Act), or as Priority fauna by DBCA.

A total of 27 troglofauna and 20 stygofauna species are currently listed as either Threatened or Priority in WA, with the majority from the Pilbara and Carnarvon Interim Biogeographic Regionalisation of Australia (IBRA) regions (Appendix 1).

Subterranean TECs (Appendix 2) and PECs (Appendix 3) are listed for WA. Of the PECs, 77 are stygofauna communities in the groundwater of calcretes of the Yilgarn Craton in the Midwest and northern Goldfields regions (i.e. Cooper *et al.* 2008; Guzik *et al.* 2008; Humphreys *et al.* 2009).

[1] The BC Act will allow for the listing of TECs when the relevant BC Act regulations come into effect.
[2] This function of the WC Act will be replaced by the BC Act when the relevant BC Act regulations come into effect.

3 EXISTING ENVIRONMENT

3.1 INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA

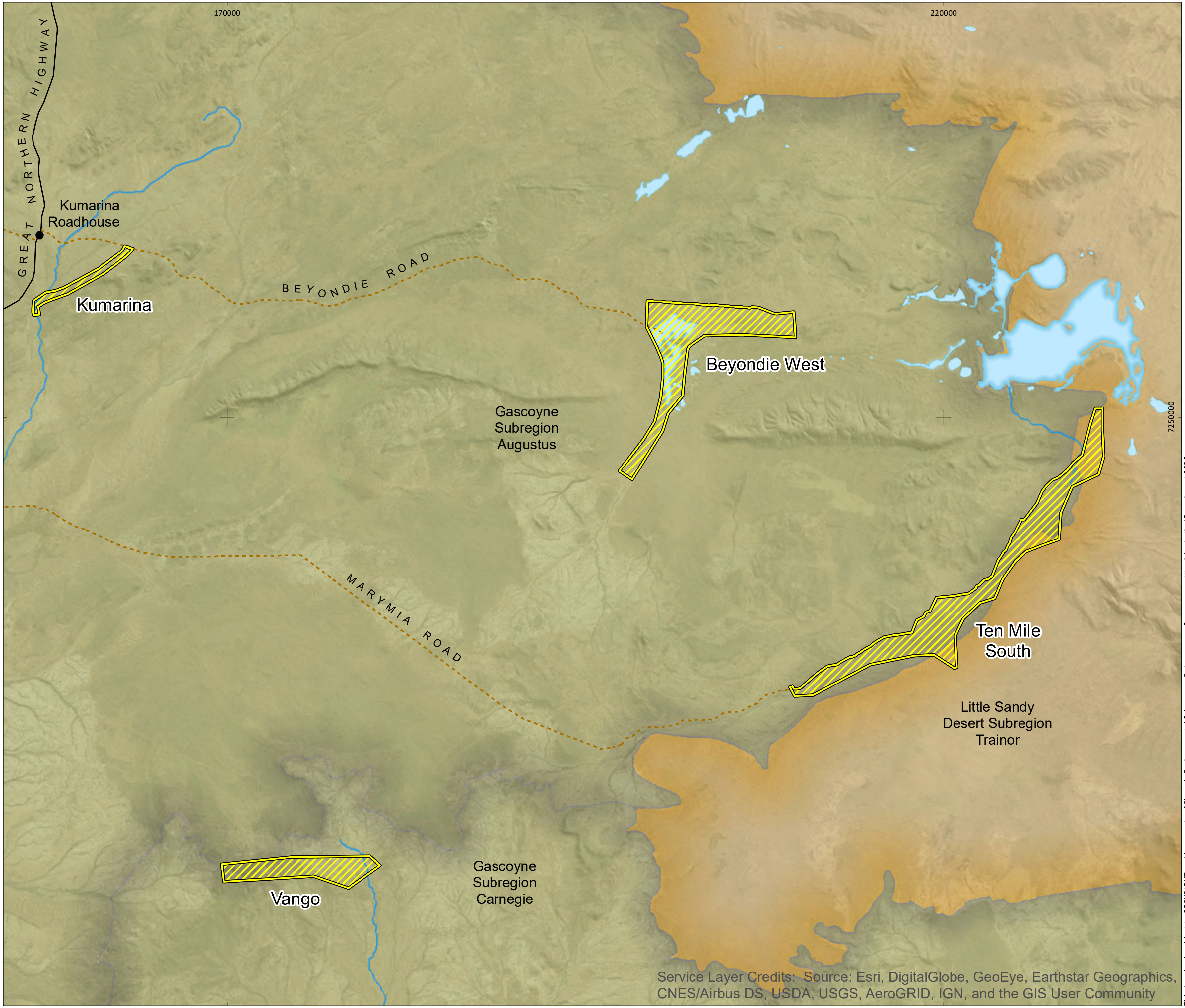
The study area is situated on the border to two IBRA bioregions; the Gascoyne bioregion and Little Sandy Desert bioregion (Figure 3-1). The FDE is located primarily within the Augustus subregion (GAS3) of the Gascoyne bioregion and is characterised by (Desmond *et al.* 2001):

- low Proterozoic sedimentary and granite ranges divided by flat broad valleys
- mulga woodland with *Triodia* on shallow stony loams on rises with mulga parkland on shallow earthy loams over hardpan on the plains
- extensive areas of alluvial deposits
- calcrete aquifers of the Carnegie drainage system
- desert climate with bimodal rainfall.

With respect to subterranean fauna, the alluvial deposits and calcrete aquifers are of importance as these geologies are known to support subterranean habitats for stygofauna (EPA 2016a).

Figure 3–1
Study area location in relation to IBRA regions and subregions

Freshwater



0 3 6 12
Kilometres
1:350,000

Client: Kalium Lakes Ltd
Project: Beyondie Sulphate of Potash Project
Author: AL
Date: 04-May-18
Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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3.2 Climate and weather

The Gascoyne bioregion has an arid climate with and summer rainfall in the east. Spatially averaged median (1890–2005) rainfall is 202 mm (DEWHA 2008a). The climate of the Little Sandy Desert bioregion is also arid with summer-dominant rainfall. Spatially averaged median (1890–2005) rainfall is 178 mm (DEWHA 2008b). The climate of south-western Little Sandy Desert has also been described as desert tropical with predominant summer rainfall (van Leeuwen 2002).

The nearest Bureau of Meteorology (BoM) weather station with long-term and actual data is Newman Airport (BoM Station 7176; Latitude 23.42°S Longitude 119.80°E), approximately 160 km to the north-west of the study area. Newman records the highest maximum mean monthly temperature (39.1°C) in December and the lowest maximum mean temperature (22.9°C) in July. The lowest mean minimum temperature is recorded in July (6.4°C) and the highest in January (25°C). Average annual rainfall is 332.6 mm with February, January, and March recording the highest monthly averages (71, 67.9, and 43.3 mm respectively) (Figure 3-2).

Pan evaporation for the south-western Little Sandy Desert bioregion ranges from 16.1 mm/day in January to 4.5 mm/day in June at an annual daily average of 10.2 mm (van Leeuwen 2002).

The three months prior to the survey (in late February) recorded overall lower rainfall than average with a total of 123.2 mm from December 2017 to February 2018 (Figure 3-2). Temperatures were about average in the year preceding the survey (Figure 3-2).

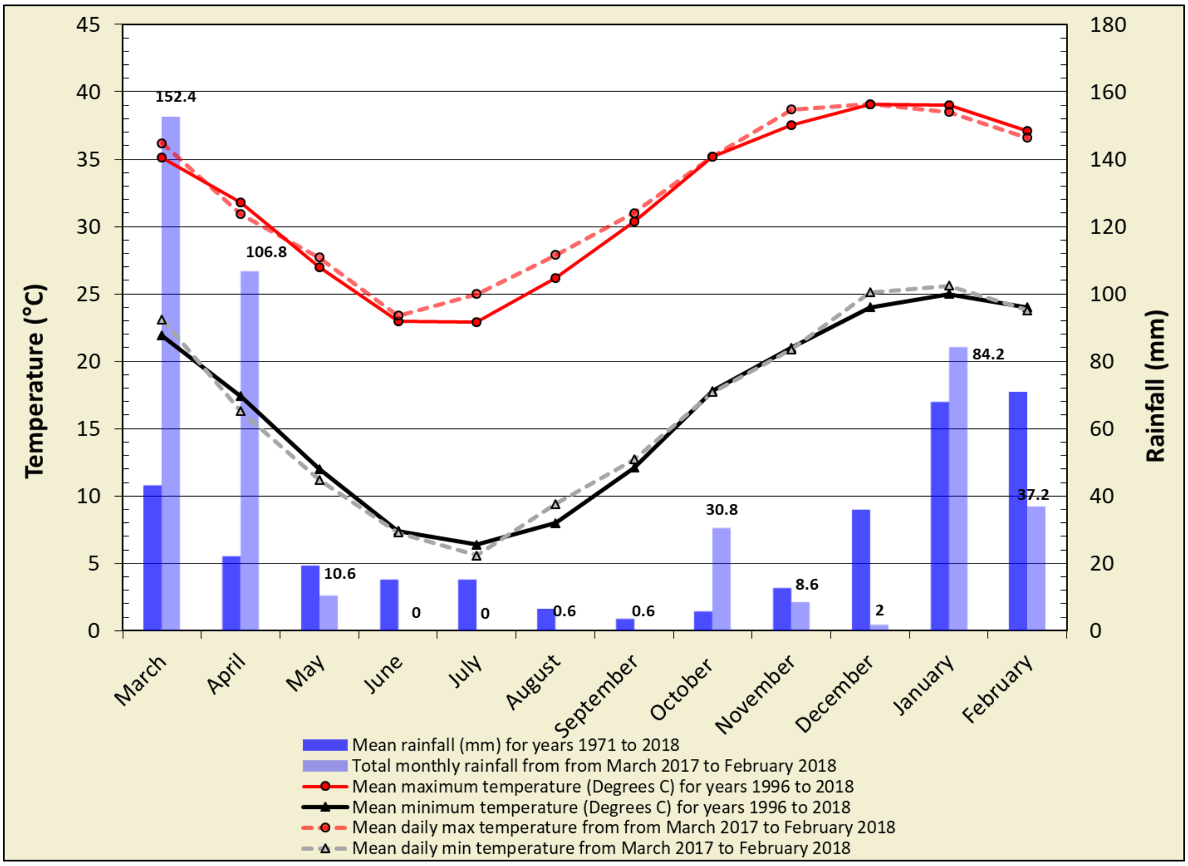

Figure 3-2 Average monthly temperatures and rainfall for Newman Airport (no. 7176) and mean monthly data for the 12 months preceding the field survey

3.3 GEOLOGY

The Project is located within the Collier, Salvation, Scorpion and NW Officer Basins which reside within the Capricorn Orogeny that marks the convergence and collision of the Archaean Pilbara and Yilgarn Craton. This was responsible for widespread granite magmatism, deformation and metamorphism (Advisian 2017a).

The four components of the FDE encompass a wide range of geologies with different minimum ages: Stenian, Statherian, Quaternary, Holocene, Cenozoic and Archean (principally the Vango FDE) (Table 3-1). The bores available at the time of the survey in general, targeted freshwater aquifers hosted in surficial alluvial deposits. The alluvial deposits are generally formed as transported sediments. Thicker deposits of colluvium may also occur within tributaries in general break of slope areas and along steeper valley sides. These deposits are heterogeneous due to the nature of their deposition. Minor, localised calcretes and silcretes are often present as carbonate deposits formed within alluvial and colluvial sediments (Advisian 2017b).

More specifically, it can be seen in Table 3-1 that the Kumarina FDE area is almost entirely dominated by recrystallised fine to coarse sandstone (Mscc; 76%) and colluvium, sheetwash with local calcrete (Qrc; 22%).

The Beyondie West FDE area is dominated by colluvium, sheetwash with local calcrete (Qrc; 48%) and Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted (Qa; 45%).

Calcrete is found throughout the Ten Mile South FDE area, being dominated by channel and flood plain alluvium, locally calcreted (Qa; 45%), colluvium, sheetwash, with local calcrete (Qrc; 26%).and massive calcrete (Czk; 21%).

The Vango FDE area is almost entirely comprised of reworked and porphyritic Archean geologies, such as siliciclastic, (meta) basalt, dolerite, amphibolite and schist, which tend to be hardened, with low permeability. The low groundwater flows in this area are largely derived from fractures. There is however some pisolitic, vuggy ferruginous laterite present (Czl; 12.5%) that represents more favourable stygofauna habitat.

In WA, the types of geology known to support stygofauna include calcretes, alluvial formations particularly when associated with alluvial or palaeochannel aquifers, fractured rock aquifers and karst limestone. Of these, alluvial or palaeochannel aquifers and to a lesser extent, calcretes are most prominent within the study area (Figure 3-3) – which form around 26% of the Ten Mile South FDE.

Calcretes are carbonate deposits that formed near the water table in arid lands as a result of concentration processes by near-surface evaporation. The calcretes are mainly associated with the palaeodrainage channels of the Pilbara and Yilgarn cratons and their associated orogens which together form the Western Shield of Australia (Beard 1998).

The study area is located immediately north (0-25 km) of the northern extent of the Yilgarn Craton and therefore strictly speaking does not occur within the craton. Given the proximity however, the role of calcretes with respect to stygofauna is discussed further.

Calcrete deposits of the Yilgarn region of central WA are believed to have formed from the groundwater flow between 30–10 Mya when continued aridity produced salt lakes, extensive alluvial fans and dunes which assisted in fragmenting the river valleys into isolated ponds (Morgan 1993). In the northern river valleys of the Western Shield calcretes are concentrated on the upstream side of the salt lakes (Morgan 1993).

Over 200 major calcretes are found in the Yilgarn and they provide habitat for a diversity of subterranean fauna (both stygo- and troglofauna), such as diving beetles (Dytiscidae) and a variety of crustaceans, including amphipods (Amphipoda), slaters (Isopoda), syncarids (Bathynellacea) and copepods (Copepoda) (Bradford *et al.* 2013; Cooper *et al.* 2008; Guzik *et al.* 2008; Humphreys 2001; Javidkar *et al.* 2015; Javidkar *et al.* 2016; Javidkar *et al.* 2017; Watts & Humphreys 2004). The calcretes are generally shallow (approximately up to 10 m deep), but may reach depths of up to 30 m (Humphreys *et al.* 2009).

The calcretes of the Western Shield that occur near salt lakes have recently been flagged as 'groundwater estuaries' of potentially high biodiversity value (Humphreys *et al.* 2009). Their groundwater profiles can be compared to the anchialine systems near ocean estuaries, where saline water intrudes under the freshwater fan of the river mouth. The complex interplay of fresh and saline water creates steep biogeochemical gradients to potentially support cascades of microbiological and micro- and macroinvertebrate communities (Humphreys *et al.* 2009).

The high endemicity of the groundwater stygofauna of calcrete deposits in the Yilgarn Craton has resulted in the listing of many of the PECs for the Midwest and the Goldfields regions of WA (DPaW 2016b) (Appendix 3).

Table 3-1 Surface geologies in each FDE area

Period	Abbreviation (Figure 3-3)	Lithology description	Total area (ha)	Approximate area (%) of total FDE area	FDE area	Approximate area (%) of individual FDE area (ha)
Stenian	Mscc	Recrystallised fine to coarse sandstone, in places glauconitic, with lesser interbedded siltstone, granule to pebble conglomerate, shale, mudstone, dolostone, pebbly sandstone, minor chert and dolostone.	373	3.6	Kumarina	75.9
					Beyondie West	1.1
					Ten Mile South	0.3
Statherian	Mspw	Coarse to medium grained white quartz sandstone, siltstone with numerous pyrite pseudomorphs, shale and minor conglomerate; rippled and cross bedded. Minor evaporite.	20	0.2	Ten Mile South	0.4
Quaternary	Qrc	Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite.	3,010	29.2	Kumarina	21.6
					Beyondie West	47.7
					Ten Mile South	26.0
Holocene	Qa	Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted.	3,766	36.5	Kumarina	2.5
					Beyondie West	44.9
					Ten Mile South	45.4
	Qd	Dunes, sandplain with dunes and swales; may include numerous interdune claypans; residual and aeolian sand with minor silt and clay; aeolian red quartz sand, clay and silt, in places gypsiferous; yellow hummocky sand.	439	4.3	Beyondie West	6.3
					Ten Mile South	4.6
Cenozoic	Czs	Sand or gravel plains; quartz sand sheets commonly with ferruginous pisoliths or pebbles, minor clay; local calcrete, laterite, silcrete, silt, clay, alluvium, colluvium, aeolian sand.	99	1.0	Ten Mile South	2.1
	Czk	Pisolitic, nodular or massive calcrete; ferruginous inclusions; calcareous cementing of bedrock and transported materials; locally with intercalated chalcedony; as low mounds, in playa lakes, or as valley calcrete; locally dissected and karstified.	1,030	10.0	Beyondie West	0.04
					Ten Mile South	21.4

Period	Abbreviation (Figure 3-3)	Lithology description	Total area (ha)	Approximate area (%) of total FDE area	FDE area	Approximate area (%) of individual FDE area (ha)
	Czl	Pisolitic, nodular or vuggy ferruginous laterite; some lateritic soils; ferricrete; magnesite; ferruginous and siliceous duricrusts and reworked products, calcrete, kaolinised rock, gossan; residual ferruginous saprolite.	197	1.9	Vango	12.5
Archean	Ay	Metasedimentary siliciclastic, meta-igneous ultramafic.	0.7	0.0	Beyondie West	0.02
	Aby	Metabasalt, high-Mg basalt, tholeiitic basalt, carbonated basalt, agglomerate, mafic schist, dolerite, amphibolite; porphyritic basalt and dolerite; komatiitic basalt; mafic pyroclastics; minor mafic schist with granite intercalations.	480	4.7	Vango	30.5
	Aey	Metamorphosed komatiite, pyroxenite, chlorite-tremolite schist, talc-chlorite schist, anthophyllite-tremolite-talc rock; olivine-cummingtonite schist; talc-carbonate-tremolite-chlorite rock, serpentinite; amphibole schist after pyroxenite.	9	0.1	Vango	0.6
	Aty	Amphibolite, mafic schist, mafic rock intercalated with granite, para-amphibolite; metabasalt, metagabbro, metapyroxenite and metadolerite; Youanmi Terrane.	137	1.3	Vango	8.7
	Ag	Undifferentiated felsic intrusive rocks, including monzogranite, granodiorite, granite, tonalite, quartz monzonite, syenogranite, diorite, monzodiorite, pegmatite. Locally metamorphosed, foliated, gneissic. Local abundant mafic and ultramafic inclusions.	523	5.1	Vango	33.2
	Afy	Felsic volcanic and volcaniclastic rocks, locally amygdaloidal or fragmental; dacite, quartz-feldspar porphyry, tuff, agglomerate, andesitic lava, quartz-muscovite schist, felsic schist, felsic gneiss.	229	2.2	Vango	14.5

Figure 3–3
Surface geology in the study area

Freshwater Development Envelope

0 3.25 6.5 13
Kilometres
1:350,000

Client: Kalium Lakes Ltd
Project: Beyondie Sulphate of Potash Project

Author: AL
Date: 04-May-18

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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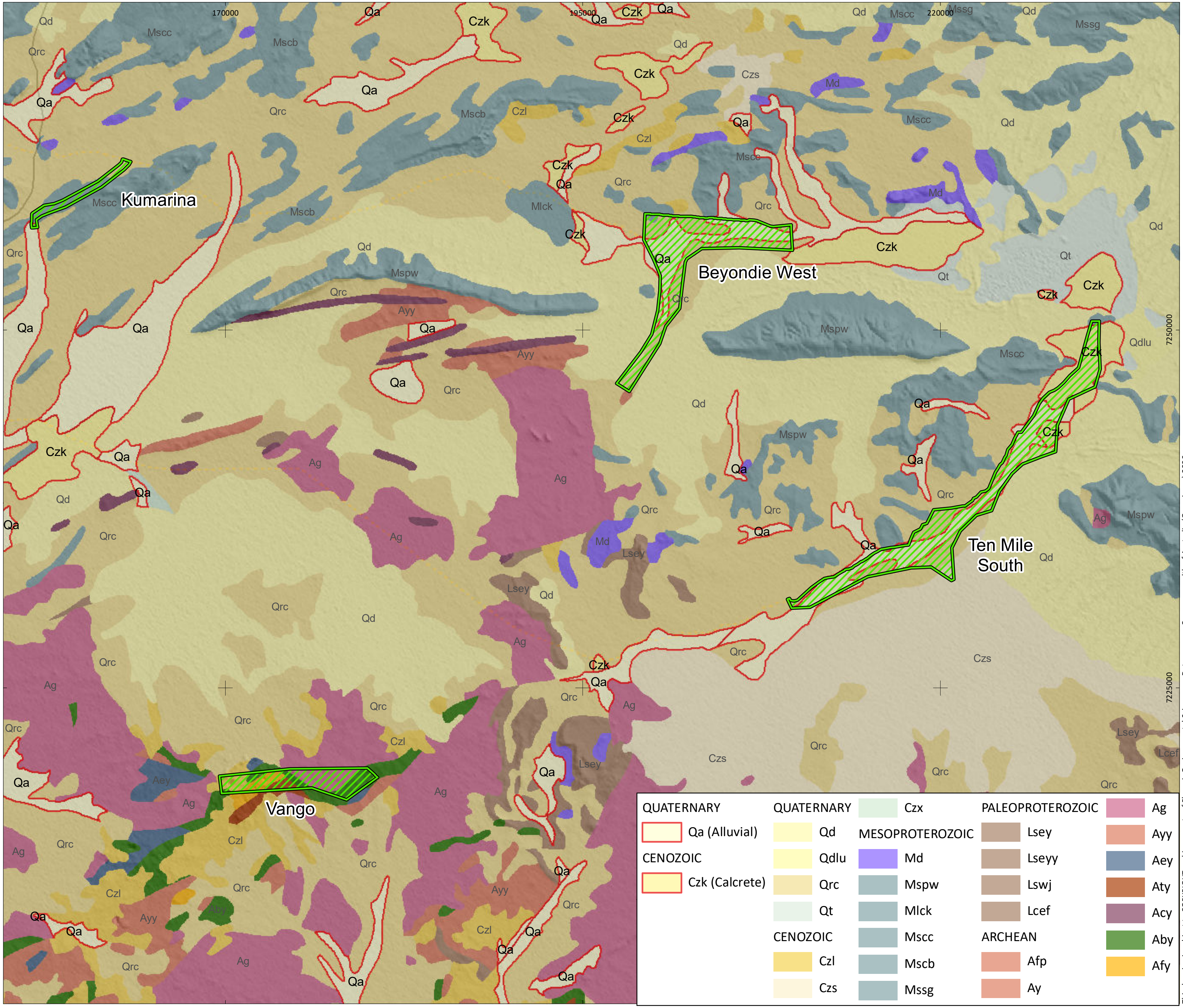

3.4 Hydrology

The four main aquifers that exist in the area are (Advisian 2017b; AQ2 2016):

- basal sands in the thalweg of the palaeochannel (target of the potassium brine resource)
- upper unconsolidated sediments in the palaeochannels (<10 m deep); i.e. alluvial (heterogenous, coarse) (targeted by the FDE) and lacustrine (gypsiferous, sand, silts, clays) deposits
- areas of saturated calcrete (especially to the south of Ten Mile Lake)
- areas of weathered or fractured bedrock.

As described in section 1, abstraction from the four distinct areas of the FDE will likely take place within aquifers containing alluvium and colluvium (often with localised, thin veneers of calcrete and silcrete, typically less than 10 m thick), which are heterogeneous due to the nature of their deposition (Advisian 2017b). Here, localised groundwater supplies may be obtained from intersections of present-day drainage, bedrock fracture zones and calcrete formation.

Where fractured bedrock supplies water to the alluvium, they can be open or closed and yields can be low to moderate and highly variable. In the unconfined alluvial zones groundwater will be rainfall dependent and higher in areas of highly heterogeneous coarser sediments. In windblown arid areas, the shallow alluvial sediments may have been eroded away to expose the calcrete deposits which have become hard outcrop features at the surface (Advisian 2017b), such as at the south of Ten Mile Lake.

Calcretes form an important water resource elsewhere in WA, for example in the Goldfields region, where they can produce significant bore yields of up to 2,000 kilolitres per day (kL/d) if there is sufficient thickness below the water table (Johnson *et al.* 1999). Calcrete is often associated with lower salinity water than other surrounding and deeper aquifers due to the ability to accept recharge. Accordingly, calcretes are also significant subterranean fauna habitat in regions within the Yilgarn Craton (see section 3.3).

Calcrete occurs in the region at the margins of the present-day salt lakes, and in some of the main sub-catchments in the palaeodrainages. In the Project area the surficial unconfined aquifer comprising alluvium and colluvium associated within the present-day drainage, contains calcrete logged at a maximum 6.57 m saturated thickness (south of Ten Mile Lake) and 5.27 m saturated thickness west of Beyondie Lakes (Advisian data in prep.).

3.5 Biological context

Subterranean habitats are perpetually dark, are extremely constant in temperature and humidity (air-filled networks) and very low in nutrients and energy (Howarth 1993). Evolution under such conditions has resulted in much specialised organisms that are restricted to the void networks (Harvey 2002; Holsinger 2000; Howarth 1993; Ponder & Colgan 2002); in the case of stygofauna these are water-filled networks such as aquifers.

Organisms specialised to live in subterranean networks often have naturally small distributions with limited capabilities of dispersal and therefore represent short-range endemics (SREs), species with distributions nominally less than 10,000 km^2 (Harvey 2002; Ponder & Colgan 2002; Volschenk & Prendini 2008). Species restricted to subterranean void systems may have considerably smaller distributions and therefore represent extreme SREs (Harvey 2002).

In WA, and particularly in the Pilbara and Midwest region, there have been a large number of subterranean fauna surveys and studies driven by the growth of the mineral resources industry;

however, the biology, diversity and distributions of most of WA's subterranean fauna are still poorly understood.

Stygofauna typically display common traits in their specialisation to subterranean life, including loss of body pigment, eyes and heightened mechano-sensory systems. Stygofauna can be distinguished by their propensity for subterranean life (Humphreys 2008):

- stygobites — restricted to subterranean habitats and usually perish on exposure to the surface environment
- stygophiles — facultatively use subterranean habitats but are not reliant on them for survival
- stygoxenes — inhabitant of surface water which may also be able to freely move from surface to subterranean systems and back.

SRE stygofauna are only represented by stygobitic species.

3.5.1 Threatening processes

Impacts to stygofauna can be classed as either:

- **primary impacts** – impacts that physically terminate the subterranean void networks
- **secondary impacts** – impacts that change the subterranean habitat without physically destroying the void networks.

Primary impacts are obvious, whereas secondary impacts tend to be cumulative and may affect a far greater area than that being developed (Hamilton-Smith & Eberhard 2000). There are commonly two key threatening processes from mining/extractive activities that impact stygofauna through the direct loss of habitat:

- **Depletion of an aquifer leading to loss of stygofauna habitat** – depletion of an aquifer that is identified as suitable for stygofauna represents a direct loss of stygofauna habitat. The significance of the impact is dependent on the depth of drawdown, the size and extent of the aquifer and the connectivity of the aquifer with adjacent habitat for stygofauna.
- **Direct removal of void networks** – direct loss of stygofauna habitat may be caused by the removal of geological formations if any aquifers are associated with these formations.

The first impact is potentially relevant to the current study area as the FDE areas are proposed to be targeted for groundwater abstraction.

Secondary impacts are those that affect the physicochemical properties of subterranean habitats. The nature of these changes can be difficult to measure and there is limited empirical evidence to support or refute these putative impacts.

3.5.2 Salinity

Globally, stygofauna are generally restricted to freshwater and rarely occur in mildly brackish waters, except in the special case of anchialine ecosystems (Bradbury & Williams 1996b; Humphreys 1999). However, the Western Shield contains a diverse assemblage of near-marine and ancient freshwater lineages inhabiting groundwater with salinity values that may reach marine conditions (Humphreys 2008). At Lake Way, Watts and Humphreys (2004) recorded a diverse stygal assemblage in a bore with surface salinity near seawater (30,000 mg/L) and a strong salinity gradient increasing to 69,000 mg/L at 6 m depth. The finer scale vertical distribution of stygofauna inhabiting groundwater in WA, which may be strongly stratified with steep gradients in salinity at micro/meso-scales, remains largely unknown (Humphreys *et al.* 2009; Subterranean Ecology 2010).

4 METHODS

4.1 DESKTOP REVIEW

A detailed desktop review was completed previously (Phoenix 2015) followed by a Level 1 survey conducted in March 2017 (Phoenix 2018). Refer to Phoenix (2015) for the detailed desktop review methods and results.

A summary of results from the Level 1 survey is provided in this report for context (section 5.1).

4.2 FIELD SURVEY

The field survey was conducted on 22–27 February 2018.

4.2.1 Survey sites

A total of 48 bores were surveyed for stygofauna (Table 4-1). This included resampling of three of 15 bores that were sampled in the Level 1 survey (Table 4-1) (Phoenix 2018).

Table 4-1 Location and details of bores sampled during field survey

Bore[1]	Latitude (GDA94)	Longitude (GDA94)
Eh-s01rev2	-24.843551	120.287592
Eh-s02	-24.848705	120.275862
Eh-s04	-24.840531	120.326679
Eh-s06	-24.855261	120.244278
Eh-s07	-24.88272	120.316525
Eh-s08	-24.86802	120.306732
Eh-s09rev2	-24.849543	120.302162
Eh-s10	-24.883832	120.300343
Eh-s11	-24.894481	120.291174
Eh-s12	-24.876179	120.333828
Eh-s13	-24.907215	120.284345
Eh-s14	-24.9151	120.290942
Eh-s15	-24.916503	120.305731
Eh-s16	-24.95356	120.259036
Eh-s17	-24.951664	120.242833
Eh-s18	-24.929697	120.261993
Eh-s19	-24.840021	120.338042
Eh-s20	-24.848847	120.33766
Eh-s21	-24.858137	120.337743
Eh-s22-150	-24.867083	120.327405
Eh-s22-65	-24.86697	120.327382

Bore[1]	Latitude (GDA94)	Longitude (GDA94)
Eh-s23	-24.873418	120.32037
Eh-s24	-24.974245	120.213893
Eh-s25	-24.977427	120.187247
Eh-s27	-24.993937	120.163895
Eh-s29rev2	-24.994793	120.232627
Eh-s30rev2	-24.947889	120.223889
Eh-w01rev2	-24.775306	120.160487
Eh-w02	-24.759997	120.18467
Eh-w03rev2	-24.776936	120.075529
Eh-w05	-24.747906	120.146118
Eh-w09	-24.778928	120.133434
Eh-w10	-24.78094	120.118884
Eh-w11rev2	-24.771878	120.180117
Garden Well	-21.780868	120.59129
KMB01	-24.756181	119.603624
KMB02	-24.767098	119.607253
KMB03	-24.79295	119.60868
KPB01	-24.752743	119.60449
Oppbore01	-24.785981	120.163005
TMAC09	-24.831019	120.357785
TMAC11	-24.812904	120.338645
TMAC16	-24.800954	120.349645
TMAC23	-24.809518	120.338262
TMAC24	-24.823423	120.34696
TMAC26	-24.814188	120.356868
Tupee Well	-24.660603	120.054702
WB09MBD	-24.802752	120.334017

[1] sites shaded grey were also sampled in the Level 1 survey in March 2017 (Phoenix 2018).

Figure 4-1
Location of bores sampled during field survey

Freshwater Development Envelope

Level 2 stygofauna survey sites

Pilot study survey sites (March 2017) (Phoenix 2018)

Level 2 stygofauna survey sites

Level 2 stygofauna survey sites

0 4 8 16
Kilometres
1:377,194

Client: Kalium Lakes Ltd
Project: Beyondie Sulphate of Potash Project

Author: AL
Date: 04-May-18

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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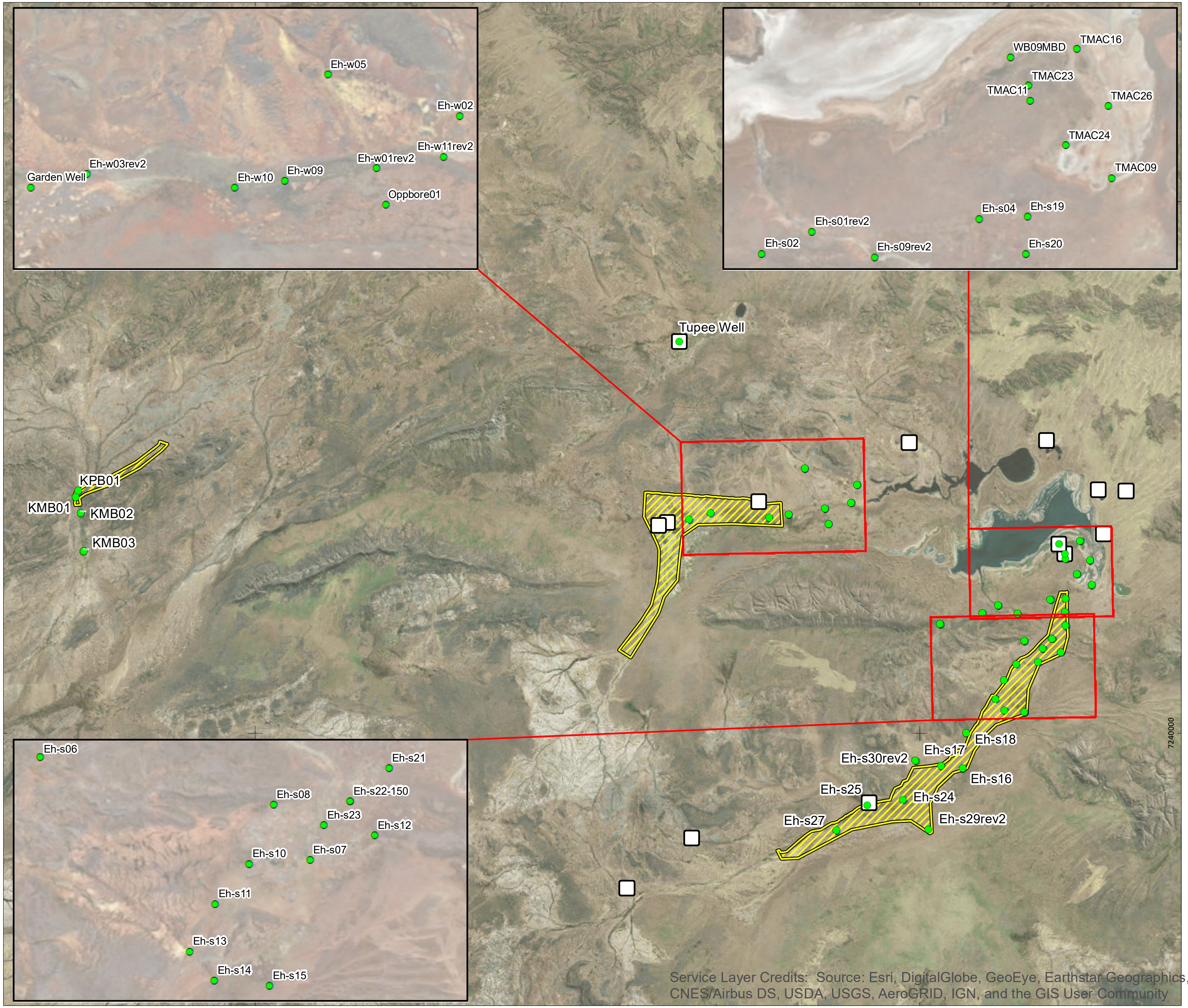


4.2.2 Fauna sampling

The Level 2 stygofauna survey used 50 µm weighted nets (diameter 90 mm or 150 mm as required based on bore diameter) to perform four stygofauna hauls. After the net was lowered to the bottom of each bore, it was used to briefly stir up sediments and their benthic inhabitants.

After each haul, the strained content was rinsed into a 120 ml plastic vial by squirting 100% ethanol down the sides of the net and around the rim of the weight, washing the sample contents into a jug, and transferred from the jug to the vial. If not already full, the sample vial was topped up with 100% ethanol. Vials were then placed in iced eskies while in the field and for transport to the Perth laboratory.

The net was thoroughly rinsed in freshwater after each sample to avoid cross-contamination of samples.

Once received in Perth samples were stored in a refrigerator in the laboratory, where they were sorted and specimens identified using high-magnification stereo-microscopes.

4.2.3 Bore and water quality data

At each bore, total depth (m) and depth to groundwater (m) were measured. Water quality parameters were measured with a YSP multiprobe in a water sample bailed up from the bore and included:

- temperature (°C)
- dissolved Oxygen (%)
- dissolved Oxygen (mg/L)
- conductivity (µs/cm)
- salinity (ppt)
- pH
- oxygen reduction potential (mV).

4.2.4 Morphological species identifications

External taxonomists were used to identify specimens from taxonomic groups which are known to have stygofaunal representatives (Table 4-2). Some of these were identified to species level (Ostracods and Copepods) to determine if they were stygobitic.

4.2.5 Molecular identifications

The identification of species based on comparisons between DNA sequences is referred to as DNA barcoding and is an expected identification tool in survey of subterranean fauna (EPA 2016a). Any gene can be used for barcoding purposes; however, the primary gene targeted is Cytochrome Oxidase Subunit I (COI) (Hebert *et al.* 2003).

Molecular identifications were conducted by Helix Molecular Solutions, based at the School of Biological Sciences, University of Western Australia (Table 4-2).

4.3 PROJECT PERSONNEL

The personnel involved in the survey are presented (Table 4-2).

Table 4-2 Project team

Name	Qualifications	Role/s
Mr Jarrad Clark	B.Sc. (Env. Sci.)	Project manager
Ms Karen Crews	B.Sc. (Env. Sci.) (Hons)	Report review
Ms Anna Leung	BSc. (Env. Sci.) (Hons)	Lab work, report writing, GIS
Mr Ryan Ellis	B.Sc. (Biology)	Field survey, lab work
Mr Tim Sachse	B.Sc. (Biology)	Field survey
Giulia Perini		Taxonomy (Syncarida)
Ms Jane McRae[1]		Taxonomy (Amphipoda)
Stuart Halse[1]	Ph.D.	Taxonomy (Copepoda, Ostracoda)
Ms Yvette Hitchen[2]		Molecular analyses (laboratory)
Dr Terrie Finston[2]	Ph.D.	Molecular analyses (analyses, report writing)

1 – Bennelongia; 2 – Helix Molecular Solutions.

5 RESULTS

5.1 DESKTOP REVIEW

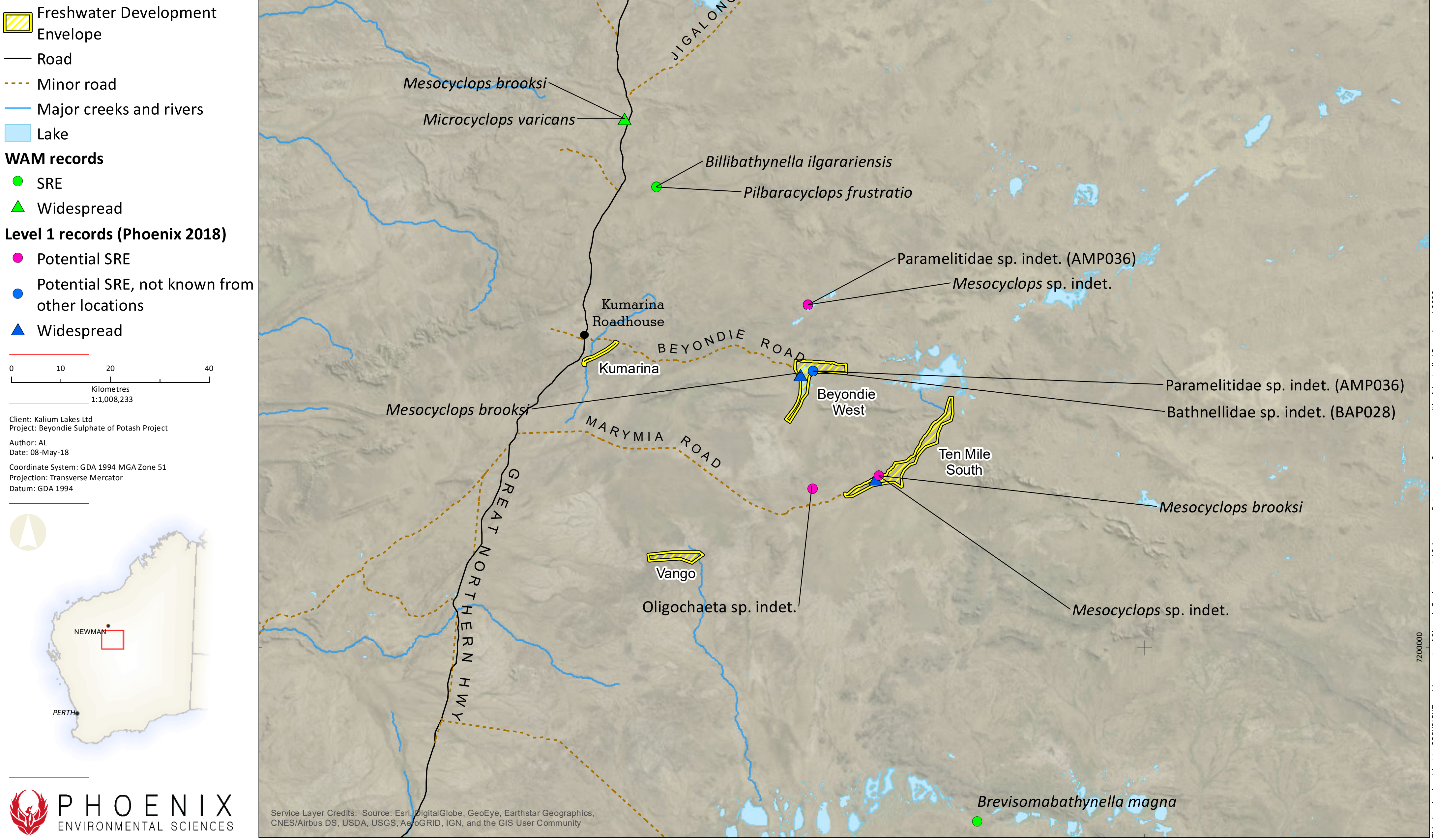
The desktop review (Phoenix 2015) identified a paucity of species in the vicinity of the Project area with seven species identified as potentially occurring of which two are potential SREs (Figure 5-1). The Level 1 survey conducted in March 2017 (Phoenix 2018) recorded three species of stygofauna: an amphipod, Paramelitidae sp. indet. (AMP036), a syncarid, Parabathynellidae (BAP028), and a copepod (*Mesocyclops brooksi*) (Table 5-1; Figure 5-1).

The amphipod and syncarid have not been recorded anywhere else and the copepod is known from a wide distribution throughout WA. Two taxa could not be identified due to life-stage and/or difficulty in identification (Table 5-1). Representatives of these two taxa are known to inhabit both underground water and surface water environments.

Table 5-1 Stygofauna recorded in the Level 1 survey (Phoenix 2018)

Higher order	Genus and species	Ecotype	SRE rating	Site
Amphipoda	Paramelitidae sp. indet. (AMP036)	Stygobitic	Potential	Garden Well, Tupee Well
Syncarida	Parabathynellidae sp. indet. (BAP028)	Stygobitic	Potential	Garden Well
Copepoda	*Mesocyclops brooksi*	Stygophile	Widespread	Beyondie Bore, No. 77 East Well
Copepoda	*Mesocyclops* sp. indet.	Unknown; immature specimens	Unknown	No. 77 East Well, Tupee Well
Oligochaeta	Oligochaeta sp. indet.	Unknown	Unknown	Broken Leg bore

Figure 5-1
Subterranean fauna records from the desktop review and Level 1 survey (Phoenix 2018)



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5.2 FIELD SURVEY

5.2.1 Water quality

Water quality parameters varied greatly between bores, in particular with respect to salinity (Table 5-2). Mean salinity (ppt) was subsaline 11.2 ppt. Thirteen bores had freshwater, 19 were subsaline, nine hyposaline, two mesosaline and five hypersaline.

Water in most (42 of the 48 bores; 87.5%) was slightly alkaline (7.02-7.94), while five were slightly acidic (6.04 – 6.86) and one was acidic (5.16) (Table 5-2). Mean Ph was an alkaline 7.25. Mean dissolved oxygen concentration (% saturation) was just above 20% and as high as 162%.

Table 5-2 Water quality data for sampled bores

Bore	Temperature (°C)	Dissolved Oxygen (%)	Conductivity (µs/cm)	Salinity (ppt)[1]	pH	Oxygen Reduction Potential (mV)
Eh-s01rev2	30.1	7.7	30,117	16.77	7.55	-334.8
Eh-s02	28.4	4.6	1,310	0.61	7.14	2.1
Eh-s04	28.5	12.4	6,231	3.11	7.86	73
Eh-s06	27.8	9.6	796	0.37	7.22	-120.9
Eh-s07	29.1	8.2	2,891	1.38	7.25	83.4
Eh-s08	28.9	21.1	3,828	1.86	7.79	104
Eh-s09rev2	29.8	10.8	3,900	1.86	7.74	51.3
Eh-s10	26.9	5.8	2,148	1.05	7.29	48.7
Eh-s11	27.6	7.2	693	0.32	7.06	-98.7
Eh-s12	27.7	5.7	5,292	2.7	7.34	-155
Eh-s13	28.2	12.1	552	0.25	6.53	-20.9
Eh-s14	28.6	9.9	1,549	0.72	7.03	-96.8
Eh-s15	29.2	38.2	1,707	0.79	7.05	134.9
Eh-s16	28.7	45.3	1,014	0.46	7.06	141.8
Eh-s17	29.3	9	391	0.17	5.16	44.6
Eh-s18	28.7	9.2	819	0.37	6.32	-66.7
Eh-s19	28.8	9.9	12,318	6.52	7.94	111.5
Eh-s20	29.4	12.2	4,187	2.02	7.34	-96
Eh-s21	28.2	32.5	2,049	0.97	7.4	72.9
Eh-s22-150	28.3	48.3	2,023	0.96	7.49	113.2
Eh-s22-65	27.9	7.8	3,049	1.49	7.23	116.1
Eh-s23	28.6	26.9	2,604	1.25	7.23	94.5
Eh-s24	28.3	7.9	1,027	0.47	7.09	173.3
Eh-s25	29.2	162	1,649	0.76	7.02	172.3
Eh-s27	27.6	49	791	0.36	7.58	141.4
Eh-s29rev2	29.2	10.2	1,916	0.89	7.04	170.2

Bore	Temperature (°C)	Dissolved Oxygen (%)	Conductivity (µs/cm)	Salinity (ppt)[1]	pH	Oxygen Reduction Potential (mV)
Eh-s30rev2	28.9	7.3	260	0.11	6.04	39.6
Eh-w01rev2	28.7	9.3	20,274	11.18	7.36	110.1
Eh-w02	28	10	26,317	15.07	7.24	49.9
Eh-w03rev2	28.8	8.8	598	0.27	6.86	-70.7
Eh-w05	27.7	31.6	2,880	1.41	7.31	117
Eh-w09	27.7	7.9	23,882	13.66	7.29	105.1
Eh-w10	27.9	8	2,545	1.23	7.18	-79.6
Eh-w11rev2	30.3	7.7	102,235	66.43	7.2	-144.7
Garden Well	27.9	16.6	976	0.46	6.82	108.7
KMB01	28.9	12.9	3,158	1.52	7.41	122.6
KMB02	27	82.9	626	0.29	7.88	118.5
KMB03	28.8	19.6	559	0.25	7.37	92.2
KPB01	29.2	11.9	2,703	1.27	7.25	129.1
Oppbore01	30.5	73.6	6,611	3.22	7.74	129
TMAC09	27.1	6.9	111,969	79.3	7.66	99.6
TMAC11	28.3	5.2	64,950	40.99	7.48	-324.6
TMAC16	26	5.5	65,107	43.16	7.44	119.1
TMAC23	28	11.1	10,509	6.56	7.74	-19.8
TMAC24	27.1	10.6	92,304	62.99	7.66	127.4
TMAC26	25.9	10.6	104,746	75.68	7.32	117.5
Tupee Well	26.7	18	5,976	3.11	7.57	106.3
Wb09MBD	27.3	14.2	88,621	59.92	7.43	61.4
Mean	**28.33**	**20.29**	**17,694.26**	**11.18**	**7.25**	**39.67**
Minimum	**25.90**	**4.60**	**260.00**	**0.11**	**5.16**	**334.80**
Maximum	**30.50**	**162.00**	**111,969.00**	**79.30**	**7.94**	**173.30**

1 – Salinity (Hammer 1986): <0.5 – freshwater; 0.5–3 ppt – subsaline; 3–20 ppt – hyposaline; 20–50 ppt – mesosaline; >50 ppt – hypersaline

5.2.2 Stygofauna

A total of ten distinct stygofauna taxa were recorded during the current field survey (Table 5-3; Figure 5-2); however, some of the taxa (*Cyclopoida* sp. indet. (juvenile) and *Candonopsis* sp.) remain unresolved and may represent species of surface water inhabitants.

Two species of amphipod Paramelitidae sp. indet. (AMP039), Paramelitidae sp. indet. (AMP040), syncarid (Parabathynellidae sp. indet. (BAP018) and Parabathynellidae sp. indet. (BAP019), copepod (*Dussartcyclops* sp. B13 and Nr. *Fierscyclops* sp. B01) and one species of ostracod (Cyprididae *gen. nov.* sp. BOS1090) have not been recorded elsewhere and are potentially SREs.

One taxa of copepod (*Cyclopoida* sp. indet. (juvenile)), ostracod (*Candonopsis* sp.) and Oligochaeta (Oligochaeta sp. indet.) remain unresolved taxonomically, the ecotype and SRE status of these taxa are therefore unknown. One species of stygofauna (*Fierscyclops fiersi*) is known to be widespread (De Laurentiis *et al.* 2001).

Stygofauna were recorded from 11 of 48 bores sampled (23%), with between one and five taxa recorded in each bore (mean = 2.2 taxa) (Table 5-4).

5.2.2.1 Kumarina FDE area

Within the Kumarina FDE area, two bores of four sampled recorded stygofauna, KPB01 and KMB01 (50% recovery). These were the most speciose recorded in the current survey, with five and four taxa, respectively (Table 5-4). These bores shared two taxa Paramelitidae sp. indet. (AMP040) and *Dussartcyclops* sp. B13) as well as one unresolved taxa, Parabathynellidae sp. indet. (a group that typically requires more permeable sediment to disperse widely; EPA 2016a; Halse *et al.* 2014) (Figure 5-2). *Dussartcyclops* sp. B13 was also recorded over 70 km to the east within the Ten Mile FDE area.

Bores KPB01 and KMB01 are located in the upper reaches of the Gascoyne River, with KMB01 being approximately 400 m downstream of KPB01 (Figure 4-1). Both are also downstream of numerous pastoral bores (Jaydinnia Bore, Woods Folly Bore, Snell Well, Main Yard bore, Mock Pool Bore, all within 10 km) and a large Main Roads production bore, that are in use but were not sampled.

The drill hole logs for these two bores recorded gravel, sand and calcrete to around 10 metres below ground level (mbgl). At KMB01, no sample was returned from 11-30 m suggesting large voids were present. At KPB01 highly impermeable mudstone was recorded from 10 mbgl. While there were voids recorded at KMB01 from 11-30 mbgl, alluvial gravel and sand sat above the (presumably calcrete) voids, while at KPB01 the 5 m inundated sequence of calcrete/alluvium gave way to impermeable mudstone from 10 mbgl.

Together, the logs for KPB01 and KMB01 suggest that while calcrete is present, in both it is not necessarily a constraint to either the larger syncarid and amphipod species or the more mobile, smaller copepods, ostracods and oligochaetes. Interestingly the two other bores sampled here, KMB02 and KMB03 are found within geology that is typically favourable for stygofauna (Qa - Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted) and failed to collect any stygobitic specimens.

5.2.2.2 Ten Mile South FDE area

The Ten Mile South FDE area was the most sampled, with 34 bores sampled and six yielding stygofauna (17% recovery). Bores Eh-s23 and Eh-s07 were the most speciose with three taxa each recorded (Table 5-4). Both recorded Paramelitidae sp. indet. (AMP039) and Nr. *Fierscyclops* (New Genus?) sp. B01. Bore Eh-s22-150 also recorded Nr. *Fierscyclops* (New Genus?) sp. B01 and Eh-s22-65 recorded the widespread *Dussartcyclops* sp. B13. Cyprididae gen. nov. sp. BOS1090 was restricted to a single bore (Eh-s23) (Figure 5-2). These four bores (Eh-s23 Eh-s07, Eh-s22-150 and Eh-s22-65) were located within the Czk geological unit ('massive calcrete').

The remaining two bores that yielded stygofauna (Eh-s11 and Eh-s13) recorded Oligochaeta sp. indet. These bores were in a large, broad floodplain (Qa - Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted) (Figure 3-3).

The drill log data from these bores however suggest the six bores that recorded stygofauna reside in surface geology that is more similar than suggested by the 1:250,000 surface geology maps (Figure 3-3; Table 5-4). All logs recorded a relatively similar alluvium and silcrete/calcrete sequences from 0-17m, after which depth less permeable clays dominate.

The drill logs for the two most speciose bores, Eh-s07 and Ehs23, also suggest that while calcretes are present, they are not likely to be restricting stygofauna habitation. For example, at Eh-s07 less permeable calcrete/silcrete is inundated for 8 mbgl (4-12 mbgl), before permeable sandstone extends from 12-22 mbgl. Similarly, at Eh-s23 a relatively thin 5 m thick saturated layer of less permeable silcrete/calcrete is sandwiched between permeable sand (0-1m) and alluvium (6-17 mbgl) before far less permeable clay occurs from 17 mbgl.

Together, this data suggests the stygofauna community in the Ten Mile FDE area, particularly the typically less mobile amphipod and ostracod taxa (Halse *et al.* 2014), may be more widely distributed than is currently known, most likely extending to the southwest along the floodplain that feeds the massive calcrete formation that forms the southern boundary of Ten Mile Lake. However, this assumption is considered less certain than for the Kumarina and Beyondie West FDE areas.

5.2.2.3 Beyondie West FDE area

Ten bores nominally associated with the Beyondie West FDE area were sampled in the current survey and three recorded stygofauna (30% recovery); two of which are outside the FDE boundary (Figure 5-2). Four were sampled in Level 1 survey (Phoenix 2018), with one bore yielding stygofauna; however, only Garden Well was within the Beyondie West FDE area (Figure 4-1). Together they recorded three species with bores Oppbore01 and Eh-w01rev2 both recording the widespread *Fierscyclops fiersi* (Figure 5-2).

Bore Eh-w01rev2 is the only bore in Beyondie West with an available drill log and which recorded a thin 4 m thick saturated calcrete sequence sitting above a clay sequence from 9-32 mbgl (Table 5-4). However, the surface geology map (Figure 3-3) suggests calcrete is also likely to feature at Oppbore01 (Czk – massive calcrete). Garden Well is located within a quaternary alluvial deposit. In the current survey it recorded Oligochaeta sp. indet. and in the Level 1 survey (Phoenix 2018) it recorded Paramelitidae sp. indet. (AMP036) and Parabathynellidae sp. indet. (BAP028). Paramelitidae sp. indet. (AMP036) was also recorded at Tupee Well in the Level 1 survey (Phoenix 2018), approximately 15 km north of Garden Well.

The data suggests that the stygofauna community in the vicinity of the Beyondie West FDE area is widespread, given the presence of the widely distributed *Fierscyclops fiersi* and more importantly, Paramelitidae sp. indet. (AMP036) which is presumably a response to the highly permeable, alluvial nature of the geology.

5.2.2.4 Vango FDE area

The Vango FDE area was not sampled in the current survey because no bores have been drilled. Here Kalium proposes to take water from the old Plutonic gold mine pits. Vango have already commenced dewatering the pit(s) associated with the K2 deposit.

Table 5-3 Stygofauna fauna collected during the current field survey and Level 1 survey (Phoenix 2018) (shaded cells)

Higher order	Genus and species	Ecotype	SRE rating	FDE														
				Kumarina		Beyondie West					Ten Mile South							None
				KMB01	KPB01	Eh-w01rev2	Oppbore01	Garden Well Bore	Tupee Well	Beyondie Bore	Eh-s07	Eh-s11	Eh-s13	Eh-s23	Eh-s22-65	Eh-s22-150	No.77 East Well	Broken Leg Bore
Amphipoda																		
Paramelitidae	Paramelitidae sp. indet. (AMP036)							•	•									
Paramelitidae	Paramelitidae sp. indet. (AMP039)	Stygobitic	Potential								•			•				
Paramelitidae	Paramelitidae sp. indet. (AMP040)	Stygobitic	Potential	•	•													
Syncarida																		
Parabathynellidae	Parabathynellidae sp. indet. (BAP018)	Stygobitic	Potential				•											
Parabathynellidae	Parabathynellidae sp. indet. (BAP019)	Stygobitic	Potential	•														
Parabathynellidae	Parabathynellidae sp. indet. (BAP028)	Stygobitic	Potential					•										
Parabathynellidae	Parabathynellidae sp. indet.	Stygobitic	Potential		•													
Copepoda																		
Cyclopoida	*Dussartcyclops* sp. B13	Stygobitic	Potential	•	•						•				•			
Cyclopoida	*Fierscyclops fiersi*	Stygobitic	Widespread			•	•											
Cyclopoida	*Cyclopoida* sp. indet. (Juvenile)	Unknown	Potential	•														
Cyclopoida	Nr. *Fierscyclops* sp. B01	Stygobitic	Potential								•			•		•		
Cyclopoida	*Mesocyclops brooksi*	Stygophile	Widespread							•							•	
Cyclopoida	*Mesocyclops sp. Indet.*	Unknown	Unknown						•								•	
Ostracoda																		
Cyprididae	Cyprididae *gen. nov.* sp. BOS1090	Stygobitic	Potential											•				
Candonidae	*Candonopsis* sp.	Unknown	Potential		•													

Higher order	Genus and species	Ecotype	SRE rating	FDE														
				Kumarina		Beyondie West					Ten Mile South							None
				KMB01	KPB01	Eh-w01rev2	Oppbore01	Garden Well Bore	Tupee Well	Beyondie Bore	Eh-s07	Eh-s11	Eh-s13	Eh-s23	Eh-s22-65	Eh-s22-150	No.77 East Well	Broken Leg Bore
Oligochaeta (worms)																		
Oligochaeta	Oligochaeta sp. indet.	Unknown	Widespread		•							•	•			•		•
Diversity				**4**	**5**	**1**	**2**	**2**	**2**	**1**	**3**	**1**	**1**	**3**	**1**	**2**	**2**	**1**

Table 5-4 Stygofauna records in current survey, drill log and depth to water data with respect to each FDE area

FDE area	Bore	Species	Depth to water (m)	Geology	Diversity
Kumarina	KMB01	Paramelitidae sp. indet. (AMP040)	2.72	Gravel/sand (0-11m)	**4**
		Parabathynellidae sp. indet. (BAP019)		Voids (11-30m)	
		Dussartcyclops sp. B13			
		Cyclopoida sp. indet. (Juvenile)			
	KPB01	Paramelitidae sp. indet. (AMP040)	4.7	Calcrete/alluvium (0-10m)	**5**
		Parabathynellidae sp. indet.		Weathered mudstone and calcrete (10-13m)	
		Dussartcyclops sp. B13		*Mudstone (13-31m)*	
		Candonopsis sp.			
		Oligochaeta sp. indet.			
Ten Mile South	Eh-s07	Paramelitidae sp. indet. (AMP039)	4.1	Calcrete/silcrete (0-12m)	**3**
		Dussartcyclops sp. B13		Sandstone (12-22m)	
		Nr. *Fierscyclops* (New Genus?) sp. B01		Shale (22-28m)	
	Eh-s11	Oligochaeta sp. indet.	5.2	Sand (0-2m)	**1**
				Silcrete (2-6m)	

FDE area	Bore	Species	Depth to water (m)	Geology	Diversity
				Clay and mudstone (6-13m)	
	Eh-s13	Oligochaeta sp. indet.	7.53	Alluvium (0-18m) then mudstone (18-21m)	**1**
	Eh-s22-150	Nr. *Fierscyclops* (New Genus?) sp. B01	10.1	Silcrete/Calcrete (0-8m) – not inundated	**2**
		Oligochaeta sp. indet.		Alluvium (8-19m)	
				Clay (19-20m)	
	Eh-s22-65	*Dussartcyclops* sp. B13	10.1	Silcrete/Calcrete (0-8m)	**1**
				Alluvium (8-19m)	
				Clay (19-20m)	
	Eh-s23	Paramelitidae sp. indet. (AMP039)	2.47	Sand (0-1m)	**3**
		Nr. *Fierscyclops* (New Genus?) sp. B01		Silcrete/Calcrete (1-6m)	
		Cyprididae *gen. nov.* sp. BOS1090		Alluvium (6-17m)	
				Clay (>17m)	
Beyondie West	Oppbore01	Parabathynellidae sp. indet. (BAP018)	7	Unknown	**2**
		Fierscyclops fiersi			
	Garden Well	Oligochaeta sp. indet.		Unknown	**1**
	Eh-w01rev2	*Fierscyclops fiersi*	5	Alluvium (0-2m)	**1**
				Calcrete (2-9m)	
				Clay (9-32m)	

Figure 5–2 Stygofauna collected during the field survey

Freshwater Development Envelope

Stygofauna recorded from the survey

Stygofauna recorded from the pilot study in March 2017 (Phoenix 2018)

0 2.75 5.5 11 Kilometres

1:350,000

Client: Kalium Lakes Ltd
Project: Beyondie Sulphate of Potash Project

Author: AL
Date: 04-May-18

Coordinate System: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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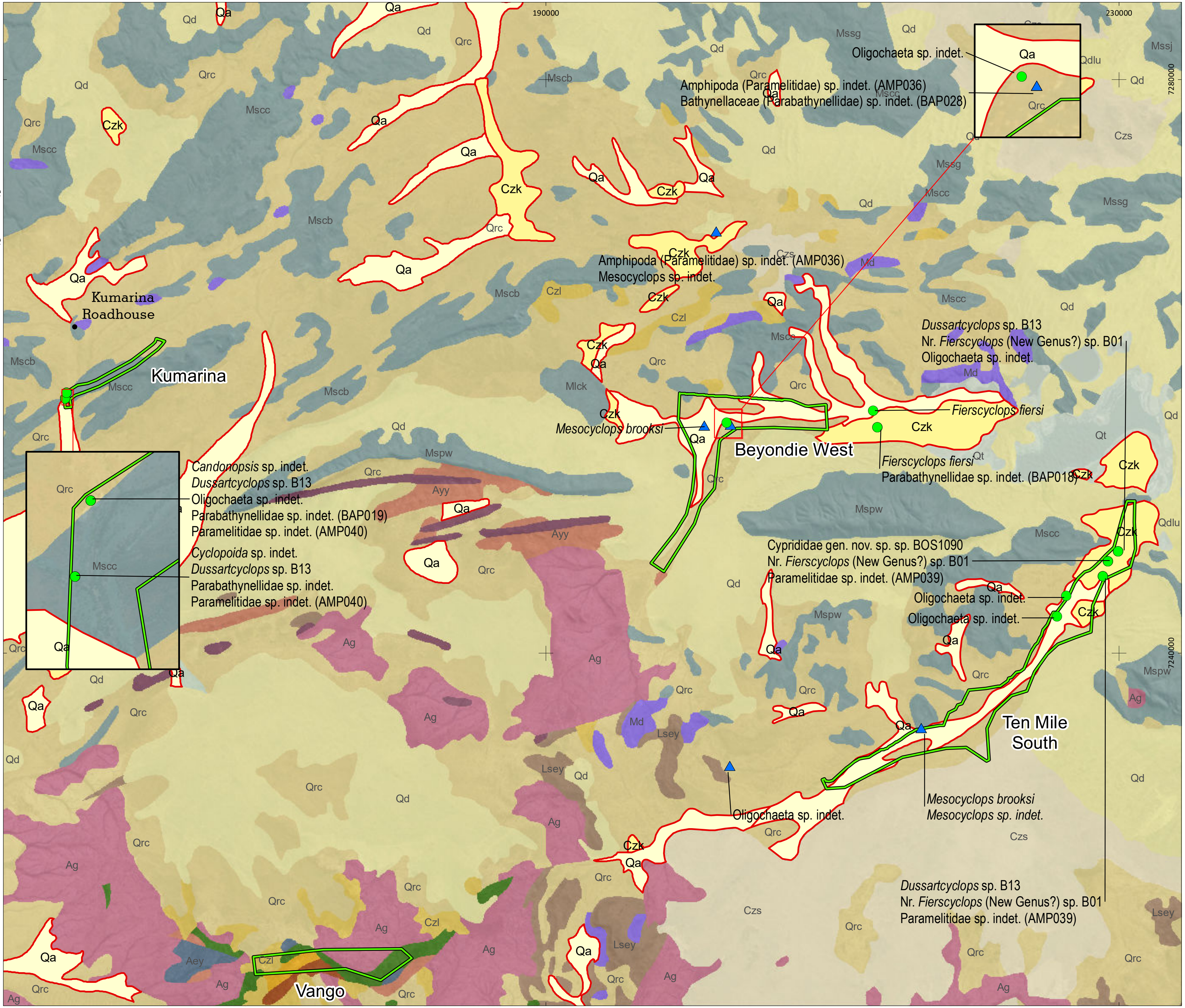

5.2.2.5 Amphipod (amphipods)

There is a considerable diversity of subterranean amphipods world-wide (Holsinger 1993). The WA fauna includes members of a number of families, such as Melitidae, Neoniphargidae, Paramelitidae, Bogidiellidae and others (Bradbury 2002; Bradbury & Williams 1997). Calcrete aquifers of the Yilgarn host a highly diverse amphipod fauna within the Hyalidae and Paramelitidae (Cooper *et al.* 2007).

Two stygobitic amphipod taxa were collected from four bores (Eh-s23, Eh-s07, KMB01 and KPB01) (Table 5-3; Table 5-4). Representatives from all four bores were submitted for molecular analyses and were all successfully sequenced. Two genetically distinct lineages both belonging to the family Paramelitidae were detected, with one lineage from bores Eh-s23 and Eh-s07 (Paramelitidae sp. indet. (AMP039)), and the other from KMBs 01 and 04 (Paramelitidae sp. indet. (AMP040)).

Neither of these species were matched to the species that was recorded in the Level 1 survey, Paramelitidae sp. (AMP036), which was found at Garden Well and Tupee Well (15 km to the north of Garden Well).

Phylogenetic analysis of the sequenced specimens with 70 reference sequences showed the lineage of the sequenced specimens differed from reference specimens by >14% sequence divergence, including the lineage detected in the Level 1 survey, indicating they represent species that have not previously been recorded in WA. The two species collected in the current survey were slightly more closely related to each other than the specimens collected in the Level 1 survey (Phoenix 2018) despite Paramelitidae sp. indet. (AMP036) being geographically closer to Paramelitidae sp. indet. AMP039.

Morphologic identifications placed these specimens near to the genus *Kruptus* which show some similar morphologic characteristics. Genetic analysis most closely groups the specimens with representatives from the genus of *Yilgarus* (three species) and lower similarities with a species of *Kruptus* and Niphargidae. Genetic and morphological disagreement in stygofauna is common because their limited dispersal capabilities (particularly for groups such as the Amphipoda) result in significant genetic structuring (Halse *et al.* 2014).

5.2.2.6 Syncarida (syncarids)

Syncarid crustaceans are often confined to subterranean environments. They are considered rare and difficult to collect and therefore very little is known about the biology and relationships (Abrams *et al.* 2013). They are regularly collected in calcretes of the Yilgarn and Pilbara cratons (Cho & Humphreys 2010; Guzik *et al.* 2008).

Syncarids were collected from three bores in the current survey (OppBore01, KMB01 and KPB01) and one bore (Garden Well) in 2017 (Phoenix 2018). Representatives from all three bores were submitted for molecular analyses and two of three specimens were successfully sequenced. Two lineages belonging to the family Parabathynellidae were detected, with one lineage from OppBore01 (Parabathynellidae sp. indet. BAP018), and one KMB01 (Parabathynellidae sp. indet. (BAP019)). Molecular analysis of the specimen from KPB01 was unsuccessful, therefore it is not clear if it belongs to either of the sequenced species.

Neither of the successfully sequenced species were matched to the species that was recorded in the Level 1 survey (Parabathynellidae sp. indet. BAP028), which was found at Garden Well (Figure 5-2).

Phylogenetic analysis of the sequenced specimens and 48 reference sequences showed the lineage of the sequenced specimens differed from reference specimens by >14% sequence divergence, including the lineage detected in the Level 1 survey (Phoenix 2018), indicating they represent a species that has not previously been recorded in WA. The two species collected in the current survey were more closely related to each other than the specimens collected in the Level 1 survey; despite BAP028 being geographically closer to Parabathynellidae sp. indet. BAP018, on the same drainage system ~11 km to the east.

Morphologic identifications placed these specimens near to the genus *Billibathynella* which showed some similar morphologic characteristics. Genetic analysis most closely grouped the specimens with the species *Iberobathynella cantabriensis* (Paramelitidae) and lower similarities with the genus *Billibathynella*. Two parabathynellids were recorded in the desktop review, *Billibathynella ilgarariensis* and *Brevisobathynella magna* (Table 5-1; Figure 5-1). Both are currently only known from their type localities, ca. 65 km north-west and approximately 95 km south of the study area, respectively (Figure 5-1) (Cho & Humphreys 2010; Hong & Cho 2009).

5.2.2.7 Copepoda (copepods)

Copepods are microscopic teardrop-shaped crustaceans that are common in freshwater and saline wetlands (Maly *et al.* 1997; Stoch 2001). The also from a considerable element of subterranean stygofauna in WA (Karanovic 2006).

Three potential SRE taxa were collected from the survey of which one of these has unresolved taxonomy and may represent one of the other two species which have not been collected before. One species is known to be widespread (*Fierscyclops fiersi*).

Dussartcyclops sp. B13 is a cyclopoid copepod and was collected from bores Eh-s22-65, Eh-s07, KMB01 and KPB01. This species was not collected in the Level 1 survey (Phoenix 2018) and is not known from any other locations.

Near *Fierscyclops* sp. B01 (new genus?) is a cyclopoid copepod which has similar morphologic characteristics to the genus of *Fierscyclops*. This species was collected at bores Eh-s22-150, Eh-s07 and Eh-s23 and was not collected in the Level 1 survey (Phoenix 2018) and is not known from any other locations.

Cyclopoida sp. indet. was collected at KMB01; however, it was a juvenile and could not be identified any further. It may represent another known species collected in the current survey, Level 1 survey or desktop study.

Fierscyclops fiersi was collected at bores Eh-w01rev2 and OppBore01 and is a known widespread species. It has been collected at other locations such as Lake Way and Lake Maitland, approximately 200 km south of the study area (OES 2012).

Three subterranean species of copepods were identified in the desktop review, including one species only known from a single locality, *Pilbaracyclops frustratio* from approximately 65 km north-west of the study area (Table 5-1; Figure 5-1). One widespread species (*Mesocyclops brooksi*) and one potential SRE taxa (*Mesocyclops* sp. indet.) was collected from the Level 1 survey but were not recollected.

5.2.2.8 Ostracoda (ostracods)

Ostracods are small bivalve crustaceans that are commonly referred to as seed shrimps (Williams 1981). The ostracod fauna is very diverse, with numerous epigean and subterranean species known (Eberhard *et al.* 2005).

Two potential SRE stygofaunal ostracods were collected from the survey, one of which is not known from any other locations (Cyprididae *gen. nov.* sp. BOS1090) and the other has unresolved taxonomy and may not be stygobitic (*Candonopsis* sp.) (Table 5-3; Table 5-4).

Cyprididae gen. nov. sp. BOS1090 was collected from bore Eh-s23 and was not collected during the Level 1 survey and is not known from any other locations. A genus could not be allocated and this taxon may represent a new genus for the family Cyprididae.

Candonopsis sp. indet. was collected from KPB01 and this genus is known to include both stygofaunal and surface water representatives and includes both widespread and SRE taxa. Specimens from the genus *Candonopsis* were not collected in the Level 1 survey (Phoenix 2018) or recorded from the desktop study (Phoenix 2015).

One ostracod species was identified from the desktop review, *Cyprinotus cingalensis* and *Deminutiocandona quasimica*, both potential SREs (Phoenix 2015).

5.2.2.9 Oligochaeta (worms)

Oligochaetes are annelid worms that inhabit a variety of habitats including subterranean waterbodies. They are commonly collected in stygofauna surveys and are generally very widely distributed (in the Pilbara, but also here; Halse *et al.* 2014), but the taxonomy of this group remains poorly understood with few described species.

Oligochaeta sp. indet. was collected from bores Eh-s11, Eh-s13, Eh-s22-150, Garden Well, and KPB01. This taxon was also collected in the Level 1 survey (Phoenix 2018) from a bore called Broken Leg Bore.

5.3 Survey limitations

The EPA *Technical Guide: Terrestrial fauna surveys* (EPA 2016c) identifies potential limitations that may be encountered during terrestrial fauna surveys. These were applied here as no equivalent guidance with respect to subterranean fauna exists (Table 5-5). With respect to this survey, limited contextual information from around the study area was identified as the main limitation.

Table 5-5 Survey limitations based on EPA Technical Guide: Terrestrial fauna surveys (EPA 2016c)

Limitations	Limitation for this survey?	Comments
Competency/experience of survey personnel, including taxonomy	No	The field and laboratory teams and report authors have extensive experience in survey of subterranean systems in WA. Taxonomically poorly known groups were identified by molecular methods.
Scope and completeness - were all planned survey methods implemented successfully, was the study area fully surveyed	No	Suitable collecting methods were used based on comparable surveys in WA and consistent with Level 2 stygofauna surveys conducted in WA.
Intensity - in retrospect, was the intensity adequate	No	The survey intensity of 48 bores was appropriate for a Level 2 stygofauna survey within the study area.
Proportion of fauna identified, recorded and/or collected	No	Fauna specimens collected match geological and hydrological conditions (i.e. no stygofauna in hypersaline water). All fauna specimens were identified to lowest possible taxonomic level.
Availability of adequate contextual information	Yes	There is good regional contextual information in relation to subterranean surveys in the Goldfields (with respect to the Yilgarn) and Pilbara regions. However, little information was available near the study area (Gascoyne and Little Sandy Desert bioregions) as evidenced by the results of the desktop review.
Timing, weather, season, cycle	No	The survey was conducted at a suitable time of the year after bores had been drilled (at least 6 months), with variable rainfall in the preceding months, some months were much lower and some were much higher but it was still the wet season at the time of survey.
Disturbances which affected the results of the survey	No	No disturbances occurring during the period of the field survey are considered to have impacted the results.
Remoteness and/or access problems	No	There were no access problems in the study area.

6 Discussion

The EPA's objective for subterranean fauna is its protection so that biological diversity and ecological integrity are maintained (EPA 2016a). Subterranean communities are often restricted to very small areas and it is supposed this is based on the limited dispersal capabilities of the fauna, with short-range endemism interpreted at a much smaller scale than in terrestrial systems (Eberhard *et al.* 2009).

The study area is situated in a poorly surveyed area where the eastern Gascoyne and south-western Little Sandy Desert bioregions intercept and where limited contextual information exists (van Leeuwen 2002). This was evident in the poor return from the desktop review that only revealed records of seven stygofaunal species records.

The desktop review findings indicated a high likelihood of occurrence of stygofauna in the FDE (Phoenix 2015). The confirmation of stygofauna presence in the FDE in the subsequent Level 1 survey (Phoenix 2018) and previously recorded near the Project initiated a more comprehensive survey of the study area.

Seven stygofauna taxa collected during the survey were unique to the study area and have not been previously collected from any other survey. Molecular analysis confirmed the amphipods and syncarids from the survey are not conspecific with any previously sequenced species from the Level 1 survey or from WA and therefore represent new species. Four of the taxa were not able to be identified to species level and therefore their SRE status is unknown, but representatives from these groups are known to be potential SREs. One species (*Fierscyclops fiersi*) is known to be widespread. It is noted that the phylogenetic analysis was limited by the lack of reference material from the region.

There appears to be distinct differences in stygofauna assemblages between each of the three FDE areas sampled, with one exception. The copepod *Dussartcyclops* sp. B13 was common to both the Kumarina and Ten Mile South FDE areas, up to 75 km apart.

Three species were found only in the Kumarina FDE area bores KMB01 and KPB01 (Parabathynellidae sp. indet. (BAP019), Paramelitidae sp. indet. (AMP040) and *Candonopsis* sp. indet).

Species that were collected only in the Ten Mile South FDE area bores were Paramelitidae sp. indet. (AMP039), Parabathynellidae sp. indet. (BAP019) (although one specimen from KPB01 was indeterminate) and Nr. *Fierscyclops* (New Genus) sp. B01.

At the Beyondie West FDE area, Parabathynellidae sp. indet. (BAP018) was recorded outside of the proposed drawdown area in the current survey, within an area of massive calcrete (Czk). In the Level 1 survey (Phoenix 2018) the amphipod Paramelitidae sp. indet. (AMP036) was recorded both inside and outside the FDE (15 km north; Figure 5-1). The widespread *Fierscyclops fiersi* and representatives of the typically widespread oligochaete (Halse *et al.* 2014) were also recorded.

The amphipod Paramelitidae sp. indet. (AMP036) and syncarid Parabathynellidae sp. indet. (BAP028) collected from the Level 1 survey (essentially from the Beyondie West FDE area) were not collected in the current survey despite being located between the species collected in the eastern and western parts of the study area.

This situation is not unexpected (i.e. a different stygobitic community in each FDE area and surrounds) as each aquifer is unlikely to be connected. However, the surface geology data and more localised drill log data suggest that within each FDE area the stygofauna community is likely to be more widespread than the extent of the areas sampled.

This is particularly the case for the Kumarina and Beyondie West FDE areas. Here, the dominant surface geologies are alluvial and extend well beyond the FDE boundaries. The drill logs for Kumarina demonstrate that Paramelitidae sp. indet. (AMP040) and *Dussartcyclops* sp. B13 occur within at least two 'habitat types' (e.g. gravel/sand and 'voids' at KMB01 and calcrete/alluvium at KPB01).

While limited drill log data is available with respect to Beyondie West bores that yielded stygofauna, Paramelitidae sp. indet. (AMP036) was found 15 km north in the Level 1 survey (Phoenix 2018), well outside Beyondie West FDE area. The massive calcrete formation (Czk) east of Beyondie West may contain more restricted species, but this area is not currently being targeted.

The situation within the Ten Mile South FDE area is not as clear. Here, taxa included those from typically restricted groups (e.g. amphipods and ostracods; Halse *et al.* 2014) and widespread groups (Oligochaeta and Cyclopoida). The taxa from restricted groups were constained to the southern half of the massive calcrete formation that comprises less than 20% of the FDE. Their absence from the northern half of the formation closer to Ten Mile Lake coincides with significantly higher groundwater salinity and lacustrine sediments. However, to the south, drill logs from the bores in the alluvial flood plain that feeds the calcrete (from which the widespread Oligochaeta sp. indet., *Mesocycplos brooksi* and *Mesocyclops* sp. indet. were recorded) were not unlike those of the calcrete formation. Further, the groups these taxa represent were also recorded within the Kumarina and Beyondie West FDE's, both of which occur in alluvial geologies. Therefore, it is considered possible that the taxa that currently appear to be restricted to the calcrete formation component of the Ten Mile South FDE, may in fact be found to the southwest within the alluvial aquifer.

Despite these local observations however, sample effort has been greatest within the Ten Mile South FDE. And further, calcrete formations (within the Yilgarn Craton in particular) are known to support restricted subterranean fauna species/assemblages in WA. Therefore, at this stage, a precautionary approach to abstraction of water from bores within the southern half of the Ten Mile South calcrete formation is considered prudent until further distributional information is available for several taxa.

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Appendix 1 Conservation significant subterranean fauna in Western Australia (DPaW 2017)

Genus and species	Common name	Troglo-/ stygofauna	Conservation rating (DPaW 2017)	Distribution (DPaW 2017)	Currently known records
Arachnida					
Araneae (spiders)					
Tartarus mullamullangensis	Mullamullalang Cave spider	T	VU	South Coast	Mullamullang Cave, Nullarbor Plain (Gray 1992)
Tartarus murdochensis	Murdoch Sink cave spider	T	VU	South Coast	Phyllistine Flattener Cave and Murdoch Sink, Nullarbor Plain (Gray 1992)
Tartarus nurinensis	Nurina Cave spider	T	VU	South Coast	Nurina Cave, Roe Plains (Gray 1992)
Tartarus thampannensis	Thampanna Cave spider	T	VU	South Coast	Thampanna Cave, Nullarbor Plain (Gray 1992)
Troglodiplura lowryi	Nullarbor cave trapdoor spider	T	VU	South Coast	Roaches Rest Cave and Cave NR. 6 Bore, Nullarbor Plain (Main & Gray 1985)
Pseudoscorpiones					
Ideoblothrus linnaei		T	P1	Pilbara	Mesa A (Harvey & Leng 2008)
Ideoblothrus sp. Mesa A (WAM T81374)		T	P1	Pilbara	Mesa A (Harvey & Edward 2007)
Indohya damocles	Cameron's Cave pseudoscorpion	T	CR	Pilbara	Cameron's Cave, Cape Range (Harvey & Volschenk 2007)
Lagynochthonius asema		T	P1	Pilbara	Mesa A (Edward & Harvey 2008)
Tyrannochthonius sp. Mesa A (WAM T81480)		T	P1	Pilbara	Mesa A
Schizomida					
Bamazomus subsolans	Eastern Cape Range bamazomus	T	EN	Pilbara	Unnamed limestone quarry, Cape Range (Harvey 2001)
Bamazomus vespertinus	western Cape Range bamazomus	T	EN	Pilbara	Cave C-215, Cape Range Peninsula (Harvey 2001)

Genus and species	Common name	Troglo-/ stygofauna	Conservation rating (DPaW 2017)	Distribution (DPaW 2017)	Currently known records
Draculoides bramstokeri	Barrow Island draculoides	T	VU	Pilbara	Barrow Island (Harvey & Humphreys 1995)
Draculoides brooksi	northern Cape Range draculoides	T	EN	Pilbara	North-eastern Cape Range Peninsula (Harvey *et al.* 2008)
Draculoides julianneae	western Cape Range draculoides	T	EN	Pilbara	Caves C-111 and C-215, Cape Range Peninsula (Harvey *et al.* 2008)
Draculoides mesozeirus	Middle Robe draculoides	T	VU	Pilbara	Middle Robe (Harvey *et al.* 2008)
Paradraculoides anachoretus	Mesa A paradraculoides	T	VU	Pilbara	Mesa A (Harvey *et al.* 2008)
Paradraculoides bythius	Mesa B/C paradraculoides	T	VU	Pilbara	Mesa B and Mesa C (Harvey *et al.* 2008)
Paradraculoides gnophicola	Mesa G paradraculoides	T	VU	Pilbara	Mesa G (Harvey *et al.* 2008)
Paradraculoides kryptus	Mesa K paradraculoides	T	VU	Pilbara	Mesa K (Harvey *et al.* 2008)
Myriapoda					
Speleostrophus nesiotes	Barrow Island millipede	T	VU	Pilbara	Barrow Island (Car *et al.* 2013; Hoffman 1994)
Stygiochiropus peculiaris	Cameron's Cave millipede	T	CR	Pilbara	Camerons Cave, Cape Range Peninsula (Shear & Humphreys 1996)
Stygiochiropus isolatus	Millipede	T	VU	Pilbara	Cave C-222, Cape Range Peninsula (Humphreys & Shear 1993)
Stygiochiropus sympatricus	Millipede	T	VU	Pilbara	Cave C-111, Cape Range Peninsula (Humphreys & Shear 1993)
Crustacea					
Amphipoda					
Bogidomma australis	Barrow Island bogidomma amphipod	S	VU	Pilbara	Barrow Island (Bradbury & Williams 1996a)
Hurleya sp. (WAM C23193)	Crystal Cave crangonyctoid amphipod	S	CR	Swan	Crystal Cave, Yanchep

Genus and species	Common name	Troglo-/ stygofauna	Conservation rating (DPaW 2017)	Distribution (DPaW 2017)	Currently known records
Liagoceradocus branchialis	Cape Range liagoceradocus amphipod	S	EN	Pilbara	Bundera Sinkhole, Cape Range Peninsula (Bradbury & Williams 1996b)
Liagoceradocus subthalassicus	Barrow Island liagoceradocus amphipod	S	VU	Pilbara	Ledge Cave B-1, Barrow Island (Bradbury & Williams 1996b)
Nedsia fragilis	Freshwater amphipod	S	VU	Pilbara	Barrow Island (Bradbury & Williams 1996a)
Nedsia humphreysi	Freshwater amphipod	S	VU	Pilbara	Barrow Island (Bradbury & Williams 1996a)
Nedsia hurlberti	Freshwater amphipod	S	VU	Pilbara	Barrow Island (Bradbury & Williams 1996a)
Nedsia macrosculptilis	Freshwater amphipod	S	VU	Pilbara	Barrow Island (Bradbury & Williams 1996a)
Nedsia sculptilis	Freshwater amphipod	S	VU	Pilbara	Barrow Island (Bradbury & Williams 1996a)
Nedsia straskraba	Freshwater amphipod	S	VU	Pilbara	Barrow Island (Bradbury & Williams 1996a)
Nedsia urifimbriata	Freshwater amphipod	S	VU	Pilbara	Barrow Island (Bradbury & Williams 1996a)
Nedsia chevronia	Freshwater amphipod	S	P2	Pilbara	Barrow Island (Bradbury 2002)
Copepoda					
Bunderia misophaga	Copepod	S	CR	Pilbara	Bundera Sinkhole, Cape Range Peninsula (Jaume & Humphreys 2001)
Speleophria bunderae	Copepod	S	CR	Pilbara	Bundera Sinkhole, Cape Range Peninsula (Jaume *et al.* 2001)
Stygocyclopia australis	Copepod	S	CR	Pilbara	Bundera Sinkhole, Cape Range Peninsula (Jaume *et al.* 2001)
Decapoda					
Stygiocaris lancifera	Lance-beaked cave shrimp	S	VU	Pilbara	Cape Range Peninsula (Knott 1993)
Stygiocaris stylifera	Spear-beaked Cave Shrimp	S	P4	Pilbara	Cape Range Peninsula (Knott 1993)
Isopoda					

Genus and species	Common name	Troglo-/ stygofauna	Conservation rating (DPaW 2017)	Distribution (DPaW 2017)	Currently known records
Abebaioscia troglodytes	Pannikin Plain Cave isopod	T	VU	South Coast	Pannikin Plain Cave, Nullarbor Plain (Vandel 1974 [imprint date 1973])
Paraplatyarthrus subterraneus	Poseidon slater	T	P1		Pilbara (Javidkar & King 2015)
Ostracoda					
Welesina kornickeri	Ostracod	S	CR	Pilbara	Bundera Sinkhole, Cape Range Peninsula (Danielopol *et al.* 2000)
Remipedia					
Kumonga exleyi	Cape Range remiped	S	CR	Pilbara	Bundera Sinkhole, Cape Range Peninsula (Yager & Humphreys 1996)
Polychaeta					
Prionospio thalanji	Bristle worm	S	CR	Pilbara	Bundera Sinkhole, Cape Range Peninsula (Wilson & Humphreys 2001)
Insecta					
Blattaria					
Nocticola flabella	Cape Range Blind Cockroach	T	P2	Pilbara	Cape Range Peninsula (Roth 1991)

Appendix 2 Subterranean Threatened Ecological Communities in Western Australia (DPaW 2016a)

Name of community	Description	Category of Threat and criteria met under WA criteria	Conservation Rating (EPBC Act 1999)	
Caves SP01	Aquatic Root Mat Community Number 1 of Caves of the Swan Coastal Plain	CR B) i), CR B) ii)	EN	Swan Coastal Plain
Caves Leeuwin01	Aquatic Root Mat Community Number 1 of Caves of the Leeuwin Naturaliste Ridge	CR B) i), CR B) ii)	EN	Warren
Caves Leeuwin02	Aquatic Root Mat Community Number 2 of Caves of the Leeuwin Naturaliste Ridge	CR B) i), CR B) ii)	EN	Warren
Caves Leeuwin03	Aquatic Root Mat Community Number 3 of Caves of the Leeuwin Naturaliste Ridge	CR B) i), CR B) ii)	EN	Warren
Caves Leeuwin04	Aquatic Root Mat Community Number 4 of Caves of the Leeuwin Naturaliste Ridge	CR B) i), CR B) ii)	EN	Warren
Cameron’s	Cameron’s Cave Troglobitic Community	CR B) i), CR B) ii)		Carnarvon Basin
Bundera	Cape Range Remiped Community	CR B) ii)		Carnarvon Basin
Ethel Gorge	Ethel Gorge aquifer stygobiont community	EN B) ii)		Pilbara
Depot Springs	Depot Springs stygofauna community	VU B)		Goldfields Region, Murchison Bioregion

Appendix 3 Subterranean Priority Ecological Communities in Western Australia (DPaW 2016b)

Name of community	Description	Threats	Category (WA)
Pilbara			
Barrow Island subterranean fauna	Barrow Island stygofauna and troglofauna	Mining and industrial development	Priority 1
Subterranean invertebrate communities of mesas in the Robe Valley region	A series of isolated mesas occur in the Robe Valley in the State's Pilbara region. The mesas are remnants of old valley infill deposits of the palaeo Robe River. The troglobitic faunal communities occur in an extremely specialised habitat and appear to require the particular structure and hydrogeology associated with mesas to provide a suitable humid habitat. Short-range endemism is common in the fauna. The habitat is the humidified pisolitic strata	Mining	Priority 1
Subterranean invertebrate community of pisolitic hills in the Pilbara	A series of isolated low undulating hills occur in the State's Pilbara region. The troglofauna are being identified as having very short-range distributions	Mining	Priority 1
Mingah Springs calcrete groundwater assemblage type on Gascoyne palaeodrainage on Mingah Spring Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Stygofaunal community of the Bungaroo Aquifer	A unique assemblage of aquatic subterranean fauna including eels, snails and other stygofauna	Groundwater drawdown, mining	Priority 1
Stygofaunal communities of the Western Fortescue Plains freshwater aquifer	A unique assemblage of subterranean invertebrate fauna	Groundwater drawdown and salinisation	Priority 4(ii)
Kimberley			
Invertebrate community of Napier Range Cave	On Old Napier Downs, Karst No. KNI	Mine close by and tourist visitation	Priority 1
Midwest			
Badja calcrete groundwater assemblage type on Moore palaeodrainage on Badja Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1

Name of community	Description	Threats	Category (WA)
Belele calcrete groundwater assemblage type on Murchison palaeodrainage on Belele Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Beringarra calcrete groundwater assemblage type on Murchison palaeodrainage on Beringarra Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Black Range South and Windsor groundwater calcrete assemblage type on Raeside and Murchison palaeodrainage on Lake Mason and Windsor Stations	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Bunnawarra calcrete groundwater assemblage type on Moore palaeodrainage on Bunnawarra Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Byro Central and Byro HS calcrete groundwater assemblage types on Murchison palaeodrainage on Byro Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Challa, Challa North and Wondinong calcrete groundwater assemblage type on Murchison palaeodrainage on Challa and Wondinong Stations	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Cogla Downs calcrete groundwater assemblage type on Murchison palaeodrainage on Yarrabubba Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Curbur calcrete groundwater assemblage type on Gascoyne palaeodrainage on Curbur Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Dalgety and Landor calcrete groundwater assemblage type on Gascoyne palaeodrainage on Dalgety Downs and Landor Stations	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Doolgunna calcrete groundwater assemblage type on Gascoyne palaeodrainage on Doolgunna Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Gabyon calcrete groundwater assemblage type on Moore palaeodrainage on Gabyon Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Gifford Creek, Mangaroon, Wanna calcrete groundwater assemblage type on Lyons palaeodrainage on Gifford Creek, Lyons and Wanna Stations	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1

Name of community	Description	Threats	Category (WA)
Hillview calcrete groundwater assemblage type on Murchison palaeodrainage on Hillview Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Innouendy calcrete groundwater assemblage type on Murchison palaeodrainage on Innouendy Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Karalundi calcrete groundwater assemblage type on Murchison palaeodrainage on Karalundi Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Killara calcrete groundwater assemblage types on Murchison palaeodrainage on Killara Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Killara North calcrete groundwater assemblage types on Murchison palaeodrainage on Killara Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Lake Austin calcrete groundwater assemblage type on Murchison palaeodrainage on Austin Downs Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Maranalgo west calcrete assemblage type on Moore palaeodrainage on Maranalgo Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Meeberrie calcrete groundwater assemblage type on Murchison palaeodrainage on Meeberrie Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Meka calcrete groundwater assemblage type on Murchison palaeodrainage on Meka Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Milgun central calcrete groundwater assemblage types on Gascoyne palaeodrainage on Milgun Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Milgun south calcrete groundwater assemblage types on Gascoyne palaeodrainage on Milgun Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Milly Milly calcrete groundwater assemblage type on Murchison palaeodrainage on Milly Milly Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Mount Augustus calcrete groundwater assemblage type on Lyons palaeodrainage on Mount Augustus Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1

Name of community	Description	Threats	Category (WA)
Mt Clere calcrete groundwater assemblage type on Gascoyne palaeodrainage on Mt Clere Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Mount Narryer calcrete groundwater assemblage type on Murchison palaeodrainage on Mount Narryer Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Mount Padbury calcrete groundwater assemblage type on Murchison palaeodrainage on Mount Padbury Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Muralgarra calcrete groundwater assemblage type on Murchison palaeodrainage on Muralgarra Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Murchison Downs calcrete groundwater assemblage type on Murchison palaeodrainage on Murchison Downs Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Ninghan calcrete groundwater assemblage type on Moore palaeodrainage on Ninghan Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Nowthanna Hill calcrete groundwater assemblage type on Murchison palaeodrainage on Yarrabubba Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Paroo calcrete groundwater assemblage type on Carey palaeodrainage on Paroo Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Polelle calcrete groundwater assemblage type on Murchison palaeodrainage on Polelle Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Taincrow calcrete groundwater assemblage type on Murchison palaeodrainage on Taincrow Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Three Rivers calcrete groundwater assemblage types on Gascoyne palaeodrainage on Three Rivers Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Three Rivers Plutonic calcrete groundwater assemblage types on Gascoyne palaeodrainage on Three Rivers Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Wagga Wagga and Yalgoo calcrete groundwater assemblage type on Yalgoo and Moore palaeodrainage on Wagga Wagga and Bunnawarra Stations	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1

Name of community	Description	Threats	Category (WA)
Windimurra calcrete groundwater assemblage type on Murchison palaeodrainage on Windimurra Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Wooramel calcrete groundwater assemblage type on Wooramel palaeodrainage on Innouendy Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Yarrabubba east calcrete groundwater assemblage types on Murchison palaeodrainage on Yarrabubba Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Yarrabubba west calcrete groundwater assemblage types on Murchison palaeodrainage on Yarrabubba Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Yoweragabbie calcrete groundwater assemblage type on Moore palaeodrainage on Yoweragabbie Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Goldfields			
Albion Downs calcrete groundwater assemblage type on Carey palaeodrainage on Albion Downs Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Banjawarn and Melrose (Lake Darlot) calcrete groundwater assemblage type on Carey palaeodrainage on Banjawarn and Melrose Stations	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Barwidgee calcrete groundwater assemblage type on Carey palaeodrainage on Barwidgee Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Black Range North calcrete groundwater assemblage type on Raeside palaeodrainage on Lake Mason Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Cunyu SBF and Cunyu Sweetwater calcrete groundwater assemblage types on Nabberu palaeodrainage on Cunyu Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Dandaraga calcrete groundwater assemblage type on Raeside palaeodrainage on Dandaraga Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1

Name of community	Description	Threats	Category (WA)
Glenayle and Carnegie Downs calcrete groundwater assemblage type on Burnside palaeodrainage on Glenayle Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Hinkler Well calcrete groundwater assemblage type on Carey palaeodrainage on Lake Way Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Lake Way South calcrete groundwater assemblage type on Carey palaeodrainage on Lake Way Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Jundee Homestead calcrete groundwater assemblage type on Carnegie palaeodrainage on Jundee Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Jundee South Hill calcrete groundwater assemblage type on Carnegie palaeodrainage on Jundee Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Kaluwiri calcrete groundwater assemblage type on Raeside palaeodrainage on Kaluwiri Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Lake Mason calcrete groundwater assemblage type on Raeside palaeodrainage on Lake Mason Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Lake Miranda east calcrete groundwater assemblage types on Carey palaeodrainage on Yakabindie Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Lake Miranda west calcrete groundwater assemblage types on Carey palaeodrainage on Yakabindie Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Lake Violet south and Lake Violet calcrete groundwater assemblage types on Carey palaeodrainage on Millbillillie Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Laverton Downs calcrete groundwater assemblage type on Carey palaeodrainage on Laverton Downs Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Lorna Glen calcrete groundwater assemblage type on Carnegie palaeodrainage on Lorna Glen Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Melita calcrete groundwater assemblage type on Raeside palaeodrainage on Melita Station (Sons of Gwalia)	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1

Name of community	Description	Threats	Category (WA)
Millbillillie: Bubble calcrete groundwater assemblage type on Carey palaeodrainage on Millbillillie Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Mount Morgan calcrete groundwater assemblage type on Carey palaeodrainage on Mount Weld Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Nambi calcrete groundwater assemblage type on Carey palaeodrainage on Nambi Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Old Cunya calcrete groundwater assemblage type on Nabberu palaeodrainage on Cunyu Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Perrinvale (Pine Well) calcrete groundwater assemblage type on Raeside palaeodrainage on Perrinvale Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Pinnacles calcrete groundwater assemblage type on Raeside palaeodrainage on Pinnacles Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Sturt Meadows calcrete groundwater assemblage type on Raeside palaeodrainage on Sturt Meadows Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Uramurdah Lake calcrete groundwater assemblage type on Carey palaeodrainage on Millbillillie Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Wiluna BF calcrete groundwater assemblage type on Carey palaeodrainage on Millbillillie Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Windidda calcrete groundwater assemblage type on Carnegie palaeodrainage on Windidda Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Yakabindie calcrete groundwater assemblage type on Carey palaeodrainage on Yakabindie Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Yandal calcrete groundwater assemblage type on Carey palaeodrainage on Yandal Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Yeelirrie calcrete groundwater assemblage type on Carey palaeodrainage on Yeelirrie Stration	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1

Name of community	Description	Threats	Category (WA)
Yuinmery calcrete groundwater assemblage types on Raeside palaeodrainage on Yuinmery Station	Unique assemblages of invertebrates have been identified in the groundwater calcretes	Mining	Priority 1
Warren			
Microbial mantles of Nullarbor caves (especially Weebubbie Cave)	Significant microbial communities in underwater sections of cave	Uncontrolled access	Priority 1
Subterranean faunal ecosystems of Nullarbor caves (known from Nurina Cave, Olwolgin Cave, Burnabbie Cave, N327, N1327)	The caves contain communities of invertebrates, other fauna and sensitive habitats including tree roots. Caves included in this community contain at least four troglobitic taxa	Uncontrolled access	Priority 3(i)