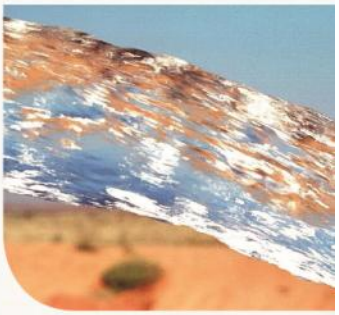

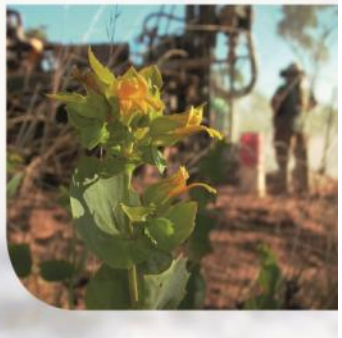

MULGA ROCK URANIUM PROJECT

SUBTERRANEAN FAUNA PILOT STUDY

REPORT FOR VIMY RESOURCES LIMITED

OCTOBER 2015

Rockwater
HYDROGEOLOGICAL AND ENVIRONMENTAL CONSULTANTS

Report No. 345-1/15/01

Mulga Rock Uranium Project - Public Environmental Review - December 2015
Appendix C - Subterranean Fauna

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REVISION	AUTHOR	REVIEW	ISSUED
Rev 0	N. Evelegh	P. Wharton	19/01/15
Rev 1	N. Evelegh	X. Moreau	26/03/15
Rev 2	N. Evelegh	-	02/10/15
Rev 3 (Final)	N. Evelegh	-	19/10/15

1 INTRODUCTION

Vimy Resources Limited (Vimy Resources) is planning to mine uranium at the Mulga Rock Uranium Project (MRUP) approximately 240 km east-north-east of Kalgoorlie (Fig. 1). Access to MRUP is via the Tropicana Gold Project haul road.

Mining will be undertaken using the open pit method from four deposits; Ambassador, Princess, Shogun and Emperor. As the ore at MRUP extends below the water table in some parts of these deposits, dewatering will be required to maintain dry mining conditions in advance of open pit mining.

Water for processing purposes will be sourced from a planned borefield at Kakarook North, about 35 km northeast of the MRUP (Fig. 1). Water sourced during pit dewatering will be used for dust suppression.

Groundwater extraction for project water supplies and mine dewatering, together with open pit mining, represent potential environmental impacts to subterranean fauna. Rockwater was engaged to undertake a pilot subterranean fauna study including stygofauna sampling at Kakarook North, troglofauna sampling at the MRUP, and assess whether or not Vimy Resources' proposal to mine uranium would impact any identified subterranean fauna values. This report presents the results of the study.

2 HYDROGEOLOGICAL SETTING

2.1 CLIMATE

MRUP is in an arid area with hot summers and mild winters. Bureau of Meteorology contour maps indicate that rainfall averages about 210 mm per annum. Annual dam evaporation is about 2,100 mm (Luke, Burke and O'Brien, 1988), an order of magnitude greater than the average rainfall.

The nearest long-term rainfall station is at Edjudina, about 110 km to the west (BoM 2013). Average rainfall data for the station (1900 to 2014) are given in Table 1.

Table 1: Average Monthly Rainfall (mm) Edjudina (BoM Station 012027)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
22.6	28.4	26.1	19.6	22	22.1	19.2	16.7	9.7	11.8	14	12.8	225

Most of the rain falls in irregular thunderstorm events or during the passage of the remnants of cyclones, with some frontal systems in winter. Daily rainfalls have been up to 98 mm (in February).

2.2 GEOLOGY

MRUP is on the south-western extremity of the Gunbarrel Basin (Fig. 2). Tertiary to Carboniferous-aged sediments overlie the Archaean and Proterozoic granitoids of the Yilgarn Craton and Albany-Fraser Range Province. The MRUP lignites lie in a buried paleochannel 1–15 km wide that can be traced for over 100 km (Fulwood and Barwick, *in* Douglas *et al* 2003).

Locally, the following broad units are present (Douglas *et al*, 1993):

- Fluviatile sands and interbedded lacustrine sediments;
- Lacustrine to paludal sediments, including lignites (peats), clay-rich lignites and carbonaceous sands and clays; and
- Basal fluviatile sands and gravels.

2.3 HYDROGEOLOGY

Descriptions of the hydrogeological setting of the MRUP are given in Groundwater Resource Consultants (GRC) (1984) and Rockwater (2013a). The stygofauna survey concerns only the Kakarook North area, where Cretaceous and Tertiary sediments have been deposited within depressions in the Proterozoic bedrock.

Mineral sand exploration holes drilled by Ramsgate Resources Ltd for the Kakarook mineral sand project intersected these sediments and, where deep, they extend below the water table. In 2013, a programme of groundwater exploration drilling was undertaken in the area by Energy and Minerals Australia (now Vimy Resources) to locate a source of low-salinity groundwater. That drilling programme identified a south-southeast trending alluvial channel or basin with a saturated thickness of alluvium of up to 37 m over a length of about 6 km and width 2 to 5 km (Rockwater 2013a). Here, groundwater occurs in graded alluvial sand/sandstone beds of Eocene age that include coarse to very coarse-grained layers that are up to fine gravel in size. The alluvial beds overlie Proterozoic bedrock.

The groundwater salinity at Kakarook North is reported to be in the range 3,950−8,070 mg/L TDS and generally under 5,000 mg/L TDS (Rockwater 2013a). It is slightly acidic to slightly alkaline (pH 6.8−7.6) and has elevated sulphate concentrations.

3 DESKTOP STUDY

The probability that a site contains a diverse subterranean fauna is largely determined by the region in which the site occurs, and local geology (Environmental Protection Authority 2007). For the Murchison and Yilgarn regions, the Environmental Protection Authority (EPA) considers that there is a high probability that diverse stygofauna communities will occur in aquifers of calcrete, alluvium and banded ironstone. The central and northern parts of the Yilgarn are the next most studied regions of Western Australia after the Pilbara (EPA 2012a), with an emphasis on calcrete groundwater assemblages. There are no published records and few previous studies of subterranean fauna in the Great Victoria Desert bioregion.

As part of the desktop study, various literature and data were reviewed, including previous subterranean fauna studies in the region, available hydrogeological reports and maps, government databases and project-specific data supplied by Vimy Resources.

3.1 DATABASE SEARCHES

Given the remote location of the MRUP, and limited previous scientific studies or environmental impact assessment (EIA) work in the vicinity, there are not expected to be nearby records of subterranean fauna in government databases other than those identified by the desktop study.

Results of a Threatened and Priority Ecological Community (TEC/PEC) database search confirmed that there are no TECs relating to stygofauna or troglofauna within 150 km of the MRUP (Fig. 3). The search found three records of Priority Ecological Communities (PEC) beyond the 150 km buffer. These included the Laverton Downs Calcrete Groundwater Assemblage (LDCGA), Banjawarn and Melrose Calcrete Groundwater Assemblage (BMCGA) and Mount Morgan Calcrete Groundwater Assemblage (MMCGA). The nearest of these to the MRUP is at Mount Morgan (MMCGA), approximately 180 km north-west of the MRUP within the Carey Paleodrainage on Mount Weld Station. All three are listed as Priority 1 communities due to unique assemblages of invertebrates (stygofauna) associated with calcrete aquifers. The principal listed threat is mining. Priority 1 ecological communities are not well defined and require further survey to evaluate their conservation status, so that they can be considered for declaration/listing as threatened ecological communities (TEC).

Searches of the WA Museum's invertebrate fauna databases were requested and the results screened for subterranean fauna records. The Crustacean, Arachnid and Mollusca databases, as well as Dr Bill Humphreys' personal research database were queried using a search area polygon bounded by the following points:

NW: -29.531^{o}, 123.252^{o}
SE: -30.534^{o} , 124.357^{o}

Results of the database searches are shown in Table 2. The only database returning any results for subterranean fauna records within the search area was the Arachnid database, which showed a total of four species of troglofauna from three families.

Table 2: WA Museum Invertebrate Fauna Database Search Results

Record	Site	Method	Number identified
OONOPIDAE (Goblin Spiders)			
Prethopalpus framenaui	Nambi Station	litter trap	3
CHTHONIIDAE (Pseudoscorpions)			
Tyrannochthonius `Helens Bore`	Cardinia, 35 km NE. of Leonora	stygofauna haul net	1
Tyrannochthonius `sp. nov.?`	23 km SW. of Nambi Station homestead	litter trap	3
CRYPTOPIDAE (Centipedes)			
Cryptopidae	Laverton Downs Station	stygofauna haul net	1

3.2 PREVIOUS STUDIES

3.2.1 Stygofauna

There are no records of stygofauna within 100 km of the MRUP area. Most records of stygofauna in the Yilgarn and Murchison relate to palaeovalley aquifers, particularly calcretes. Calcrete aquifers are known to contain significant stygofauna communities in the Yilgarn (Cooper *et al.* 2007, also see Humphreys 2008), with particular 'hotspots' of stygofauna diversity occurring in the eastern drainage at Paroo, Lake Violet, Lake Way and Hinkler Well (Humphreys 2001). These calcrete habitats contain a unique stygofauna mainly comprising a wide range of crustacean species and dytiscid diving beetles.

Subterranean fauna studies at the Tropicana Gold Project, approximately 110 km to the north-east of the MRUP, by Ecologia Environment (2009a) and Subterranean Ecology (2009) surveyed for stygofauna in a fine-grained sandstone aquifer. Stygofauna was not detected in either the water supply area or the operational mining areas and it was concluded that the groundwater habitats of the area were devoid of stygofauna.

A study of the genetic structure of animals collected in calcrete aquifers in the Yilgarn by Guzik *et al.* (2011) found that individual aquifers vary in their faunal composition and the population genetic substructure of species. Stygofauna was sampled at three sites over a 15 km distance in the Laverton Downs Calcrete Groundwater Assemblage to explore the mechanisms of speciation in subterranean ecosystems. Multispecies population fragmentation was investigated using species that were recorded at multiple sites. Below species-level genetic divergence was identified in several species of groundwater isopods and diving beetles, and in a single amphipod species that occurred throughout the survey area. The LDCGA is listed as a PEC (see Section 3.1).

A desktop assessment of stygofauna at the Ben Hur Project, 50 km north of Laverton, identified potential for stygofauna to be present based on project geology and groundwater conditions (Rockwater 2013b). Brackish water from shears and fractures in Archaean greenstone rocks was considered to represent potential stygofauna habitat. However, fractured rock aquifers of the Eastern Goldfields are not typically recognised as core stygofauna habitat and the likelihood of a significant stygofauna community was deemed to be low.

A subterranean fauna study was conducted for the Duketon Gold Project, located 130 km north of Laverton (roughly 300 km north-west of the MRUP) by Bennelongia (2007). The survey recorded 24 stygofauna species, with 88% of these being from reference sites in or near calcrete. The habitats of the Archaean greenstone in the mine area yielded nematodes, an oligochaete, a copepod and an ostracod. No species was restricted to the mine pits, but three harpacticoid copepods and a bathynellid syncarid were only recorded in the water supply area, located in a nearby calcrete aquifer.

Stygofauna has previously been recorded in aquifers of the Abercromby and Lake Way Palaeovalleys, approximately 470 km north-west of the MRUP (Ecologia Environment 2005, 2006, Outback Ecology 2011). The calcrete stygofaunal communities around Lake Way have been recognised for their richness and diversity by global standards and were nominated for listing as threatened ecological communities in 2008. These are currently listed as Priority Ecological Communities (PECs).

Toro Energy plans to develop a uranium deposit at Lake Way. Outback Ecology (2011) undertook sampling at the Lake Way, Centipede and West Creek Projects and showed that the distributions of many taxa were relatively widespread within the calcrete aquifer system of the survey area. Most of the stygofauna species collected from a mining disturbance area were also found from sites outside the mining area and the EPA concluded that all species were likely to be more widespread in large areas of suitable habitat in adjacent calcrete aquifers (EPA 2012b).

Sampling for stygofauna was undertaken at the Magellan Lead Project, west of Wiluna (Biota 2005). Six of the seven taxa recorded from impact bores were shown to be distributed more widely; either in reference bores or elsewhere in the region. The results suggested there was population connectivity, at least at a local catchment level through the calcrete aquifer system, across a range of stygal groups.

3.2.2 Troglofauna

The closest troglofauna study to the MRUP was undertaken by Ecologia Environment (2009b, 2009c, 2010a and 2010b) at the Tropicana Gold Project, approximately 110 km to the north-east of the MRUP. A troglofauna sampling programme was conducted at Tropicana, where a total of 411 samples were taken over seven sampling rounds. The samples yielded 14 animals of four troglofaunal species. Two of the four species were restricted to the project area. The most common strata which yielded troglofauna were channel-filled sediments, lower and upper saprolite, sand, fine gravel and fresh rock, all recording troglofauna in more than 60% of holes sampled. The troglofaunal community at the project was shown to be sparse, and further geological mapping and investigation confirmed that the potential habitat was likely to extend beyond the project footprint. It was also suggested that similar troglofauna habitat may be widespread across lateralised weathering environments in Australia.

A large sampling programme at Lake Way (Toro Energy) consisted of 134 traps and 106 net hauls from 121 holes across three deposits (Outback Ecology 2011). The sampling targeted alluvium and shallow calcretes and yielded a total of 208 specimens representing 20 species. Isopods were the most abundant and diverse group recorded (seven species), followed by pseudoscorpions (three species). The long-term conservation risk to troglofauna for the project was determined to be low.

Sampling for the Duketon Gold project, 300 km NW of the MRUP, targeted the superficial alluvium and colluvium, Cainozoic sandstone and laterite (Bennelongia 2007). No troglofauna species were collected by the survey, and it was concluded that there was no risk to troglofauna from the mining proposal.

3.3 POTENTIAL HABITAT AT THE MRUP

3.3.1 Stygofauna

The geology and groundwater conditions at the MRUP suggest that there is a low potential for stygofauna to occur in most areas of the Project. Groundwater is saline to hypersaline, with salinities up to 140,000 mg/L TDS recorded in the southern parts of Emperor and Shogun (GRC 1984). Groundwater salinity in between the Shogun and Ambassador prospects

and at Ambassador is generally lower, in the range 10,000−48,000 mg/L TDS. The water is generally slightly alkaline in the Ambassador area (pH 7−8), and acid elsewhere (pH 3−5) (GRC 1984). Assessment of stygofauna in the vicinity of the Project is the subject of a separate report.

The groundwater at Kakarook North, in the vicinity of a planned project water supply borefield, has a lower salinity than that of the MRUP area (generally in the range 4,100−6,100 mg/L TDS) and is neutral to slightly alkaline (pH 6.8−7.6) (Rockwater 2013a). Measured water quality in the area suggests that groundwater conditions at Kakarook North are suitable for stygofauna, based on values previously reported for stygofauna communities in Western Australia.

3.3.2 Troglofauna

The presence and extent of troglofauna communities are influenced by local geological characteristics. True troglofauna are confined to, and dependant on, subterranean fissures and voids that have some vertical connectivity through to the surface, which facilitates the supply of air, moisture and food to suitable habitat.

The superficial aeolian sands at the MRUP do not represent core habitat for troglofauna and the upper sandy unit of the underlying tertiary sediments is considered unlikely to contain suitable voids for troglofauna. However, lateral voids or wash zones where ancient root channels have refilled within Miocene sands have been identified as a potential habitat. These conditions may be favourable to troglofauna as they may provide a significant network of voids. However, it is unclear whether or not these wash zones represent suitable voids or sandy fills that have been cleared as a drilling artefact.

Root voids in more pronounced mottle zones at Ambassador are shown in Plate 1. Plate 2 shows similar material at Princess Deposit, where mottling is more limited and no root voids are evident.

A suite of wireline probes (full wave sonic, density, resistivity, neutron and induction) from surface in mudded exploration bores – used to identify secondary or fault-related porosity – failed to identify obvious voids within wall formations. This suggests that, if present, such voids are limited in their lateral extent as well as volumetrically.

Plate 1: Mottling and root channels within Miocene sands in drill core at the Ambassador deposit (hole NND5794, 13.5−16.15 m bgl).

Plate 2: Representative drill core within Miocene sands from the Princess deposit (hole NNA5795, 11.5 – 13.85m bgl).

3.4 POTENTIAL IMPACTS OF MINING

Aspects of the project that may potentially impact subterranean fauna were considered as part of the desktop study. Potential impacts comprise two categories: direct and indirect. Direct impacts include aspects of the mining proposal that may result in destruction of habitat and removal of any local subterranean fauna communities. These direct impacts can potentially result in extinction of endemic species, if present. Indirect impacts include threatening processes that are more likely to lead to reduction in population sizes and secondary impacts to subterranean fauna habitat.

The potential threats associated with the mining proposal that may impact groundwater habitats at Kakarook North include:

- Altering water levels through groundwater production for water supply; and
- Altering groundwater quality through changes to hydrology and recharge.

Groundwater drawdown through extraction for the Project's water supply is considered to be the principal potential impact on stygofauna at Kakarook North, as it has potential to result in habitat loss or alteration. Assessment of impacts associated with dewatering the uranium deposits are beyond the scope of this study. However, dewatering and changes to groundwater chemistry in the vicinity of the mine are unlikely to represent a significant impact on stygofauna (if present) as much of the groundwater is hypersaline and acidic.

The principal impact of the project on troglofauna is direct loss of habitat through construction of the mine pits. Strip mining of the superficial aeolian sands and underlying "overburden" material would remove the most likely voids suitable for troglofauna at MRUP, prior to mining the underlying mineralised lignite.

Other aspects of the MRUP that could indirectly affect troglofauna habitats include:

- Vibrations from heavy equipment that could cause subterranean voids to collapse during construction and operations;
- Reduction in organic inputs (i.e. vegetation clearing and stockpiling of topsoil may reduce the flow of organic material into shallow subterranean systems; and
- Changes to the local surface hydrology (which could alter local recharge/discharge points).

It is expected that the indirect impacts would be less significant, and these could generally be covered by environmental management plans and operational procedures during the life of the MRUP. Indirect impacts have not been assessed in further detail by the present study.

4 SAMPLING METHODOLOGY

The subterranean fauna sampling methodology implemented for the MRUP was prepared in accordance with relevant EPA guidance statements (EPA 2007, EPA 2013). The investigation constitutes a pilot-scale study and the sampling effort complies with the requirements of the EPA.

Sampling at the MRUP was undertaken by Daisy Scott, Project Environmental Scientist and Nick Evelegh, Principal Environmental Scientist (both of Rockwater Pty Ltd) from 6–10 October in accordance with Regulation 17 Permit No. SF 10036 (Licence to Take Fauna for Scientific Purposes), issued by the Department of Parks and Wildlife (DPaW).

4.1 STYGOFAUNA

Site selection for stygofauna sampling at Kakarook North was undertaken after reviewing lithological logs and bore completion data. A Vimy Resources geologist provided assistance with interpretation of geological data and bore completion logs to enable selection of the most suitable monitoring bores for stygofauna sampling. These were generally bores that produced the most water during bore development.

Prior to stygofauna sampling at each bore, water quality was measured using a three-litre bailed water sample, with instruments provided by Vimy Resources. Water quality parameter readings (including conductivity, pH, dissolved oxygen, redox and temperature) were recorded immediately after the sample was bailed. Measurements of total depth, collar height, diameter and other bore details were also recorded.

Stygofauna sampling was undertaken using modified plankton nets at twelve sites within the Kakarook North area. Each site was sampled using sampling nets with a diameter approximately two-thirds of the bore casing and filter mesh sizes 50 µm and 150 µm. The sampling nets consisted of a steel collar that supports a 'cone' of filter mesh, tapering to a hollow brass weight at the base. A clear polycarbonate vial with the bottom removed and replaced with 50 µm filter mesh was screwed into the brass weight to collect samples filtered by the sampling nets. Nets were suspended by a carabineer and three trace wires attached to the steel collar.

Net samples were obtained by lowering sampling nets into each bore using a reel of fishing braid until they reached the bottom of the bore where they were agitated to disturb sediment and any animals that may be present. Each biological sample was taken using three net-hauls of the 50 µm stygofauna sampling net and three net-hauls of the 150 µm sampling net, which were combined and stored in 120 mL polycarbonate vials. Samples were preserved using 100% (absolute) ethanol.

To avoid contamination between sites, the sampling nets were thoroughly washed with a decontaminant solution (Decon 90) and then rinsed with distilled water. All samples were transported to Perth and forwarded to specialist stygofauna biologists for sorting and identification.

4.2 TROGLOFAUNA

Lithological logs and geological cross-sections were examined in the field with Vimy Resources' geologists at the MRUP. Many of the exploration holes had either swollen or collapsed completely, thereby preventing access for sampling purposes. A range of recently drilled vertical pre-collar holes were identified as the most suitable sites.

Troglofauna samples were collected using modified haul nets and baited traps from an appropriate spread of sampling sites across the MRUP area. Scrape samples were taken immediately before baited traps were set using the method described by Halse and Pearson (2014). Scrape and trap samples from each site were processed separately, although they were recorded as one sample when calculating sampling effort.

Vented PVC troglofauna traps were baited with a mixture of moist native vegetative litter. The litter was previously soaked in water overnight and irradiated in a microwave oven on maximum power setting for 10–15 minutes (to kill any surface invertebrates and assist in breakdown) prior to use. Once the leaf litter was added to the traps they were immediately installed into each hole at the pre-determined depth. A cap or plug was placed over the hole to minimise the amount of terrestrial fauna and debris entering the traps, and to maintain a humid environment.

The trap samples were collected by Vimy Resources personnel on 28 November 2014 under instruction from Rockwater. Eleven of the thirty troglofauna traps installed were not recovered due to either bushfire or collapse of loose sand. Samples were transported in an esky and delivered to the laboratory of Bennelongia Environmental Consultants (Bennelongia) on 1 December 2014 for processing.

In the laboratory, samples were immediately placed into Berlese funnels with a light/heat source above to encourage the movement of invertebrates out of the leaf litter and into a solution of ethanol preservative below. The remaining leaf litter was also searched under dissecting microscopes for any dead specimens. Troglomorphic specimens were identified to the lowest possible taxonomic level.

The investigation followed the requirements of the EPA for a Level 1 troglofauna survey; with 18 samples taken in the Princess/Ambassador area and 15 samples taken at Emperor/Shogun (Table 3).

Table 3: Number of troglofauna samples collected (sampling effort) at the MRUP

Site	Scrape	Trap	Total Samples[#]
Princess	3	2	3
Ambassador	14	12	15
Emperor	3	2	8
Shogun	6	3	7
TOTAL	**26**	**19**	**28**

[#] Scrape and trap samples from the same site are considered as one sample when calculating sampling effort.

5 RESULTS

5.1 WATER QUALITY

Results of field water quality measurements from 11 bores in the Kakarook Borefield area indicate that groundwater is slightly acidic, with pH ranging from 5.24 to 6.26. These field measurements are slightly lower than the values reported for water samples taken from the borefield in 2013 (Rockwater 2013b), but are similar to those reported during pumping tests in 2015; pH 5.5−7.7 (Rockwater 2015). Results of the field water testing and site details are provided in Appendix I.

The water is brackish to slightly saline with groundwater salinities ranging from 2,040 to 7,550 mg/L TDS. Groundwater salinity is generally less than 5,300 mg/L TDS; the exception being NGW21 (7,550 mg/L TDS). Dissolved oxygen ranged from 1.5–9.4 mg/L, well within the range of values previously reported for stygofauna communities in Western Australia. However, dissolved oxygen readings from bailed samples are unlikely to accurately reflect *in-situ* conditions.

5.2 STYGOFAUNA

Twelve bores in the Kakarook North area were sampled for stygofauna. In addition, two filtered and preserved stygofauna samples (in pure ethanol) pumped from NGW17 in December 2013 (90 L) and January 2014 (1000 L) were supplied by Vimy Resources and analysed as part of the pilot study. Five single-haul stygofauna samples were also taken at Emperor and submitted for processing although this was beyond the scope of the stygofauna survey, which focussed on Kakarook North.

Stygofauna was recorded from two sites at Kakarook North, NGW14 and NGW17 (Table 4). Bore locations and sampling results are shown in Figure 4, together with the predicted extent of drawdown as a result of the planned borefield development.

A total of 66 individuals were collected in the Kakarook North area, representing at least three potential stygal species of two higher taxonomic groups (Nematoda and Oligochaeta). Stygofauna was not detected in stygofauna samples from the Emperor deposit; however, aquatic nematodes were collected as by-catch in a troglofauna sample from one site at Emperor.

The groundwater oligochaete Enchytraeus sp. 1 (PSS) recorded at NGW14 and NGW17 is a species complex that has been recorded in other parts of Western Australia including the Pilbara, Kimberley and Northern Goldfields regions. Tubificidae sp. MR1 is a potential new species and has only been recorded from the Kakarook North area. Other species/complexes of Tubificidae have been recorded in the Pilbara and Kimberley with distribution ranges at

least an order of magnitude greater than the size of the Kakarook North investigation area (see Halse *et al.* 2014b).

Nematodes were collected from one site (NGW17) at Kakarook North. They were also recorded during troglofauna scrape-sampling at Emperor (hole NNA5710) and Ambassador (hole NNA5380). However, given that the Emperor and Ambassador exploration holes were dry, the specimens were collected above the water table and so may not be considered as stygofauna.

Table 4: Results of stygofauna sampling at the MRUP

Order	Family	Taxon	No. of animals	Site
OLIGOCHAETA				
Enchytraeida	Enchytraeidae	Enchytraeus sp. 1 (PSS)	18	NGW14 (3), NGW17 (15)
Haplotaxida	Tubificidae	Tubificidae sp. MR1	45	NGW17 (45)
NEMATODA				
-	-	Nematoda sp.	7	NNA5380[#] (1), NNA5710[#] (3), NGW17 (3)
		TOTAL	**70**	

[#] Stygofauna records from Emperor & Ambassador

5.3 TROGLOFAUNA

Thirteen troglofaunal animals from two orders (Cephalostigmata and Isopoda) were collected in the pilot sampling phase (Table 5). These included one species from the Ambassador deposit (Fig. 5) and two species from the Emperor deposit (Fig. 6). Based on the sampling intensity of the pilot study (28 samples), the capture rate (0.46 animals per sample) and diversity (0.07 species per sample) are comparable with moderately diverse troglofauna communities recorded in the Yilgarn (e.g. Rockwater 2012a).

One additional troglofauna species (*Symphyella* sp. B19) was recorded during stygofauna sampling at Kakarook North (Table 5, Fig. 4). Troglofauna was not detected at Shogun or Princess.

All specimens were in good condition, displayed strong troglomorphic characteristics and were identified to the lowest possible taxonomic rank (morphospecies). The three taxa recorded by the survey are likely to represent new species of genera previously collected in the Yilgarn region and their taxonomic status is unlikely to advance until specialist taxonomic work is undertaken on the relevant taxonomic groups.

Table 5: Results of troglofauna sampling at the MRUP

Order	Family	Taxon	No. of animals	Site
CRUSTACEA				
Isopoda	Platyarthridae	*Trichorhina* sp. B21	9	NNA5366 (2), NNA5108 (1), NNA5380 (1), NNA5710 (4), NGW17 (1)
SYMPHYLA				
Cephalostigmata	Scutigerellidae	*Hanseniella* sp. B28	3	NNA5498 (1), NNA5709 (2),
Cephalostigmata	Scutigerellidae	*Symphyella* sp. B19	1	NGW14
		TOTAL	**13**	

The only two trap sites that recorded troglofauna at Ambassador, NNA5366 and NNA5108, were trapped at depths of 5 m and 10 m, respectively. The remaining troglobitic animals were collected either by scrape-sampling, or as stygofauna by-catch. The presence of troglofauna at depths of less than 10 metres suggests that there is subterranean habitat in the surficial sands and sandstone of Eocene and Miocene age.

6 DISCUSSION

6.1 STYGOFAUNA

A pilot-scale sampling programme targeting stygofauna was undertaken to sample the alluvial basin at Kakarook North. Fourteen samples in total were taken from twelve sites in accordance with relevant EPA guidelines (EPA 2007, 2013). Stygofauna was recorded from two sites and included groundwater oligochaetes and nematodes. Nematodes, although listed in the EPA guidelines, are not required to be identified to lower taxonomic levels due to limitations in their taxonomic framework (EPA 2007). Based on the sampling results of the pilot study, stygofauna is not considered to be a significant issue for the Project

One of two Oligochaeta species recorded by the pilot study (Tubificidae sp. MR1) is a potential new species and is currently known only from the proposed borefield area at Kakarook North. Assessment of the potential impact of the borefield development on this species is constrained by the limited sampling effort of the stygofauna survey and the taxonomic framework of the group. The second oligochaete, Enchytraeus sp. 1 (PSS), is a species complex that has been recorded in other parts of Western Australia including the Pilbara (e.g. Bennelongia 2013, Rockwater 2012a).

The groundwater at Kakarook North is slightly saline with a range of 2,040 to 7,550 mg/L TDS (generally less than 5,030 mg/L TDS), with slightly acidic pH values and moderate to

high dissolved oxygen concentrations, which suggests that the aquifer conditions are not a limiting factor for stygofauna. Based on sampling results, the palaeochannel aquifer contains suitable groundwater conditions (habitat) for stygofauna. Previous stygofauna studies in the Yilgarn have recorded stygofauna in groundwater with salinity up to 40,000 mg/L TDS and acidic pH (e.g. Rockwater 2012b).

The alluvial channel or basin at Kakarook North is reported to have a saturated thickness of up to 40 m over a length of at least 16 km and width 5 to 8 km (Rockwater 2015). Potential habitat for stygofauna is therefore extensive in this palaeodrainage and will extend beyond the planned borefield, within Tertiary sediments of Eocene and Miocene age. Existing drilling data indicate that these sediments occur over a range of several tens of kilometres in the Project area. Furthermore, groundwater habitats in other palaeodrainage systems of the Northern Goldfields (Fig. 2) may provide additional habitat for similar stygofauna assemblages in the region.

A project water supply of approximately 1.8GL/a of low-salinity water will be needed for about 12 years. The results of groundwater modelling (Rockwater 2015) indicate that pumping that volume from a borefield of 16 bores at Kakarook North could draw-down water levels in the aquifer by up to 12m after 12 years. The impact of drawdown on stygofauna in an aquifer of up to 40 m saturated thickness that extends for tens of kilometres beyond the proposed borefield is unlikely to be significant.

6.2 TROGLOFAUNA

Troglofauna sampling for the MRUP recorded two symphylans and an isopod. The results of the pilot study suggest that subterranean habitats of the MRUP area may contain a moderately diverse troglofauna community by Yilgarn standards. The capture rate was significantly higher than the nearest study at Tropicana, approximately 110 km to the north-east. At Tropicana, four species were recorded from 411 samples (Ecologia Environment 2009b, 2009c, 2010a and 2010b).

No species recorded by the pilot study is currently known only from the proposed mine pits at the MRUP. Both *Trichorhina* sp. B21 and *Hanseniella* sp. B28 were recorded outside the 500 m development buffer at the Emperor deposit. In addition, *Trichorhina* sp. B21 was recorded as by-catch in a stygofauna sample at Kakarook North, indicating a range of approximately 50 km for the species. One additional troglofauna species (*Symphyella* sp. B19) was recorded during stygofauna sampling at Kakarook North.

The occurrence of *Trichorhina* sp. B21 at five sites over a geographic range of 50 km in shallow sandy strata suggests that troglofauna habitat in the vicinity of the Project area

(including Kakarook North) and the broader Great Victoria Desert bioregion may be extensive. Another symphylan collected by the study, *Hanseniella* sp. B28, is known from two sites at Emperor deposit, indicating a linear range of about 4 km.

There is very little information available regarding distribution ranges of members of these troglofauna groups. Several species of *Hanseniella* have demonstrated ranges of 13 to >80 km in the Yilgarn, through EIA work at the Koolyanobbing Range, Mt Jackson Range, Helena Aurora Ranges, Parker Range and in the northern part of the Yerilgee Greenstone Belt, approximately 150 km north-west of Kalgoorlie (Rockwater 2010, Rockwater 2012c, Bennelongia 2008).

Hanseniella species have been shown to occur in a variety of habitats, including a number of BIF units in the Yilgarn, as well as from a variety of other rock types including gossan, ferricrete, schist and phyllite (Rockwater 2012c).

Based on collections at the MRUP, and of other species of the Scutigerellidae (Family) , it is considered unlikely that the two Symphyla (*Hanseniella* sp. B28 and *Symphyella* sp. B19) recorded by the pilot study will have short distribution ranges.

In other parts of Western Australia such as the Yilgarn, platyarthrid isopods of the genus *Trichorhina* have been recorded over wide geographic ranges, including 52 km at Mt Caudan (Rockwater 2010) and 75 km at the Koolyanobbing and Jackson Ranges (Bennelongia 2008). The group has been recorded from a range of rock types including BIF, amphibolite, schist and phyllite.

Although habitat characterisation is not conclusive based on the results of the pilot study, it is likely that the troglofauna species at the MRUP are present at shallow depths in strata that are widespread in the region. The sedimentary lithologies from which troglofauna have been recorded at the MRUP occur over a linear range of at least 50 km in the Project area. They are well represented in other parts of the Great Victoria Desert bioregion and are not unique in a regional context.

7 CONCLUSION

The subterranean fauna pilot study at the MRUP has confirmed that suitable habitat exists in the Project area for stygofauna and troglofauna. There were no subterranean threatened ecological communities or protected subterranean fauna species identified within the MRUP area.

Three potential stygofauna species (two oligochaetes and a nematode) recorded in a palaeochannel aquifer at Kakarook North, are unlikely to be significantly impacted by the development of a planned borefield.

Of three troglofauna species recorded by the study, two may be directly impacted by the MRUP mining proposal. Both of those species were also identified from sites outside the Project area that are well beyond the disturbance footprint. The pilot study has identified a potentially widespread troglofauna habitat over a distance of at least 50 km in the broader region and further sampling could identify additional species. However, it appears unlikely that the abundance, diversity and geographic distribution of the troglofauna community or the conservation status of any individual troglofauna species at the MRUP would be impacted by the Project.

Dated: 19 October 2015 **Rockwater Pty Ltd**

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Nick Evelegh
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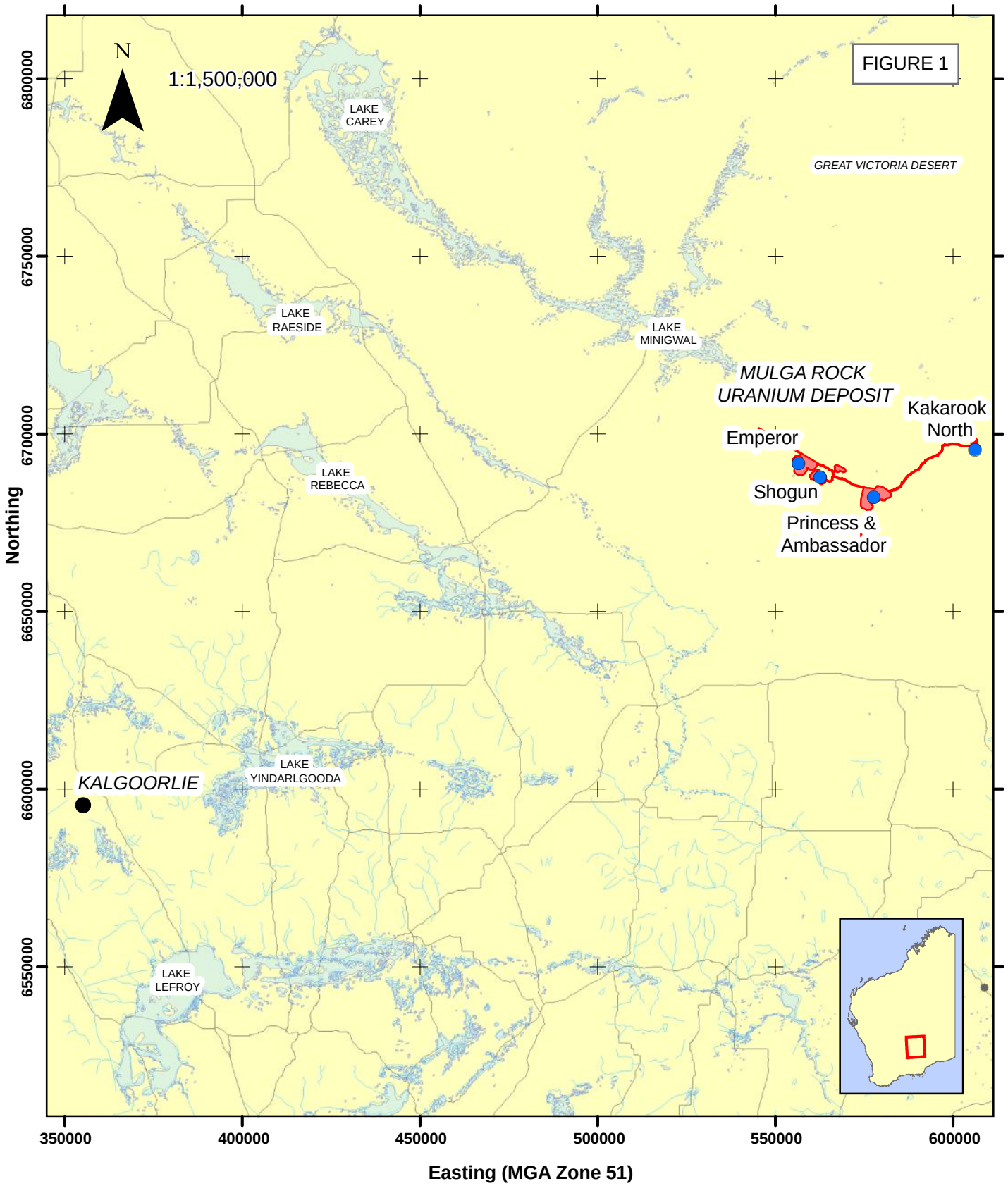
FIGURES



L:/GIS Projects/345-1 - EAMA/ Fig. 1 - Locality

Client: Vimy Resources Ltd

Project: Mulga Rock Uranium Project
Subterranean Fauna Study

Date: October 2015

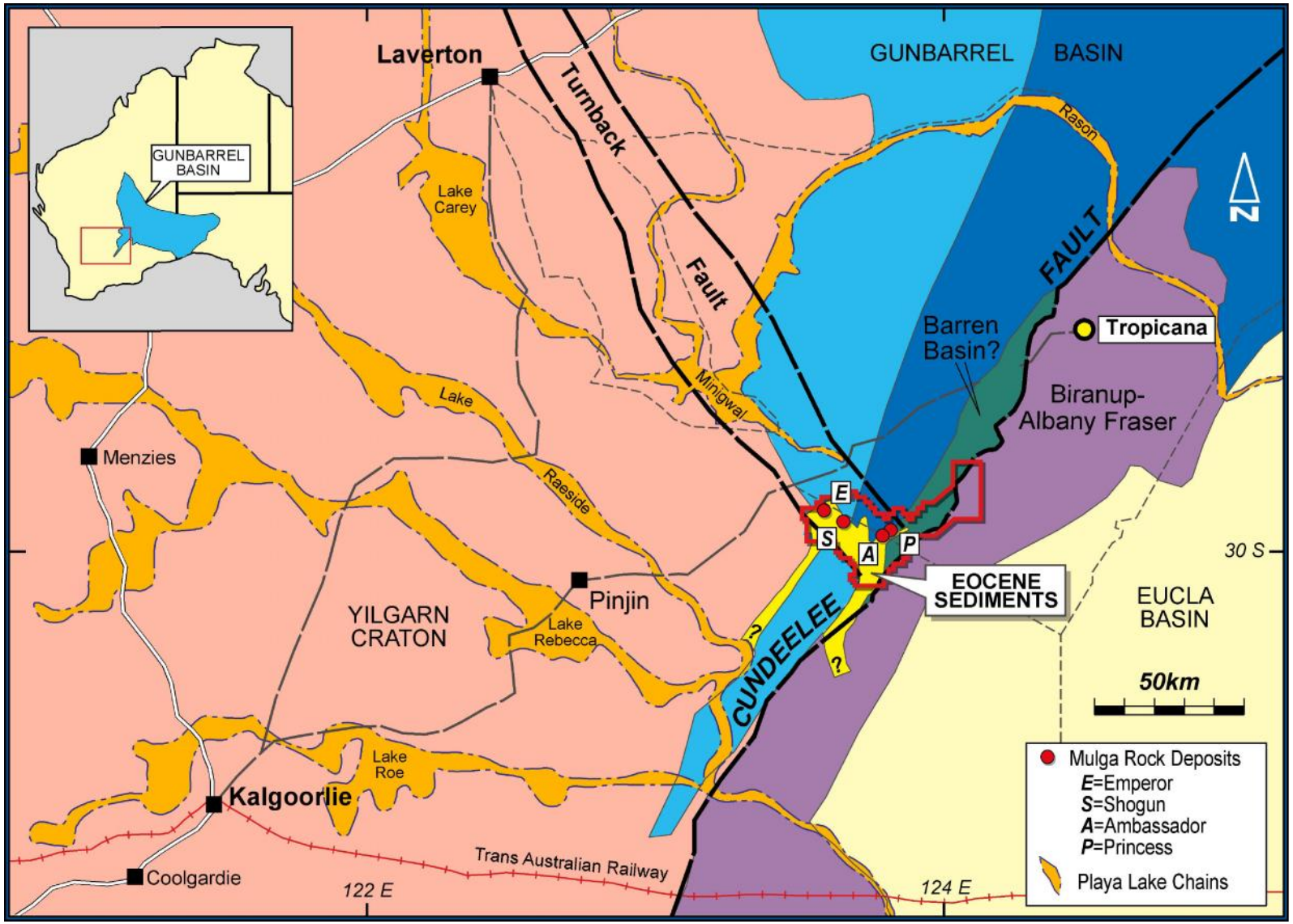
Dwg. No: 345.1/15/1-1

MULGA ROCK URANIUM PROJECT

LOCALITY MAP

Rockwater PROPRIETARY LIMITED

FIGURE 2



L:/GIS Projects/345-1 - EAMA/ Fig. 2 - Palaeodrainages

Source: Vimy Resources

Client: Vimy Resources Ltd

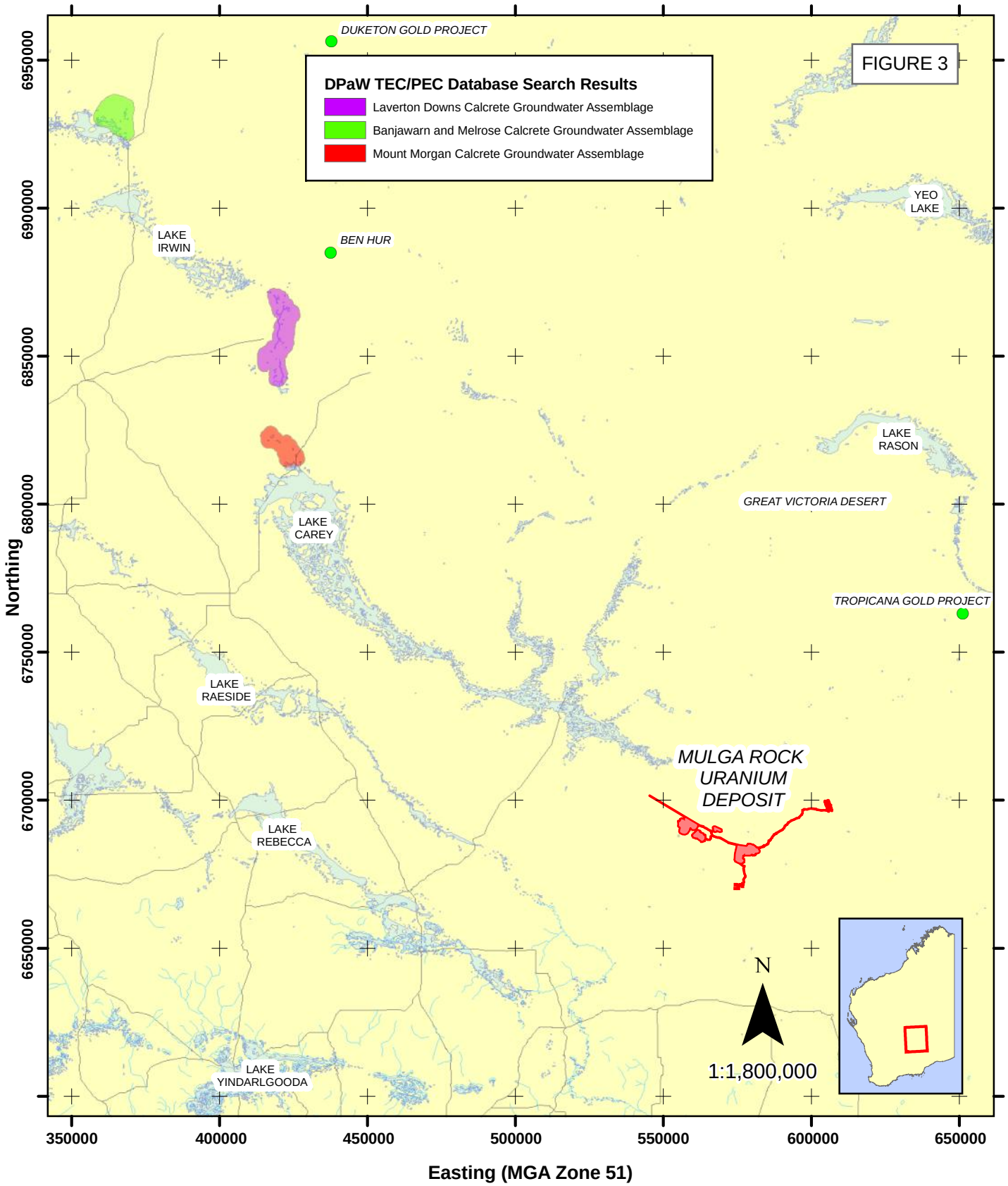
Project: Mulga Rock Uranium Project Subterranean Fauna Study

Date: October 2015

Dwg. No: 345.1/15/1-2

MRUP DEPOSITS AND GEOLOGY SHOWING STRUCTURAL SUBDIVISIONS AND PALAEODRAINAGES

Rockwater PROPRIETARY LIMITED



L:/GIS Projects/345-1 - EAMA/ Fig. 3 - DPaW Database Results

Client: Vimy Resources Ltd

Project: Mulga Rock Uranium Project
Subterranean Fauna Study

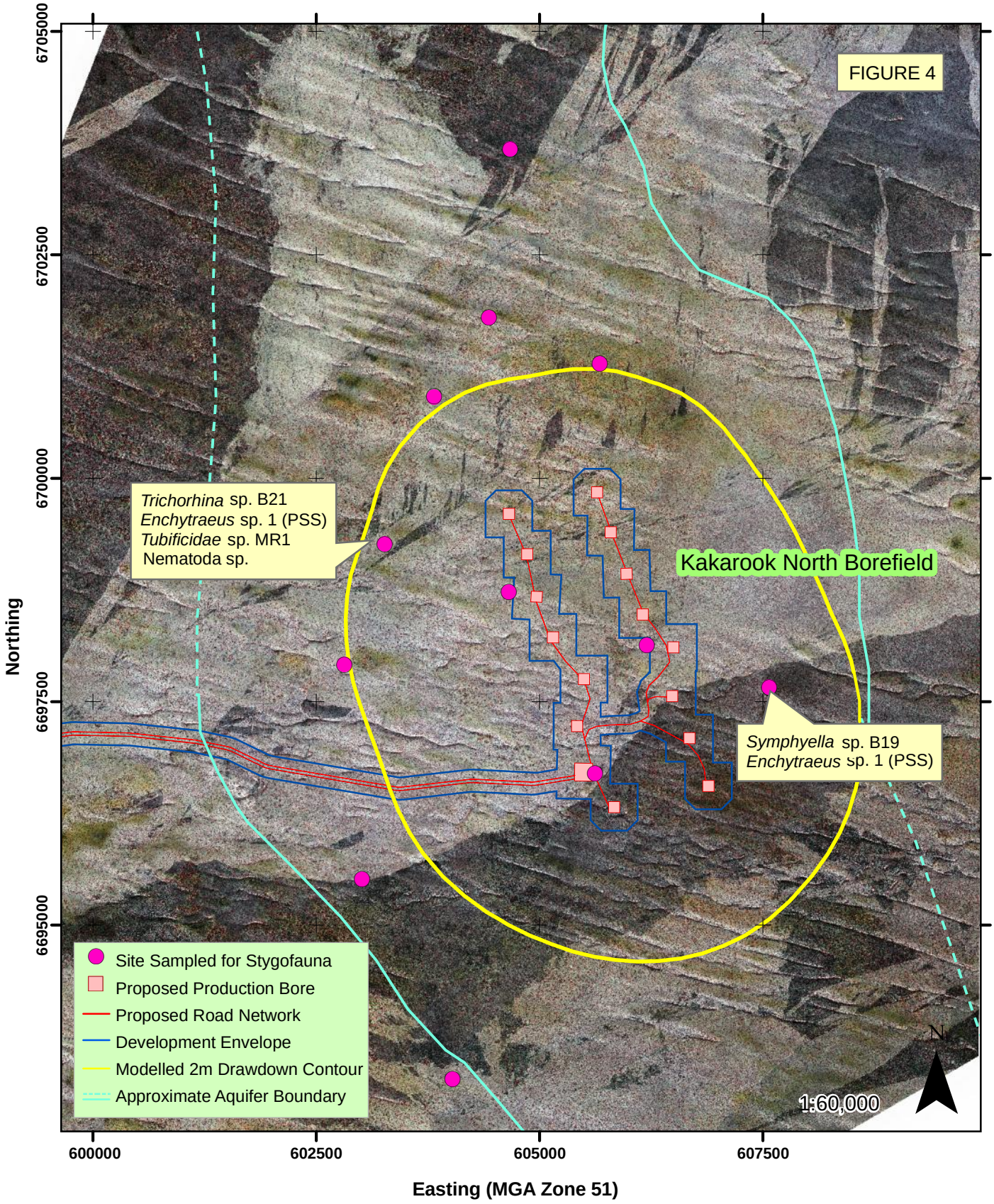
Date: October 2015

Dwg. No: 345.1/15/1-3

DPaW TEC/PEC

DATABASE SEARCH RESULTS

Rockwater PROPRIETARY LIMITED



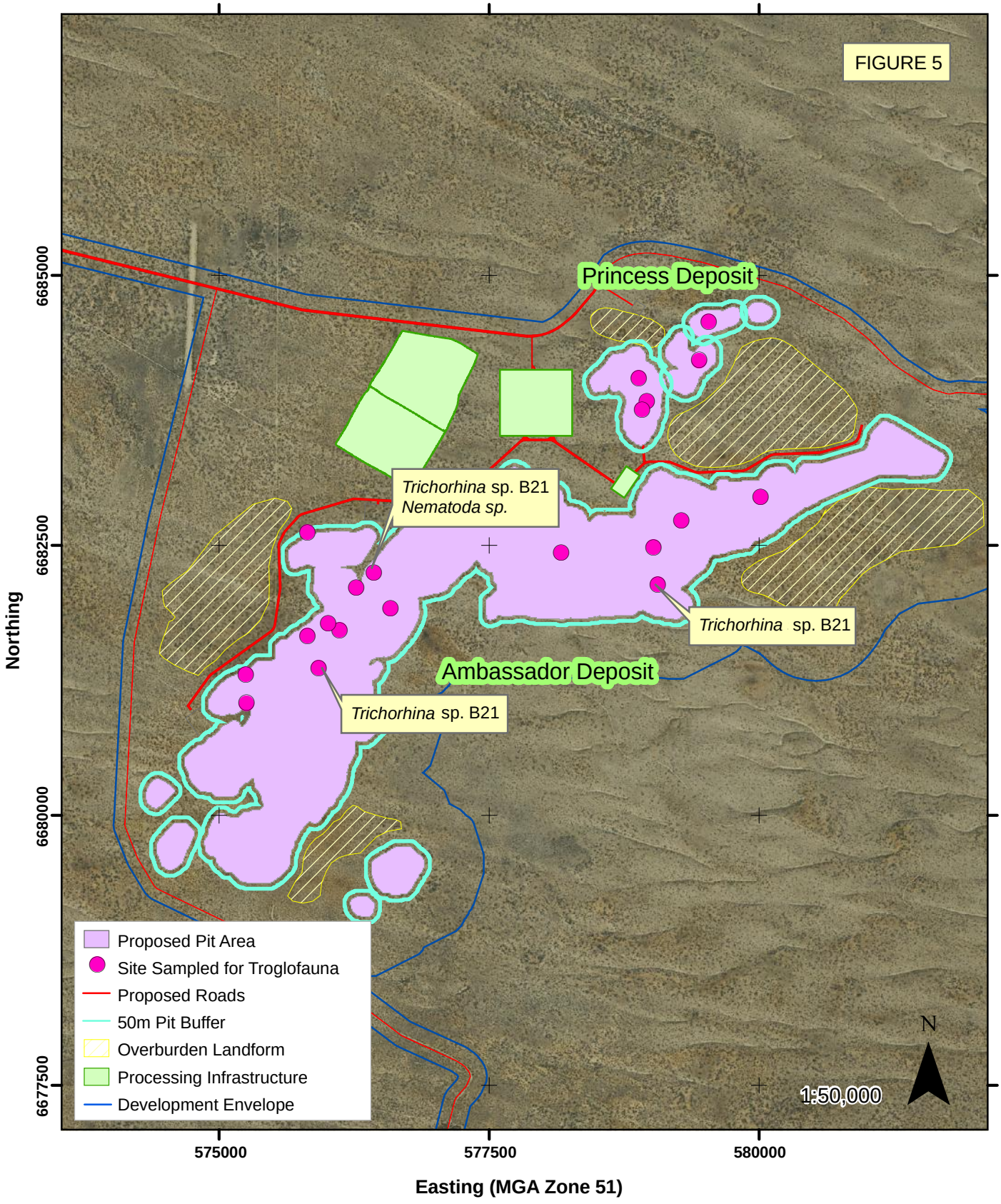
L:/GIS Projects/345-1 - EAMA/ Fig. 4 - Kakarook North

Client: Vimy Resources Ltd
Project: Mulga Rock Uranium Project
Subterranean Fauna Study
Date: October 2015
Dwg. No: 345.1/15/1-4

STYGOFAUNA SITES

KAKAROOK NORTH BOREFIELD

Rockwater PROPRIETARY LIMITED



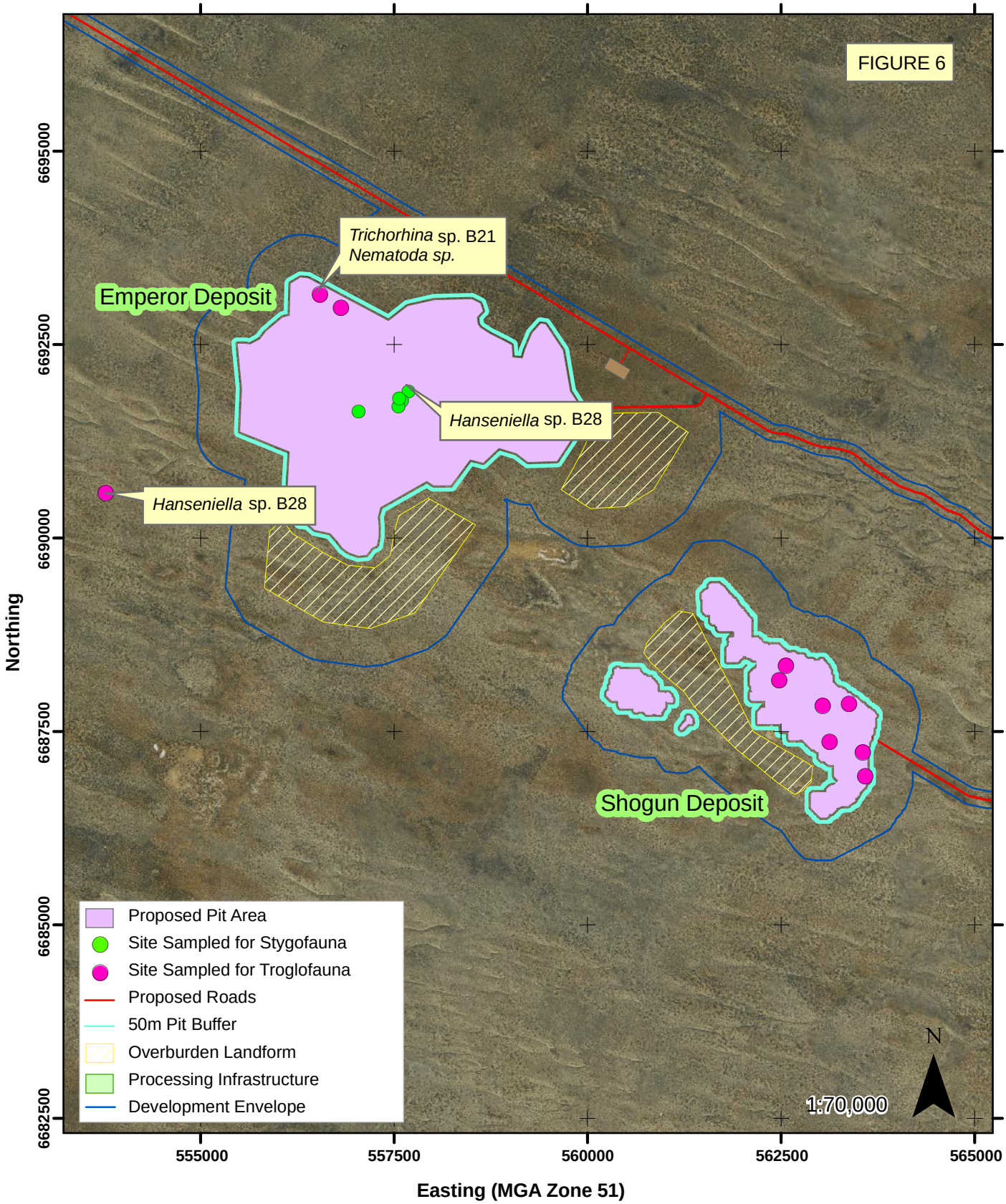
L:/GIS Projects/345-1 - EAMA/ Fig. 5 - Princess and Ambassador

Client: Vimy Resources Ltd
Project: Mulga Rock Uranium Project
Subterranean Fauna Study
Date: October 2015
Dwg. No: 345.1/15/1-5

TROGLOFAUNA SITES

PRINCESS AND AMBASSADOR DEPOSITS

Rockwater PROPRIETARY LIMITED



L:/GIS Projects/345-1 - EAMA/ Fig. 6 - Emperor and Shogun

Client: Vimy Resources Ltd
Project: Mulga Rock Uranium Project
Subterranean Fauna Study
Date: October 2015
Dwg. No: 345.1/15/1-6

SUBTERRANEAN FAUNA SITES

EMPEROR AND SHOGUN DEPOSITS

Rockwater PROPRIETARY LIMITED

APPENDIX I

Appendix I: Site and Sampling details for Stygofauna Sampling at the MRUP.

Site Details												Bore Construction			Sampling Details		Water Quality							Strat
Site id	Zone	Easting	Northing	RL	Type[1]	Prelim Status[2]	Drill Date	Depth	WL (m)	Collar Height	Dip	Construction Date	Slotted Section (m bgl)	Diameter (mm)	Sampled Date	Time	Method[3]	Temperature (degrees)	EC (mS/cm)	Salinity (ppk)	pH	ORP (mV)	DO (mg/L) #	
Kakarook North																								
NGW04	51	603808	6700916	339	M	I	25/03/13	33.64	17.24	0.11	-90	25/03/13	18-51	44	9/10/14	14:34	B	24.5	7.64	4.15	5.53	133	2.1	Eoc
NGW06	51	605674	6701286	337	M	I	26/03/13	22.33	15.28	0.15	-90	26/03/13	18-30	44	9/10/14	15:30	B	22.8	3.91	2.04	6.17	114	2.7	Eoc
NGW07	51	604422	6701798	339	M	I	26/03/13	27.66	16.97	0.15	-90	26/03/13	23-45	44	9/10/14	14:56	B	23.1	7.49	4.03	6.26	121	1.7	Eoc
NGW10	51	604667	6703690	339	M	I	27/03/13	24.32	18.34	0.12	-90	27/03/13	16-31	44	9/10/14	16:04	B	23.5	6.7	3.59	6.19	160	4.1	Eoc
NGW14	51	607566	6697666	340	M	I	29/03/13	29.19	23.43	0.15	-90	29/03/13	19-31	44	9/10/14	11:40	B	24.5	6.3	3.36	6.3	165	7.9	Mio + Eoc
NGW15	51	606194	6698136	337	M	I	29/03/13	28.94	15.30	0.12	-90	29/03/13	17-42	44	9/10/14	12:31	B	24	7.36	3.83	6.06	116	2.2	Eoc
NGW16	51	604658	6698729	336	M	I	29/03/13	40.27	17.29	0.13	-90	29/03/13	21-48	44	9/10/14	13:05	B	22.7	7.58	4.09	6.21	94	1.5	Eoc
NGW17	51	603258	6699262	338	M	I	30/03/13	28.51	16.65	0.13	-90	30/03/13	17-29	44	9/10/14	15:40	B	23.6	6.59	3.51	5.36	159	5.6	Eoc
NGW18	51	605617	6696705	331	M	I	30/03/13	36.63	16.65	-	-90	30/03/13	22-52	44	9/10/14	10:32	-	Bent PVC - unable to bail						-
NGW20	51	602815	6697919	333	M	I	31/03/13	20.60	12.11	0.14	-90	31/03/13	10-20	44	9/10/14	9:51	B	22.9	9.58	5.26	5.52	145	4.8	Eoc + Cre
NGW21	51	603004	6695516	328	M	I	31/03/13	23.03	12.36	0.18	-90	31/03/13	12-18	44	9/10/14	9:15	B	22.6	14	7.55	5.98	97	9.2	Eoc
NGW24	51	604024	6693284	321	M	I	31/03/13	23.13	14.64	0.1	-90	31/03/13	18-30	44	9/10/14	8:20	B	-	9.06	4.94	5.24	220	3.1	Eoc
Emperor																								
ET01	51	557032	6691641	324	A	I	03/08/81	83		0	-90	03/08/81	-	-	8/10/14	11:00	-	-	-	-	-	-	-	Eoc
NNA5494	51	557674	6691904	322	A	I	15/02/09	81	31.12	0.1	-90	15/02/09	71-77	50	8/10/14	12:22	-	-	-	-	-	-	-	Eoc
NNA5495	51	557595	6691788	321	A	I	15/02/09	78	WET	-	-90	15/02/09	70-76	50	8/10/14	11:40	-	-	-	-	-	-	-	Eoc
NNA5497	51	557557	6691709	321	A	I	15/02/09	78	30.23	0.16	-90	15/02/09	69-75	50	8/10/14	12:06	-	-	-	-	-	-	-	Eoc
NNA5498	51	557553	6691813	322	A	I	15/02/09	81	31.37	0.2	-90	15/02/09	70-76	50	8/10/14	11:25	-	-	-	-	-	-	-	Eoc

Notes: [1] M – Monitoring Bore, A – Aircore Hole
[2] I – Impact
[3] B – Bailed
DO corrected for conductivity at 8 mS/cm and 24°C

Mioc: Miocene, Eoc: Eocene, Cre: Cretaceous

APPENDIX II

Appendix II: Site and Sampling details for Troglofauna Sampling at the MRUP.

Site id	Zone	Easting	Northing	RL	Type	Prelim Status	WL (m)	Collar Height	Dip	Sampled Date	Time	Sampled For	Trap Depth (m)	Comments	Strat*
Princess															
NNA5561	51	578957	6683837	340	Aircore	Impact	Dry	0	90	7/10/2014	9:37	T (T)	13	Trap Lost	-
NNA5640	51	578910	6683762	345	Aircore	Impact	Dry	0	-90	7/10/2014	10:23	T (T)	15	Trap Lost	
NND5792	51	579447	6684215	353	Aircore	Impact	Dry	0	-90	7/10/2014	11:07	T (S + T)	15	-	Mio-Eoc
NND5793	51	579528	6684574	354	Aircore	Impact	Dry	0	-90	7/10/2014	12:01	T (S + T)	10	-	Mio
NNA5802	51	578879	6684050	346	Aircore	Impact	Dry	0	-90	7/10/2014	12:25	T (S + T)	10	Trap Lost	-
Ambassador															
NNA5294	51	580007	6682952	338	Aircore	Impact	Dry	0	-90	7/10/2014	14:10	T (S + T)	3.8	Trap Lost	-
NNA5366	51	579062	6682141	343	Aircore	Impact	Dry	0	-90	10/10/2014	9:54	T (S + T)	5	-	Plio-Plei
NNA5807	51	579017	6682483	367	Aircore	Impact	Dry	0	-90	7/10/2014	15:40	T (S + T)	5	-	Plio-Plei
NND5776	51	578163	6682437	351	Aircore/Diamond	Impact	Dry	0	-90	7/10/2014	16:05	T (S + T)	12	-	Mio
NND5780	51	579277	6682737	344	Aircore/Diamond	Impact	Dry	0	-90	7/10/2014	15:00	T (S + T)	7	-	Mio
NNA5091	51	576109	6681717	337	Aircore	Impact	Dry	0	-90	10/10/2014	9:19	T (S + T)	8.5	-	Plio-Plei
NNA5105	51	575810	6681665	336	Aircore	Impact	Dry	0	-90	10/10/2014	9:00	T (S + T)	3	-	Plei-Holo
NNA5108	51	575920	6681367	333	Aircore	Impact	Dry	0	-90	10/10/2014	8:45	T (S + T)	10	-	Mio
NNA5182	51	575810	6682621	334	Aircore	Impact	Dry	0	-90	10/10/2014	7:05	T (S + T)	8.5	-	Mio
NNA5380	51	576431	6682249	331	Aircore	Impact	Dry	0	-90	10/10/2014	7:29	T (S + T)	4.5	Trap Lost	-
NNA5406	51	575240	6681309	331	Aircore	Impact	Dry	0	-90	10/10/2014	8:17	T (S + T)	7.5	Trap Lost	-
NNA5477	51	575245	6681040	327	Aircore	Impact	Dry	0	-90	10/10/2014	7:58	T (S + T)	3	-	Plio-Plei
NND5772	51	576009	6681778	336	Aircore/Diamond	Impact	Dry	0	-90	7/10/2014	17:55	T (T)	9	-	Eoc
NND5773	51	576262	6682110	341	Aircore/Diamond	Impact	Dry	0	-90	7/10/2014	17:18	T (S + T)	7.5	-	Mio
NND5774	51	576580	6681916	360	Aircore/Diamond	Impact	Dry	0	-90	7/10/2014	17:00	T (S + T)	8.5	-	Mio
Emperor															
NNA5709	51	553763	6690581	344	Aircore	Impact	Dry	0	-90	8/10/2014	10:00	T (S + T)	10	-	Plio/Mio
NNA5710	51	556539	6693151	343	Aircore	Impact	Dry	0	-90	8/10/2014	9:15	T (S + T)	4	-	Plio-Plei
NNA5711	51	556812	6692985		Aircore	Impact	Dry	0	-90	8/10/2014	8:40	T (S + T)	7.5	Trap Lost	-
Shogun															
NNA5713	51	562563	6688351	331	Aircore	Impact	Dry	0	-90	8/10/2014	13:58	T (S + T)	14	Trap Lost	-
NNA5716	51	563377	6687856	330	Aircore	Impact	Dry	0	-90	8/10/2014	17:05	T (S + T)	5	Trap Lost	-
NNA5717	51	563038	6687833	327	Aircore	Impact	Dry	0	-90	8/10/2014	14:45	T (S + T)	21	-	Eoc
NNA5719	51	562470	6688167	329	Aircore	Impact	Dry	0	-90	8/10/2014	14:19	T (S + T)	10	Trap Lost	-
NNA5724	51	563128	6687365	326	Aircore	Impact	Dry	0	-90	8/10/2014	15:25	T (S + T)	12	Trap Lost	-
NNA5726	51	563554	6687234	327	Aircore	Impact	Dry	0	-90	8/10/2014	16:41	T (S + T)	12	-	Eoc
NNA5728	51	563583	6686920	327	Aircore	Impact	Dry	0	-90	8/10/2014	15:50	T (T)	7	-	Mio

Note: *Holo: Holocene, Plei: Pleistocene, Plio: Pliocene, Mio: Miocene, Eoc: Eocene