

5 June 2008



## GREATER KARARA IRON ORE PROJECT SUBTERRANEAN FAUNA BIOLOGICAL REPORT

*Providing sustainable environmental strategies,  
management and monitoring solutions  
to industry and government.*



  
**ecologia**  
ENVIRONMENT

**Greater Karara Iron Ore Project**  
**(comprising the Karara Iron Ore Project**  
**and Mungada Iron Ore Project)**

**Subterranean Fauna**  
**Biological Report**

Prepared by *ecologia* Environment



Prepared for Coffey Natural Systems



**5 June 2008**

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## EXECUTIVE SUMMARY

The greater Karara Iron Ore Project, located in the Mid West region of Western Australia, approximately 220 km east of Geraldton and 400 km north east of Perth (Figure 1-1) comprises:

- the Karara Iron Ore Project, located on Karara Ridge,
- the Mungada Iron Ore Project, located on Blue Hills North and Terapod.

Although the subterranean fauna biological survey data for both projects is presented here, the current Environmental Impact Assessment relates only to the Karara Iron Ore Project. This project will consist of open-cut mining of magnetite ore and on-site processing to produce magnetite concentrate. This material will be transported to the Port of Geraldton for export to international markets. The project will also include the construction of an airfield at the mine site. The Karara Iron Ore Project has an expected life of 40 years, mining 45 Mtpa (total mining rate) of an estimated resource of 929 Mt and reserve of 497 Mt. This Project is expected to intersect the water table at Karara and therefore potentially impact upon any stygofauna present.

The Mungada Iron Ore Project will consist of open pit mining, on-site crushing and screening and transport to the Port of Geraldton for export. The project will also include the construction of mine site accommodation facilities and infrastructure. The Project has an expected life of 10 years. Mining is expected to remain above the water table. However groundwater abstraction is currently being investigated for potable and process usage from parts of the project.

A subterranean fauna desktop review (Biota 2007) concluded that there was minimal potential troglobitic habitat within the geological strata for both the Mungada and Karara Iron Ore Projects. However, prospective localities were identified and a small number of sites were subsequently sampled (Biota 2007). A single specimen of a new species of troglobitic Pseudoscorpion (nymph) and three individual Isopods specimens which were potentially troglobitic, were recorded.

Further survey work was considered necessary in order to further define the troglobitic species composition and distribution for an accurate and informed EIA.

A subterranean fauna sampling programme was subsequently developed (Bennelongia 2007) and approved by the Department of Environment and Conservation (DEC). Subsequently, Coffey Natural Systems commissioned *ecologia* Environment to execute this plan. Constraints in terms of the number of bores available for stygofauna sampling and drill holes open for troglofauna sampling have necessitated some minor changes to the sampling programme, mainly relating to the timing of sampling. Unfortunately, the drill hole from which the troglobitic pseudoscorpion was recorded was found to be blocked and thus not re-sampled.

The sampling regime failed to find any Stygofauna species / communities within the modelled water drawdown footprint for the Karara Iron Ore Project. Five orders of stygobite were recorded from seven pastoral bores (Ostracoda sp. 1, Syncarida sp.1, Oligochaeta sp.1, Isopoda sp.1 and Copepoda (Harpacticoida sp.1 and Calanoida sp.1). All of these specimens were recorded from bores/wells located within the unconfined alluvial aquifer(s) that surround the Karara and Mungada BIF ranges. The BIF aquifers are known as fractured rock aquifers and as can be seen from the shape of the modelled drawdown

contours (Figure 5-1); these aquifer types are in little to no hydraulic connection. If the aquifers were connected (which might otherwise suggest inadequate or incorrect sampling techniques by the absence of specimens), then the shape of the drawdown contour would be expected to be more rounded or elliptical. Thus with considerable confidence it is concluded that the Karara and Mungada Iron Ore Projects will not impact upon stygofauna communities as those communities are located within the unconfined alluvial aquifers that surround the BIF ranges.

No obligate troglofauna species were recorded in addition to the pseudoscorpion species recorded in 2007 (Biota 2007b), despite a sampling effort far in excess of that required under Guidance Statement 54a. It is suggested that there is thus no additional suitable subterranean habitat within the great Karara Iron Ore project. The area near the northern most extent of the Mungada Ridge is the only troglofauna habitat in the immediate area.

Based on recent Pilbara data, post wet season sampling appears to identify the most representative troglofauna. Thus the timing of the survey may have been a limitation. However, February 2008 received twice the monthly expected rainfall total and the original specimens were recorded from traps installed between February and May 2007; late summer and autumn months. Therefore the issue of timing is by no means definitive.

## 1.0 INTRODUCTION

### 1.1 PROJECT BACKGROUND

The greater Karara Iron Ore Project, located in the Mid West region of Western Australia, approximately 220 km east of Geraldton and 400 km north east of Perth (Figure 1-1), comprises:

- the Karara Iron Ore Project, located on Karara Ridge,
- the Mungada Iron Ore Project, located on Mungada Ridge, approximately 12 km east of Karara Ridge.

The Karara Iron Ore Project will consist of open-cut mining of magnetite ore and on-site processing to produce magnetite concentrate. The Karara Iron Ore Project has an expected life of 40 years, mining 45 Mtpa (total mining rate) of an estimated resource of 929 Mt and a reserve of 497 Mt. This Project is expected to intersect the water table at Karara and therefore potentially impact upon any stygofauna present.

Process water will be sourced from a borefield near Mingenew and piped to the mine site.

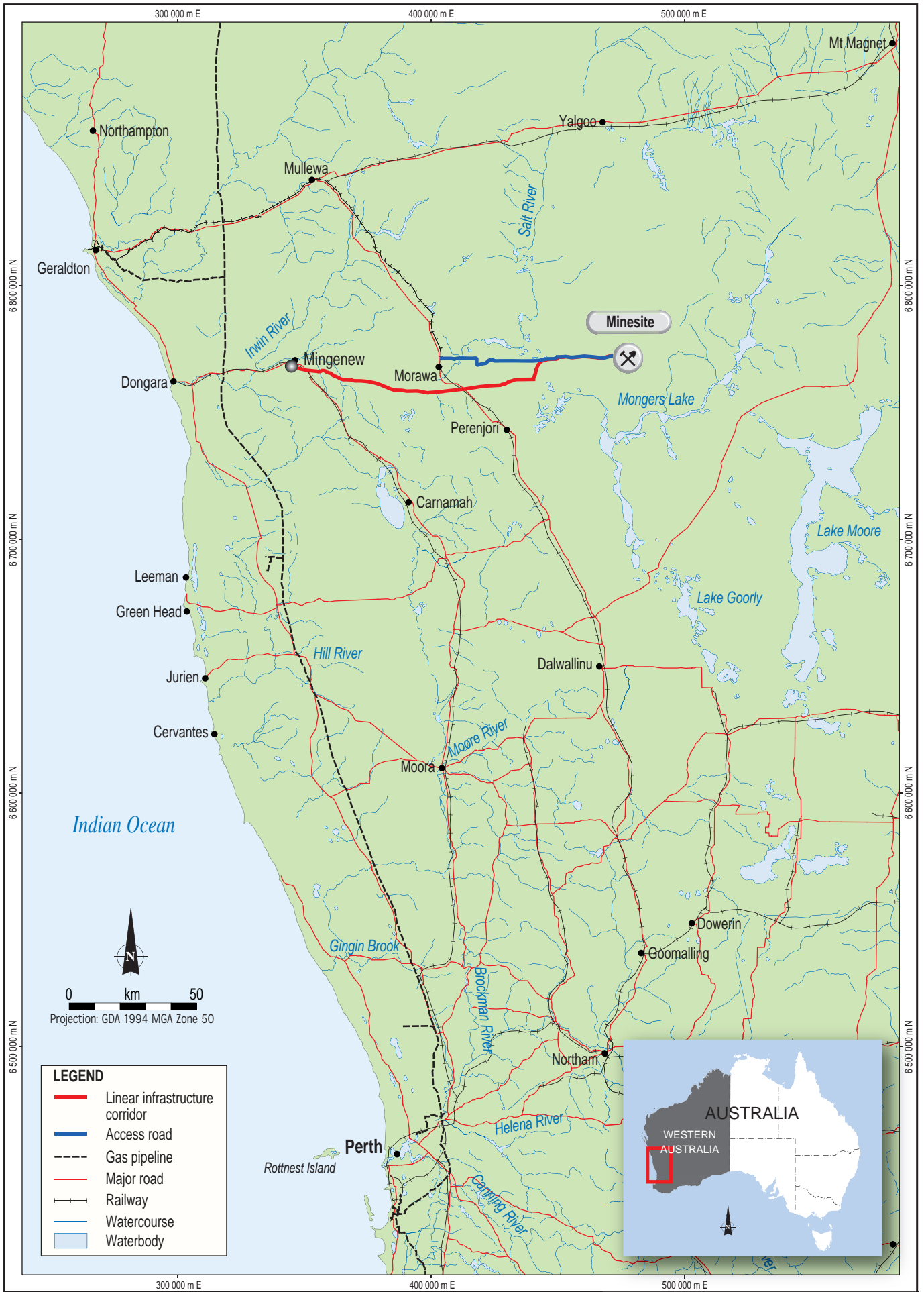
The Mungada Iron Ore Project will consist of open pit mining, on-site crushing and screening. The first stage of mining, for which current approvals are being sought, will be above the water table. However groundwater abstraction is currently being investigated for potable and process usage from parts of the project.

A subterranean fauna sampling programme reflecting was subsequently developed (Bennelongia 2007) and approved by the Department of Environment and Conservation (DEC). Subsequently, Coffey Natural Systems commissioned *ecologia* Environment to execute this plan. Constraints in terms of the number of bores available for stygofauna sampling and drill holes open for troglofauna sampling have necessitated some minor changes to sampling programme, mainly relating to the timing of sampling.

### 1.2 TROGLOFAUNA

Troglofauna are communities of terrestrial subterranean animals that inhabit air chambers in underground caves or small, humid voids. They are divided into three ecological categories: a) troglobites - obligate underground species that are unable to survive outside of the subterranean environment, b) troglfiles - facultative species that live and reproduce underground but that are also found in similar dark, humid microhabitat on ground surface; and c) troglroxenes - species that regularly inhabit underground caves and cavities for refuge but normally return to surface environment to feed. A fourth group, accidentals, wander into cave systems but cannot survive there (Howarth 1983).

A species is considered truly troglobitic if it displays morphological characteristics that appear to restrict it to subterranean habitats (Howarth 1983). These include a significant reduction or a complete loss of eyes, pigmentation, wings, and a circadian rhythm (24-hour biological cycle), as well as development of elongated appendages, slender body form and, in some species, a lower metabolism. Troglobitic faunal assemblages are dominated by arthropods such as schizomids, pseudoscorpions, spiders, harvestmen, centipedes, millipedes, diplurans and mites. Many species are relict rainforest litter fauna from previous tropical climate eras (Humphreys 1993), therefore depending on subterranean habitats that are constantly humid.



**LEGEND**

- Linear infrastructure corridor
- Access road
- - - Gas pipeline
- Major road
- |— Railway
- Watercourse
- Waterbody

0 km 50

Projection: GDA 1994 MGA Zone 50



File No:  
g1327\_KIOP\_PER\_CH01\_f001

Karara Mining Limited  
Karara Iron Ore Project

Project location and elements

Figure No:  
**1.1**

The food resources for the subterranean ecosystems are largely allochthonous (not formed in the region where found) and carried into caves and cavities by plant roots, water and animals (Howarth 1983).

True troglobites are incapable of dispersing on the surface and thus are subject to dispersal barriers due to the geological structure of their habitat. Such dispersal limitations result in extremely small, fragmented species ranges and thus high levels of endemism (EPA 2003), which is characteristic of subterranean fauna worldwide (Strayer 1994). Examples include the millipede *Stygiochiropus peculiaris*, which is restricted to a single cave system at Cape Range (Humphreys and Shear 1993). However, exceptions exist, genetic analyses of troglobitic mites from Pilbara provide evidence that these microscopic organisms have wide-range distribution, suggesting that they use other means of dispersal, possibly on the surface (Biota 2006).

The presence of troglofauna in Western Australia is still poorly documented. To date, troglofauna have been recorded from karstic limestone systems at Cape Range, Barrow Island and in the Kimberley (Harvey 1988; Humphreys 2001; Biota 2005), pisolitic mesa formations in the Pilbara (Biota 2006) and in the cave systems of Yanchep (EPA 2005), Margaret River (Eberhard 2006) and across the Nullarbor (Moore 1995).

A subterranean fauna desktop review for the proposed greater Karara Iron Ore Project was completed in April 2007 (Biota 2007). This review concluded that four prospective troglofauna habitats were evident from inspection of the diamond drill cores available. Consequently a 'pilot study' of prospective habitats was conducted in June 2007 (Biota 2007). A single juvenile troglobitic pseudoscorpion (Cthonidae: *Tyrannochthonius*) and three specimens of a presumed troglophilic isopod species were recorded near the perimeter of the proposed Mungada Iron Ore Project. Further surveying was conducted to determine the extent of troglofauna within the Blue Hills area and the results are presented within this report. This strategy was considered consistent with the Environmental Protection Authority's (EPA's) Guidance Statement 54: Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia (EPA 2003).

### **1.3 STYGOFAUNA**

Stygofauna ("stygo" meaning adapted to living underground and referring to the River Styx in Greek and Roman mythology) are obligate, groundwater dwelling fauna known to be present in a variety of rock types including karst limestone, fissured rock (e.g. granite) and porous rock (e.g. alluvium) (Mamonier, Vervier et al. 1993). They are typically adapted for the subterranean environment with features such as lack of pigmentation, elongated appendages, filiform body shape (worm like) and reduced or absent eyes. Many of these fauna have other primitive features which link them to geological periods when vast areas of Australia were covered by tropical forests. They are regarded as 'relict' fauna which have survived in aquifers over geological timeframes (Humphreys 1993; Danielopol and Stanford 1994; Humphreys 2001).

The presence of stygofauna in Western Australia has been well documented, especially from regions such as Pilbara, Kimberley, mid-west and south-western Western Australia (De Laurentiis, Pesce et al. 2001; Humphreys 2001; Wilson and Keable 2002; Eberhard 2004; Karanovic 2004; Cho, Park et al. 2005). The aim of the sampling program was to define the abundance, diversity and distribution of stygofauna in the project area so that a strategy to ensure the protection of important habitats for subterranean communities could be developed. This is consistent with the Environmental Protection Authority's (EPA's)

Guidance Statement 54: Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia (EPA 2003).

## 2.0 LEGISLATIVE FRAMEWORK

Subterranean fauna are protected at a State level under the *Wildlife Conservation Act 1950* (WC Act) and their environment is protected under the *Environmental Protection Act 1986* (EP Act). The WC Act was developed to provide for the conservation and protection of wildlife in Western Australia. Under Section 14 of this Act, all fauna and flora within Western Australia is protected; however, the Minister may, via a notice published in the *Government Gazette*, declare a list of fauna taxa identified as likely to become extinct, or is rare, or otherwise in need of special protection. The current listing was gazetted on the 1 December 2006. Currently there are only a handful of subterranean species (stygo fauna) which are listed under the WP Act. These are almost entirely restricted to the Cape Range karstic system. No subterranean fauna from the Midwest region are currently listed as requiring special protection.

A Guidance Statement has been developed specifically to advise the public about the minimum requirements for environmental management with respect to subterranean fauna. EPA Guidance Statement 54: *Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment 2003* states that:

“Proposals that, if implemented, could potentially have a significant impact on stygo faunal or troglofaunal habitat by:

- lowering the water table sufficiently to dry out the zone in which some species live, or otherwise artificially changing water tables; or
- changing water quality (e.g. increasing salinity levels or altering haloclines, increasing nutrient levels or the availability of organic matter, or introducing other pollutants); or
- destroying or damaging caves (including changing their air temperatures and humidity);

will be subject to formal EIA (Environmental Impact Assessment) under the EP Act.”

The EP Act is an Act to provide for an Environmental Protection Authority, for the prevention, control and abatement of environmental pollution, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing. Section 4a of this Act outlines five principles that must be addressed to ensure that the objectives of the Act are addressed. Three of these principles are relevant to native fauna and flora:

- *The Precautionary Principle*

Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

- *The Principles of Intergenerational Equity*  
The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
- *The Principle of the Conservation of Biological Diversity and Ecological Integrity*  
Conservation of biological diversity and ecological integrity should be a fundamental consideration.

Projects undergoing formal EIA assessment are required to address guidelines produced by the EPA, in this case Guidance Statement 56: Terrestrial Fauna Surveys for Environmental Impact in Western Australia (EPA 2004), Guidance Statement 54: Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia (EPA 2003), and principles outlined in the EPA's Position Statement No. 3 Terrestrial Biological Surveys as an element of Biodiversity Protection (EPA 2002). Additionally, a requirement to protect subterranean fauna, and to prevent or manage activities that may cause a decline in subterranean fauna populations is now written into the Licence to Operate for most mining and industrial activities.

Subterranean fauna in Western Australia are also protected at a Federal level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act was developed to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance, to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources, and to promote the conservation of biodiversity. The EPBC Act includes provisions to protect native species (and in particular prevent the extinction, and promote the recovery, of threatened species) and ensure the conservation of migratory species. In addition to the principles outlined in Section 4a of the EP Act, Section 3a of the EPBC Act includes a principle of ecologically sustainable development dictating that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.

## 2.1 SURVEY OBJECTIVES

Coffey Natural Systems commissioned *ecologia* Environment (*ecologia*) to undertake subterranean surveys for the greater Karara Iron Ore Project of the Blue Hills study area as part of the environmental impact assessment for the project.

The EPA's objectives with regards to fauna management are to:

- maintain the abundance, species diversity and geographical distribution of Subterranean invertebrate fauna; and
- protect Specially Protected (Threatened) fauna, consistent with the provisions of the *Wildlife Conservation Act 1950*.

Hence, the primary objective of this study was to provide sufficient information for the EPA to assess the impact of the project on subterranean fauna in the area against these objectives.

### 3.0 THE BIOPHYSICAL ENVIRONMENT

#### 3.1 CLIMATIC AVERAGES

The climate in the Karara area (taken from B.O.M. Morawa) data is semi-arid with a mean annual rainfall of approximately 335 mm. Annual evaporation is 2,315 mm and far exceeds the annual rainfall. Monthly average temperatures and rainfall recorded at Morawa, 91 km to the west of the mine site are illustrated in Figure 3-1 and Figure 3-2 respectively. These figures and data illustrate the region experiences a hot Mediterranean climate, characterised by a rainfall regime similar to that of the southwest region, that is, the majority of rainfall received occurs from May – August (see also Table 3-1 and Table 3-2).

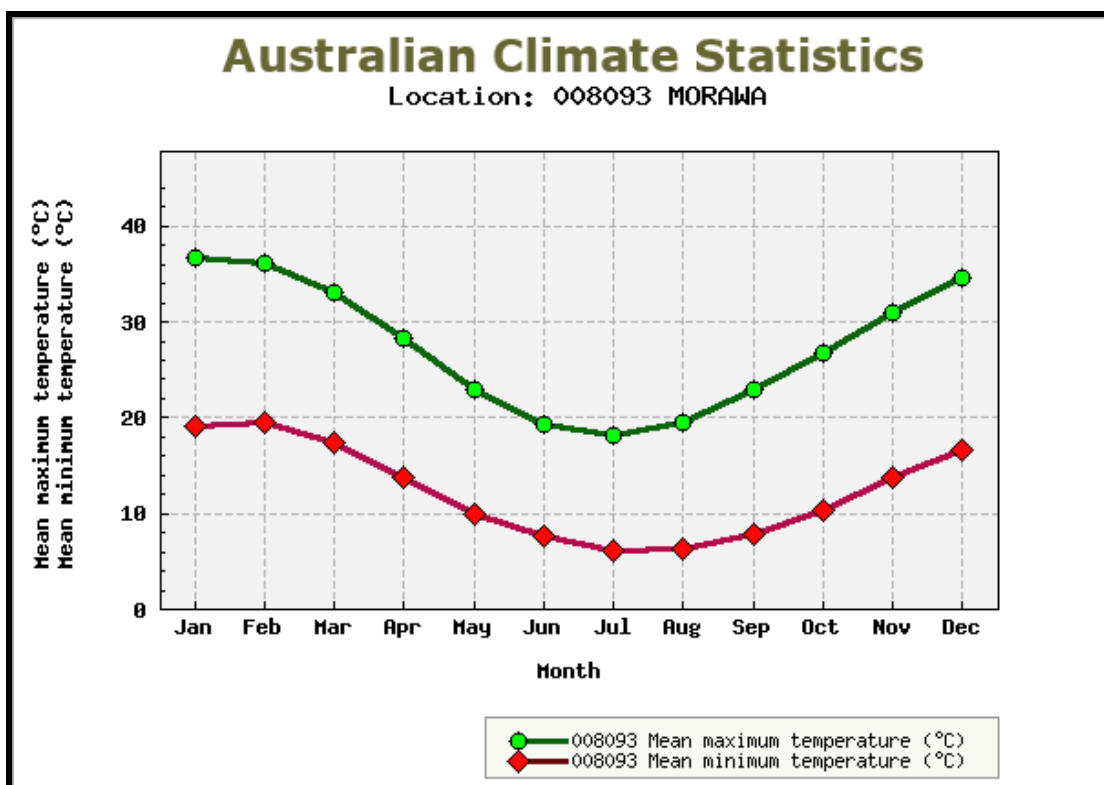


Figure 3-1 Morawa Historic Annual Daily Temperature Data (Source: <http://www.bom.gov.au/climate/averages>)

Table 3-1 Morawa Historic Annual Daily Temperature Data (Source: <http://www.bom.gov.au/climate/averages>)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean maximum temperature (°C)	36.7	36.2	33.1	28.2	22.9	19.3	18.2	19.5	23.0	26.7	31.0	34.5	27.4	79
Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean minimum temperature (°C)	19.1	19.5	17.5	13.8	9.9	7.6	6.2	6.4	7.8	10.3	13.8	16.7	12.4	79

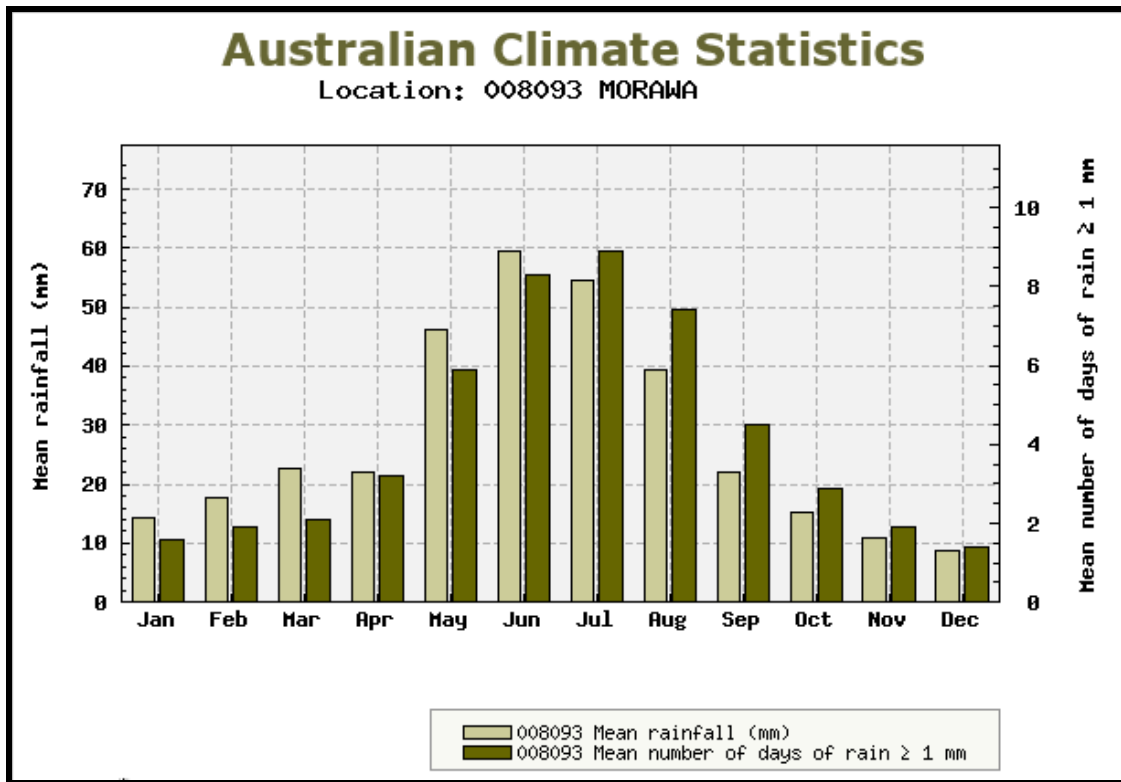


Figure 3-2 Morawa Historic Annual Rainfall Data (Source: <http://www.bom.gov.au/climate/averages>)

Table 3-2 Morawa Historic Annual Rainfall Data (Source: <http://www.bom.gov.au/climate/averages>)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean rainfall (mm)	14.4	17.6	22.6	22.0	46.2	59.5	54.4	39.3	22.0	15.1	10.9	8.8	332.8	92
Mean number of days of rain ≥ 1 mm	1.6	1.9	2.1	3.2	5.9	8.3	8.9	7.4	4.5	2.9	1.9	1.4	50.0	91

### 3.2 CLIMATIC VARIABLES DURING THE TIME OF SURVEY

The climatic variables experienced during the sampling period were similar to that historically experienced. The mean daily maximum temperature was 35.1 °C and the mean daily minimum temperature was 18.6 °C. Of the 152 days of which the subterranean fauna surveys were undertaken, a total of 66.6 mm of rain was received over 17 days.

February was the wettest month with 57.6 mm (86.4% of the total period) of rain received over nine days. This data is more than twice the total monthly rainfall average and more than four times the average monthly number of rain days (Figure 3-1); the result of a number of summer low pressure systems in succession.

### 3.3 GROUNDWATER

The regional ground water level generally occurs at around 255 m AHD. Annual evaporation far exceeds annual rainfall although some minor subsurface recharge does occur during intense rainfall events. Storage systems for ground water in the region may be broadly divided to three types (Johnson and Wright 2001) .

- *Shallow Alluvial Sediments* - Limited volumes of ground water are stored in surficial sandy sediments associated with current drainages.
- *Fractured Bedrock* - Bedrock in the project area consists of Archaean supracrustal rocks enclosed in gneissic rocks and intruded by later granitoid rocks. The supracrustal sequence comprises a basal volcanic facies conformably overlain by clastic and chemical sedimentary rocks. The sedimentary sequence which is the focus of attention in this project consists of siltstone, felspathic sandstone, pebbly sandstone and minor beds of quartz-pebble conglomerate overlain by, and interbedded with, banded iron-formation and well-laminated to massive, graded pelitic shale. It has been observed from drill core that the sedimentary sequence is almost completely porous in the oxidised upper levels. Secondary permeability in the fresh deeper levels is less pronounced but may be enhanced by the presence of large strike slip faults that truncate the orebody.
- *Palaeodrainages* - Drainage during the Tertiary sub-era in the region was in an arcuate river system which flowed around the Karara Ridge/ Blue Hills/ Mungada Ridge and Koolanooka Hills to the west, north and east. This is now delineated by a series of salt lakes (Lake Nullewa to the north and Weelhamby Lake to the east) which flow periodically during intense rainfall events.

### 3.4 BIOGEOGRAPHY

The project is based at the Karara Station 260 km east of Geraldton. Karara Station lies near the western border of the Yilgarn Craton within the southern region of the Western Murchison district.

The Western Murchison subregion is described as:

“Mulga low woodlands, often rich in ephemerals, on outcrop and fine textured Quaternary alluvial and alluvial surfaces mantling granitic and greenstone strata of the northern part of the Yilgarn Craton. Surfaces associated with the occluded drainage occur throughout the hummock grasslands on Quaternary sandplains, saltbush shrublands on calcareous soils and Halosarcia low shrublands on saline alluvia.” (Desmond and Chant)

The area of the Western Murchison subregion is 78,500 km<sup>2</sup> ha. Only 0.06% of the subregion is classed as conservation land.

Calcrete aquifers are present in the eastern part of the subregion. Calcrete is known to provide suitable habitat for stygofauna. There is a limited understanding of stygofauna distribution in this sub-region, however Humphries (2001) suggests that the Murchison system contains significant stygofauna assemblages. Recent troglofauna sampling by Western Australian Museum staff has also recorded significant troglofauna communities within the dry portions of these same calcrete systems (B. Humphreys pers. comm). However, the troglofauna of the Midwest Banded Ironstone Formations and other geological structures is poorly known.

## 4.0 METHODS

Methods for stygofauna and troglofauna surveys are outlined in EPA Draft Guidance Statement 54a. However, in the case of troglofauna sampling, this area of EIA is still very much in its infancy and therefore sampling methods appear to vary considerably from project to project and consultant to consultant (B. Humphreys pers.comm. 07/02/2008). The sampling methods implemented for the current study are outlined below.

### 4.1 TROGLOFAUNA SURVEY SAMPLING DESIGN AND INTENSITY: MUNGADA IRON ORE PROJECT

Troglofauna sampling was conducted for the Karara Mining Limited’s Mungada Iron Ore Project. The “impact area” is defined as that area of material directly removed to access the ore body. A desktop assessment of the greater Karara Iron Ore Project area (Biota 2007) indicated that the rock structure, as revealed by diamond drill cores, presented a limited likelihood of troglofauna occurrence. However, one area in particular suggested the possibility of troglofauna presence. As such, this area was targeted with a small scale “pilot” trapping programme. This programme revealed the presence of a species of troglobitic pseudoscorpion from a drill hole considered to be outside of the impact footprint of the proposed project at that time. Given that troglofauna were recorded from the area, a more widespread and comprehensive survey programme was developed (Bennelongia 2007). This programme was approved by the DEC, and the results of that programme are presented herein.

#### 4.1.1 Survey timing

Troglofauna sampling consisted of a three phase survey, occurring back to back from October 2007 to February 2008 primarily in the summer months (Table 4-1). Trap deployment details (number of traps and depths) are listed in Table 4-2 and Table 4-3 respectively. The locations of the drill holes sampled are presented in Figure 4-1.

**Table 4-1 Troglofauna Survey Schedule**

Phase	Deployed	Recovered	Trapping Duration
Phase one	30 <sup>th</sup> October - 1 <sup>st</sup> November 2007	10 - 14 <sup>th</sup> December 2007	44 days
Phase two	10 - 14 <sup>th</sup> December 2007	29 <sup>th</sup> - 31 <sup>st</sup> January 2008	49 Days
Phase three	29 <sup>th</sup> - 31 <sup>st</sup> January 2008	25 <sup>th</sup> – 28 <sup>th</sup> March 2008	55 Days

#### 4.1.2 Survey sampling methods

RC Drill holes were sampled using custom designed traps, with two trap units deployed (20 m apart) per drill hole. Prior to traps being deployed, the water level of each drill hole was measured using a Standing Water Level Meter. The traps were placed such that the deeper trap unit was suspended approx 2-5 m above the water level and positioned so that the traps hung against the wall of the hole. The drill holes were re-sealed after the insertion of traps to maintain humidity levels and to reduce contamination from surface fauna.

Leaf litter was added to the traps immediately prior to inserting traps into bores. Leaf litter was collected from under vegetation close to the sampled drill holes. The leaf litter was soaked for at least 2 hours and then sterilised by microwaving at high setting for 3 minutes.

This process destroys any terrestrial predators present in the leaf litter that may reduce or completely remove troglofauna colonising the traps.

Traps were left in the ground on average for 49 days to ensure troglofauna colonisation. After this period, the traps were recovered and the leaf litter from each trap was placed into plastic collection jars, which were immediately sealed to avoid contamination. Samples were then brought back to the *ecologia* Environment Perth laboratory for fauna extraction and sorting.

#### 4.1.3 Site selection

A subterranean fauna desktop review was completed in April 2007 (Biota 2007). This review concluded that only four prospective troglofauna habitats were evident from inspection of the diamond drill cores available. Consequently a 'pilot study' was conducted in June 2007 involving 12 drill holes and 36 traps, with a number of drill holes being unserviceable due to blockages (Biota 2007). A single juvenile troglobitic pseudoscorpion (Cthonidae: *Tyrannochthonius*) and three specimens of a presumed troglophilic isopod species were recorded at drill hole MGD198. This hole was considered to be beyond the project area, however because of its close proximity to the proposed Terapod pit, the decision was made to expand the survey. This site was not sampled in this survey however, as it was found to be blocked above the original trap depth.

Consequently *ecologia* and CNS undertook a review of the characteristics of all available drill holes (based on the following criteria) in order to expand the scope of the sampling effort:

- Holes had to be less than 20° off vertical, due to problems with insertion and removal of traps;
- Holes had to be deeper than 20 m in total depth;
- Holes had to have a water table within 100m of the surface (if possible).

A large number of holes were thus identified as candidates for trapping, and in December 2007, 112 traps were deployed in 56 drill holes (Table 4-2). Of these, 107 were recovered.

Phase two of the troglofauna survey entailed deployment of 106 traps of which 102 were recovered.

Phase three of the troglofauna survey entailed deployment of 102 traps of which all were recovered

The loss of traps were due to blockages, which developed during the trapping period or because of inadvertent drill hole rehabilitation.

All traps locations are shown in Figure 4-1.

#### 4.1.4 Laboratory methods

Specimens were recovered from the leaf litter using Tullgren Funnels (Brady 1969) and then processed under a Leica S6 microscope with each taxon being placed into a separate vial containing 100% ethanol (to allow for potential DNA analysis) and assigned a unique identification code for tracking. All vials were labelled with the date, site, GPS coordinates and the name of the collector(s). These details were written on the outside of the container and on waterproof paper placed in each vial.

#### **4.1.5 Taxonomy and nomenclature**

Any troglobitic forms were to be identified to the lowest taxonomic resolution necessary. *ecologia* scientists conducted the preliminary sample processing and troglobitic determination, with any troglobitic specimens being sent to the relevant taxonomic specialists for further identification.

**Table 4-2 Summary of Troglifauna trap Deployment and Recovery**

Drill hole ID	Area	Phase 1		Phase 2		Phase 3	
		Deployed	Recovered	Deployed	Recovered	Deployed	Recovered
MGC255	MUNGADA SOUTH	2	2	2	2	2	2
MGC253	MUNGADA SOUTH	2	2	2	2	2	2
MGC247	MUNGADA SOUTH	2	2	2	2	2	2
MGC248	MUNGADA SOUTH	2	2	2	2	2	2
MGC250	MUNGADA SOUTH	2	2	2	2	2	2
MGC257	MUNGADA SOUTH	2	2	2	2	2	2
MGC058	MUNGADA SOUTH	2	2	2	2	2	2
MGC439	MUNGADA SOUTH	2	2	2	2	2	2
MGC057	OUTSIDE MUNGADA SOUTH	2	2	2	2	2	2
MGC055	OUTSIDE MUNGADA SOUTH	2	2	2	2	2	2
MGC056	OUTSIDE MUNGADA SOUTH	2	2	2	2	2	2
MGC081	OUTSIDE MUNGADA SOUTH	2	2	2	2	2	2
MGC174	OUTSIDE MUNGADA SOUTH	2	2	2	2	2	2
MGC173	OUTSIDE MUNGADA SOUTH	2	2	2	2	2	2
MGC172	OUTSIDE MUNGADA SOUTH	2	2	2	2	2	2
MGC170	OUTSIDE MUNGADA SOUTH	2	2	2	2	2	2
MGC390	OUTSIDE MUNGADA SOUTH	2	2	2	2	2	2
MGC039	OUTSIDE TOR	2	2	2	2	2	2
MGC031	GULLY TOR WAGONWHEEL	2	2	2	2	2	2
MGC118	GULLY TOR WAGONWHEEL	2	0	0	0	0	0
MGC116	GULLY TOR WAGONWHEEL	2	2	2	2	2	2
MGC109	GULLY TOR WAGONWHEEL	2	2	2	2	2	2
MGC399	GULLY TOR WAGONWHEEL	2	2	2	2	2	2
MGC288	GULLY TOR WAGONWHEEL	2	2	2	2	2	2
MGC434	GULLY TOR WAGONWHEEL	2	2	2	0	0	0
MGC202	TERAPOD	2	2	2	2	2	2
MGC237	TERAPOD	2	2	2	2	2	2
MGC242	TERAPOD	2	2	2	2	2	2
MGC275	TERAPOD	2	2	2	2	2	2

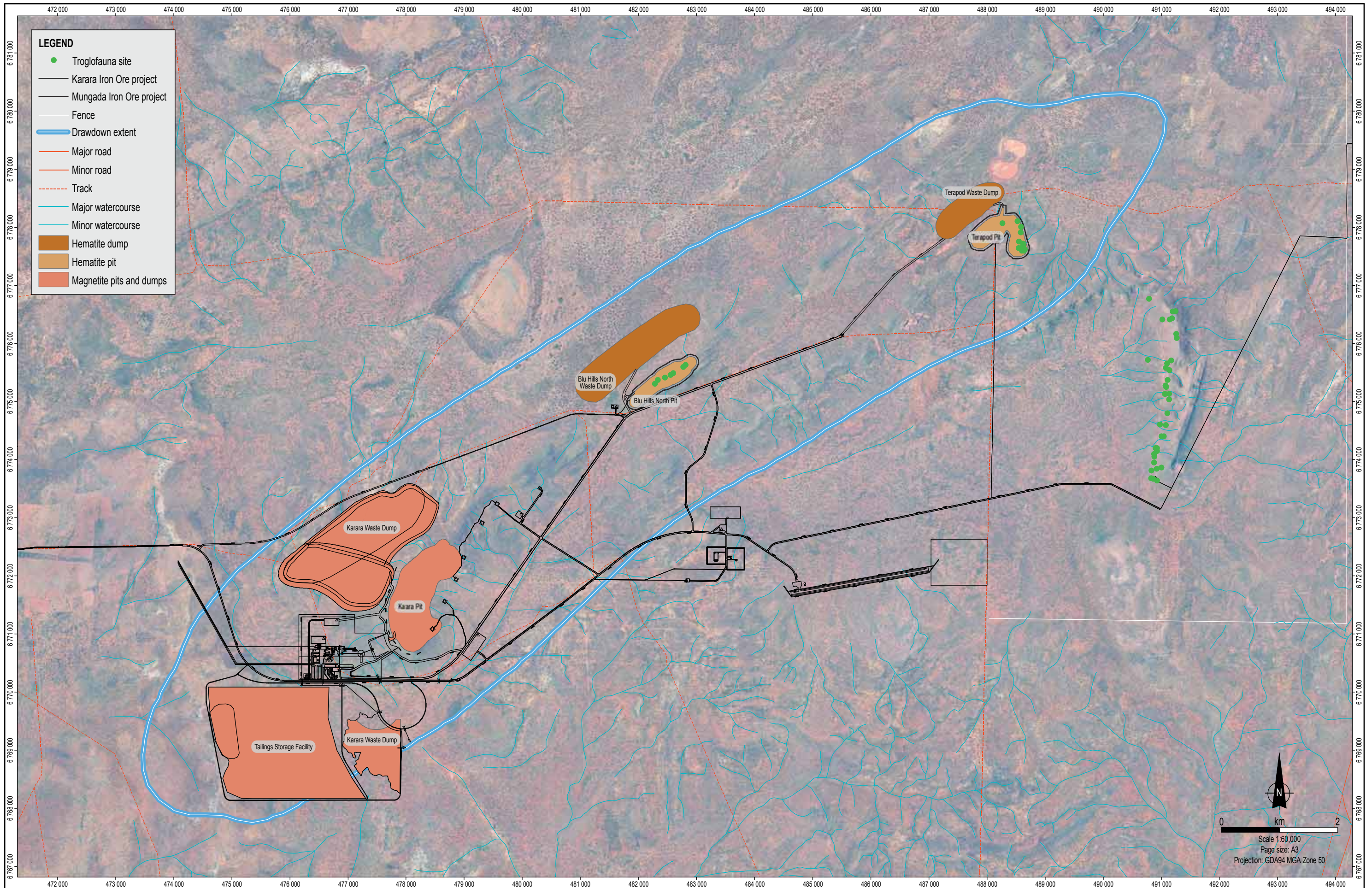
Drill hole ID	Area	Phase 1		Phase 2		Phase 3	
		Deployed	Recovered	Deployed	Recovered	Deployed	Recovered
MGC008	OUTSIDE TERAPOD	2	2	2	2	2	2
MGC416	OUTSIDE TERAPOD	2	0	0	0	0	0
MGC417	OUTSIDE TERAPOD	2	2	2	2	2	2
MGC152	OUTSIDE TERAPOD	2	2	2	2	2	2
MGC151	OUTSIDE TERAPOD	2	2	2	2	2	2
MGC404	OUTSIDE TERAPOD	2	2	2	2	2	2
MGC005	OUTSIDE TERAPOD	2	2	2	2	2	2
MKC304	BLUE HILLS	2	2	2	0	0	0
MKC115	BLUE HILLS	2	2	2	2	2	2
MKC117	BLUE HILLS	2	2	2	2	2	2
MKC280	BLUE HILLS	2	1	2	2	2	2
MKC333	BLUE HILLS	2	2	2	2	2	2
MKC265	OUTSIDE BLUE HILLS	2	2	2	2	2	2
MKC361	OUTSIDE BLUE HILLS	2	2	2	2	2	2
MGC164	SKYHOOK	2	2	2	2	2	2
MGC262	SKYHOOK	2	2	2	2	2	2
MGC140	SKYHOOK	2	2	2	2	2	2
MGC077	SKYHOOK	2	2	2	2	2	2
MGC078	SKYHOOK	2	2	2	2	2	2
MGC136	SKYHOOK	2	2	2	2	2	2
MGC309	OUTSIDE SKYHOOK	2	2	2	2	2	2
MGC342	OUTSIDE SKYHOOK	2	2	2	2	2	2
MGC317	OUTSIDE SKYHOOK	2	2	2	2	2	2
MGC044	OUTSIDE SKYHOOK	2	2	2	2	2	2
MGC045	OUTSIDE SKYHOOK	2	2	0	0	0	0
MGC022	OUTSIDE SKYHOOK	2	2	2	2	2	2
MGC167	OUTSIDE SKYHOOK	2	2	2	2	2	2
<b>Total</b>		<b>112</b>	<b>107</b>	<b>106</b>	<b>102</b>	<b>102</b>	<b>102</b>
Total Inside Project Impact Area		60	57	58	54	54	54
Total Outside Project Impact Area		52	50	48	48	48	48

Table 4-2 (Continued)

**Table 4-3 The Approximate Depths of Traps Deployed in Phases 1- 3.**

Area	Hole ID	Depth of trap 1 (m)	Depth of trap 2(m)
Terapod	MGC151	60	80
Terapod	MGC152	60	80
Terapod	MGC202	60	80
Terapod	MGC417	60	80
Terapod	MGC416	80	60
Terapod	MGC008	40	60
Terapod	MGC237	60	80
Terapod	MGC005	40	60
Terapod	MGC275	20	40
Terapod	MGC242	40	60
Terapod	MGC404	40	60
Blue Hills North	MKC333	40	60
Blue Hills North	MKC280	20	40
Blue Hills North	MKC117	30	50
Blue Hills North	MKC115	40	60
Blue Hills North	MKC304	20	40
Blue Hills North	MKC265	20	40
Blue Hills North	MKC361	20	40
Gully / Tor / Wagon Wheel	MGC031	60	70
Gully / Tor / Wagon Wheel	MGC109	70	90
Gully / Tor / Wagon Wheel	MGD116	80	100
Gully / Tor / Wagon Wheel	MGD118	100	120
Gully / Tor / Wagon Wheel	MGC288	80	100
Gully / Tor / Wagon Wheel	MGC399	60	80
Gully / Tor / Wagon Wheel	MGC434	80	90
Gully / Tor / Wagon Wheel	MGC039	60	80
Skyhook	MGC309	40	60
Skyhook	MGC164	60	80
Skyhook	MGC342	40	60
Skyhook	MGC262	30	50
Skyhook	MGD077	40	60
Skyhook	MGD078	50	70
Skyhook	MGC044	70	90
Skyhook	MGC317	50	70
Skyhook	MGC136	40	60
Skyhook	MGC140	40	60
Skyhook	MGC022	40	60
Skyhook	MGD045	40	60
Skyhook	MGC167	40	60
Mungada South	MGC172	20	40
Mungada South	MGC170	40	60
Mungada South	MGC174	20	40
Mungada South	MGC173	20	40
Mungada South	MGC247	20	40
Mungada South	MGC248	20	40
Mungada South	MGC250	20	40
Mungada South	MGC439	20	40
Mungada South	MGC253	20	40
Mungada South	MGC390	10	20
Mungada South	MGC057	10	20
Mungada South	MGC058	10	20
Mungada South	MGC056	10	20

Area	Hole ID	Depth of trap 1 (m)	Depth of trap 2(m)
Mungada South	MGC055	20	30
Mungada South	MGC255	20	40
Mungada South	MGC081	50	70
Mungada South	MGC257	20	40



Notes: Produced by CNS at the request of Ecologia  
Source:  
Roads, drainage and fences from GEODATA TOPO 250K (optimum scale 1:250,000)  
Mine layout from Gindalbie Metals Ltd

coffey natural systems  
Date: 27.05.2008  
MXD: Gindalbie IronoreGIS  
File Name: 8009\_rev\_F03.01\_GIS\_AI

Gindalbie Metals Ltd  
Karara Iron Ore Project

Troglifauna Trapping Sites  
Figure No: 4.1

## 4.2 STYGOFAUNA SURVEY SAMPLING DESIGN AND INTENSITY

Stygofauna sampling was conducted for the greater Karara Magnetite Project across Karara Ridge. The “impact area” is defined as the footprint of the drawdown area produced by the dewatering process required to enable mining below the water table (see Figure 4-2 and Figure 4-3).

A number of reference sites beyond the proposed drawdown footprint were also sampled. These included regional pastoral bores/wells (up to 30 km away) and uncased Karara Mining Limited RC drill holes and water bores at locations within the Mungada Iron Ore Project area (which does not extend below the water table). The aim of sampling these bores and wells was to determine the presence/absence of stygofauna beyond the project impact area.

### 4.2.1 Survey timing

The stygofauna survey consisted of a three phase survey. Each phase was spaced three months apart. The survey timing is presented below (Table 4-4).

**Table 4-4 Survey Timing and Specifics**

Aspect	Type	Bores Sampled Phase 1 (19 <sup>th</sup> – 24 <sup>th</sup> November 2007)	Bores Sampled Phase 2 (13 <sup>th</sup> – 19 <sup>th</sup> February 2008)	Bores Sampled Phase 3 (5 <sup>th</sup> – 9 <sup>th</sup> May 2008)	Total Sample Size to Date
Impact areas	Vertical uncased drill holes (155 mm) and water monitoring bores	12	18*	7*	37
Non-impact areas	Pastoral wells (1.5m x 0.8m), Vertical uncased drill holes (155 mm) and some newly developed water monitoring bores	6	10*	16*	32
<b>Sample Size</b>		<b>18</b>	<b>28</b>	<b>23</b>	<b>69</b>

\*These included ‘new’ pastoral wells and water monitoring bores not sampled in phase one. The pastoral wells were not sampled in Phase 1 (and Phase 2 for some) because of access difficulties. The cased water bores not sampled in Phase 1 did not have the necessary three month settlement period at the time. These were thus subsequently sampled in Phases 2 and 3.

### 4.2.2 Survey Sampling Methods

Water chemistry measurements were gathered using a 90 FL multi-parameter meter (Phase 1) and a Yeo-Kal (Phase 2). The standing water level and total bore depth was obtained using a Solinst water level meter.

The following physico-chemical parameters were measured in each of the bores sampled at approximately 30cm below the standing water level:

- Temperature (°C);
- pH;
- conductivity (µS/cm) ;

- Total Dissolved Salts (ppt and mg/L);
- Oxygen Reduction Potential (mV);
- Dissolved Oxygen (Percent saturation); and
- Dissolved Oxygen (mg/L).

Stygofauna sampling followed those methods recommended by the EPA (EPA 2003; EPA 2007). The number of hauls and diameter of the nets differed depending on whether a monitoring bore, an RC drill hole or a pastoral well was sampled (Table 4-5).

**Table 4-5 Stygofauna Sampling Specifics for Each Type Sample Site**

Type	Net Diameter	Number of hauls (50um mesh)	Number of hauls (150um mesh)	Total Number of Hauls
52 mm Water Monitoring Bore	45 mm	3	3	6
155 mm RC vertical uncased drill hole	100 mm	3	3	6
155 mm cased production bore	100 mm	3	3	6
Pastoral Well (~1.5m x 0.8m)	200 mm	5	5	10

#### 4.2.3 Survey Sites

The bores, drill holes and wells sampled for the Karara Iron Ore Project are presented in Table 4-6. These sites are also mapped in Figure 4-2 and Figure 4-3 .

Stygofauna sampling has occurred at 40 sites comprising 17 bores inside the Karara Iron Ore impact area, two bores within the Mungada Iron Ore impact area, four RC holes at the Tor deposit and 17 pastoral bores / wells.

Each site was sampled twice over the three phases of sampling, with the exception of four RC drill holes and two pastoral wells. The RC holes at Tor were sampled in November 2007 and upon return in February 2008, two had been rehabilitated, and a third was blocked above the water table. Therefore only one of the uncased RC drill holes at Tor Ridge was successfully sampled for a second time (MGC 106). The Old Shearing Shed Well was sampled in February, but upon return in May, was deemed too dangerous to re-sample, and so an additional site, Mungamia Well was sampled to maintain the sample size.

#### 4.2.4 Laboratory methods

Sample sorting was completed by Melissa White and Catherine Taylor at *ecologia*'s Perth laboratory under a Lecia S6 microscope. Each stygofauna specimen was placed in a vial with 100% ethanol (to allow for potential DNA analysis) and assigned a unique identification code for tracking. All vials were labelled with the date, site, GPS coordinates and the name of the collector(s). These details were written on the outside of the container and on waterproof paper placed in each vial.

#### **4.2.5 Taxonomy and nomenclature**

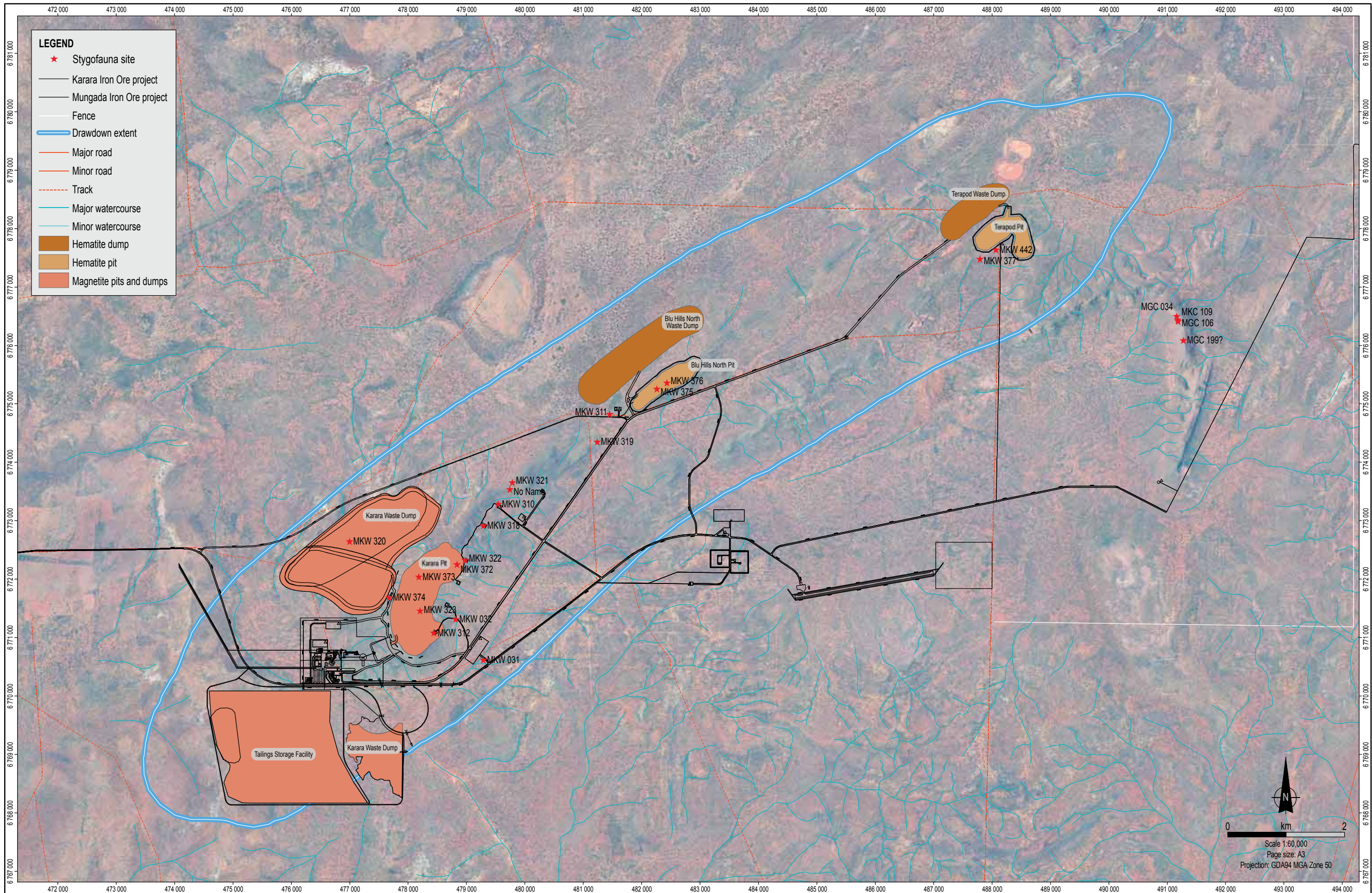
The recorded specimens were identified to the lowest taxonomic resolution necessary. *Ecologia* scientists conducted the preliminary sample processing and stygofaunal determination. Specimens were sent to the relevant taxonomic specialist for further identification.

**Table 4-6 Summary of Stygofauna Samples**

Site ID	Sample Type	Sampled Phase One (Nov 07)	Sampled Phase Two (Feb 07)	Sampled Phase Three (May 07)	Area	Karara Magnetite Impact Area
MKW 311	Bore	Yes	Yes	No	Karara	Inside
MKW 320	Bore	Yes	Yes	No	Karara	Inside
MKW 321	Bore	Yes	Yes	No	Karara	Inside
No Name Bore	Bore	Yes	Yes	No	Karara	Inside
MKW 318	Bore	Yes	Yes	No	Karara	Inside
MKW 322	Bore	Yes	Yes	No	Karara	Inside
MKW 319	Bore	Yes	Yes	No	Karara	Inside
MKW 031	Bore	Yes	Yes	No	Karara	Inside
MKW 323	Bore	Yes	Yes	No	Karara	Inside
MKW 032	Bore	Yes	Yes	No	Karara	Inside
MKW 312	Bore	Yes	Yes	No	Karara	Inside
MKW 310	Bore	Yes	Yes	No	Karara	Inside
MKW 372	Bore	No*	Yes	Yes	Karara	Inside
MKW 373	Bore	No	Yes	Yes	Karara	Inside
MKW 374	Bore	No	Yes	Yes	Karara	Inside
MKW 377*	Bore	No	Yes	Yes	Karara	Inside
MKW 442	Bore	No	Yes	Yes	Karara	Inside
MGC 034	RC Hole	Yes	No	No	Tor	Outside
MGC 199	RC Hole	Yes	No	No	Tor	Outside
MGC 106	RC Hole	Yes	Yes	No	Tor	Outside
MKC 109	RC Hole	Yes	No	No	Tor	Outside
MKW 376	Bore	No	Yes	Yes	Blue Hills North	Outside
MKW 375	Bore	No	Yes	Yes	Blue Hills North	Outside
Mulga Bore	Bore	Yes	No	Yes	Regional	Outside
Garden Well	Well	Yes	No	Yes	Regional	Outside
Murray's Bore	Bore	Yes	No	Yes	Regional	Outside
Pop Bore	Bore	Yes	No	Yes	Regional	Outside
Tootah Well	Well	Yes	No	Yes	Regional	Outside
Blue Well Bore	Bore	Yes	No	Yes	Regional	Outside
Well Good	Well	No	Yes	Yes	Regional	Outside
Dees Well	Well	No	Yes	Yes	Regional	Outside

Site ID	Sample Type	Sampled Phase One (Nov 07)	Sampled Phase Two (Feb 07)	Sampled Phase Three (May 07)	Area	Karara Magnetite Impact Area
Monitor Well	Well	No	Yes	Yes	Regional	Outside
Quondong Well? (maybe Kitchen Well?)	Well	No	Yes	Yes	Regional	Outside
Shearing Shed Well	Well	No	Yes	Yes	Regional	Outside
Old Homestead Well	Well	No	Yes	No	Regional	Outside
Little Damperwah Well	Well	No	Yes	Yes	Regional	Outside
East Damperwah Well	Well	No	Yes	Yes	Regional	Outside
Bowgada Well	Well	No	Yes	Yes	Regional	Outside
Mundgada Well	Well	No	Yes	Yes	Regional	Outside
Mungamia Well	Well	No	No	Yes	Regional	Outside

\*Note: Holes were not sampled either due to sample sites being blocked, rehabilitated, degraded and deemed dangerous or had not had sufficient time to settle after drilling.



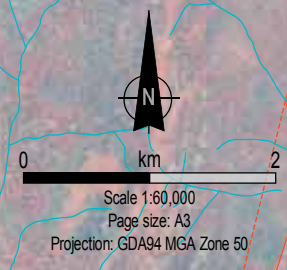
Notes: Produced by CNS at the request of Ecologia  
 Source:  
 Roads, drainage and fences from GEODATA TOPO 250K (optimum scale 1:250,000)  
 Mine layout from Gindalbie Metals Ltd

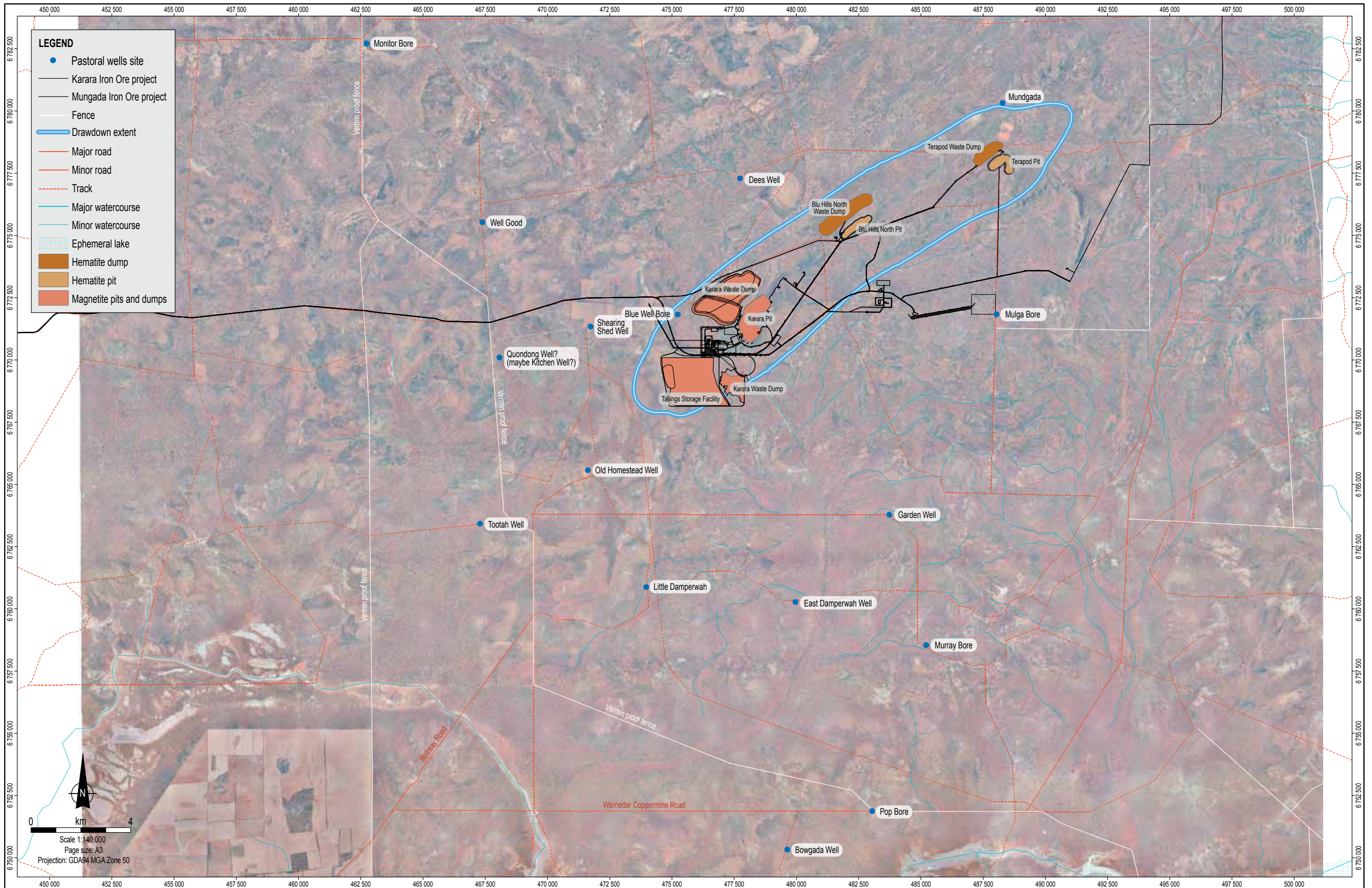
Date: 27.05.2008  
 MXD: Gindalbie IronoreGIS  
 File Name: 8009\_rev\_F03.02\_GIS\_AI

**Gindalbie Metals Ltd**  
**Karara Iron Ore Project**

**Map of Local Karara Stygofauna Sampling Sites**

Figure No: **4.2**





Notes: Produced by CNS at the request of Ecologia  
 Source:  
 Roads, drainage and fences from GEODATA TOPO 250K (optimum scale 1:250,000)  
 Mine layout from Gindalbie Metals Ltd

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 Date: 27.05.2008  
 MXD: Gindalbie IronoreGIS  
 File Name: 8009\_rev\_F03.03\_GIS\_AI

Gindalbie Metals Ltd  
 Karara Iron Ore Project

Map of Pastoral Wells  
 Sampled in the Region

Figure No:  
**4.3**

### 4.3 SURVEY TEAM

The survey was executed by ecologia Environment. The following personnel contributed to the successful completion of the project:

Team Member	Position	Qualifications
Jarrad Clark (Project Manager)	Senior Invertebrate Zoologist	BSc. (Environmental Management)
Melissa White	Level 2 Invertebrate Zoologist	BSc. (Zoology / Marine Science) Hons.
Catherine Taylor	Invertebrate Zoologist	BSc (Environment Science) Hons.
Laura Quinn	Invertebrate Zoologist	BSc ( Forensic Biology)

## 5.0 RESULTS

### 5.1 TROGLOFAUNA

No troglobitic specimens were collected from Phases one, two or three components of the troglofauna survey for the Mungada Iron Ore Project. Thus, based on the troglobitic pseudoscorpion and isopod specimens recorded from drillhole MGD198, at the northern-most extremity of the proposed Terapod Pit, represents the only local troglofauna habitat.

### 5.2 STYGOFAUNA

Stygofauna have not been collected from within the fractured rock aquifers located within the Banded Ironstone Formation. However, as can be seen from Table 5-1 a number of bores and wells located within the surrounding unconfined alluvial aquifers did record a number of stygofauna orders. All records are from pastoral bores and wells located well beyond of the drawdown footprint of the Karara Iron Ore Project (Figure 5-1) and thus, the project will not impact upon these stygobitic species.

In total five Orders of stygofauna were recorded from seven sites. Given the location and paucity of stygofauna sampling in the region it has been assumed that these specimens are all new to science. They have been given to Brenton Knott (UWA stygofauna researcher) for determination and the identifications are expected in the coming weeks.

**Table 5-1 Stygofauna Presence**

Site ID	Sample Type	Phase One (Nov 07)	Phase Two (Feb 07)	Phase Three (May 07)
Murray's Bore	Bore	Ostracoda sp. 1	Absent	Isopoda sp. 1
Well Good	Well	Absent	Ostracoda sp. 1	Absent
Dees Well	Well	Absent	Copepoda (Harpacticoida)	Absent
Shearing Shed Well	Well	Absent	Syncarida sp.1	Absent
Old Homestead Well	Well	Absent	Copepoda (Calanoida) sp. 1 Ostracoda sp. 1	Absent
Little Damperwah Well	Well	Absent	Ostracoda sp. 1 Copepoda (Calanoida) sp. 1	Absent
Bowgada Well	Well	Absent	Oligochaeta	Absent

#### 5.2.1 Water Quality Results

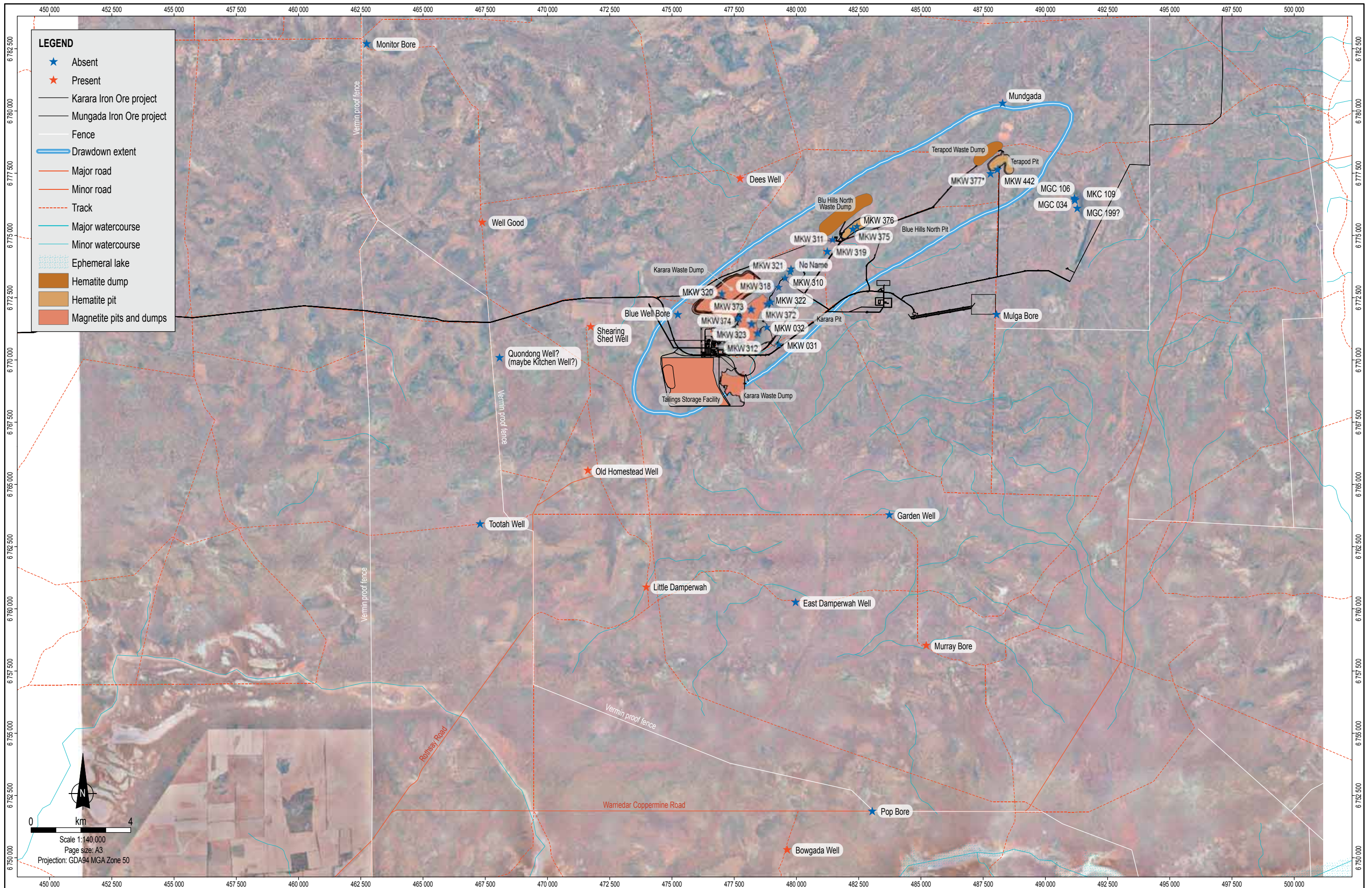
The water quality data for the three sampling rounds are presented in Table 5-2, Table 5-3 and Table 5-4. Six physico-chemical parameters (Temperature, pH, Conductivity, Total Dissolved Solids, Oxidation Reduction Potential and Dissolved Oxygen) were measured in the field from water bailed out of the bores and wells.

The water chemistry results collected from Phase three of sampling (Table 5-4) are clearly the result of a faulty water quality meter. On site maintenance and validation was unable to rectify the problem.

Overall the bores and wells appeared to be quite acidic with very few measurements being above a pH of 7.0. In fact the majority were nearer to a pH of 4.0. At this level of acidity very few epigeal aquatic macro-invertebrates are able to survive, and thus the same is thought to be true of stygobitic aquatic invertebrates. However, clearly this is not the case

in this study, where seven wells, all with considerably acidic water columns, recorded stygofauna species.

The salinity as measured by Electrical Conductivity ( $\mu\text{s}/\text{cm}$ ) and Salinity (ppm) on the other hand does not preclude the presence of stygofauna and as such they were recorded. The majority of sites were brackish to saline. But none were hyper-saline. An EC of 60,000  $\mu\text{s}/\text{cm}$  for example would suggest that stygofauna will not be present. This was not the case at any of the sampled bores and wells.



Notes: Produced by CNS at the request of Ecologia  
 Source:  
 Roads, drainage and fences from GEODATA TOPO 250K (optimum scale 1:250,000)  
 Mine layout from Gindalbie Metals Ltd

**coffey**  
 natural systems

Date: 27.05.2008  
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**Gindalbie Metals Ltd**  
**Karara Iron Ore Project**

**Map of Stygofauna Presence  
 in Pastoral Bores**

Figure No:  
**5.1**

**Table 5-2 Phase One Water Quality Data for Sampled Bores and RC Holes**

Hole ID	Temp. (°C)	pH	Salinity (ppt)	EC (µs/cm)	D.O. (ppm)	D.O. (%sat)	ORP (mV)	Depth To Water (m)	Total Depth (m)
MKW311	27.1	4.00	12.55	19320	35.10	0.35	316	10.0	163.0
MKW320	19.3	4.13	13.32	20370	3.55	39.40	324	35.0	83.0
MKW321	22.4	4.10	0.93	1605	4.79	56.90	327	32.5	77.0
NO NAME	23.2	4.13	6.48	10230	3.39	35.10	322	33.5	77.0
MKW318	24.3	4.07	4.69	7550	1.15	14.20	320	39.26	69
MKW322	25.2	4.26	0.87	1487	3.53	41.60	320	42.4	55
MKW319	21.3	4.06	3.28	5600	4.45	52.50	323	12.7	96.0
MKW031	23.3	3.95	21.50	32400	94.00	10.00	326	13.5	40.0
MKW323	23.0	3.98	6.34	10300	1.51	17.60	323	24.0	46.0
MKW032	23.8	4.04	0.64	1107	2.64	30.00	323	20.7	36.0
MKW312	26.3	4.09	1.04	1776	2.54	32.10	321	32.0	100
MGC034	27.3	3.90	0.93	1593	1.88	13.20	320	71.0	150.0
MGC199 ??	27.8	4.40	1.04	1784	1.61	20.60	300	100.3	150.0
MGC106	23.8	4.01	0.34	598	3.70	43.10	318	120.0	150.0
MGC109	23.8	4.04	0.55	968	1.93	23.50	262	100.2	130.0
MKW310	28.3	4.84	0.97	1956	1.49	18.90	214	46.27	85

**Table 5-3 Phase 2 Water Quality Data for Sampled Drill Holes and Bores**

Hole ID	Temp. (°C)	pH	Salinity (ppt)	EC (µs/cm)	D.O. (ppm)	D.O. (%sat)	ORP (mV)	Depth To Water (m)	Total Depth (m)	
MKW 311	24.29	6.41	12.06	20180	5.1	65	139	10.03	95	
MKW 320	22.16	6.87	12.29	20610	8.3	102.5	145	34.95	106	
MKW 321	24.06	6.6	0.54	1136	4.5	53.5	-81	32.62	77	
No Name	23.92	6.19	0.96	1942	5.4	65	82	33.25	blocked at 43	
MKW 318	26.85	5.4	3.17	5971	7.4	92.3	140	39.26	69	
MKW 322	29.07	5.38	0.71	1498	6.11	81.2	153	42.24	55	
MKW 319	25.69	5.75	2.79	5266	4	49.6	156	12.62	94	
MKW 031	26.17	6.81	36.57	55260	4.8	72.4	103	13.65	blocked at 39	
MKW 323	26.54	5.52	6.83	11980	4.6	59.3	9	22.64	45.5	
MKW 032	27.84	5.42	0.41	890	.9	87.3	139	20.78	40	
MKW 312	25.31	5.67	0.86	1770	6.5	72.1	83	31.89	100	
MGC 034	Rehabilitated									
MGC 199?	Rehabilitated									
MGC 106	Could not get water							122.5	150.0	
MKC 109	blocked									
MKW 310	16.00	3.75	0.99	1993	5.9	71.3	75	46.27	85	
MKW 376	26.89	7.08	0.73	1498	2.8	31.5	118	55.79	71	
MKW 375	26.51	7.09	0.75	1532	2.3	29.4	114	45.2		
MKW 372	Could not get water							65.09	83	
MKW 373	22.48	8.08	1.04	2061	3.6	40.3	93	65.16	76	
MKW 374	23.71	7.34	0.66	1360	2.9	33.3	106	46.37	106	
MGW441	22.73	7.28	1.21	2418	4.4	47.21	130	29.57	61	
MGW 442	22.92	7.34	0.55	1051	5	58	115	37.5	67	
Well Good	25.11	4.04	2.37	4498	2.4	28.7	109	9.98	15	
Dees Well	24.98	4.98	10.5	17750	3.1	39.4	138	12.78	16.48	
Monitor Bore	25.65	4.87	4.3	7864	2.9	36.7	123	10.75	14	
Quondong Well	24.89	5.02	2.19	4205	2.5	30.4	-81	16.62	19.43	
Shearing Shed Well	23.99	5.98	1.49	2923	0.7	7.6	86	7.96	13	
Old Homestead Well	26.2	6.02	1.22	2440	2	23.3	72	4	5.1	
Little Damperwah	25.25	5.21	1.3	1573	1.7	20.2	92	8.43	10	
East Damperwah Well	24.66	6.23	0.94	1910	1.4	16.1	91	16.17	18.21	
Bowgada Well	27.01	5.73	1.72	3627	1.6	18.5	-68	18.03	19.36	
Mungada	Dry, could not get water									

**Table 5-4 Phase 3 Water Quality Data for Sampled Drill Holes and Bores**

Hole ID	Temp. (°C)	pH	Salinity (ppt)	EC (µs/cm)	D.O. (ppm)	D.O. (%sat)	ORP (mV)	Depth To Water (m)	Total Depth (m)
MKW 376	25.0	4.11	0.13	-0.50	-0.11	-1.2	310	60.39	71.0
MKW 375	25.0	4.26	0.00	-0.51	-0.12	-1.4	313	45.75	58.0
MKW 372	24.8	4.18	824.00	1452	0.9	9.9	315	65.09	72.0
MKW 373	25.0	4.21	312.00	573	-0.12	-1.4	318	65.88	74.5
MKW 374	25.0	4.36	0.13	-0.51	-0.12	-1.4	316	46.75	105.0
MGW441	25.0	4.04	0.13	-0.54	-0.11	-1.2	313	30.62	56.0
MGW 442	25.0	4.27	0.13	-0.54	-0.11	-1.2	313	37.39	68.0
Mungamia Well	25.0	4.04	0.13	-0.54	-0.12	-1.4	323	20.35	36.0
Mungada Well	25.0	3.97	0.13	-0.54	-0.13	-1.4	322	25.41	27.0
Blue Well Bore	25.0	3.97	0.13	-0.54	-0.12	-1.4	322	20.17	25.0
Old Homestead Bore	25.0	4.16	0.13	-0.54	-0.12	-1.4	320	3.92	4.5
Tootah Well	25.0	3.94	0.13	-0.54	-0.12	-1.4	320	11.27	15.0
Pop Bore	25.0	3.94	0.13	-0.54	-0.12	-1.4	319	13.77	16.0
Bowgada Well	25.0	3.89	0.13	-0.54	-1.2	-0.11	319	18.09	19.0
Quondong Well	25.0	4.43	0.02	-0.55	-0.13	-1.5	319	11.74	18.5
Monitor Well	25.0	3.88	0.13	-0.54	-0.11	-1.2	319	10.78	13.0
Good Well	25.0	3.88	0.13	-0.54	-0.12	-1.2	319	10.16	13.0
Little Damperwah Well	25.0	3.84	0.13	-0.54	-0.11	-1.2	326	8.50	9.5
East Damper Well	25.0	3.85	0.13	-0.54	-0.11	-1.2	332	16.4	18.0
Dee's Well	25.0	3.85	0.13	-0.54	-0.11	-1.2	325	11.71	17.0
Mulga Bore	25.0	3.76	0.13	-0.54	-0.12	-1.4	330	30.02	32.0
Garden Bore	25.0	3.84	0.13	-0.54	-0.12	-1.4	333	20.67	23.0
Murray Bore	25.0	3.86	0.13	-0.54	-0.12	-0.11	329	18.94	24.5

\*Due to the high number of identical recordings, clearly the water quality meter was not functioning properly and thus these measurements can not be regarded as accurate.

## 6.0 DISCUSSION

### 6.1 TROGLOFAUNA

No troglobitic specimens were collected from the Phase one, two or three components of the troglofauna survey for the Mungada Iron Ore Project. Thus, based on the troglobitic pseudoscorpion and isopod specimens recorded from MGD198, it would appear that the northern-most extremity of the proposed Terapod Pit represents the only local troglofauna habitat (unfortunately this was an angled drill hole, as is the nature of BIF exploration requirements and it was subsequently unable to be re-sampled due to hole collapse).

There is an alternative explanation as to the absence of troglofauna. The sampling may have been undertaken at the wrong time of the year. As troglofauna surveys are an emerging area of EIA there is still relatively little data on which to draw solid conclusions. This is especially true of the Midwest region. Recent data from the Pilbara suggests that troglofauna appear to be more widespread and abundant in the four months following the wet season (February to May) (*ecologia* 2008 in press). The wet season in the greater Karara Iron Ore Project area is from May to August, a typical Mediterranean rainfall regime. Thus, based on the experience of the Pilbara, the ideal troglofauna sampling period would be expected to be August to November.

The original small scale survey was conducted between 23<sup>rd</sup> February and the 2<sup>nd</sup> of May (Biota 2007b) which are late summer and autumn months. Given the Pilbara, this period would be unlikely to record all resident fauna. For example, at Robertson Range (*ecologia* 2008 in press) in the east Pilbara, a September - October sampling period recorded only 1 isopod species, but a January to March sampling period (post wet season) recorded three additional orders. Thus at Terapod, a post winter survey may have recorded additional groups such as detritivores on which the pseudoscorpion species could predate.

That being said, February 2008 was a particularly wet month. Thus, if the fauna require a 30 period of gestation (a common arthropod gestation period), it would be expected that fauna may be present in the final trapping round, assuming that 57 mm of monthly rainfall is sufficient to infiltrate troglofauna habitat and trigger a response in breeding and movement / activity. This quantity of rainfall, over a 9 day period, in a month when the annual evaporation rate is at its greatest, is unlikely to infiltrate more than a meter in the soil; and hence unlikely to reach obligate subterranean fauna species. Thus the impact of the timing of the survey on the results is by no means clear cut.

An extensive trapping regime was undertaken with a sample size achieved greater than that required by EPA Guidance Statement 54a. The original subterranean fauna desktop review identified only a small number of prospective sites (Biota 2007). Some of these were subsequently sampled (many were blocked and could not be re-sampled) and just a single site recorded a individual obligate troglobitic specimen (Biota 2007). Therefore it is suggested that the result is a true reflection of the paucity of suitable subterranean in the BIF stratigraphy at the greater Karara Iron Ore Project.

## 6.2 STYGOFAUNA: KARARA IRON ORE PROJECT

Stygofauna were not collected from within the drawdown footprints of the proposed Karara and Mungada Iron Ore project areas during the three phases of surveying.

Outside the impact area however, seven pastoral wells or bores recorded five Orders of stygobites. These included Ostracods, Syncarids, Oligochaetes, Copepods (Harpacticoida and Calanoida) and Isopods. Due to the paucity of stygofauna sampling in the region, it has been assumed that these are new species. Examination by *ecologia* laboratory assistants has concluded that a single species is likely to be represented in each respective group.

These bores and wells are situated beyond the Karara and Mungada impact areas (see Figure 5-1) and thus neither project is expected to impact upon stygobitic species or communities. These species are located within the unconfined alluvial aquifers that surround the BIF ranges and appear to be widespread locally. Within the ranges, groundwater is held within fractured rock aquifers. It can be seen from the shape of the drawdown contour modelling that these two aquifer types are unlikely to be in hydraulic connection, and that even if they are, then only to a very limited extent. The drawdown largely follows the shape of the ridge itself and barely extends out on to the surrounding plains, where the stygofauna were found. Thus it is concluded that stygofauna will not be impacted upon by these proposals.

Interestingly however, it is generally assumed that water columns with an acidity below 5.0 (pH) are unlikely to record stygofauna. Three rounds of sampling both the pastoral wells/bores and Karara Mining Limited bores / RC drill holes has suggest that the aquifers of the area (both fractured rock and unconfined alluvial) are in general, highly acidic and, should not contain stygobitic species. However, five orders were recorded. As the water quality measurements were taken from water bailed from the top two metres of the water column it is possible that these measurements are not representative of the aquifer proper. Low flow sampling or more rigorous pumping techniques might produce more neutral pH results.

## 7.0 RECOMMENDATIONS

- 1 Stygofauna was not recorded from within the Karara Iron Ore project impact footprint. Given that the results are believed to be a true reflection of the situation in both streams of survey, no recommendations can be made with regard to the implementation of the project.
- 2 Two bores were sampled for stygofauna from within the proposed Mungada Iron Ore project impact area. Although stygofauna were not recorded in the bores, further sampling would be recommended to confirm their absence from the Mungada Iron Ore project impact areas.
- 3 Further clarification of the troglifauna community presence and distribution for the Mungada Iron Ore Project at Terapod could be determined by trapping in the months of August to November.

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## **9.0 APPENDIX A: GPS DATA AND PHYSICAL PROPERTIES OF SAMPLED BORES, RC HOLES AND WELLS**

**Table 9-1 Physical Characteristics and GPS Data For Sampled Bores and Drill Holes**

Hole ID	Material	Area	Diameter (mm)	GPS Data (GDA 94)
MKW 311	PVC Cased Bore	Karara	155	50 481455E 6774831N
MKW 320	RC uncased	Karara	155	50 476999E 6772652N
MKW 321	RC uncased	Karara	155	50 479785E 6773661N
No Name	RC uncased	Karara	155	50 479746E 6773543N
MKW 318	RC uncased	Karara	155	50 479294E 6772923N
MKW 322	RC uncased	Karara	155	50 478979E 6772332N
MKW 319	PVC Cased Bore	Karara	155	50 481240E 6774357N
MKW 031	RC uncased	Karara	155	50 479291E 6770624N
MKW 323	RC uncased	Karara	155	50 478207E 6771464N
MKW 032	RC uncased	Karara	155	50 478816E 6771321N
MKW 312	PVC Cased Bore	Karara	155	50 478441E 6771087N
MGC 034	RC uncased	WW/ Tor	155	50 491169E 6776507N
MGC 199?	RC uncased	WW/ Tor	155	50 491282E 6776093N
MGC 106	RC uncased	WW/ Tor	155	50 491192E 6776421N
MKC 109	RC uncased	WW/ Tor	155	50 491187E 6776445N
MKW 310	RC uncased	Karara	155	50 479545E 6773293N
MKW 376	PVC Cased Bore	Karara	155	50 482436E 6775367N
MKW 375	PVC Cased Bore	Karara	155	50 482263E 6775262N
MKW 372	PVC Cased Bore	Karara	52	50 478838E 6772259N
MKW 373	PVC Cased Bore	Karara	52	50 478184E 6772046N
MKW 374	PVC Cased Bore	Karara	52	50 477677E 6771691N
MKW 377*	PVC Cased Bore	Karara	155	50 487799E 6777487N
MKW 442	PVC Cased Bore	Karara	155	50 488070E 6777645N
Mulga Bore	Pastoral Well	Regional	~1.5m x 0.8m	50 488045E 6771836N
Garden Well	Pastoral Well	Regional	~1.5m x 0.8m	50 483738E 6763780N
Murray Bore	Pastoral Well	Regional	~1.5m x 0.8m	50 485219E 6758544N
Pop Bore	Pastoral Well	Regional	~1.5m x 0.8m	50 483050E 6751877N
Tootah Well	Pastoral Well	Regional	~1.5m x 0.8m	50 467295E 6763422N
Blue Well Bore	Pastoral Well	Regional	~1.5m x 0.8m	50 475238E 6771832N

Hole ID	Material	Area	Diameter (mm)	GPS Data (GDA 94)
Well Good	Pastoral Well	Regional	~1.5m x 0.8m	50 467382E 6775537N
Dees Well	Pastoral Well	Regional	~1.5m x 0.8m	50 477741E 6777294N
Monitor Bore	Pastoral Well	Regional	~1.5m x 0.8m	50 462739E 6782709N
Quondong Well	Pastoral Well	Regional	~1.5m x 0.8m	50 468073E 6770100N
Shearing Shed Well	Pastoral Well	Regional	~1.5m x 0.8m	50 471739E 6771342N
Old Homestead Well	Pastoral Well	Regional	~1.5m x 0.8m	50 471622E 6765573N
Little Damperwah	Pastoral Well	Regional	~1.5m x 0.8m	50 473968E 6760882N
East Damper Well	Pastoral Well	Regional	~1.5m x 0.8m	50 479964E 6760273N
Bowgada Well	Pastoral Well	Regional	~1.5m x 0.8m	50 479637E 6750331N
MundgadaWell	Pastoral Well	Regional	~1.5m x 0.8m	50 488283E 6780320N
Mungamia Well	Pastoral Well	Regional	~1.5m x 0.8m	50 485291E 6778328N

## **10.0 APPENDIX B: GPS DATA OF RC HOELS SAMPLED FOR TROGLOFAUNA**

**Table 10-1 The Location and Area of the Troglifauna Traps**

Hole ID	GPS Coord	Area
MGC151	488634E 6777599N	Terapod
MGC152	488651E 6777617N	Terapod
MGC202	488602E 6777599N	Terapod
MGC417	4886232E 677667N	Terapod
MGC416	488619E 6777687N	Terapod
MGC008	488622E 6777721N	Terapod
MGC237	488547E 6777758N	Terapod
MGC005	488579E 6777912N	Terapod
MGC275	488265E 6778071N	Terapod
MGC242	488522E 6778107N	Terapod
MGC404	488587E 6778011N	Terapod
MKC333	482770E 6775598N	Blue Hills North
MKC280	482810E 6775631N	Blue Hills North
MKC117	482596E 6775489N	Blue Hills North
MKC115	482552E 6775463N	Blue Hills North
MKC304	482455E 6775414N	Blue Hills North
MKC265	482335E 6775374N	Blue Hills North
MKC361	482282E 6775310N	Blue Hills North
MGC031	490790E 6776770N	Gully / Tor / Wagon Wheel
MGC109	491185E 6776438N	Gully / Tor / Wagon Wheel
MGD116	491246E 6776559N	Gully / Tor / Wagon Wheel
MGD118	491195E 6776554N	Gully / Tor / Wagon Wheel
MGC288	491258E 6776166N	Gully / Tor / Wagon Wheel
MGC399	491266E 6776094N	Gully / Tor / Wagon Wheel
MGC434	491143E 6776418N	Gully / Tor / Wagon Wheel
MGC039	491018E 6776417N	Gully / Tor / Wagon Wheel
MGC309	491076E 6775582N	Skyhook
MGC164	491171E 6775708N	Skyhook
MGC342	491097E 6775660N	Skyhook
MGC262	491139E 6775544N	Skyhook
MGD077	491107E 6775376N	Skyhook
MGD078	491073E 6775277N	Skyhook
MGC044	491084E 6775251N	Skyhook
MGC317	491075E 6775279N	Skyhook
MGC136	491134E 6775138N	Skyhook
MGC140	491136E 6775040N	Skyhook
MGC022	491065E 6775133N	Skyhook
MGD045	491065E 6775135N	Skyhook
MGC167	491103E 6774803N	Skyhook
MGC172	490979E 6774610N	Mungada South
MGC170	491078E 6774598N	Mungada South
MGC174	491002E 6774405N	Mungada South
MGC173	491043E 6774405	Mungada South
MGC247	490924E 6774199N	Mungada South
MGC248	490900E 6774200N	Mungada South
MGC250	490928E 6774150N	Mungada South
MGC439	490875E 6774102N	Mungada South
MGC253	490881E 6774054N	Mungada South
MGC390	490831E 6773813N	Mungada South

Hole ID	GPS Coord	Area
MGC057	490822E 6773683N	Mungada South
MGC058	490769E 6775718N	Mungada South
MGC056	490861E 6773674N	Mungada South
MGC055	490924E 6773645N	Mungada South
MGC255	490922E 6773846N	Mungada South
MGC081	491004E 6773864N	Mungada South
MGC257	490877E 6773951N	Mungada South