OCTOBER 2009

BROCKMAN RESOURCES LIMITED

STYGOFAUNA REPORT

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BROCKMAN RESOURCES LTD
MARILLANA IRON ORE PROJECT

STYGOFAUNA REPORT

28 October 2009

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ecologia Environment
1025 Wellington Street
WEST PERTH WA 6005
Phone: 08 9322 1944
Fax: 08 9322 1599
Email: admin@ecologia.com.au

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EXECUTIVE SUMMARY

This report presents the findings from the stygofauna surveys that were undertaken for Brockman Resources Limited by *ecologia* Environment between February and July 2009.

The Marillana Iron Ore Project (the Project) is located in the Hamersley Iron Provence 100 km north-west of Newman. Brockman Resources Limited (Brockman) propose to mine on tenement M47/1414 and transport the ore to Port Hedland by road or rail.

Tenement E47/1408 (the project area) covers 96 km^2 of the Fortescue Valley and borders the Hamersley Range where extensive areas of supergene iron ore mineralisation are developed within the dissected Brockman Iron Formation which caps the Range. The iron ore mineralisation within the project area is best described as detrital hematite-goethite material with grades ranging from 40 – 63 % Fe.

Two phases of sampling were conducted within the proposed pit area, each comprising 44 samples (88 samples in total), thus satisfying the requirements of Environmental Protection Authority's (EPA) *Guidance Statement 54a*. In addition, a single phase of sampling was undertaken in six nearby bores off-tenement.

Four stygobitic species were collected during the survey. One of the species, the amphipod *Pilbarus millsi,* was found both inside and outside the tenement. Two of the species (unidentified copepod and oligochaete) were found only within the tenement. The fourth species, the isopod *Pygolabis weeliwolli*, was found only outside the tenement. The amphipod and the isopod were the focus of recent publications within which it was indicated that these species were present in the Weeli Wolli Creek and Marillana Creek palaeo-drainage channel.

Although the other two species could not be identified to specific level due to their sub-adult stage and significant damage, they are expected to occur outside the tenement. This is because their body size is significantly smaller than the size of the amphipod and the isopod and thus they are expected to be subject to the same or lesser dispersal limitation.

On a regional scale, the impact on the Weeli Wolli Marillana palaeo-drainage system is expected to be very low. The tenement lies down-stream at the end of the Weeli Wolli Marillana palaeo-drainage and thus the proposal is unlikely to have a significant effect on the wider palaeo-drainage system.

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1 INTRODUCTION

The Project is located in the Hamersley Iron Province 100 km north-west of Newman (Figure 1-1). Brockman Resources Limited (Brockman) proposes to mine on tenement M47/1414 and transport the ore to Port Hedland by road or rail. An existing railway line already runs through the tenement, roughly west-east.

The iron ore mineralisation within the area is best described as detrital hematite-goethite material with grades ranging from 40-63% Fe. Brockman are proposing to operate an open pit mine, mining at a rate of 38 Mtpa, producing 17 Mtpa of ore.

The proposed mining operations will require clearing of up to 2,980 ha.

The Project was referred to the Environmental Protection Agency (EPA) under Section 38 of the *Environmental Protection Act 1986*. The EPA will formally assess the Project on the basis of the Project's potential to result in significant environmental impacts.

Projects undertaken as part of the Environmental Impact Assessment (EIA) process are required to address guidelines produced by the EPA, in this case Guidance Statement 54: *Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia*, Guidance statement 54a: *Sampling Methods and Survey Considerations for Subterranean Fauna 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).

Native fauna and flora in Western Australia are protected at a federal level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and at a state level under the *Wildlife Conservation Act 1950* (WC Act).

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

- maintain the abundance, species diversity and geographical distribution of terrestrial flora and fauna; and
- identify and protect significant fauna, flora and vegetation biodiversity, consistent with the provisions of the *Wildlife Conservation Act 1950*.

The purpose of the survey and this report is to:

- Provide information suitable for inclusion in a Public Environmental Review document on the presence/absence of stygofauna in the immediate project area.
- Provide information on the presence and/or likelihood of occurrence of rare fauna in the project area.

The primary objective of the proposed survey will be to provide broad-scale baseline data on the presence or absence of stygofauna in the project area, as well as determining potential risks to the conservation of significant fauna, should they be recorded, thereby enabling Brockman to formulate appropriate management documents for the Project.

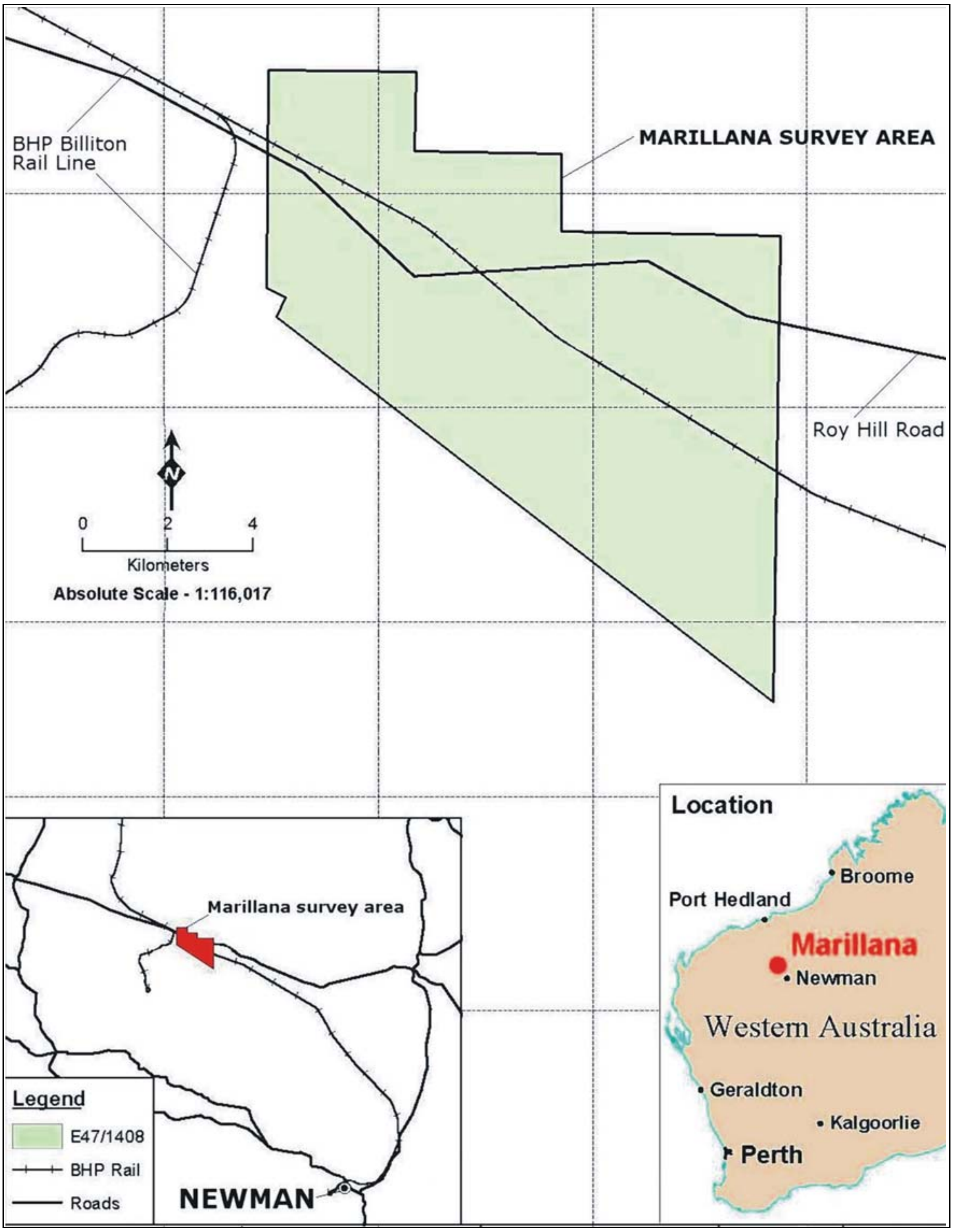

Figure 1-1 Location of the Marillana Iron Ore Project

1.1 LITERATURE REVIEW

Stygofauna are obligate, groundwater dwelling fauna, adapted for a subterranean aquatic environment. This environment is devoid of light, may have restricted available space (i.e. porous or fissured rock) and relatively constant temperature. These species have evolved unique features such as a lack of pigmentation, elongated appendages, filiform body shape (worm like) and reduced or absent eyes. Many species are believed to be relict taxa with affinities with Tethys, Pangea and its derived landmasses (Humphreys 1993; Knott 1993; Danielopol *et al.* 1994; Humphreys 1999, 2001).

Stygofauna are known to be present in the groundwater associated with a variety of geologies. These include (but are not limited to) calcrete aquifers associated with palaeochannels, haematite sandstone aquifers (e.g. Koolan Island), clay-sandstone aquifers on the Swan and Scott Coastal Plains (ecologia 1998; Humphreys 2001; ecologia 2006b, a; Rockwater 2006), and porous aquifers (e.g. alluvium) (Mamonier *et al.* 1993), fractured-rock aquifers, springs and hyporheic habitats (Eberhard *et al.* 2005). Recent experience west of Lake Way near Wiluna, has shown that palaeochannel aquifers with an EC of 60,000uS/cm can harbour diverse and abundant stygal assemblages (ecologia 2006a).

The presence of stygofauna in Western Australia has been well documented, especially from regions such as the Pilbara and Kimberley, and less so in the Midwest and Southwestern regions of Western Australia (De Laurentiis *et al.* 2001; Humphreys 2001; Wilson *et al.* 2002; Eberhard 2004; Karanovic 2004; Cho *et al.* 2005). Australian stygofauna is dominated by crustaceans including Amphipoda (Bradbury *et al.* 1997), Isopoda (Wilson 2001), Ostracoda (Karanovic *et al.* 2002; Martens *et al.* 2002; Karanovic *et al.* 2003; Karanovic 2005) and Speleogriphacea (Poore *et al.* 1998; Poore *et al.* 2003).

1.2 GEOLOGY AND SOILS

Thorne and Tyler (Thorne *et al.* 1997) mapped the geological units of Western Australia (1:250,000). Locally, the project area is characterised by:

- alluvium and colluvium deposits forming red-brown clayey and sandy soils, on the lower slopes and sheet-wash areas (flat clay pans);
- aeolian sand deposits in sheets and longitudinal dunes (sandy plains and sand dunes);
- alluvium, unconsolidated silt, sand and gravel; in drainage channels and adjacent floodplains (creek lines and floodplains);
- hematite-goethite deposits on banded iron-formations and adjacent scree deposits (rocky hill slopes); and
- banded Iron formation and pelite (as part of the Brockman Iron Formation on the rocky hill slopes).

The project area lies on the Fortescue valley floor to the northeast of the Hamersley Range. The area is flat lying and consists of mainly transported colluvium and alluvium deposits, with minor outcrops of Canga and Archaean Wittenoom Dolomite. The combined thickness of the transported cover is up to 80 m, and it hosts the targeted detrital deposits.

The soil types in the project area are (i) red earth plains of the Fortescue valley, the surface cover of which consists of stony gravels, (ii) dissected pediments forming low stony hills and (iii) outwash plains. Both (ii) and (iii) support a surface cover of gravel and hard setting loamy soils with red clay subsoils forming dissected stony pediments, hills and mesas.

As a consequence of the sparse vegetation cover and the erosive force of heavy summer cyclonic rains, much of the soil on the hill slopes has been transported down to the valleys and plains.

1.3 CLIMATE

Marillana station is situated in the Pilbara region of Western Australia and experiences an arid-tropical climate with two distinct seasons; a hot and wet summer (wet season) from October to April and a mild and dry winter (dry season) from May to September. Annual evaporation exceeds rainfall by as much as 500 mm per year. Seasonally low but unreliable rainfall, together with high temperatures and high diurnal temperature variations are also characteristic climate of the region.

The closest Bureau of Meteorology (BOM) weather station to the project area is at Sand Hill (22.78° S, 119.62° E) (BOM 2008). Although data collection ceased at this station in 1984, as the Sand Hill weather station is located approximately 45 km to the south-east of the Upper Marillana exploration site, it provides a good indication of climatic conditions experienced within the project area.

The average annual rainfall in at Sand Hill is 337 mm, occurring over 40 rain days. Most of the rainfall occurs in the summer period, with over 70% of total annual precipitation occurring between December and March (Figure 1-2).

Mean annual maximum and minimum temperatures for Sand Hill are 32.9°C and 17.5°C respectively. Mean monthly maxima range from 40.5°C during January to 23.7°C in July, while mean monthly minima range from 24.9°C in January to 8.9°C in July (Figure 1-2).

Weather conditions for the period during the survey were taken from the Wittenoom BOM weather station (22.24 °S, 118.34 °E), which is 100 km north-west of the project area. Data from the Wittenoom weather station are summarised in Figure 1-3 and Figure 1-4.

The project area is *ca*. 100 km NNW of Newman, and 100 km ESE of Wittenoom. The nearest and most appropriate point from which the Australian Bureau of Meteorology records climatic data is Wittenoom. Like the proposed area of development, Wittenoom is situated on the northern foot of the Hamersley range. A summary of climatic data for Wittenoom are provided in and Figure 1-3 and Figure 1-4 and correlate with the Sand Hill data.

December and January are the hottest months with average temperatures of 39.6°C for both months. The overnight minima also peak in January with an average temperature of 23.1°C. Winters are mild with the July average maximum and average minimum temperatures being 24.2°C and 11.9°C respectively (Figure 1-3). The mean annual rainfall for Wittenoom is 457.6 mm, with the January and February being the wettest months (Figure 1-4).

Seasonal rainfall and its replenishment of aquifers is suspected to play an important role in the distribution of stygofauna in aquifers. The EPA (2007) therefore encourages the sampling of stygofauna over two seasons, and ideally with three months separating them. This survey satisfies this criterion.

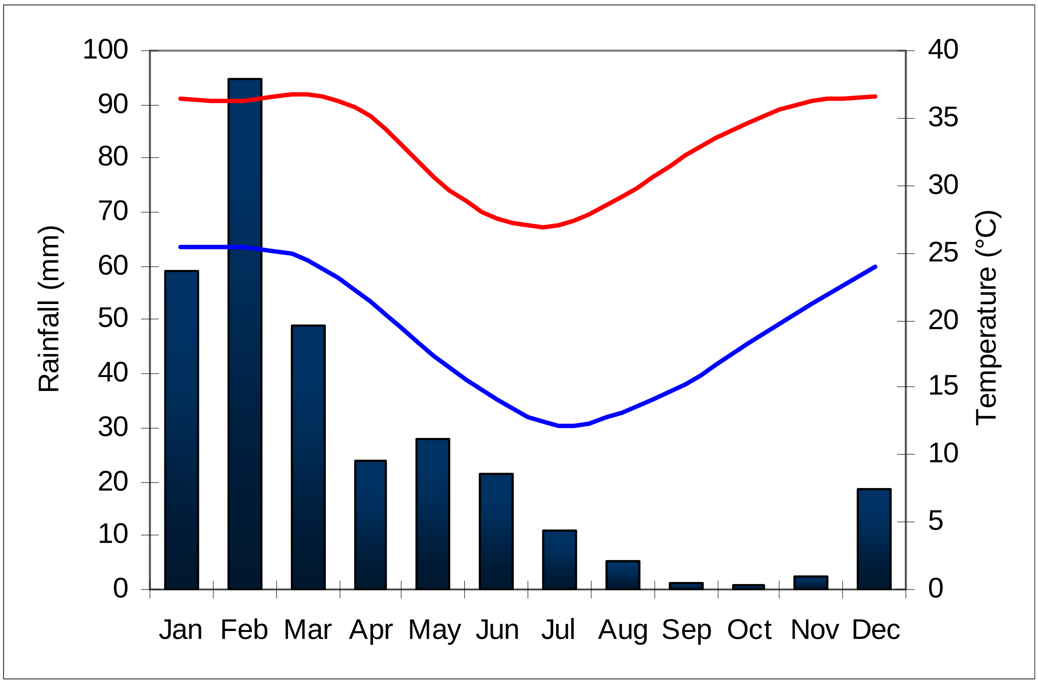

Figure 1-2 Summary of Climatic Data at Sand Hill (BOM 2008). Red line: maximum temperature; blue line: minimum temperature; bars: rainfall

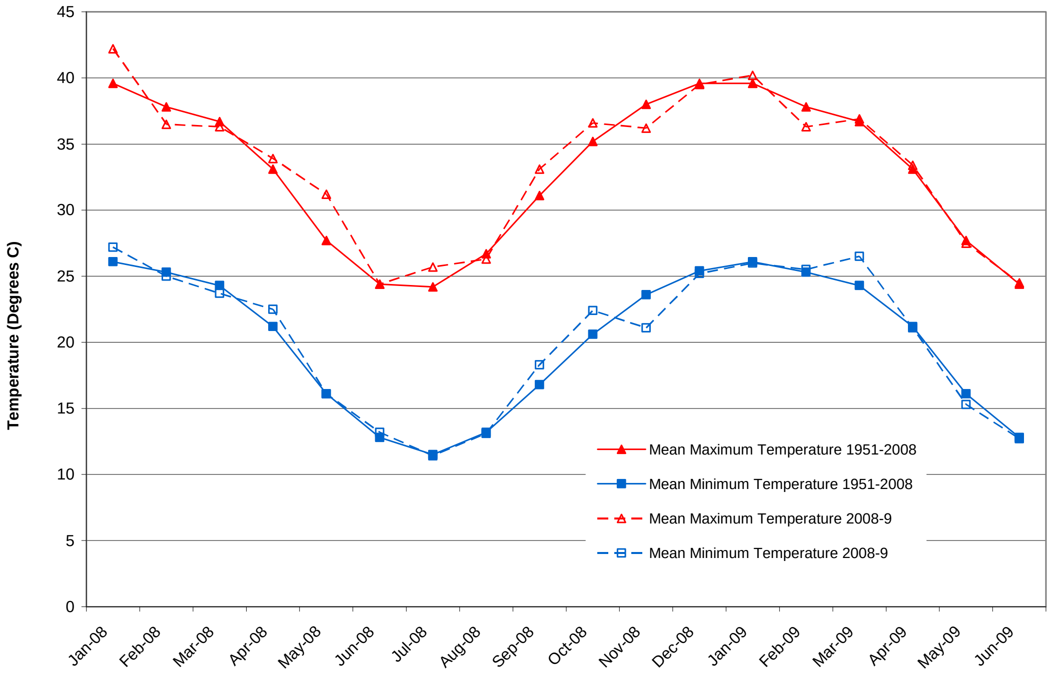

Figure 1-3. Wittenoom temperature summary: average monthly maximum and minimum temperatures plotted with the sampling month averages for 2008 and 2009 (BOM 2009).

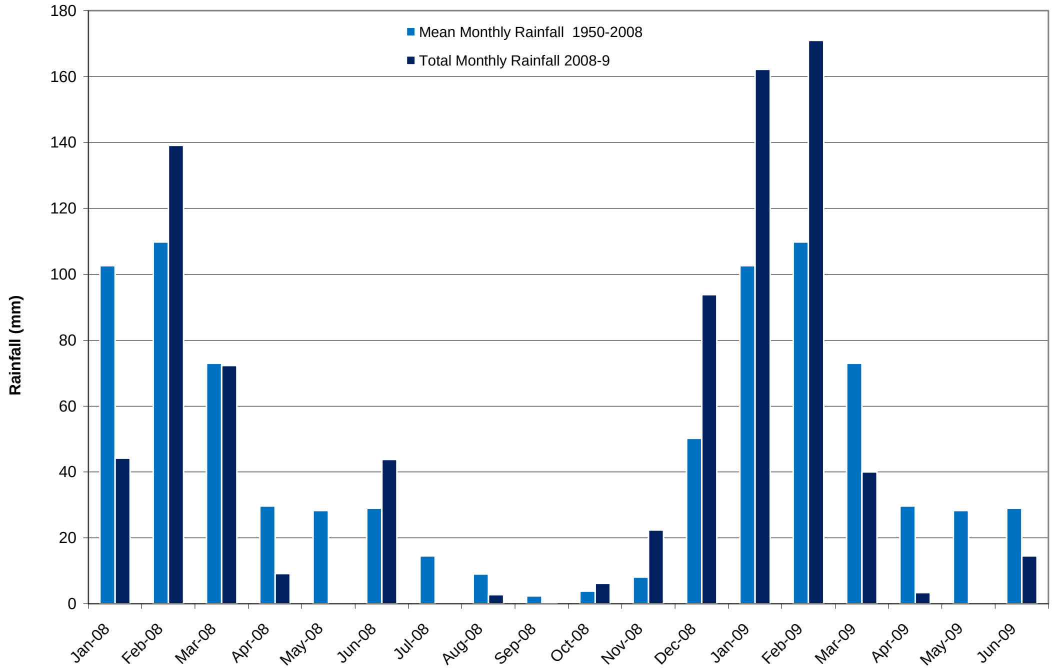

Figure 1-4. Wittenoom Rainfall Summary: Average Monthly Rainfall Plotted With the Sampling Month Totals for 2008 and 2009 (BOM 2009).

1.4 BIOGEOGRAPHY

Western Australia encompasses 26 Interim Biogeographic Regionalisation for Australia (IBRA) bioregions and 53 subregions, each affected by a range of different threatening processes and with varying levels of sensitivity to impact (DEC 2002). The EPA utilises IBRA regions and subregions as the largest unit for EIA decision-making in relation to the conservation of biodiversity (EPA 2002).

The Project lies in the Fortescue Valley (Fortescue Plains subregion) along the north-eastern escarpment of the Hamersley Ranges (Hamersley subregion) within the Pilbara Biogeographic Region (Figure 1-5). The mining operations will focus on the iron rich detrital deposits eroded from this escarpment.

Figure 1-5 The Pilbara IBRA Bioregion and Subregions with the Location of Marillana Iron Ore Project indicated.

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2 METHODS

2.1 SURVEY OBJECTIVES

Brockman commissioned *ecologia* Environment (*ecologia*) to undertake a stygofauna survey of the project area as part of the environmental impact assessment for the Project. The primary objective of this study was to provide sufficient information for the EPA to assess the impact of the Project on subterranean invertebrate fauna in the area against the EPA objectives below:

- 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.*

Specifically, the objectives of this survey were to undertake a survey that satisfies the requirements documented in EPA's Guidance Statement 54a and Position Statement No. 3, thus providing:

- A review of background information (including literature and database searches).
- An inventory of stygofauna species occurring in the study area, incorporating recent published and unpublished records.
- An inventory of species of biological and conservational significance recorded or likely to occur within the project area and surrounds.
- A review of regional and biogeographical significance, including the conservational status of species recorded in the project area.

2.2 SAMPLING DESIGN AND INTENSITY

Stygofauna sampling consisted of three survey phases. Phases one and two were conducted within the proposed area of development and phase three was conducted outside of the proposed area of development. The survey schedule is summarised in Table 2-1.

Table 2-1. Stygofauna Survey Schedule

Phase	Dates (2009)	Bores Sampled	Area	Bore Type
1	16-19 February	44	Proposed Development	Modified exploration bores
2	24-26 May	44	Proposed Development	Modified exploration bores
3	7-10 July	6	Off Tenement	Pastoral Bores

The survey design and intensity adopted by *ecologia* conform with the EPA's Guidance Statement No. 54a: *Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (EPA 2004) as well as with the broader legislative framework (Appendix 1).

2.3 SURVEY TIMING

Phases one and two (inside the proposed area of development) were conducted during February and May 2009, respectively. Phase three was conducted outside of the proposed area of development, during July 2009. Although the seasonal fluctuations of stygofauna communities are largely unknown, it is thought that communities expand due to new habitat and influx of nutrients after wet season. Thus, surveys conducted during this time (such as this one) have a higher chance of collecting stygofauna present within the aquifer (B. Durrant, DEC, pers. comm.).

2.4 SURVEY SAMPLING METHODS

Forty four exploration bores were modified to facilitate stygofauna survey (Figure 2-1).

The survey methods adopted by *ecologia* have been developed in consultation with the DEC and adhere to the draft methodology described by the EPA's Guidance Statement No. 54a: *Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (EPA 2004).

Sampling of bores took place in three stages:

1. The physical parameters of the bore were described:
    - bore location, using a GPS device;
    - the construction material of each bore (e.g. PVC, steel); and
    - the bore diameter (mm).
2. Water chemistry measurements were gathered using a 90 FL multi-parameter meter. The standing water level of each bore was obtained using a Solinst water level meter. All water samples for measurement were obtained using sterile one-use bailers.

    The following parameters were measured in each of the bores from samples taken from approximately 30cm below the standing water level:
    - water temperature [°C];
    - pH;
    - conductivity [mS/cm];
    - Total Dissolved Salts (TDS) [ppK];
    - Oxygen Reduction Potential (ORP) [mV]; and
    - Dissolved Oxygen (DO) [ppM and % Saturation];
3. Stygofauna sampling followed those methods recommended by the DEC. The entire water column was dragged for stygofauna a total of six times; three times using a 150 µm net and an additional three times using a 50 µm net. The specific methods were as follows:
    - an appropriate net diameter was chosen (most commonly 47 mm);
    - the net was slowly lowered into the bore until it hit the bottom. Care was taken not to let the net free fall;
    - once the net had reached the bottom of the bore, it was gently raised and lowered approximately 1 m, six times, to stir up the sediments at the bottom;

- the net was then slowly pulled up through the water column (<1 m/sec) in order to reduce the chance of animals being pushed out of the net by pressure wave;
- once the net was at the surface, it was immediately placed in a 50 µm Endicott sieve. The vial was removed from the net and all contents washed into the sieve using deionised water. The net was thoroughly rinsed over the sieve;
- the sieve contents were then washed into one corner and transferred into 120 ml preservation vials using absolute ethanol (100%);
- each vial was labelled with the date and bore name;
- after dragging the water column six times, all equipment was placed into a 25 L tub containing Decon90® for sterilisation to prevent cross-contamination of sites; and
- stygofauna samples were kept on ice in the field and in a dark location before being preserved. Sample sorting was completed at *ecologia's* Perth laboratory.

2.5 LABORATORY METHODS

The stygofauna specimens were filtered from the water samples using a 53 um sieve and placed directly into 100% ethyl alcohol. This was done to ensure that the biological material was appropriately preserved for genetic analyses, should it be required at a later date to identify specimens. 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.

2.6 TAXONOMY AND NOMENCLATURE

All putative stygofauna forms recovered were identified to the greatest taxonomic resolution possible. The specimens were identified to order level by *ecologia* scientists and then sent to various experts for lower level taxonomic identification. Species that could not be identified were assigned morphospecies names.

Taxonomic Determinations:

- M. D. Scanlon (Bennelongia Environmental Consultants): Oligochaeta
- B. Knott (University of Western Australia): Amphipoda
- D. Tang (University of Western Australia): Copepoda
- E. S. Volschenk (*ecologia* Environment) using Keable *et al.* (2006): Isopoda

2.7 STATISTICAL ANALYSES

Species accumulation curves, and extrapolations of diversity were calculated using EstimateS v8.2 (Colwell 2009). The program's default settings were used; except that 10,000 (rather than 50) sample order randomizations were used.

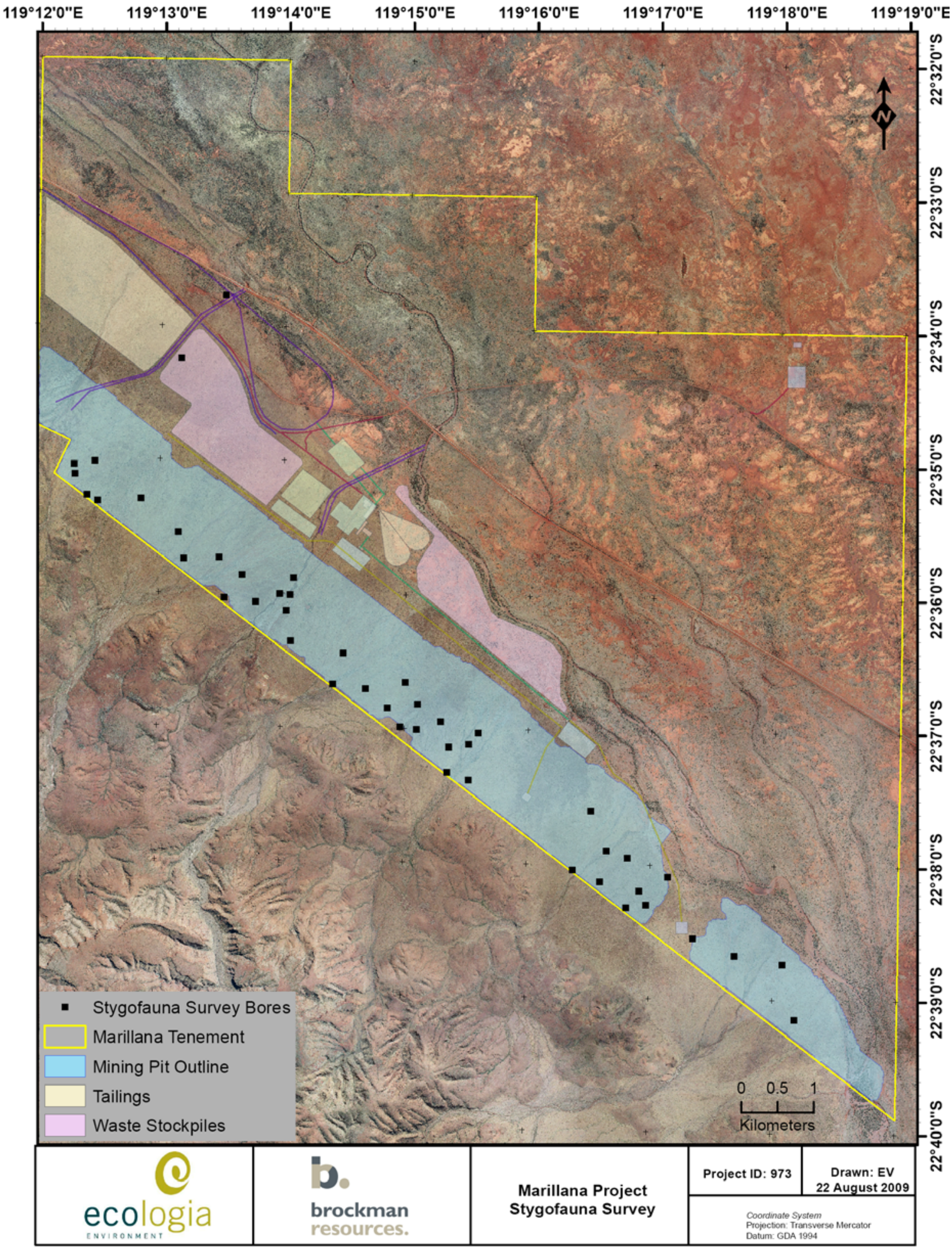

Figure 2-1. Proposed Impact Footprint (shaded) in relation to survey bore locations of Phase 1 and 2 (black squares).

3 RESULTS

Four stygobitic species were found during this survey (Table 3-1, Figure3-1 and Figure 3-2). Of these species, three were found within the proposed area of development and one species was found outside of the tenement.

Table 3-1. Stygofauna Survey Result

Bore ID	UTM			Decimal Degrees		Stygobitic Species				
	Zone	North	East	East	North	*Pi. millsi*	*Py. weeliwolli*	Copepod	Enchytraeid	Phase
MRC0282	50	729693.04	7498374.38	119.234483	-22.60598			1		1
MRC0577	50	735822.29	7493998.68	119.294717	-22.64463	2				1
MSD001	50	726879.06	7500404.37	119.206817	-22.58803				1	1
MRC0501	50	733844.26	7496012.44	119.275183	-22.62673	4				2
MRC0567	50	736653.5	7493112.4	119.302933	-22.65252	1				2
MRC0804	50	728776.23	7498976.37	119.225467	-22.60067	5				2
*Pug Bore	50	738295	7492878	119.3189374	-22.65441	7	4			3
*Coolana Well	50	745835	7493902	119.3921034	-22.64409	1				3
*MAPBO1	50	743746	7490464	119.3723234	-22.67542	1				3
*Waitawhile	50	749667	7483498	119.431022	-22.73743	2	1			3

* Indicates Bores off Tenement.

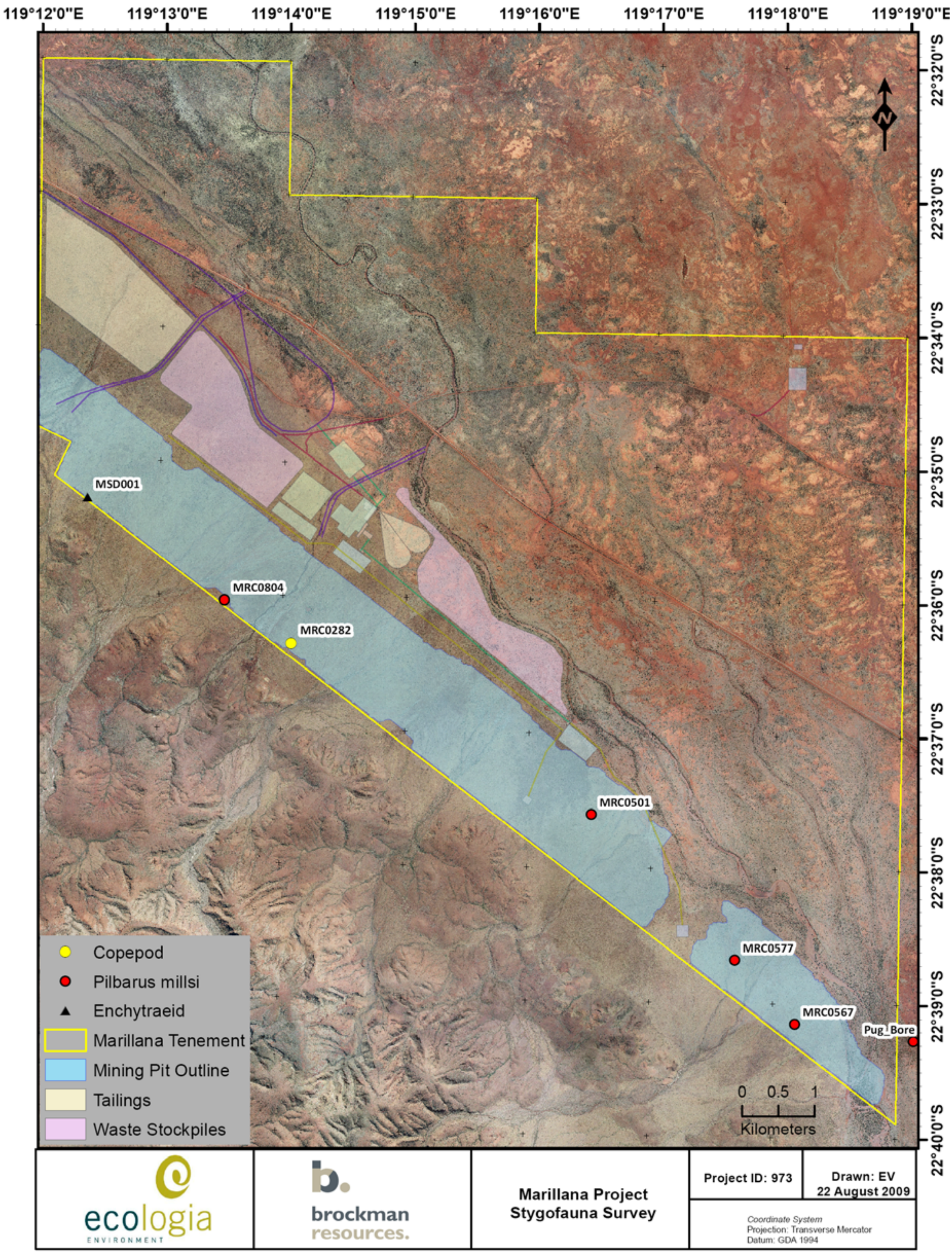

Figure 3-1. Proposed Impact footprint (shaded) with Stygobitic taxa and their bores plotted. Note proximity to tenement of Pug Bore (bottom Right).

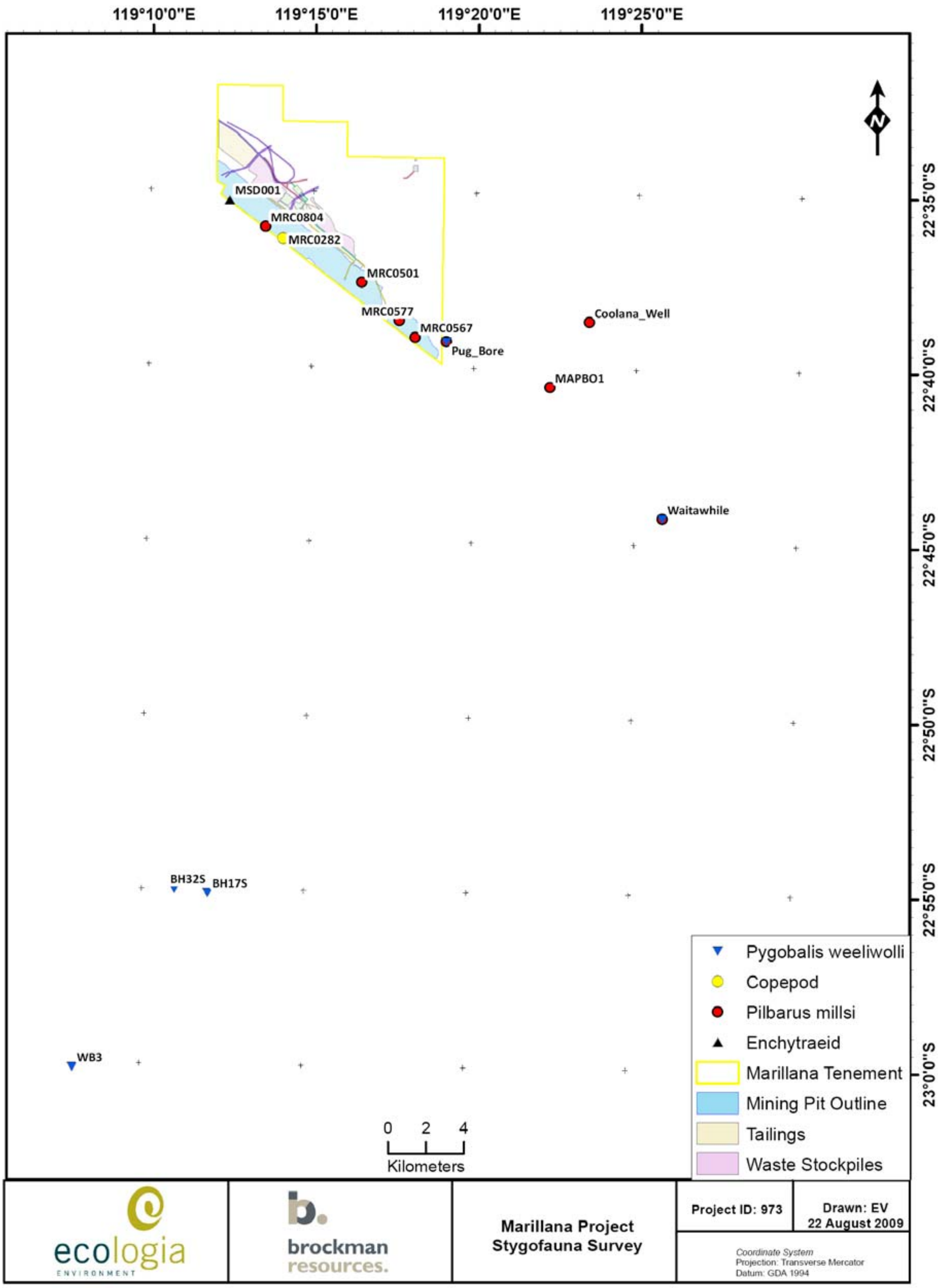

Figure 3-2. Locations of Stygofauna Records Inside and Outside of Tenement.

3.1 STYGOFAUNA

3.1.1 Order (Amphipoda)

Pilbarus millsi Bradbury and Williams 1997 (family Paramelitidae)

Pilbarus millsi (Figure 3-3) was found in sample wells MRC0804, MRC0567, MRC050, MRC0577 (within the proposed area of development) (Table 3-1¸Figure 3-1 and Figure 3-2) as well as from the outside tenement survey in Pug Bore, Coolana Bore, MAPB01 Bore and Waitawhile Bore (Table 3-1, Figure 3-2).

Until recently, *Pi. millsi* was thought to have a widespread distribution throughout the Pilbara region (Finston *et al.* 2007). Using molecular evidence (COI gene sequences), Finston *et al* (2007) revealed significant divergences between populations within the Pilbara which were consistent with different species. Of these cryptic species populations, Finston *et al* (2007) found the Marillana Creek and Weeli Wolli Creek populations to comprise a "Fortescue lineage" associated with the Weeli Wolli and Marillana Creeks.

Figure 3-3. Lateral Aspect of *Pilbarus millsi;* Scale bar 0.25 mm.

3.1.2 Order (Isopoda)

Pygolabis weeliwolli Keable *et al* (Tainisopidae)

Pygolabis weeliwolli (Figure 3-4) was described in 2006, from three bores in the Weeli Wolli Creek area: bore BH32S, bore BH17S and bore WB3 (Figure 3-2) (Keable *et al.* 2006). The survey conducted by *ecologia* located additional specimens from Pug Bore and Waitawhile Bore outside the E47/1408 tenement (Table 3-1 and Figure 3-2).

Figure 3-4. Lateral Aspect of *Pygolabis weeliwolli;* Scale bar 1.0 mm.

3.1.3 Subclass (Copepoda)

Copepod Marillana (family unknown)

A single copepod specimen was collected from bore MRC0282 (Table 3-1 and Figure 3-1). The specimen was badly damaged, making even ordinal level identification impossible. The species could not be sequenced owing to previously having been cleared with Lactic Acid during slide preparation (D. Tang, UWA, pers. comm.).

3.1.4 Order (Oligochaeta)

Enchytraeid Marillana (family Enchytraeidae)

A single enchytraeid oligochaete specimen was collected from bore MSD001 (Table 3-1 and Figure 3-1). This specimen was a subadult and thus could not be identified to species (M. Scanlon, Bennelongia, pers. comm.)

3.2 DIVERSITY AND SURVEY EFFORT

Diversity estimation (Table 3-2) and species accumulation curve (Figure 3-5) was calculated using “EstimateS” (Colwell 2009). The observed diversity is very close to Chao1 and Chao2 estimators, but significantly less than the ICE estimation (Table 3-2). The ICE estimation of diversity suggests that less than 50% of the diversity was discovered, where Chao1 and Chao2 estimations suggests a fairly thorough survey, with only one additional species expected. The species accumulation curve (Figure 3-5) is also indicative of additional taxa being present as the curve shows no sign of a plateau.

Table 3-2. Species Diversity Estimates for Definitive Troglobites: ICE, (Incidence-based Coverage Estimator); Chao1(Chao 1984), Chao2 (Chao 1984, 1987).

	Observed Diversity	Statistical Diversity Estimation		
		ICE (mean)	Chao1 (mean)	Chao2 (mean)
All Sites (88 samples)	3	6.9	4	3.98

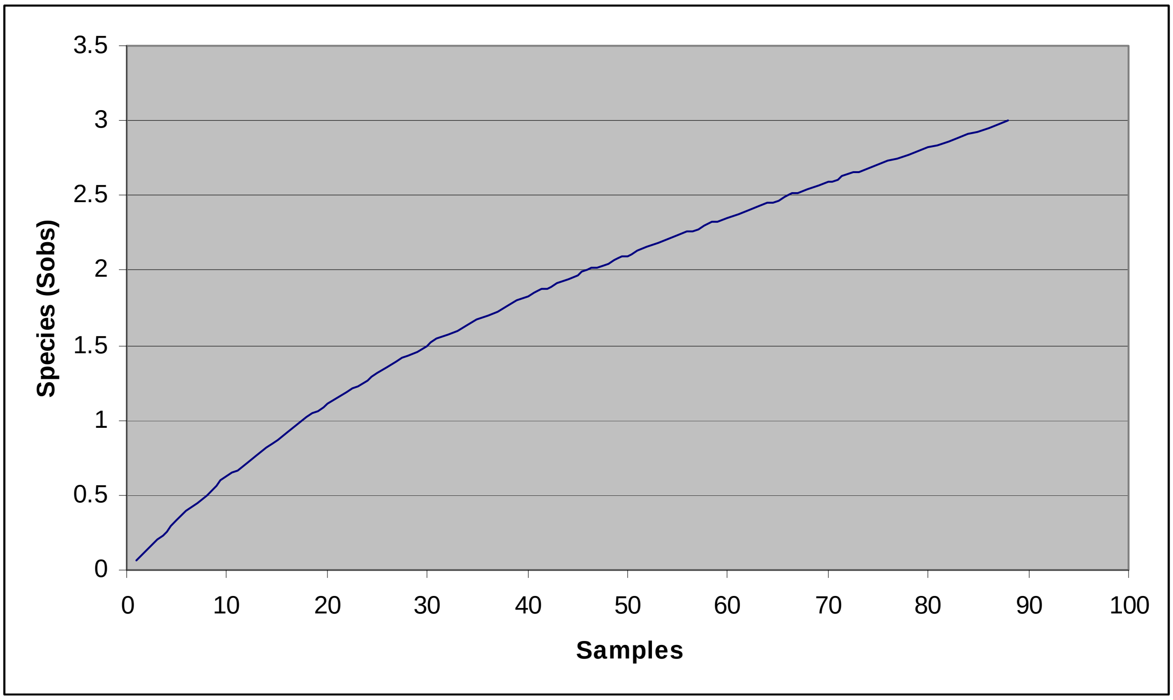

Figure 3-5. Species Accumulation Curve of Stygofauna Calculated From All Sample Bores.

3.3 WEELI WOLLI AQUIFER: STYGOFAUNA HABITAT

The main aquifer sequence within the project area is the ore body itself, representing a palaeo-channel of the ancestral Weeli Wolli Creek (Coffey 2009). More broadly, the aquifer comprises channel iron deposits overlain by an uncemented pisolite gravel, hematite and banded iron formation (BIF) detritals. Underlying the detrital ore body are low permeability strata including BIF, shale and Dolomite.

In the vicinity of the project area, the Weeli Wolli palaeo-drainage area is likely to be restricted to the alluvial outwash fans associated with the Hamersley Range front. The detrital sequences along the base of the ranges are bounded to the north by distal clayey-alluvial deposits that form the flood plain of the Fortescue Valley. These alluvial deposits are generally of low permeability and thus likely to represent the northern limit of the stygofauna habitat (Coffey 2009). To the south of the tenement the aquifer is likely to follow the Weeli Wolli Creek and Marillana Creek palaeo-channels into the Hamersley Range.

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4 THREATENING PROCESSES

Threatening processes to stygofauna involve two main types of impact. These can be classified as primary and secondary impacts. Primary impacts are direct and physical in nature and result from the physical removal of the habitat. Secondary impacts on the stygofauna community relate to other aspects of a mining operation that may affect the quality of the stygofauna habitat, such as changes to the water chemistry.

4.1 PRIMARY IMPACT: PHYSICAL DESTRUCTION OF HABITAT

Physical destruction of the habitat is likely to result from the developments of the mining pit. This impact physically removes part of the stygofauna habitat on tenement.

4.1.1 Mining Pit

The majority of the detrital iron resource that the Project aims to target is situated within the palaeo-channel and almost completely below the standing water table. As the targeted deposit represents a significant component of the aquifer (Coffey 2009), approximately 50% of the stygofauna habitat within the proposed pit shell will be removed.

In a regional context, however, the proportion of the stygofauna habitat to be impacted on in this way is small relative to the known distribution of the species discovered during the survey (Figure 3-2). The habitat extends well outside of the boundary of the development and species of the largest stygobites are known from further upstream of the Weeli Wolli palaeo-channel system (Figure 3-2), suggesting that this habitat is at least continuous along this palaeo-channel.

4.2 SECONDARY IMPACTS: ALTERATION OF AQUIFER HYDROLOGY AND BIOCHEMISTRY

4.2.1 Altering Aquifer Hydrology

Alteration of the subterranean hydrology is likely to occur from dewatering operations in the proposed mining pit, which will result in a draw-down cone in the area surrounding the pit. Preliminary data from Aquaterra indicate that the drawdown contours will be highly localized, thus negligible impact from groundwater drawdown is expected on the broader hydrology of the Weeli Wolli Palaeo-channel or the stygofauna community residing within this palaeo-drainage system.

4.2.2 Altering Aquifer Biochemistry: Contamination

Ground contamination results from a pollutant (usually liquid) entering the subterranean water system and interfering with the life processes occurring within the system. Chemical spills can have varying degrees of impact, depending on the size of the spill and nature of the chemical/s spilled. The most likely type of chemical contamination is diesel, owing to its extensive use for mine machinery. In this instance, a Project Environmental Management Plan (EMP) will be utilised to manage the likelihood and consequence of spills.

4.2.3 Altering Aquifer Biochemistry: Nutrient Starvation

While the proposed development will result in considerable clearing on tenement (2, 980 ha), the energy input to the aquifer involves a much larger area, particularly the upper catchment of Weeli Wolli and Marillana Creeks. Water-born nutrients are carried with the flow of subterranean water and thus nutrient levels are not expected to decrease beneath, or downstream of, the proposed infrastructure footprint.

Therefore no significant alteration to the nutrient content in the palaeo-channel is likely to result from the proposed development.

5 CONCLUSION

The sampling effort was sufficient in terms of the requirements of the *EPA Guidance Statement No 54a* (EPA 2007).

The two largest species detected during this survey, *Pi. millsi* and *Py. weeliwolli*, have distribution ranges extending well outside of the proposed area of development (Figure 3-2). Their large size and wide distribution pattern suggests an extensive and interconnected stygobitic habitat comprising relatively large pore spaces. Therefore, it seems likely that the much smaller enchytraeid oligochaete and copepod species will follow similar distribution patterns as their adults and larvae would be capable of dispersing through the aquifer to the same (or larger) degree as *Pi. millsi* and *Py. weeliwolli*.

The full extent of impact of the proposed development is difficult to quantify because; a) the full extent of the habitat of these species is unknown; b) some areas of known habitat are likely to be impacted on by other developments and proposed developments.

However, because of the availability of habitat off-tenement the Project is unlikely to have a significant direct effect on the stygofauna in the Weeli Wolli Creek Palaeo-drainage system.

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APPENDIX 1 Legislative Framework

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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.

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 stygofaunal 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.

APPENDIX 2 Stygofauna Survey Bore Locations (UTM WGS84) and Water Chemistry Records

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Bore ID	E.O.H. (m)	Tot. Depth (m)	DTW (m)	pH	DO (mg/L)	ORP (mV)	SpC (mS/cm)	Salin (PSS)	Temp (°C)	DO%
MRC0282 729693.04E 7498374.38N	66.00	40.40	32.89	7.37	4.50	121	1.305	0.65	30.65	54.3
MRC0245 730278.832E 7497777.362N	74.00	48.00	39.50	7.74	7.20	132	0.801	0.39	30.56	82.3
MRC0845 730729.93E 7497710.68N	60.00	48.80	33.25	7.65	7.99	152	0.872	0.42	30.76	96.8
MRC0841 731031.39E 7497447.04N	48.00	33.00	28.30	7.81	5.21	158	1.050	0.52	30.16	66.3
MRC0848 731279.33E 7497796.6N	60.00	44.80	23.40	7.72	6.93	158	1.012	0.50	30.59	85.5
MRC0801 731449.86E 7497496.86N	62.00	44.30	22.31	7.76	5.66	145	1.125	0.56	30.51	60.3
MRC0803 731205.5E 7497178.31N	?	48.10	25.63	7.89	4.83	146	0.787	0.40	30.70	55.4
MRC0314 731432.37E 7497143.65N	48.00	34.20	25.00	7.91	1.80	137	1.312	0.66	31.26	16.6
MRC0797 731765.86E 7497249.61N	54.00	46.20	22.52	8.03	9.48	139	1.560	0.79	31.38	129.4
MRC0273 730418.81E 7498199.47N	72.00	57.60	33.42	7.98	10.07	138	1.176	0.59	30.44	136.4
MRC0567 736653.5E 7493112.4N	47.00	40.70	22.80	8.17	37.83	94	0.526	0.26	29.42	450.8
MRC0431 736490.99E 7493876.43N	?	41.80	20.35	7.99	11.21	122	0.773	0.38	29.77	110.3
MRC0577 735822.29E 7493998.68N	?	24.60	20.71	8.03	8.15	128	1.201	0.60	30.23	89.1
MRC0413 735252.22E 7494247.75N	52.00	35.80	20.40	8.04	19.99	135	1.224	0.61	30.37	154.4
MRC0462 734602.16E 7494712.79N	46.00	44.60	21.52	8.17	19.00	-313	2.120	1.08	30.24	109.3
MRC0463 734326.62E 7494674.11N	42.00	36.10	23.86	8.43	9.38	-135	1.405	0.71	30.92	108.5
MRC0776 734506.04E 7494912.16N	71.00	43.35	21.26	8.29	20.03	-57	1.123	0.56	31.05	24.0
MRC0460 734907.65E 7495100.92N	46.00	37.60	17.50	8.17	21.17	-300	0.993	0.49	30.30	184.5
MRC0472 734348.98E 7495359.61N	54.00	40.30	20.15	8.12	22.68	-186	1.036	0.51	30.90	258.2
MRC0773 733966.28E 7495031.61N	63.00	55.80	25.88	8.00	21.45	-33	1.590	0.80	31.55	241.8
MRC0767 733588.7E 7495197.19N	59.10	43.60	26.95	7.82	15.94	18	1.383	0.70	31.32	191.5

Bore ID	E.O.H. (m)	Tot. Depth (m)	DTW (m)	pH	DO (mg/L)	ORP (mV)	SpC (mS/cm)	Salin (PSS)	Temp (°C)	DO%
MRC0658 734056.09E 7495468.72N	58.00	39.40	22.39	8.25	14.50	60	1.358	0.68	30.15	161.7
MRC0501 733844.26E 7496012.44N	47.00	42.50	19.96	8.26	6.81	53	1.590	0.80	30.03	77.8
MRC0543 732149.69E 7496442.01N	47.00	41.40	29.12	8.18	5.59	6	1.710	0.86	30.67	64.5
MRC0712 731852.22E 7496549.4N	?	40.85	31.63	8.08	9.66	43	1.382	0.69	30.86	101.5
MRC0705 732287.85E 7497095.85N	45.00	36.50	21.17	8.01	10.66	54	2.100	1.07	31.09	54.0
MRC0707 732156.87E 7496939.99N	51.00	38.05	24.70	7.99	7.90	112	1.670	0.84	31.09	97.6
MRC0625 731877.44E 7496905.75N	52.00	37.90	26.35	7.95	16.08	132	1.276	0.63	31.53	166.8
MRC0308 729688.2E 7499015.12N	60.00	44.68	25.67	7.92	6.18	111	1.225	0.61	30.86	76.3
MRC0290 729633.1E 7498804.13N	?	41.62	25.73	7.94	12.91	152	1.067	0.53	30.73	136.7
MRC0826 729208.52E 7498919.05N	56.00	48.73	28.84	8.14	20.06	121	0.932	0.46	30.88	210.8
MRC0804 728776.23E 7498976.37N	54.00	45.40	35.93	7.87	7.55	142	0.787	0.39	31.26	97.0
MRC0596 728217.75E 7499522.55N	80.00	?	41.49	7.74	9.96	145	0.111	0.07	30.60	120.4
MRC0601 726712.83E 7500689.89N	66.00	59.60	37.00	8.13	0.67	112	1.098	0.55	30.37	7.5
MSD004 726704.47E 7500830.94N	?	?	35.08	-	-	-	-	-	-	-
MRC0057 726990.42E 7500869.93N	66.00	47.80	32.34	7.88	4.04	122	2.150	1.10	31.17	51.0
MSD001 726879.06E 7500404.37N	?	68.85	37.63	8.03	3.99	-10	1.257	0.63	31.35	46.0
MRC0031 727028.25E 7500322.91N	?	69.20	36.59	7.61	5.02	57	1.520	0.76	31.74	58.1
MRC0819 727626.76E 7500350.19N	75.00	57.10	34.17	8.07	0.37	124	2.550	1.31	30.99	4.5
MRC0173 728143.13E 7499884.27N	64.00	46.80	38.47	8.21	0.41	135	0.901	0.44	31.00	4.2
MRC0813 728702.14E 7499534.61N	66.00	55.10	35.16	7.98	0.17	134	1.174	0.58	31.25	2.2
MRC0806 729021.85E 7499292.68N	66.00	49.90	37.14	7.66	0.15	179	0.867	0.42	31.33	2.5
MRC0302 729541.85E 7499024.51N	60.00	45.35	25.46	7.82	0.24	160	1.313	0.66	31.35	3.2

Bore ID	E.O.H. (m)	Tot. Depth (m)	DTW (m)	pH	DO (mg/L)	ORP (mV)	SpC (mS/cm)	Salin (PSS)	Temp (°C)	DO%
MRC0831 729732.82E 7499249.17N	50.00	44.50	23.10	8.05	0.11	160	0.873	0.43	30.79	1.5

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