FEBRUARY 2010

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

ecologia ENVIRONMENT

BROCKMAN RESOURCES LIMITED
TROGLOFAUNA ASSESSMENT

BROCKMAN RESOURCES
MARILLANA IRON ORE PROJECT

TROGLOFAUNA REPORT

brockman
resources.

15 February 2010

This page has been left intentionally blank

Document Status						
Rev No.	Author	Reviewer/s	Date	Approved for Issue		
				Name	Distributed To	Date
1	E.S. Volschenk & M. White	M. Davis	25/8/2009	M. Davis	J. Greive	04/09/09
2	E.S. Volschenk	E.S. Volschenk	17/10/2009	E.S. Volschenk	J. Greive	22/10/09
3	E.S. Volschenk	M. Barter	29/10/2009	M. Barter	J. Greive	29/10/09
4	E.S. Volschenk	M. Barter	09/11/2009	M. Barter	J. Greive	09/11/09
5	M. Barter		11/02/2010	M. Barter	J. Greive	11/02/2010
6	M. Barter		15/02/2010	M. Barter	J. Greive	15/02/2010

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

This page has been left intentionally blank

Table of Contents

Tables

Figures

Appendices

This page has been left intentionally blank

EXECUTIVE SUMMARY

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

The Project 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 Hamersley Range. The iron ore mineralisation within M47/1414 is best described as detrital hematite-goethite material with grades ranging from 40 – 63 % Fe.

A three phase troglofauna survey was initially undertaken within the proposed pit area of M47/1414. The phases were conduced as follows: Phase one (61 samples), 29 May - 14 July; Phase two (61 samples), 14 July - 15 September; Phase three (30 samples), 13 August – 14 October. Trapping in 61 bores was undertaken over two back-to-back phases during 2009 (122 survey samples) and, in conjunction with the additional 30 samples, provided a total of 154 samples within the proposed pit area; thus satisfying the requirement of the EPA Guidance Statement 54a.

Five definitive troglobites were discovered during these three phases and additional survey phases were then undertaken from new survey bores drilled outside of the proposed pit area. The follow-up phases were conducted as follows: Phase four (45 bores) 16 February - 15 April 2009; Phase five (44 bores) 15 April 2009 -26 May 2009; Phase six (39 bores) 26 May - 10 July 2009. This survey comprised 128 samples and produced one additional troglobitic species and two troglobitic species that were previously sampled during the first three phases.

A total of six definitive (unambiguous) troglobitic species were collected during the survey: emisine bug (Hemiptera); beetle (Coleoptera); schizomid (Schizomida); slater (Isopoda); pseudoscorpion (Pseudoscorpiones) and polyxenid millipede (Polyxenida). One tentative troglobitic beetle was also discovered. Species richness estimation predicted up to seven species based on the data collected and, coupled with species accumulation curves, indicated that the survey was comprehensive.

Schizomid evolutionary relationships were used to determine the degree of isolation of the troglobitic community on the tenement. This is because schizomids are known from other areas within the Pilbara (all troglobitic) and most of the species have had their DNA sequenced. The gene COI was sequenced for the Marillana schizomid and analysed with the other Pilbara species in order to place it within the context of the Pilbara schizomid diversity. The species was found to be unique and most closely related to a group of schizomids found in the upper reaches of Weeli Wolli.

Geological data showed that no solid rock exists above the water table within the strata surveyed; therefore the habitat in which the troglobites exist is presumed to be air-filled spaces in alluvial deposits that run through this stratigraphy. This represents a novel environment for troglobites in the Pilbara. The alluvial deposits appear to be associated with drainage channels and fans leading out from the Hamersley Range.

To understand the likely extent of habitat available to troglofauna off-tenement, a detailed assessment of the subterranean geology of the project area and regional

surrounds was undertaken. The assessment utilised drill core samples taken from on-tenement and historical exploration drill data.

Longitudinal models of the geological strata above the standing water table were developed and were overlaid with the holes where troglofauna had been found. This assessment showed that troglofauna are likely to inhabit both the siliceous detritals (SD) and the haematite-rich detritals (HD) above the existing water table (~ 20-40 mbgl). These strata are shown to extend uninterrupted off-tenement both along the ranges and to the east towards the marsh (see Figure 3-10). It was noted that the present-day creeklines do not appear to bisect the strata and thus are unlikely to act as a barrier to fauna dispersal.

1 INTRODUCTION

Brockman Iron Pty Ltd (Brockman) proposes to conduct a mining operation at its Marillana Iron Ore Project area (the Project), approximately 100 km north-west of Newman. The area is covered by tenement E 47/1408 (the project area) (Figure 1-1) and encompasses approximately 96 km^2 of the Fortescue Valley.

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 potential environmental impacts of the Project.

The purpose of the survey was to:

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

The scope of this work encompassed the following areas:

- The preparation of survey methods compliant with WA Department of Environment and Conservation (DEC) requirements and EPA guidance statements, and assistance with obtaining approval of the proposed methods from appropriate authorities.
- The conduct of a comprehensive troglofauna survey (~6 week duration per phase), focussing on the disturbance footprint.

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*.

1.1 PROJECT BACKGROUND

The Project is located in the Hamersley Iron Province 100 km north-west of Newman (Figure 1-1). Brockman proposes to mine on tenement M47/1414 (part of E47/1408) and transport the ore to Port Hedland. An existing railway line already runs through the tenement, roughly west-east.

The exploration lease, tenement E47/1408, has an area of 9,532 ha and is located in the Fortescue Valley, bordering 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 M47/1414 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 up to 90 Mtpa.

The proposed mining operations will require clearing up to 2,985 ha.

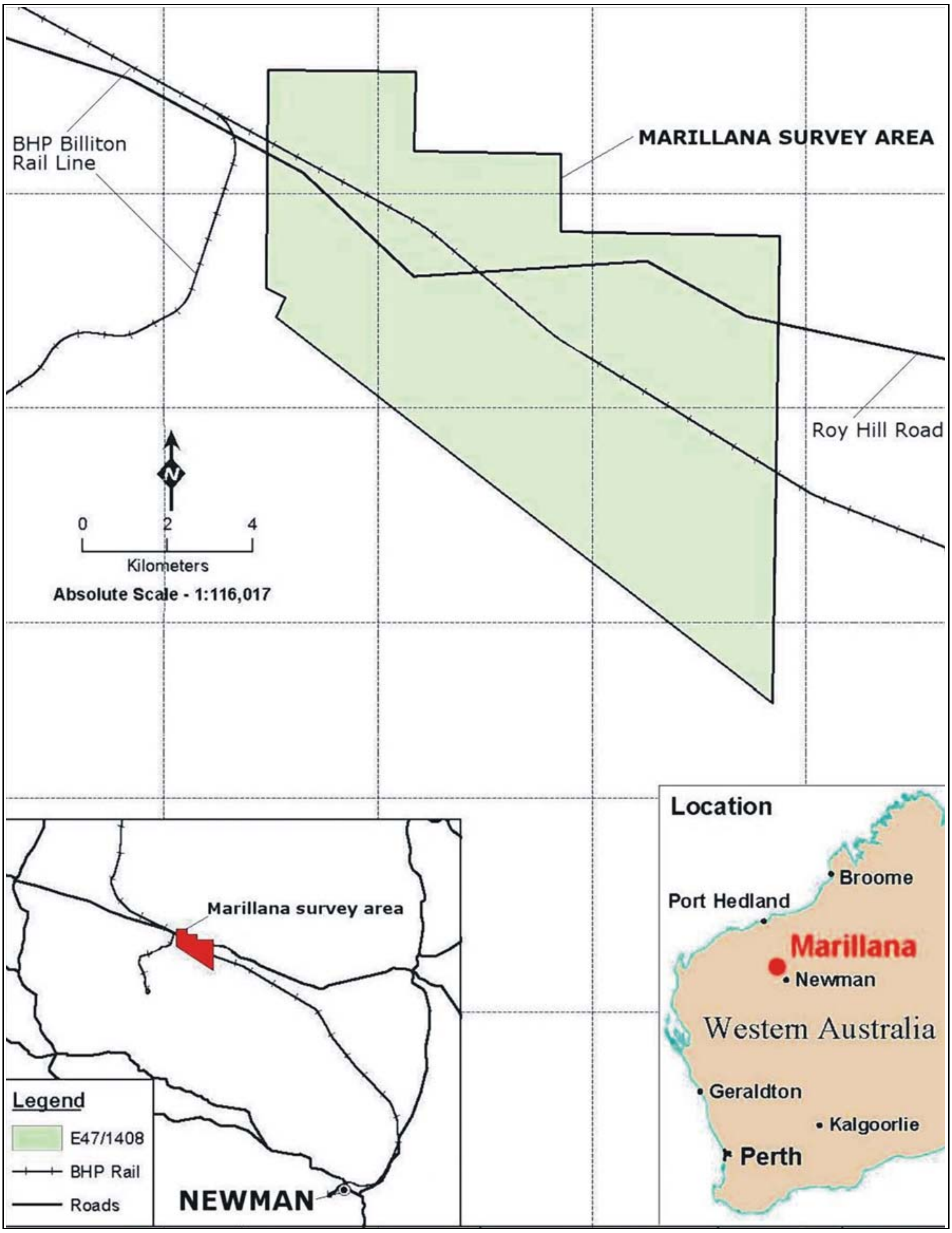


Figure 1-1 Location of the Marillana Project

1.2 LITERATURE REVIEW

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) troglophiles - facultative species that live and reproduce underground but that are also found in similar dark, humid microhabitat on ground surface; and c) trogloxenes - 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 and Shear 1993.), and are therefore entirely reliant on humid subterranean habitats.

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.).

The presence of troglofauna in Western Australia is still poorly documented. To date, troglofauna have been recorded from karst limestone systems at Cape Range, Barrow Island and in the Kimberley (Harvey 1988; Humphreys 2001; Biota 2005), pisolitic mesa formations in the Pilbara (Biota 2006b, 2007) and in the cave systems of Yanchep (EPA 2005), Margaret River (Eberhard 2006) and across the Nullarbor (Moore 1995).

Until recently, knowledge of troglofauna had been limited to observations from karst landforms, e.g. caves in Yanchep, Margaret River, Cape Range Peninsula and along the Nullarbor Plain; however, the recent discovery of troglobitic species within the iron ore rich Mesa landforms of the Pannawonica area, the Banded Ironstone Formations at Blue Hills and on Barrow Island suggests that troglofauna are likely to be found in a wider variety of landforms, geologies and regions within Western Australia.

1.3 GEOLOGY AND SOILS

Thorne and Tyler (Thorne and Tyler 1997) mapped the geological units of Western Australia (1:250,000). Locally, Marillana 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 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.

1.4 CLIMATE

Marillana is situated in the Pilbara region of Western Australia and experiences an arid-tropical climate with two distinct seasons; a hot and wet summer from October to April (wet season) and a mild and dry winter from May to September (dry season). 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 currently in operation area is at Sand Hill (22.78° S, 119.62° E) (BOM 2008). The Sand Hill weather station is located approximately 45 km to the south-east of the Upper Marillana exploration site, providing an indication of climatic conditions experienced within the project area.

The average annual rainfall in the study region 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.

The Sand Hill weather station closed in August 1984, and therefore daily weather conditions during the fauna survey were taken from the Wittenoom BOM weather station (22.24 °S, 118.34 °E), which is 100 km north-west of the project are and currently the closest in operation (BOM 2008). Data from the Wittenoom weather station are summarised in Figure 1-3 and Figure 1-4.

Troglobites have been shown to respond to seasonal variation, especially rainfall, as this influences (replenishes) the aquifer and elevates deep soil moisture levels which contribute to the high humidity environments that troglobites require (Howarth 1982; Humphreys 1991). During the sampling period, the average daily maximum and minimum temperatures for 2008 were similar to the monthly average maximum and minimum temperatures, respectively (Figure 1-3). Rainfall during the sample period was highly variable (Figure 1-4) as is summarised below:

- June (2008) receiving higher than average rainfall;
- July-October (2008) received significantly less than average rainfall;
- November (2008) to February (2009) received higher than average rainfall, and
- March – July (2009) was typically dry with lower than average rainfall.

While the winter of 2008 was drier than average, the summer of late 2008-early 2009 was much wetter than average (Figure 1-4) and thus troglobite activity is expected to have been optimal during this period and in the following months of March and April.

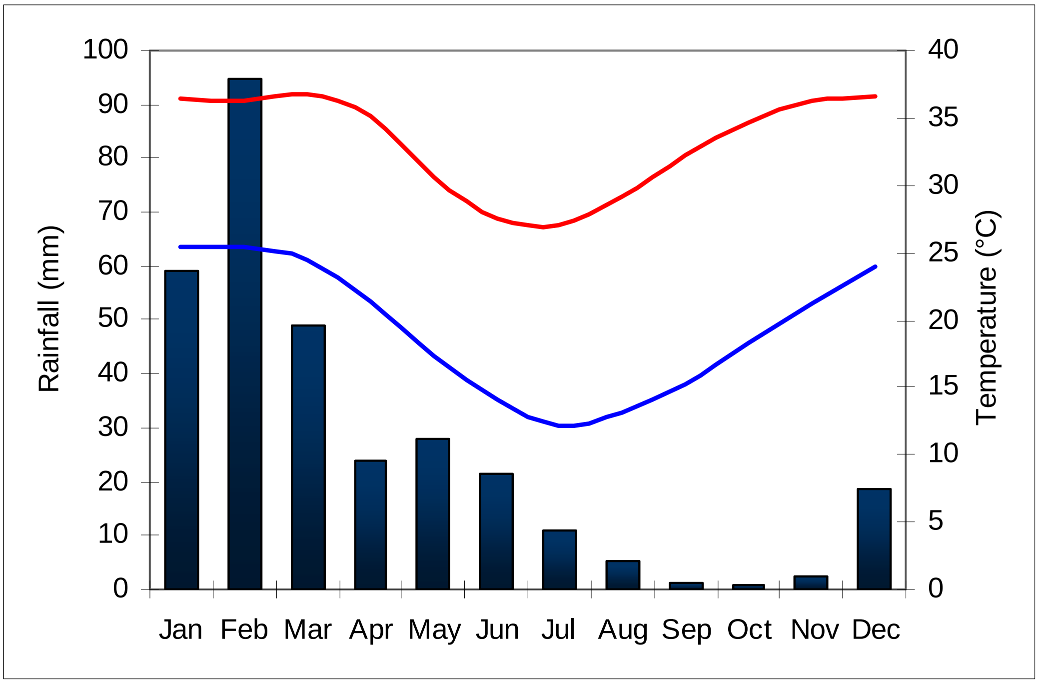


Figure 1-2 Summary of Climatic Data at Sand Hill (BOM 2008). Red line: maximum temperature; blue line: minimum temperature; bars: rainfall

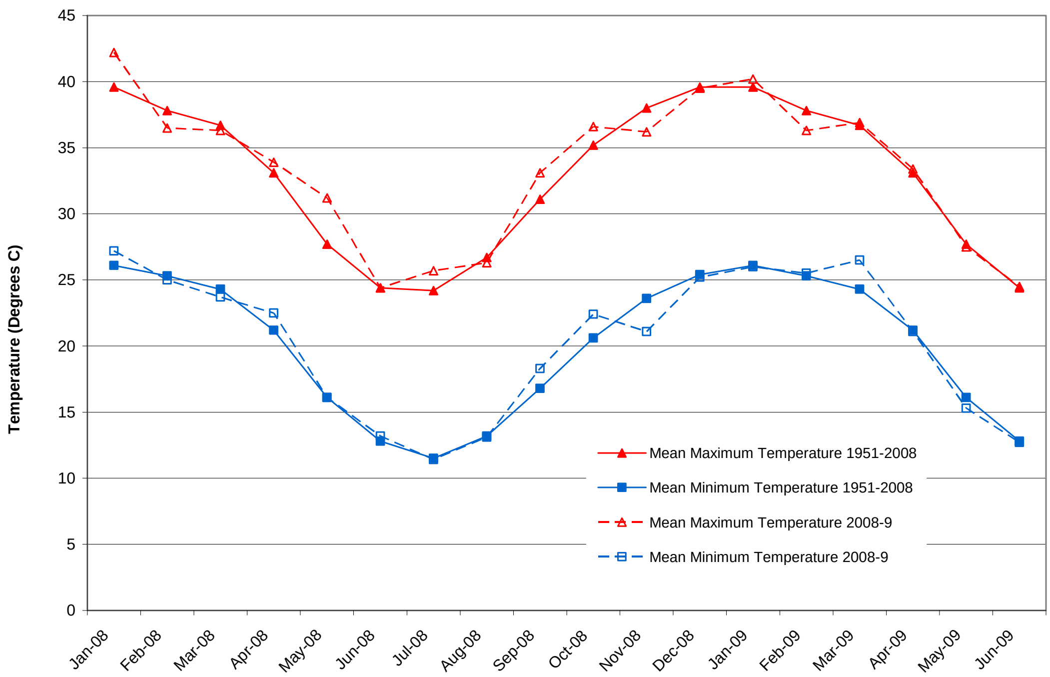


Figure 1-3 Wittenoom temperature summary: average monthly maximum and minimum temperatures plotted with the sampling month averages for 2008 and 2009. Data from Australian Bureau of Meteorology: http://www.bom.gov.au.

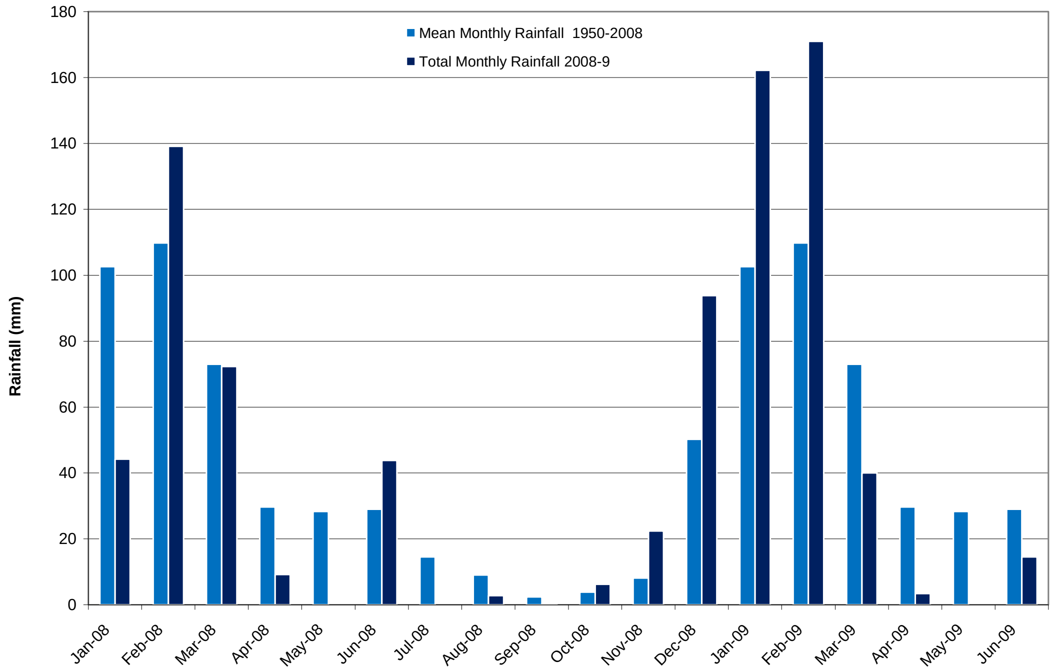


Figure 1-4 Wittenoom rainfall summary: average monthly rainfall plotted with the sampling month totals for 2008 and 2009. Data from Australian Bureau of Meteorology: http://www.bom.gov.au.

1.5 BIOGEOGRAPHY

Western Australia encompasses 26 IBRA (Interim Biogeographic Regionalisation for Australia) 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.

2 METHODS

2.1 SURVEY OBJECTIVES

Brockman commissioned *ecologia* Environment (*ecologia*) to undertake a troglofauna survey of the project area to inform the EIA 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 fauna in the area against these objectives.

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.*

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

- A review of background information (including literature and database searches).

- An inventory of troglofauna 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

The legislative framework guiding troglobitic surveys is detailed in Appendix 1. The survey methods adopted by *ecologia* have been developed in consultation with the DEC in order to conform with: a) the methodology proposed by the Environmental Protection Authority's Guidance Statement No. 54a: *Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (EPA 2004) and b) the broader legislative framework (Appendix 1). The limited state of knowledge with respect to troglobite biology (i.e. species and community distributions, maturity, longevity etc) is such that the temporal and spatial replication attained is developed largely at the discretion of the environmental consultant conducting the survey.

2.3 SURVEY TIMING

Troglofauna sampling consisted of six survey phases conducted between June 2008 and mid July 2009 (Table 2-1).

Table 2-1 Troglofauna Survey Schedule

Phase	Deployed	Recovered	Trapping Duration
Phase One (61 bores)	26-29 May 2008	14-18 July 2008	~ 49 days
Phase Two (61 bores)	14-18 July 2008	15-18 September 2008	~ 59 days
Phase 3 [Rockhole] (30 bores)	13-16 August 2008	14-16 October 2008	~ 60 days
Phase Four 45 bores	16-23 February 2009	15-20 April 2009	~52 days
Phase Five 44 bores	15-20 April 2009	21-26 May 2009	~32 days
Phase Six 39 bores	21-26 May 2009	7-10 July 2009	~43 days

2.4 SURVEY SAMPLING METHODS

Drill holes were sampled using custom designed traps which were suspended on ropes and lowered into drill holes. Individual trap units were constructed from PVC pipe which was cut into 20 cm sections. The ends of the traps were sealed with PVC fittings which had 2 cm gaps to allow access by troglobites. The middle section was fitted with a screw fitting so that two 20 cm sections could be connected and disconnected, allowing access to the trap contents. The middle section was also made more accessible to troglofauna by drilling 5 mm holes at 10 cm intervals along and around the length.

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. Traps were deployed in a total of 136 sites (bores), resulting in a total of 280 samples. The survey schedule is summarised in Table 2-1. Trap location and species captures are detailed in Appendix 2. The locations of the drill holes sampled are shown in Figure 2-1.

Leaf litter bait, which was added to the traps immediately prior to their insertion into bores, was collected from under vegetation close to the sampled drill holes and was heat treated by microwaving at high setting for 3 minutes. This process destroys any epigean invertebrates present in the leaf litter that may confound observations.

Traps were left in the ground on average for 49 days to maximize the chance of troglofauna colonisation. After this period, the traps were recovered and the leaf litter from each trap was placed into paper bags that were subsequently placed into plastic snap-lock bags: the paper facilitating as a barrier to prevent specimens from drowning in moisture condensing on the surfaces. Bags were stored in cooler boxes during transport to the *ecologia* Environment Perth laboratory for fauna extraction and sorting.

2.5 LABORATORY METHODS

Specimens were recovered from the leaf litter using Tullgren Funnels (Brady 1969; Upton 1991). This process involves placing the sample in a funnel beneath a source of light and heat (i.e. 60 W light bulb) which encourages live specimens to move downward through the funnel as the leaf litter in the sample dries. At the base of the funnel, the invertebrates fall into a vial of alcohol which preserves them until they can be identified.

Samples are 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).

2.6 TAXONOMY AND NOMENCLATURE

Any troglobitic forms recovered were identified to the greatest taxonomic resolution possible. *Ecologia* scientists conducted the preliminary sample processing and troglobitic determination; however, as troglobites represent the most extreme cases of short-range endemism, they are nearly always new and undescribed species. In cases for which taxonomic experts were available, relevant specimens were sent for identification or troglobite evaluation. Groups for which taxonomic expertise was not available were assigned morphospecies names.

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.

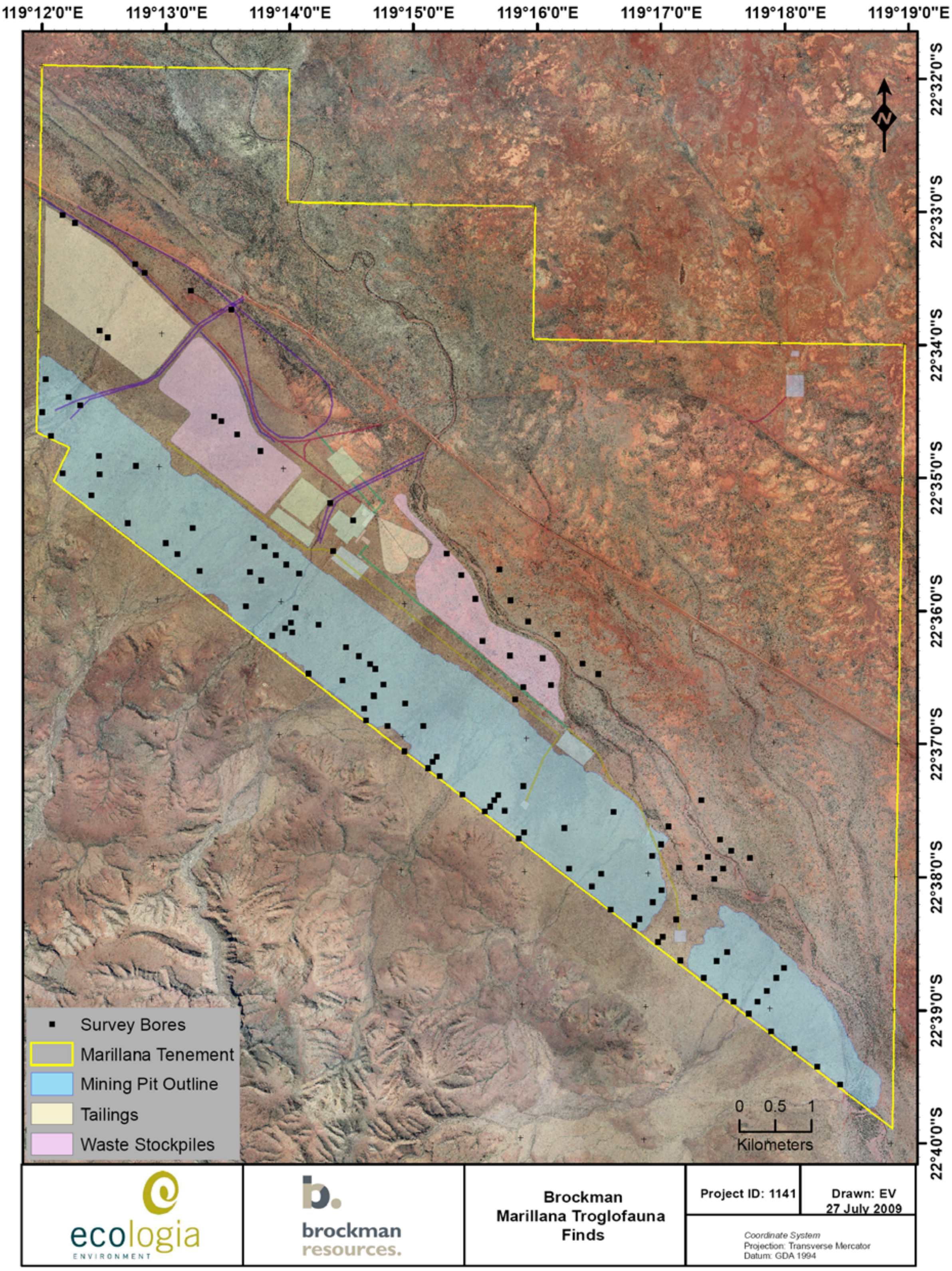


Figure 2-1 Proposed Impact Footprint (shaded areas) in Relation to Survey Bores (clack squares).

3 RESULTS AND DISCUSSION

Six definitive troglobites were detected during this survey (Table 3-1). Additional organisms, mites (Acarina) and springtails (Collembola) were routinely discovered; however, these did not show pronounced troglomorphism and represent surface species that have entered boreholes. The distribution and identity of definitive troglobites is mapped in Figure 3-2.

Table 3-1 Summary of Definitive and Tentative Troglobite Finds

Order	Family	Morphospecies	Phase	Number of Individuals	Hole ID
Definitive Troglobites					
Schizomida	Hubbardiidae	*Draculoides* 'marillana'	1 2	2	MRC219 MRC212
Pseudoscorpiones	Olpiidae	Olpiid 'marillana'	2	1	MRC175
Isopod	Armadillidae	Armadillid 'marillana'	2 5	2	MRC367 Trog24
Hemiptera	Reduvidae (Emesinae)	Emesine 'marillana'	2	1	MRC112
Polyxenida	Polyxenidae	Polyxenid 'marillana'	2 5 6	7	MRC247 MRC084 Trog41a Trog04
Coleoptera	Undetermined	Coleoptera 'marillana2'	5	6	Trog41a
Tentative Troglobite					
Coleoptera	Undetermined	Coleoptera 'marillana1'	2	5	MRC247, MRC213

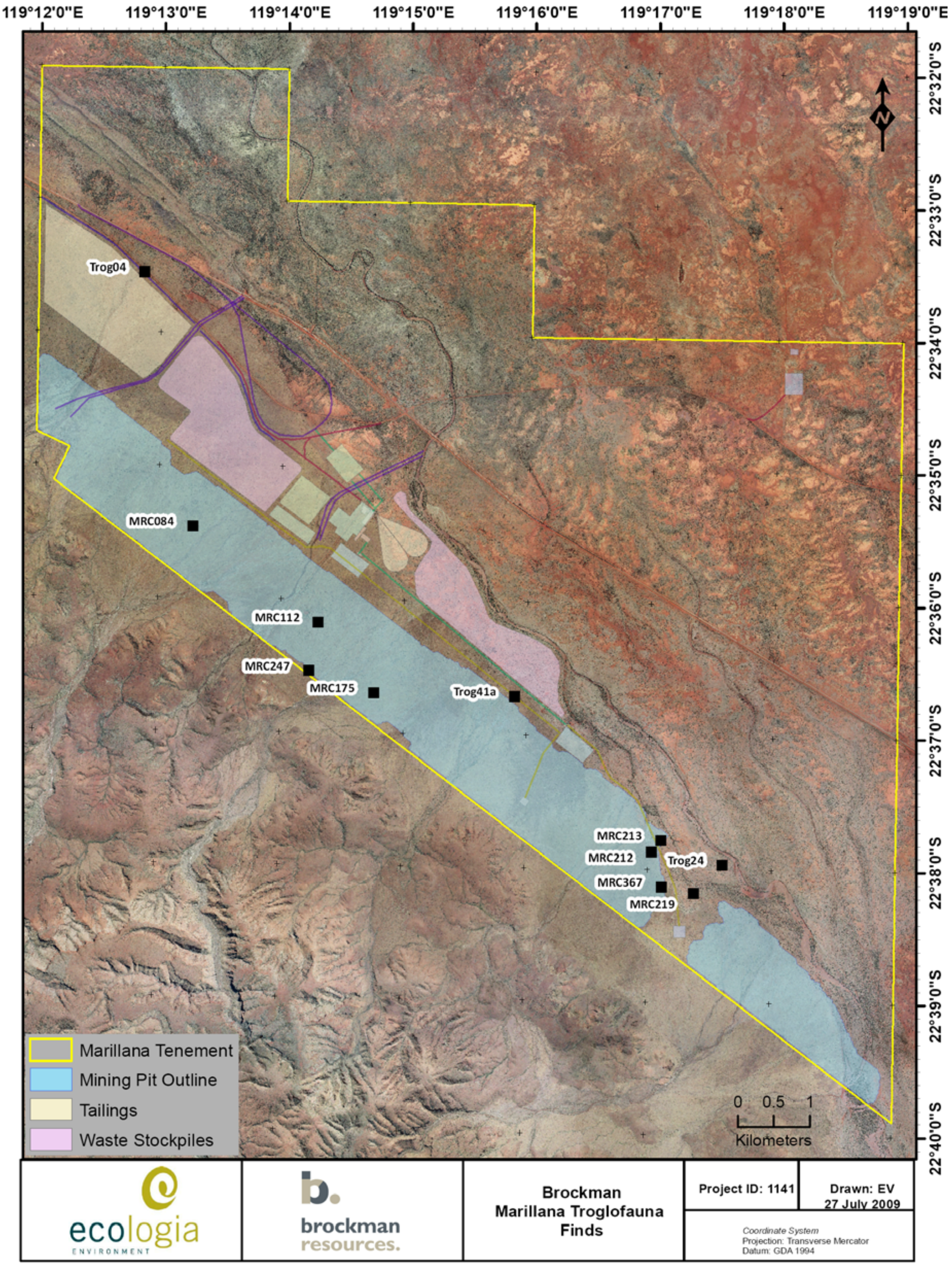


Figure 3-1 Proposed Impact Footprint (shaded areas) and Locations of Tentative and Definitive Troglobites (black squares).

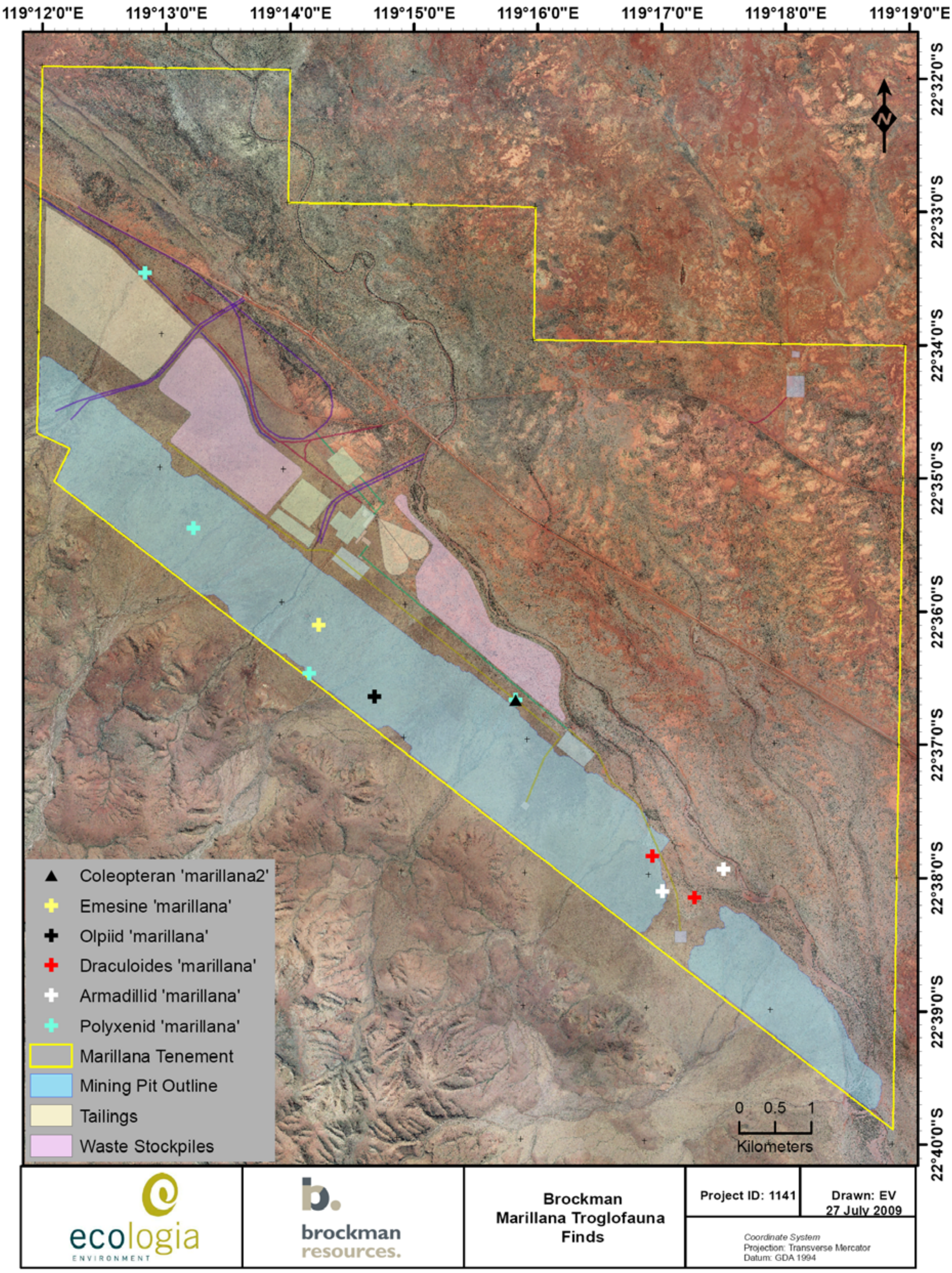


Figure 3-2 Proposed Impact Footprint (shaded areas) In Relation the Distribution of Definitive Troglobites and their Identities.

3.1 TROGLOBITES AND TENTATIVE TROGLOBITES

Several different types of invertebrates were found during this survey, many of which are unlikely to be troglobitic given the presence of well formed body pigmentation, eyes or wings. The taxa listed here fall into two categories:

- Definitive troglobites: species that are without doubt troglobitic, and possessing clear adaptations to subterranean existence: loss or reduction of eyes, pigmentation, wings and attenuation of the appendages
- Tentative troglobites: species that may be troglobitic, but belong to groups of organisms typically pale and eyeless and often associated with deep soils rather than microcavernous and mesocavernous subterranean void spaces.

3.1.1 Order Schizomida (schizomids)

Draculoides 'marillana'

Two specimens of schizomid (Figure 3-3) were detected from survey boreholes MHRC219 and MRC212 (Figure 3-1 and Figure 3-2).

Schizomids are small arachnids that superficially resemble spiders (Harvey 1992). They are found in moist environments in tropical and subtropical regions of the world (Brusca and Brusca 2003). Their reliance on high humidity environments and their absence in the terrestrial short range endemic survey indicate that this species is a definitive troglobite.

All schizomids are predatory, sensing their prey with antenna like front legs and capturing it with raptorial pelipalps (Harvey 1992; Harvey *et al.* 2008). All Australian schizomid species belong to the family Hubbardiidae and are represented by the genera *Draculoides* Harvey and *Paradraculoides* Harvey in Western Australia (Harvey *et al.* 2008). All of the Western Australian species are recorded from cavernicolous environments in the northern half of the state (Harvey 1991; Harvey 1992; Biota 2006a; Harvey *et al.* 2008).

Molecular analysis of the gene Cytochrome Oxidaze Subunit One (COI) was undertaken in order to determine if this represented a previously known species. A summary of the results of this analysis is presented in Appendix 3.

Figure 3-3 Dorsal Aspect of *Draculoides* 'marillana'. Scale bar 1mm.

3.1.2 Order Pseudoscorpiones (pseudoscorpions)

Olpiid 'marillana' (family Olpiidae)

A single undescribed species of olpiid (family Olpiidae) pseudoscorpion (Figure 3-4) was recorded from borehole MR175 (Figure 3-1 and Figure 3-2). The family Olpiidae is very diverse and contains numerous undescribed species (Mark S. Harvey, WAM, pers. com.). The specimen collected was sub-adult and thus specific identification was impossible, however the species is a definitive troglobite. This troglobite species has previously been described from Mesa K in the Robe Valley (Biota 2007).

In general, pseudoscorpions are predatory arachnids that capture and subdue their invertebrate prey using pincer-like anterior appendages (Brusca and Brusca 2003).

Figure 3-4 Dorsal Aspect of Olpiid 'marillana'. Scale bar 0.5 mm.

3.1.3 Order Isopoda (slaters)

Armadillid 'marillana' (family Armadillidae)

Two specimens of a new species of oniscoid isopods (slaters) were detected from holes MRC367 and Trog24 (Figure 3-1 and Figure 3-2). The species is pale and blind and is a definitive troglobite (S. Judd, ECU, pers. com.).

Terrestrial isopods are a diverse order of the subphylum Crustacea with more than 4000 species known (Brusca and Brusca 2003). Isopods are known from nearly all environment types, including subterranean habitats (Brusca and Brusca 2003). The suborder Oniscoidea contains all terrestrial species, members of which are generally omnivorous or herbivorous (Brusca and Brusca 2003).

Figure 3-5 Dorsal Aspect of Armadillid 'marillana'. Scale bar 0.5 mm.

3.1.4 Order Hemiptera (sucking bugs)

Emesine 'marillana' (family Reduvidae, subfamily Emesinae)

One specimen of an undescribed emesine bug species was collected from sample bore MRC112 (Figure 3-1 and Figure 3-2). The specimen was white and possessed eyes that lacked pigment while epigean species possess well developed compound eyes and body pigmentation (Figure 3-6). This species is clearly a definitive troglobite.

Emesine bugs are characterised by extremely long and thin legs and possess mantis-like raptorial front legs (Gross and Malipatil 2000). They occur worldwide and all known species are predatory, using their raptorial front legs to capture and secure prey items (Gross and Malipatil 2000). Emesines are known from cave habitats; however, taxonomic knowledge of the Western Australian species is very poor. Approximately 44 named species are known from Australia (Gross and Malipatil 2000).

Figure 3-6 Lateral Aspect of Emesine 'marillana'.

3.1.5 Order Polyxenida (pincushion millipedes)

Polyxenid 'marillana'

Seven specimens of polyxenid millipede were found during the survey from sample bores MRC247, MRC084, Trog41a and Trog04 (Figure 3-1 and Figure 3-2). The specific identity of this species is presently unknown as the general taxonomy of Australian polyxenid millipedes is poorly known. Polyxenids typically have well pigmented bodies and well developed eyes and the pale and blind features of the species collected during this survey (Figure 3-7) indicate that it is a definitive troglobite.

Polyxenids are very small, caterpillar-like millipedes, usually less than 5mm in length. They possess numerous setae over the dorsal surfaces; giving them a bristly or pincushion-like appearance. Polyxenids are herbivorous or omnivorous and epigean species may occur in very large numbers (aggregations) at certain times of the year (Koch 1985).

Figure 3-7 Dorsal Aspect of the Polyxenid 'marillana'. Scale bar 0.2 mm.

3.1.6 Order Coleoptera (beetles)

Two different types of beetles were collected during this survey and for the purpose of this report were assigned the morphospecies names Coleoptera 'marillana1' and Coleoptera 'marillana2' (Figure 3-8).

Coleoptera 'marillana1'

Five specimens of an unknown beetle species were detected from sample bores MRC247 and MRC213 (Figure 3-1). The specimens possess much reduced eyes spots and lacks pigmentation; however they are also extremely tiny (Figure 3-8) leading to the conclusion that they may be an element of the soil fauna. For this reason this species is only tentatively considered to be a troglobite.

Coleoptera 'marillana2'

Six specimens of this species were detected from sample bore Trog41a (Figure 3-1 and Figure 3-2). The larger size of this species and its complete lack of eyes and pigmentation (Figure 3-8) lead to the conclusion that this is more likely to be a definitive troglobite species.

Figure 3-8 Dorsal Aspect of 2 Coleoptera: Left, Coleoptera 'marillana1'; Right, Coleoptera 'marillana2'. Scale bar 0.2 mm.

3.2 DIVERSITY AND SURVEY EFFORT

The observed diversity matched closely the predicted diversity estimates (Table 3-2) and suggested that the survey effort was comprehensive. This was also indicated by the plateauing species accumulation curve (Figure 3-9). Diversity Estimation predicted up to one additional definitive troglobite species to be present within the subterranean habitat when all survey bores were considered.

Anecdotal evidence indicated that geological strata of the survey bores north of Weeli Wolli Creek contained high levels of clay and thus may not be representative survey samples because the geology may be unsuitable for troglobites. Some support for this position comes from the lack of troglobites from samples north of the creek line (Figure 2-1 and Figure 3-1). For this reason, diversity and species accumulation plots were also calculated using survey bores south of Weeli Wolli Creek only, excluding bores Trog13-19, and Trog21-23 (total of 10 bores) from the analysis. Removal of these samples did not alter diversity estimates (Table 3-2).

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 (280 samples)	6	7.19	6.25	6.24
South Weeli Wolli Sites (250 samples)	6	7.19	6.25	6.24

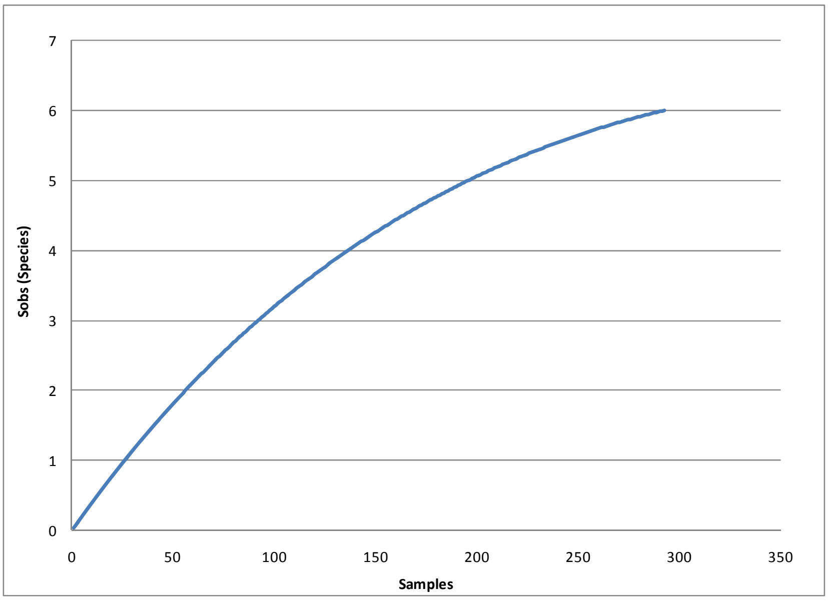


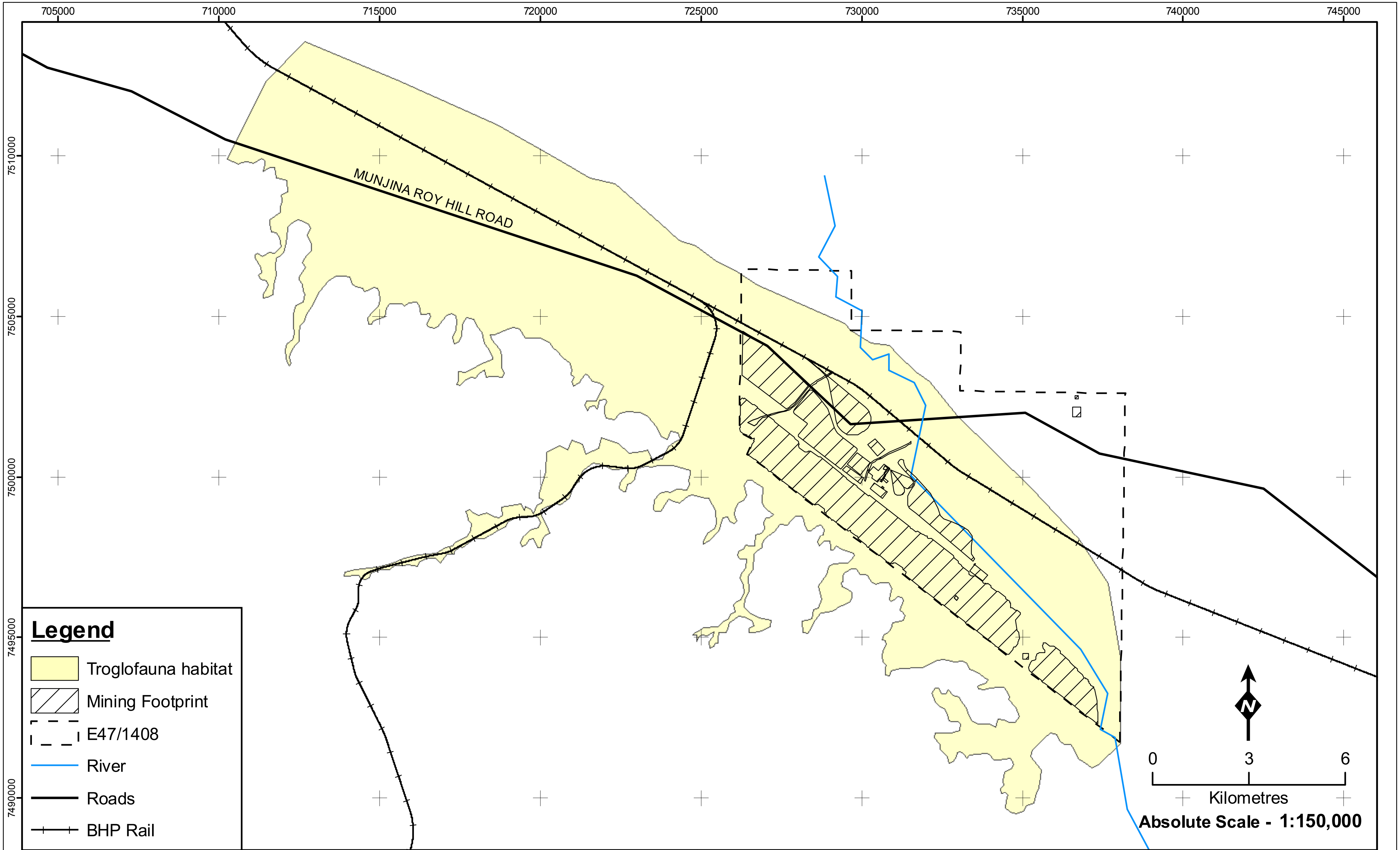
Figure 3-9 Species Accumulation Curve of Definitive Troglobites Calculated from all Sample Bores.

3.3 GEOLOGY: SUBTERRANEAN HABITAT

The geological strata in which the Marillana troglobites were collected is characterised by sedimentary deposits, both aeolian and alluvial in origin (Kneeshaw *et al.* 2002). Exploration data from Brockman indicate that there is no rock above the water table in the pit area of the tenement. In the Pilbara region troglobitic arthropods have typically been associated with fractured or otherwise porous rock: i.e. the Robe River Mesas (Biota 2006b, c; Eberhard 2007).

Data from the Brockman exploration drilling programme were used to generate an understanding of the likely habitat supporting these troglobites. The above water table strata consist of layered aeolian and alluvial deposits of Pliocene origin (*ca* 5Ma) (Kneeshaw *et al.* 2002). One or more of these strata supports air filled spaces large enough to sustain the troglobite community discovered. The most likely is one or more layers of coarse gravel beds. Diamond drill cores taken from these near troglobite finds have been examined however they to not show any clear habitable zone. It is likely that this is due to an artefact of obtaining the cores from unconsolidated aeolian and alluvial strata. Whilst it is possible that the process of drilling also collapses the void spaces, core recovery measurements however do not show any loss of core within these intervals.

Longitudinal models of the geological strata above the standing water table were developed across the pit, extending out to the northwest and northeast along the base of the ranges. Holes where troglofauna had been found were overlaid onto the cross sections to better determine the geological strata that the troglofauna occupied. This assessment showed that troglofauna are likely to inhabit both the siliceous detritals (SD) and the haematite-rich detritals (HD) above the existing water table (~ 20-40 mbgl). These strata are shown to extend uninterrupted off-tenement both along the ranges and to the east towards the marsh (see Figure 3-10). It was noted that the present-day creeklines do not appear to bisect the strata and thus are unlikely to act as a barrier to fauna dispersal.



ecologia
ENVIRONMENT

brockman
resources.

Likely Troglofauna Habitat

Figure: 3-10
Project ID: 1140

Drawn: SG
Date: 11/02/10

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: S089

A4

4 THREATENING PROCESSES

One of the important features of troglobitic habitats is their extremely stable environmental parameters (primarily temperature and humidity) and very low energy and nutrient influx (Howarth 1982; Howarth 1983; Howarth 1993; Humphreys 2000).

Two types of impact are likely to occur from the proposed development: A) physical destruction of the subterranean habitat; and B) alteration of the microclimatic and nutrient influx into the subterranean habitat.

4.1 PHYSICAL DESTRUCTION OF SUBTERRANEAN HABITAT

Physical destruction of the habitat is likely to result from two aspects of the proposed development, pit mining and vibration (see below). Both impacts result in a destruction of the air filled cavities and therefore a destruction of the troglobitic habitat affected.

4.1.1 Mining Pit

The troglobitic habitat within the proposed mining pit will be completely removed in order to access the underlying resource, which lies below the water table. The two mine pits occupy an area of approximately 1,648 ha. This impact is discussed further below under Section 4.3.

4.1.2 Vibration

Sufficient levels of vibration from heavy machinery or heavy vehicles are likely to cause the collapse of subterranean void spaces. The extent and severity of this impact is unknown because the location of the subterranean community is not clear, nor is the actual impact of vibration clearly understood. It is likely that the unconsolidated strata containing the troglobitic habitat will be more sensitive to vibration than would be expected of void spaces formed in rock.

4.2 ALTERATION OF SUBTERRANEAN MICROCLIMATE AND BIOCHEMISTRY

Alteration of the subterranean microclimate, particularly humidity, can result from alteration of surface and subterranean hydrology. Alteration of nutrient influx and contamination of the subterranean environment with pollutants can also cause significant changes to the subterranean microclimate. Details of these changes are listed below.

4.2.1 Altering Surface Hydrology

Alterations to the surface hydrology can result either in flooding of the troglobitic habitats where water is dammed or dehydration of the troglobitic community where important water is diverted away from the troglobitic habitats. Large scale changes to surface hydrology may also change aquifer recharge and thus alter water table depth.

4.2.2 Altering Subterranean Hydrology

Alteration of the subterranean hydrology is likely to occur from dewatering operations in the proposed mining pit. Dewatering results in a draw-down cone in the area surrounding the mining pit. Dewatering impact is typically considered to be a ‘secondary impact’ and very little data exits to support or make predictive commentary on this type of impact.

The draw down model after 20 years predicts an extensive drawdown cone (Figure 4-1) extending beyond the modelled distribution of the troglobite community. Based on (Sands 2001), Bennelongia (2008) argued that the draw-down of the water table would expose more additional habitat for troglobite colonization. This hypothesis is plausible if habitat below the water table can be demonstrated to be conducive to supporting troglobites (comprising porous strata). However empirical support for this hypothesised expansion of troglobite habitat has never been demonstrated and the hypothesis remains speculative.

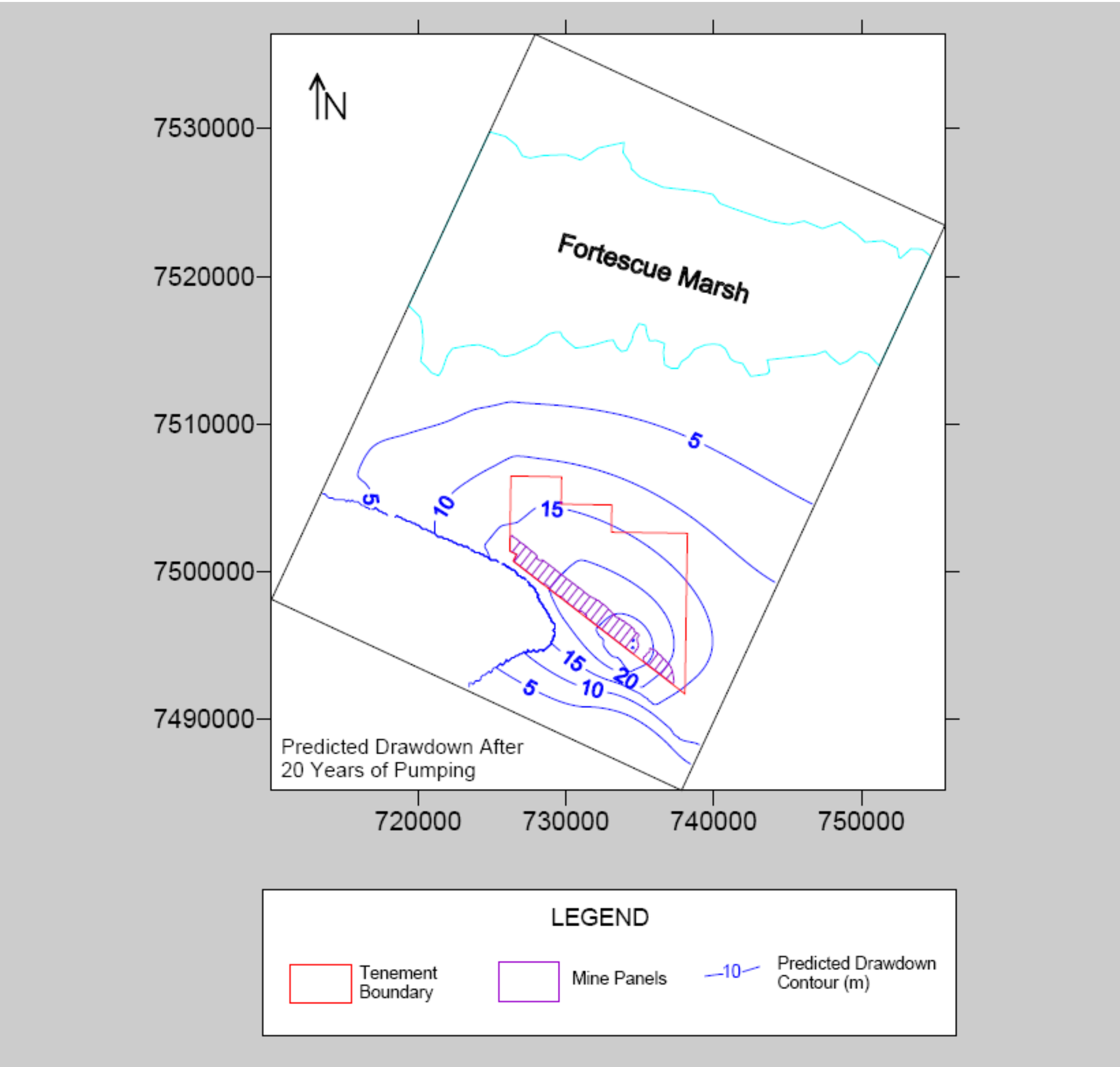


Figure 4-1 Groundwater Drawdown Model After 20 years

4.2.3 Altering Subterranean Biochemistry: Contamination

Ground contamination results from a pollutant (usually liquid) entering the troglobitic habitat 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 a contamination by diesel, owing to its extensive use as a machinery fuel.

In this instance, management plans will reduce the chance and size of diesel spills occurring.

4.2.4 Altering Subterranean Biochemistry: Nutrient Starvation

Alteration of nutrient influx into the troglobitic habitat can arise from large scale surface clearing, such as in areas proposed for the infrastructure and the waste dump. Most troglobitic communities are solely dependent on allochthonous nutrients (derived from surface environments). Organic compounds dissolved in rainwater percolate through the subterranean strata and are the sole nutrient source for most troglobitic systems (Howarth 1993). The level of this type of nutrient influx is therefore extremely low and removal of the nutrient source by clearing large areas of surface vegetation is likely to result in starvation of the troglobitic community directly beneath it. This impact is discussed further below under Section 4.3.

4.3 IMPACT OF INFRASTRUCTURE AND THE MINING PIT

The combined direct and indirect impact of the proposed project is the sum of the area of the mining pit and major elements of the infrastructure footprint (Figure 3-10).

The direct impact as a result of excavation of the mine pits is 1,648 ha or, 8.2% of the predicted troglofauna distribution (20,203 ha). Indirect (or secondary) impacts resulting from the clearing of vegetation for mine infrastructure (such as the waste dumps, plant and stockpiles) total 936 ha or 4.6% of the predicted available troglofauna habitat.

Table 4-1 summarises the predicted direct and indirect impacts to troglofauna habitat.

Table 4-1 Projected Direct and Indirect Project Impacts on Troglofauna

	FOOTPRINT (ha)	% IMPACT
Pit	1,648	8.2%
Mine Infrastructure	936	4.6%
TOTAL	**2,584**	**12.8%**

This page has been left intentionally blank

5 CONCLUSION

5.1 SUBTERRANEAN GRAVEL ENVIRONMENT: MSS IN THE PILBARA?

This survey detected a diverse population of troglobitic invertebrates within the subterranean strata of the proposed project area. The environment in which the troglofauna occurs appears to be coarse subterranean gravels as the entire stratigraphy above the water table is comprised of alluvial detritals. No consolidated rock formations occur in the area above the water table.

Layered porous gravel strata has been identified as the most likely habitat that these organisms inhabit; however, the exact limits of the habitat are not known. This appears to be the first record of such habitats containing troglobites in the Pilbara (Bill Humphreys, pers. com.). In other parts of the world a similar habitat is known to sustain troglobites: MSS (Juberthie *et al.* 1980). It appears most likely that these habitats are associated with historical alluvial drainage from the Hamersley Range.

5.2 TROGLOBITE DIVERSITY AND AGE

The schizomid specimens collected during the survey were sub-adult and thus could not be identified to species using morphology alone. Analysis of COI mtDNA sequences with sequences from other species of schizomids found through northern Western Australia (summarized in Appendix 3) indicate that this is a new species of schizomid.

This species is likely to have been isolated from its nearest relatives for several million years. This pattern of isolation is also likely to be reflected in the other invertebrate species from this troglofauna community making this a unique community.

This page has been left intentionally blank

6 REFERENCES

Bennelongia Environmental Consultants. 2008. Subterranean fauna sampling at Balmoral South Iron Ore Project and adjacent areas - Prepared for International Minerals Pty Ltd. 2008/42.

Biota. 2005. Barrow Island Gordon Gas Development. Unpublished report for The Gordon Venture.

Prepared for Robe River Iron Associates. 2006a. Mesa A and Robe Valley Mesas Troglobitic Fauna Survey 64. March 2006

Biota Environmental Sciences Pty Ltd. 2006b. Mesa A and Robe Valley Troglobitic Fauna: Subterranean Fauna Assessment. Report Prepared for Robe River Iron Associates. June 2006

Biota Environmental Sciences Pty Ltd. 2006c. Supplementary Report (Further Troglofauna Sampling at Mesa A) - Mesa A/Warramboo Iron Ore Project, Public Environmental Review. Report Prepared for Robe River Iron Associates. September

Prepared for Pilbara Iron. 2007. Mesa K Remnant Mining Project Troglobitic Fauna Survey. 52. June 2007

2008. Bureau of Meterology, accessed http://www.bom.gov.au/climate.

Brady, J. 1969. Some Physical Gradients Set Up In Tullgren Funnels During The Extraction of Mites From Poultry Litter. The Journal of Applied Ecology. 6:391 - 402.

Brusca, R. C. and Brusca, G. J. 2003. Invertebrates, 2nd edition. Sinauer Associates, Sunderland, Mass., USA.

Chao, A. 1984. Non-parametric estimation of the number of classes in a population. Scandinavian Journal of Statistics 11.

Chao, A. 1987. Estimating the population size for capture-recapture data with unequal catchability. Biometrics. 43:783-791.

Colwell, R. K. 2009. EstimateS: Statistical estimation of species richness and shared species from samples. Persistent URL: purl.oclc.org/estimates.

Department of Environment and Conservation. 2002. A Biodiversity Audit of Western Australia’s 53 Subregions. Accessed http://www.dec.wa.gov.au/science-and-research/biological-surveys/a-biodiversity-audit-of-wa.html.

Eberhard, S. 2007. Subterranean Fauna Extracts. Report prepared for the Department of Environment and Conservation Western Australia.

Eberhard, S. M. 2006. Jewel Cave Precinct Management Plan *in* Association, R. p. f. t. A.-M. R. T., ed.

Environmental Protection Authority. 2002. Position Statement No. 3 Terrestrial Biological Surveys as an element of Biodiversity Protection.

EPA. 2003. Guidance for the Assessment of Environmental Factors, Statement No. 54: Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia. EPA.

Environmental Protection Authority. 2004. Guidance for the Assessment of Environmental Factors No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia. 40. 28 June 2004

Environmental Protection Authority. 2005. Strategic Advice on Managed Aquifer Recharge using Treated Wastewater on the Swan Coastal Plain, Perth, Western Australia.

Gross, G. F. and Malipatil, M. B. 2000. Superfamily Reduvoidea. pp. 494-496 *in* CSIRO, ed. The Insects of Australia. Melbourne University Press, Carlton.

Harvey, M. S. 1988. A new troglobitic schizomid from Cape Range, Western Australia (Chelicerata:Schizomida). Records of the Western Australian Museum. 14:15-20.

Harvey, M. S. 1991. New cave dwelling schizomids (Schizomida: Hubbardiidae) from Australia. Records of the Western Australian Museum. Supplement 64:171-185.

Harvey, M. S. 1992. The Schizomida (Chelicerata) of Australia. Invertebrate Taxonomy. 6:77 - 129.

Invertebrate Systematics 2008. Molecular and morphological systematics of hypogean schizomids (Schizomida : Hubbardiidae) in semiarid Australia. 167-194

Howarth, F. G. 1982. Bioclimatic and geological factors governing the evolution and distribution of Hawaiian cave insects. Entomologia Generalis. 8:17-26.

Howarth, F. G. 1983. Ecology of cave arthropods. Annual Review of Entomology. 28:365-389.

Howarth, F. G. 1993. High-Stress Subterranean Habitats and Evolutionary Change in Cave-Inhabiting Arthropods. The American Naturalist. 142:S65-S77.

Humphreys, W. F. 1991. Experimental Re-Establishment of Pulse-Driven Populations in a Terrestrial Troglobite Community. The Journal of Animal Ecology. 60:609-623.

Humphreys, W. F. 2000. Background and Glossary. pp. 3-14 *in* Wilkens, H., Culver, D. C., and Humphreys, W. F., eds. Ecosystems of the World 30: Subterranean Ecosystems. Elsevier Science, Amsterdam.

Humphreys, W. F. 2001. Groundwater calcrete aquifers in the Australian arid zone: the context to an unfolding plethora of stygal biodiversity. Records of the Western Australian Museum, Supplement No. 64: Subterranean Biology in Australia 2000:63-83.

Humphreys, W. F. and Shear, W. A. 1993. Troglobitic millipedes (Diplopoda : Paradoxosomatidae) from semi-arid Cape Range, Western Australia: Systematics and biology. Invertebrate Taxonomy. 7:173-195.

Juberthie, C., Delay, B., and Bouillin, M. 1980. Extension du milieu souterrain en zone non calcaire: description d'un nouveau milieu et de son peuplement par les coleopteres troglobies. Memoires de Biospeleologie 7:19-52.

Kneeshaw, M., Kepert, D. A., Tehnas, I. J., and Pudovskis, M. A. 2002. From Mt Goldsworthy to mining Area C - reflections on forty years of iron ore exploration in the Pilbara. Iron Ore 2002. AusIMM Conference, Perth.

Koch, L. E. 1985. Pincushion millipedes (Diplopoda: Polyxenida): their aggregations and identity in Western Australia. Western Australian Naturalist. 16:30-32.

Moore, B. P. 1995. Two remarkable new genera and species of troglobitic Carabidae (Coleoptera) from Nullarbor caves. Journal of Australian Entomological Society. 34:159-161.

Sands, G. 2001. Soil water concepts. . Accessed http://www.extension.umn.edu/distribution/cropsystems/DC7644.html.

Strayer, D. L. 1994. Bodysize and abundance of benthic animals in Mirror Lake, New Hamphshire. Freshwater Biology. 32:83-90.

Thorne, A. M. and Tyler, I. M. 1997. Roy Hill, Western Australia (1:250 000 geological series explanatory notes).

Upton, M. S. 1991. Methods for Collecting, Preserving and Studying Insects and Allied Forms (4th Ed.). The Australian Entomological Society. Miscellaneous Publication No. 3. Brisbane Australia.

This page has been left intentionally blank

APPENDIX 1 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.

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 Troglofauna Survey Locations (UTM WGS84)

Bore Hole ID	Zone	Easting	Northing	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
MRC238	50	737328	7492339	-	-	X	X	X	X
MRC237	50	737009	7492586	-	-	X	X	X	X
MRC 233	50	736695	7492838	-	-	X	X	X	X
MRC232	50	736368	7493077	-	-	X	X	X	X
MRC227	50	736056	7493326	-	-	X	X	X	X
MRC228	50	736185	7493489	-	-	X	X	X	X
MRC230	50	736440	7493816	-	-	X	X	X	X
MRC231	50	736550	7493952	-	-	X	X	X	X
MRC229	50	736308	7493643	-	-	X	X	X	X
MRC143	50	735850	7493491	-	-	X	X	X	X
MRC226	50	735736	7493570	-	-	X	X	X	X
MRC221	50	735431	7493818	-	-	X	X	X	X
MRC222	50	735614	7494056	-	-	X	X	X	X
MRC223	50	735761	7494172	-	-	X	X	X	X
MRC220	50	735114	7494062	-	-	X	X	X	X
MRC215	50	734799	7494309	-	-	X	X	X	X
MRC216	50	734865	7494386	-	-	X	X	X	X
MRC217	50	735051	7494628	-	-	X	X	X	X
MRC219	50	735302	7494938	-	*Draculoides* 'marillana'	X	X	X	X
MRC365	50	734544	7494633	-	-	X	X	X	X
MRC214	50	734482	7494551	-	-	X	X	X	X
MRC366	50	734728	7494871	-	-	X	X	X	X
MRC367	50	734854	7495031	-	Armadillid 'marillana'	X	X	X	X
MRC369	50	735095	7495347	-	-	X	X	X	X
MRC207	50	734143	7494769	-	-	X	X	X	X
MRC213 (Z032)	50	734846	7495677	-	Coleoptera 'marillana1'	X	X	X	X
MRC212	50	734722	7495515	*Draculoides* 'marillana'	-	X	X	X	X
MRC361	50	733889	7495090	-	-	X	X	X	X
MRC363	50	734014	7495257	-	-	X	X	X	X
MRC203	50	733573	7495336	-	-	X	X	X	X
Z017	50	734187	7496122	-	-	X	X	X	X
MRC337	50	733502	7495897	-	-	X	X	X	X
MRC342	50	732945	7495838	-	-	X	X	X	X
MRC330	50	732681	7496135	-	-	X	X	X	X
MRC329	50	732937	7496479	-	-	X	X	X	X
NW02	50	726389	7501334	-	-	X	X	X	X
MRC072	50	726268	7501662	-	-	X	X	X	X
MRC073	50	726317	7502122	-	-	X	X	X	X
MRC089	50	729148	7499447	-	-	X	X	X	X
MRC275	50	730483	7498408	-	-	X	X	X	X
MRC013	50	728146	7499699	-	-	X	X	X	X
MRC44/2	50	727978	7499851	-	-	X	X	X	X
MRC046 43/3	50	727456	7500126	-	-	X	X	X	X
MRC261 44/4	50	726954	7500506	-	-	X	X	X	X
MRC259 45/5	50	726551	7500819	-	-	X	X	X	X
MRC058	50	727063	7500804	-	-	X	X	X	X
MRC067	50	727054	7501059	-	-	X	X	X	X
MRC254	50	727570	7500920	-	-	X	X	X	X

Bore Hole ID	Zone	Easting	Northing	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
MRC084	50	728356	7500059	-	Polyxenid 'marillana'	X	X	X	X
MRC162	50	728456	7499459	-	-	X	X	X	X
MRC315/x29	50	731552	7497309	-	-	X	X	X	X
MRC312/x23	50	731296	7497624	-	-	X	X	X	X
MRC310/x21	50	731055	7497310	-	-	X	X	X	X
MRC178/RH26	50	730996	7497890	-	-	X	X	X	X
MRC176/RH24	50	730732	7497552	-	-	X	X	X	X
MRC247	50	729961	7498042	-	Polyxenid 'marillana', Coleoptera 'marillana1'	X	X	X	X
MRC156	50	729303	7499329	-	-	X	X	X	X
MRC170	50	729830	7499424	-	-	X	-	-	-
MRC164	50	729090	7498973	-	-	X	X	X	X
MRC292	50	729454	7498563	-	-	X	X	X	X
MSD06	50	729779	7498955	-	-	X	X	X	X
MRC285	50	729731	7498609	X	X	-	X	X	X
MRC271	50	673997	7524346	X	X	-	X	X	X
RH35 (Trog1)	50	728754	7501535	X	X	-	X	X	X
MRC112	50	730096	7498719	X	X	Emesine 'marillana'	X	X	X
MRC154	50	729716	7498745	X	X	-	X	X	X
MRC403	50	729294	7501123	X	X	-	X	X	X
MRC175	50	730863	7497732	X	X	Olpiid 'marillana'	X	X	X
RH23	50	730759	7497396	X	X	-	X	X	X
MRC182	50	731294	7496966	X	X	-	X	X	X
MRC183	50	731612	7496731	X	X	-	X	X	X
MRC356 (MRC282)	50	731679	7496820	X	X	-	X	X	X
MRC357	50	731736	7496895	X	X	-	X	X	X
MRC184	50	731683	7496821	X	X	-	X	X	X
MRC557	50	731774	7496615	X	X	-	X	X	X
MRC544	50	732090	7496367	X	X	-	X	X	X
MRC534 (Z139)	50	732404	7496131	X	X	-	X	X	X
MRC533 (Z140)	50	732471	7496197	X	X	-	X	X	X
MRC381	50	732534	7496279	X	X	-	X	X	X
MRC382	50	732592	7496355	X	X	-	X	X	X
MRC195	50	732873	7495749	X	X	-	X	X	X
MRC098	50	730863	7497732	X	X	-	X	X	X
MRC177	50	730873	7497729	X	X	-	X	X	X
MRC279	50	730430	7497947	X	X	-	X	X	X
MRC284	50	729635	7498664	X	X	-	X	X	X
MRC107	50	730887	7498100	X	X	-	X	X	X
MRC128	50	730888	7498107	X	X	-	X	X	X
MRC277	50	730812	7498173	X	X	-	X	X	X
MRC276	50	730656	7498278	X	X	-	X	X	X
MRC400	50	728973	7501361	X	X	-	X	X	X
MRC399	50	728652	7501604	X	X	-	X	X	X
Trog34	50	7498257	733202.9	X	X	X	-	-	X
Trog33	50	7497878	733322.2	X	X	X	-	-	-
Trog32	50	7496756	734739.9	X	X	X	-	X	X
Trog35	50	7498282	732747.2	X	X	X	-	-	-
Trog37	50	7498489	732368.1	X	X	X	-	-	X
Trog38	50	7499070	732272.3	X	X	X	-	-	-

Trog17 (NWW)	50	7498180	733758.8	X	X	X	-	-	-
Trog14 (NWW)	50	7499059	732762.5	X	X	X	-	-	-
Bore Hole ID	**Zone**	**Easting**	**Northing**	**Phase 1**	**Phase 2**	**Phase 3**	**Phase 4**	**Phase 5**	**Phase 6**
Trog18 (NWW)	50	7498033	733972.6	X	X	X	-	-	-
Trog13 (NWW)	50	7499484	732606.1	X	X	X	-	-	-
Trog16 (NWW)	50	7498579	733404.9	X	X	X	-	-	-
Trog15 (NWW)	50	7498762	732999.7	X	X	X	-	-	-
Trog39	50	7499402	732078.5	X	X	X	-	-	x
Trog40	50	7499708	731874	X	X	X	-	-	-
Trog31	50	7496568	734596.4	X	X	X	-	-	X
Trog23 (NWW)	50	7495478	736074.3	X	X	X	-	-	-
Trog22 (NWW)	50	7495584	735818.8	X	X	X	-	-	-
Trog21 (NWW)	50	7495743	735663.6	X	X	X	-	-	-
Trog29	50	7496002	735132.8	X	X	X	-	-	-
Trog28	50	7495920	734944.7	X	X	X	-	-	-
Trog27	50	7495493	735495.2	X	X	X	-	-	-
Trog24	50	7495334	735701.9	X	X	X	Armadillid 'marillana'	-	-
Trog26	50	7495350	735383.3	X	X	X	-	-	-
Trog25	50	7495192	735583.1	X	X	X	-	-	-
Trog30	50	7496305	734643.8	X	X	X	-	X	X
Trog20	50	7496047	735574	X	X	X	-	X	X
Trog19 (NWW)	50	7496286	735402.9	X	X	X	-	-	-
Trog01	50	7504396	726551.4	X	X	X	-	-	-
Trog02	50	7504284	726721.3	X	X	X	-	-	-
Trog05	50	7503350	728331.4	X	X	X	-	-	-
Trog06	50	7503087	728888.2	X	X	X	-	-	-
Trog08	50	7499737	730302.3	X	X	X	-	-	X
Trog04	50	7503596	727690.3	X	X	X	-	-	Polyxenid 'marillana'
Trog03	50	7503718	727563.5	X	X	X	-	-	-
Trog07	50	7502699	727178	X	X	X	-	-	-
Trog43 (MRC406)	50	7500399	730259.1	X	X	X	-	-	-
Trog42 (MRC407)	50	7500161	730577.8	X	X	X	-	-	-
Trog45 (MRC169)	50	7499551	729653.2	X	X	X	-	-	-
Trog44 (MRC170)	50	7499425	729829.6	X	X	X	-	-	-
Trog46 (MRC168)	50	7499679	729504.2	X	X	X	-	-	-
Trog47 (MRC167)	50	7499801	729355.2	X	X	X	-	-	-
Trog48 (MRC166)	50	7499914	729200.9	X	X	X	-	-	-
Trog50 (MRC075)	50	7501874	726632.5	X	X	X	-	-	-
Trog49 (MRC076)	50	7501754	726795.3	X	X	X	-	-	-
Trog51 (MRC392)	50	7502793	727064.5	X	X	X	-	-	-
TROG41A	50	7497683	732822.1	X	X	X	-	Polyxenid 'marillana', Coleoptera 'marillana2'	-
TROG36A	50	7497851	732941.3	X	X	X	-	-	

APPENDIX 3 Schizomid Sequencing Report

Sequence report from Dr Terrie Finston

University of Western Australia

School of Animal Biology

A 690 base-pair (bp) fragment of the COI gene was sequenced for the schizomid specimen WAMT81112. It was analysed with 13 sequences of all described species of *Draculoides* and *Paradraculoides* from the Pilbara, Barrow Island and Cape Range Peninsula (Harvey et al., 2008). The dataset also contained 18 specimens of undescribed schizomids from the Packsaddle and Jirrpalar Ranges. These ranges lie within the eastern part of the Hamersley Range in the central Pilbara region. There were 20 unique genetic types (= haplotypes). A Bayesian phylogenetic tree was constructed using MrBayes software to display relationships among the haplotypes. Three specimens of undescribed schizomids from the Cape Preston area were used as outgroups.

The phylogenetic tree shows the presence of two major groups (A-B; Fig. 1). Group A contains the five recognized species of *Paradraculoides*, as well as one species of *Draculoides* (*D. mesozeirus*). Group B contains all of the eastern Pilbara species, including WAMT81112, as well as three described species of *Draculoides* (*D. julianneae*, *D. vinei*, and *D. bramstokeri*). Within group B, there are seven distinct groups or lineages (B1-B7; Fig. 1). Divergences between lineages within group B range from 4.8 to 16.2%, and in particular WAMT81112 differs from all other lineages in the group by 10.5 to 15.2 % (Table 1). To put his into context, the divergence between two described species, D. julianneae (B6) and D. vinei (B7) range from 4.8 to 5.0%.The high divergence between WAMT81112 and all other lineages in the group indicate that WAMT81112 has been evolving independently for millions of years, and is likely to represent a new, distinct species.

Table 1. Uncorrected p-distances for COI between lineages of schizomids. Distances between WAMT81112 (B2) and other lineages shown in yellow.

	B1	B2	B3	B4	B5	B6	B7
B1	*****						
B2	12.5-12.8	*****					
B3	12.5-15.0	10.5-12.8	*****				
B4	15.3-16.2	14.3-15.2	13.8-15.3	*****			
B5	13.4-13.7	13.8-14.1	14.0-15.6	15.2-15.9	*****		
B6	11.4-11.7	12.8-13.0	13.0-14.1	13.1-14.3	12.4-13.0	*****	
B7	11.4-11.8	12.4	12.1-12.8	12.0-13.3	11.7-12.0	4.8-5.0	*****

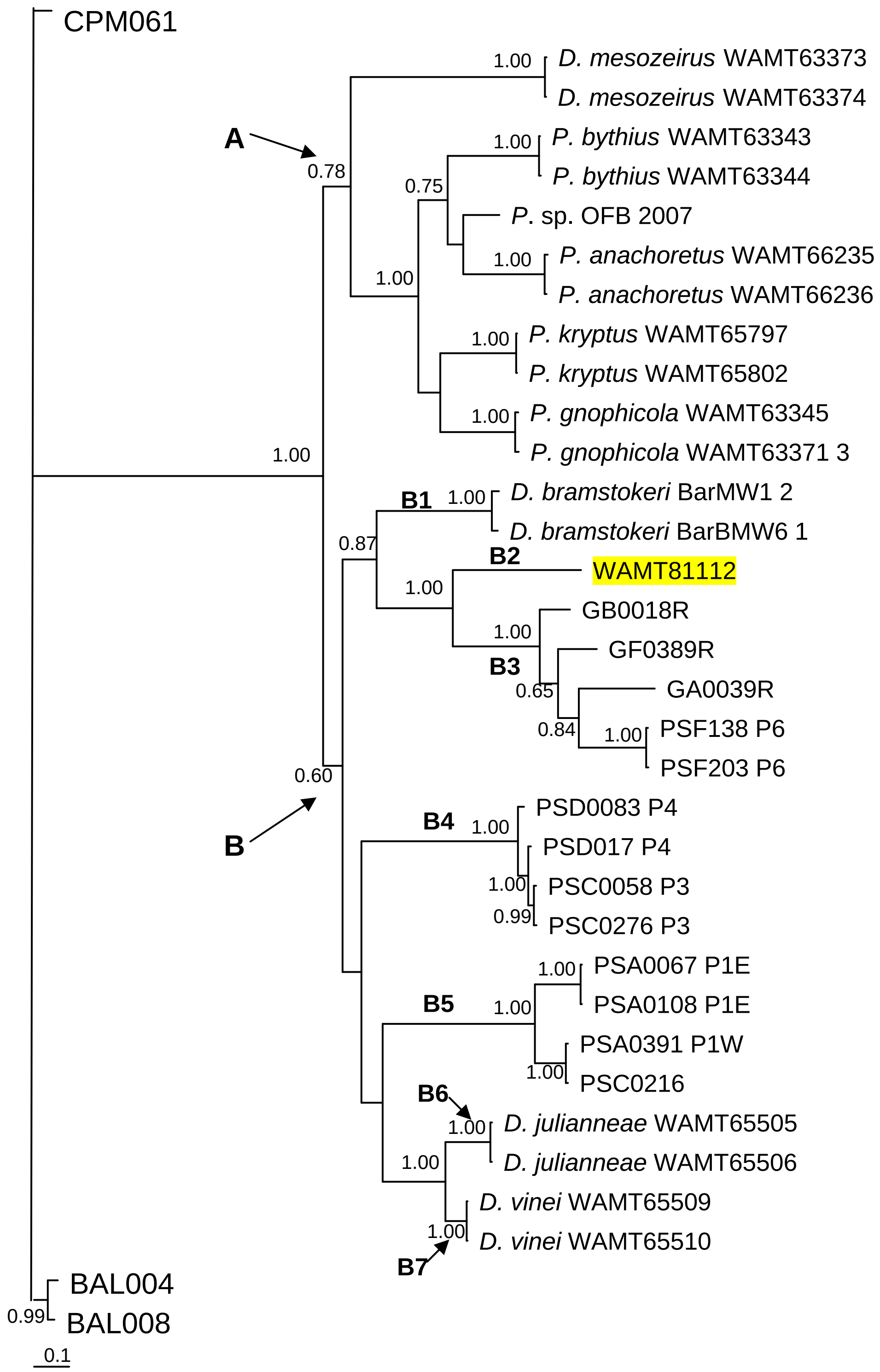


Fig.1. Most probable tree based on Bayesian inference for COI. Posterior probabilities (an indication of the robustness of the groupings) is shown on the branches. Groupings are labelled as in the text and Table 1.

APPENDIX 4 Minutes of Meeting with the DEC, Brockman and Ecologia

Following are the minutes of our meeting of Monday 15 December.

Minutes of meeting

Date: Monday 15 December 2008, 1:00 pm

Present

- Tania Jackson (DEC)
- Bradley Durrant (CALM)
- Paul Bartlett (Brockman)
- Brendan Hynes (Brockman)
- Garry Connell (Ecologia)
- Erich Volschenk (Ecologia)

Introduction to the Marillana project

- Brockman is an ASX listed iron ore junior, with the Marillana project the prime project.
- Project is a proposed Iron Ore mine, targeting detrital iron ore and buried Channel Iron Dedposit (CID)
- Located on the Northern flank of the Hamersley range adjacent to the Weeli Wolli creek Delta, approximately 20 km south of the Fortescue marsh.
- The Brockman tenement borders BHP Billiton, Rio Tinto, Hancock and FMG tenements.
- Project was initially planned to be 2- stage, with stage 1 a lower capacity, above water table operation to be followed by the larger stage 2 project.
- Brockman announced the cancellation of the stage 1 project in November 2008 and is now focussing on the larger stage 2 project.
- Short Range Endemic (SRE) invertebrate survey, Flora and vertebrate fauna surveys completed in 2008 with no significant conservation issues to report.
- Stygofauna sampling bores established ready for first sampling in early 2009
- 2 stages of Troglofauna surveys completed in 2008.

Summary of troglofauna finds to date at Marillana

- Two communities of troglofauna identified on the tenement to date, using trapping techniques.
- Schizomid included in the findings.

DNA profiling results

- Indications from DNA profiling are that the Schizomid is a new species, not previously identified at the WA Museum, and also not closely related to the species found within the Hamersley range.

Geology and the subterranean habitat at Marillana

- Very low calcium with no limestone karst systems present (No solution caves).
- The habitat is characterised by coarse gravelly soils.
- Gravelly materials deposited in colluvial fans at the outfalls of water courses from the Hamersley Ranges onto the Fortescue plain.
- Troglofauna inhabit voids in the gravelly soils.
- Drill core generally crumbles with virtually no competent solid core available.

- Similar geology (and hence subterranean habitat) expected to continue west into Karijini
- Landform changes to the east with Weeli Wolli creek potentially a barrier in the continuity of the geology.

Summary of the Troglofauna survey and test work processes at marillana

- Sampling carried out on the Brockman tenement only.
- Sample locations evenly spread throughout the planned area of disturbance.
- Trapping techniques only have been used to date.
- Traps located at 10m and 20m depths.
- DEC suggested employing down-hole camera and scraping of bore hole walls in addition to the trapping methods.
- A strengthening of current test work would be required to demonstrate whole of community or pockets of habitat.
- Sampling required for areas outside of zone of influence (pit and infrastructure areas). On tenement would be acceptable.
- DEC accept the difficulty in obtaining results/sampling regimes off the Brockman Tenement due to the current mine lease and ownership restrictions.

Other troglofauna survey work being carried out in the Pilbara

- CALM were unable to obtain funding for a regional survey. Only regional Stygofauna survey under way with CALM
- FMG-no known troglofauna survey work.
- BHP have a significant troglofauna survey programme under way, using Bennelongia and Subterranean Ecology
- BC Iron have a survey under way and have found troglofauna at Nullagine North of the Fortescue marsh

Public domain troglofauna research and survey work

- There is currently no central database for troglofauna research
- Information would be effectively available for other scientific purposes once it is in the WA museum.

Access to unpublished troglofauna work commissioned by the state (CALM or DEC)

- Not applicable.

DEC role in information sharing between mining companies.

- It was agreed for CALM to contact BHP regarding sharing information on troglofauna.
- Brockman to contact BC Iron regarding sharing of information on troglofauna.

On tenement/off tenement data comparisons

- It will be necessary to compare any available troglofauna species found off the Marillana tenement with species found on tenement to establish the significance of the species.

Guidelines for suitable subterranean fauna management plans.

- It will be necessary for Brockman to preserve sufficient habitat to ensure the continuation of the species.
- A risk assessment based approach to the trog community should be included in the submission.

Forward work programme for the EIA submission .

- Aiming for a submission to DEC in February 2009 for project referral.
- A PER is the anticipated level of EIA.
- It was recommended Brockman continue survey work on the Marillana tenement to demonstrate the extent of the community.
- It will be necessary to demonstrate a comprehensive sampling approach in the submission.

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

ecologia
ENVIRONMENT