



# West Angelas and Deposit A Stygofauna Survey



Prepared for Pilbara Iron

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# West Angelas Deposit A Stygofauna Survey

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# 1.0 Introduction

## 1.1 Project Background

The West Angelas Project is an iron ore mining, processing and transport operation located in the Eastern Pilbara (Figure 1.1). Mining operations are currently taking place at the first of several mesas located approximately 130 km east of the township of Newman. So far there have been eight deposits identified (A through H), with only the main ore deposits A and B properly defined in preparation for mining.

The Environmental Protection Authority (EPA) formally assessed the project at the level of Environmental Review and Management Programme (ERMP) (Robe River Iron 1999). The proposal was subsequently approved for implementation by the Minister for the Environment on the 28<sup>th</sup> of June 1999 (Ministerial Statement 514).

While none of the Ministerial Conditions on Statement 514 relate specifically to stygofauna surveys, several proponent commitments addressed continued monitoring for the purpose of conserving stygobitic populations. In compliance with commitments 10 and 11, a stygofauna survey was carried out from the 4<sup>th</sup> to the 6<sup>th</sup> of March focusing on those bores within and around the Deposit A mine pit area (), in preparation for the commencement of dewatering later this year.

## 1.2 Brief overview of Subterranean Fauna

Subterranean fauna has been recorded from Western Australia since the 1940s. Two broad categories of fauna are generally considered to comprise true subterranean fauna (Danielopol et al. 1994):

- Stygofauna – obligate groundwater-dwelling, aquatic fauna.
- Troglifauna – obligate cave or karst-dwelling, terrestrial subterranean fauna occurring above the watertable.

A broad overview of typical ecological characteristics of subterranean fauna and their environment is provided in Table 1.1.

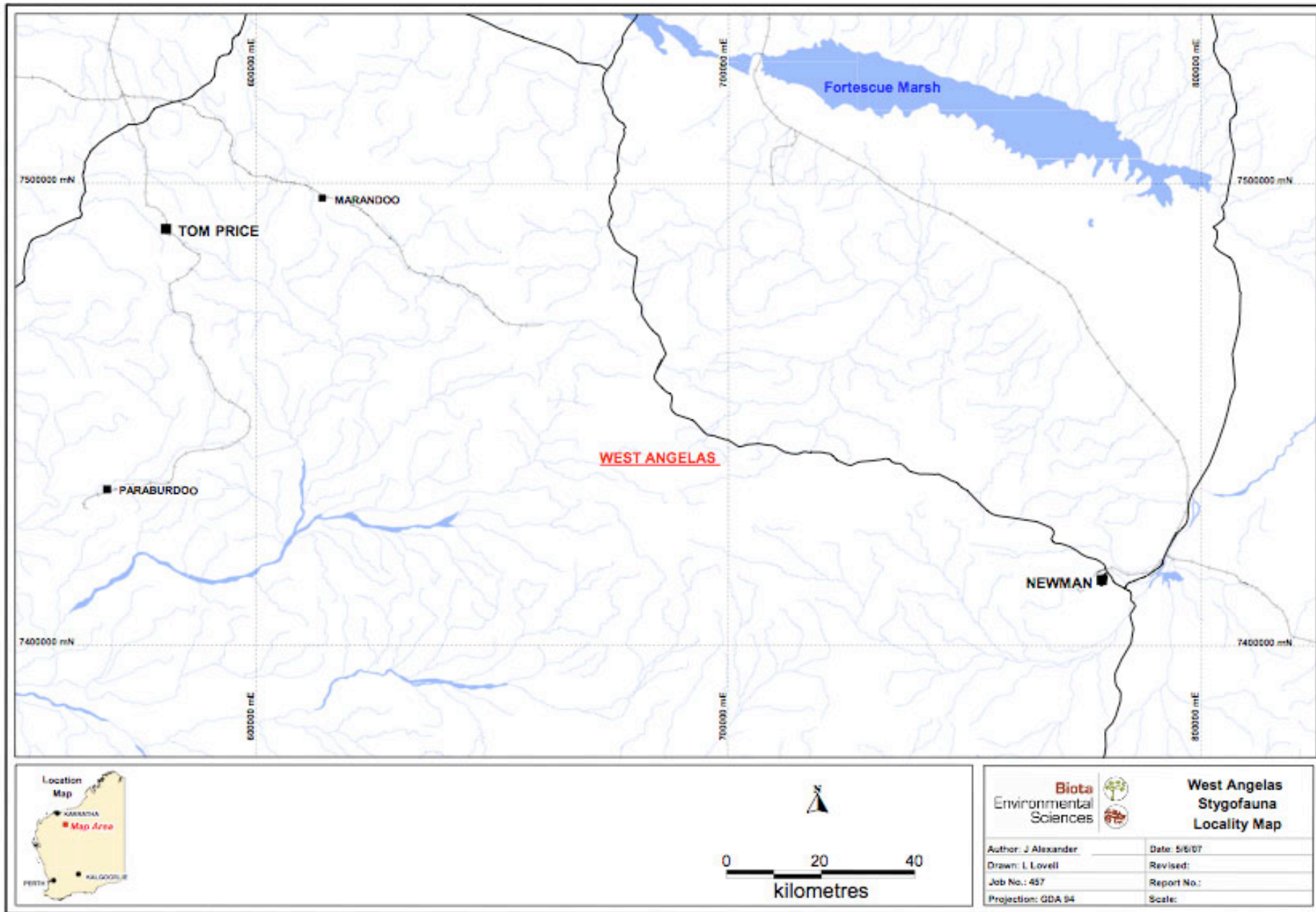


Figure 1.1: Location of West Angelas Mining operations.

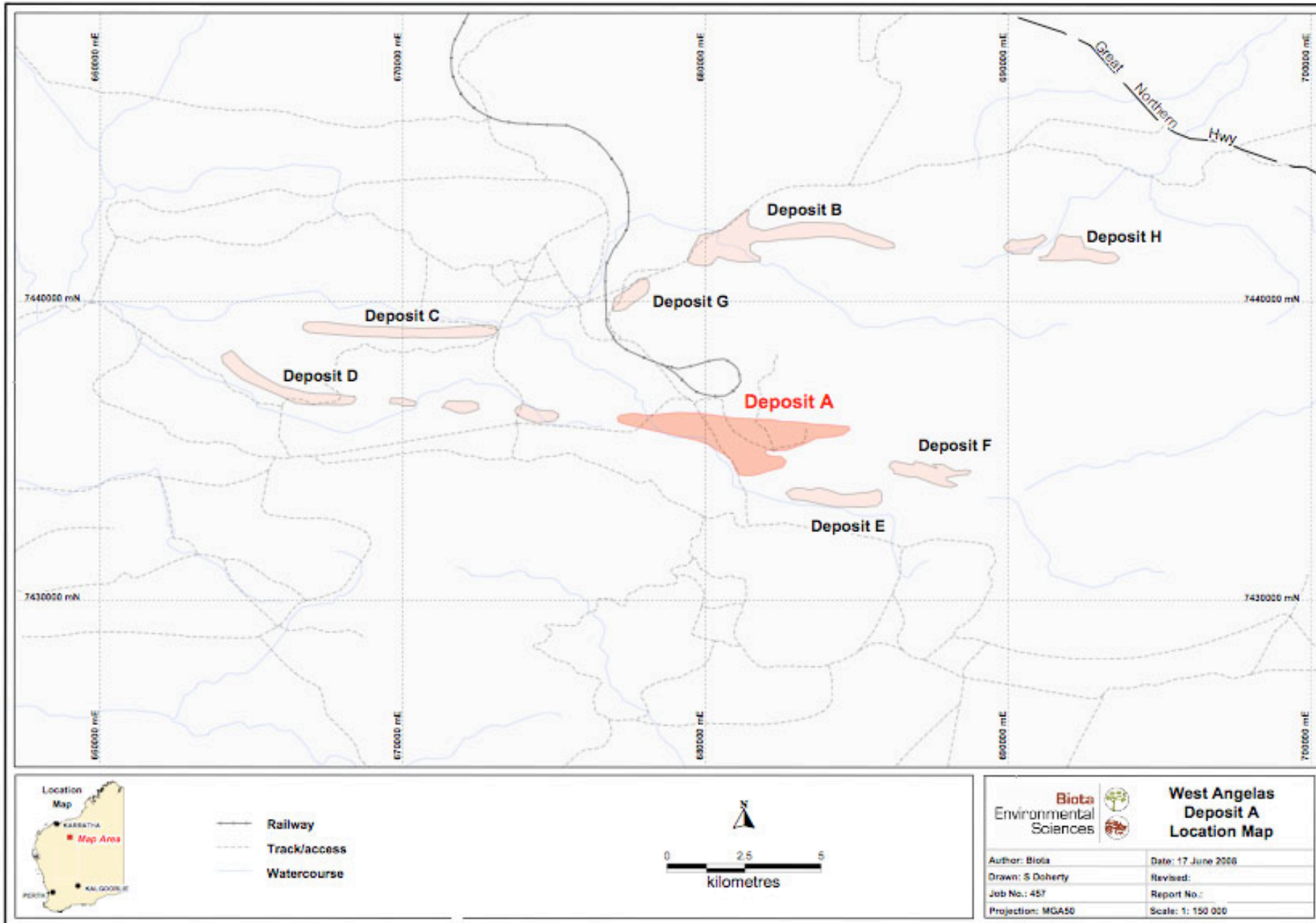


Figure 1.2: Deposit A location map in relation to deposits B – H

**Table 1.1: Characteristics of subterranean ecosystems and their components** (adapted from Danielopol et al. 1994).

<b>Environment</b>	Constant darkness
	Physical inertia which increases with depth
	Predictability: hydrologic and chemical variation usually not very evident in interstitial environments
	Restricted variety of habitats: lack of vegetation, reduction of space
	Habitat heterogeneity results from arrangement of grains, void size, physical and chemical characteristics of aquifers within the pore space
<b>Organisms</b>	Obligate groundwater dwellers (stygofauna) or obligate cave or karst dwelling terrestrial subterranean fauna (troglofauna)
	Morphological, physiological and behavioural specialisations to subterranean environment: <ul style="list-style-type: none"> <li>• general lack of pigmentation</li> <li>• ocular regression</li> <li>• appendages long and numerous</li> <li>• highly developed chemical and mechanical receptors</li> <li>• convergence of vermiform body shape for different taxa</li> </ul>
<b>Biocenosis</b>	Dominance of one species
	Richness, diversity and density low and variable
	A-type strategy of Greenslade (1983): <ul style="list-style-type: none"> <li>• slower metabolic rates and growth, reduced motor output</li> <li>• lengthening of each stage of the lifecycle, late maturity, increase in longevity</li> <li>• less frequent reproduction, lower fecundity</li> <li>• unique behaviours such as stereotropism, thigmotropism and thigmotactism</li> </ul>
<b>Functional Characteristics</b>	Heterotrophy and allotrophy
	Short, simple food webs with few trophic links
	Detritus feeders dominant
	System with low productivity
	Invertebrate diets not specialised, polyphagous

Groundwater food webs studied overseas are typically almost entirely heterotrophic, with bioproduction primarily dependent on the transport of resources (biomass, detritus) from the surface (allotrophy; Gibert et al. 1994). There are few primary producers (chemolithotrophic bacteria; Danielopol et al. 1994). Groundwater microbes (i.e. bacteria, fungi and protozoans) are the primary consumers, with general short direct trophic links to most meiofauna in the system.

Subterranean fauna in Western Australia have not been studied to the same extent as in other countries. Those that have been described are regarded as relicts, descendents from ancient pre-Gondwanan lineages. Some stygofauna species such as those inhabiting Cape Range represent relict lineages that are closely related to fauna of Gondwana, the ancient Tethys Sea and epigeal ancestors that occurred prior to the break-up of Pangaea (review in Humphreys 1999).

Stygofauna are those fauna that inhabit groundwater, sometimes occurring very close to the surface. They tend to be highly specialised to, and obligate dwellers of, subterranean groundwater habitats ('stygobites'). Stygofauna are known to be present in a variety of rock types including karst (limestones), fissured rock (e.g. granite) and porous rock (e.g. alluvium) (Marmonier et al. 1993). The types of animals that have become stygal (groundwater-inhabiting) in Western Australia include platyhelminthes, oligochaetes, crustaceans, water mites and water beetles, (Humphreys 1999, Watts and Humphreys 1999). Much attention has been directed to the crustacean fauna, which includes ostracods, copepods, remipedes, bathynellid syncarids, spelaeogriphaceans, thermosbaenaceans, isopods and amphipods.

### 1.3 Previous Stygofauna Studies at West Angelas

Historically, stygofauna surveys have focused on two borefields adjoining the West Angelas project area. These borefields, Turee Creek B and West Angelas, were considered the most likely groundwater areas to initially be impacted, with Turee B located approximately 30 km to the west

of the existing mining operations and West Angelas borefield lying directly within the mining area encompassing most of Deposit A.

Three stygofauna surveys have been carried out in the West Angelas project area prior to the current study:

- a baseline survey conducted in 1998 (Ecologia 1998);
- a follow up monitoring survey completed during 2002 (Ecologia 2002); and
- a monitoring survey undertaken by Biota Environmental Sciences (2003).

Stygofauna were collected from both the Turee Creek B and West Angelas borefields during these previous surveys (Biota, 2004). However there have been no records of stygofauna from within the Deposit A aquifer during historical sampling efforts (table 3.1).

## 1.4 Purpose and structure of this document

None of the Ministerial Conditions on Statement 514 relate specifically to stygofauna or the commencement of dewatering. Several proponent commitments (7-13 and 15-17) addressed stygofauna, but most of these do not specifically relate to the commencement of dewatering activities.

Of the actions listed in Commitment 7, the only commitment relevant to dewatering, include '*sampling and identification of stygofauna species within areas where groundwater drawdown from abstraction and mine dewatering is predicted.*' This report is an interim progress report, providing an account of the work completed thus far during the stygofauna programme and an account of Pilbara Iron's compliance with this requirement.

## 2.0 Methodology

### 2.1 Stygofauna Survey and Analysis Team

The design of the sampling program, including the bore selection was completed jointly between Pilbara Iron and Biota Environmental Sciences. Sampling encompassed the mining operation within and surrounds of Deposit A at West Angelas minesite and was completed by Mr Garth Humphreys and Mr Jason Alexander both of Biota Environmental Sciences from the 4<sup>th</sup> to the 6<sup>th</sup> of March 2008. Collected samples were transported to Perth and subsequently sorted by Mr Jason Alexander.

### 2.2 Sampling Design and Effort

Of the nineteen bores chosen for stygofauna sampling (Table 2.1, Figure 2.1) in and around the Deposit A aquifer, fifteen bores were successfully sampled. Boreholes were strategically selected from a number of production bores, monitoring bores and drillholes based on their location in relation to the affected area. An even spread of sites were selected based on accessibility, age and depth of the targeted bores.

**Table 2.1: Sampling effort and locations of bores sampled (WGS84, Zone 50)**

Bore	Easting (m E)	Northing (m N)	Successfully sampled	Comment
PB2	682040	7434380	Y	
PB3	682676	7434524	N	No access
PB4	683524	7435216	Y	
PZ06WA001	684217	7435312	N	No access
PZ06WA007	682484	7434903	Y	
PZ06WA008	682388	7435218	N	Could not find
PZ06WA010	682892	7435517	Y	
PZ06WA011	680150	7435744	Y	
PZ06WA016	680794	7434591	Y	
PZ07WA015	683212	7435489	Y	
PZ07WA017	683923	7435183	Y	
PZ07WA018	683514	7434972	Y	
PZ07WA019	683098	7434986	Y	
WB033	672788	7437711	Y	
WB059	682242	7438003	N	Contaminated*
WOB043	682886	7440849	Y	
WOB052	680179	7438925	Y	

\* Bore contaminated with dead fauna material. Not sampled due to health issues. However, a subsequent increase in bacterial and microbial levels generally signifies a lack of stygobitic activity.

### 2.3 Stygofauna Sampling Method and Data management

Stygofauna sampling at West Angelas followed a similar format to other stygofauna sampling projects undertaken previously around the Pilbara and at West Angelas. Methodologies and approach are consistent with those outlined in the Environmental Protection Act (EPA) Guidance statement 54 (EPA 2003).

Groundwater sampling is undertaken by the use of modified plankton haul nets. These sampling nets are constructed from 70µm plankton mesh, with 50 mm and 100 mm apertures attached to a weighted catch jar. Each bore was dragged a minimum of three times unless there was a risk of

losing the net. On the final haul the net was agitated gently, which acts to stir the benthos layer and any fauna for more effective specimen collecting. On the surface, the net was flushed thoroughly with tepid water and the resulting sample placed in a labelled container and into a shaded esky in order to preserve the sample until identification.

Following the completion of a bore, the nets were thoroughly rinsed with treated water and, if possible, left to dry before using in another borehole. This prevented cross contamination between boreholes.

Samples were transported back to Perth where they were live sorted in a laboratory, under a dissecting microscope (magnification up to 40x).

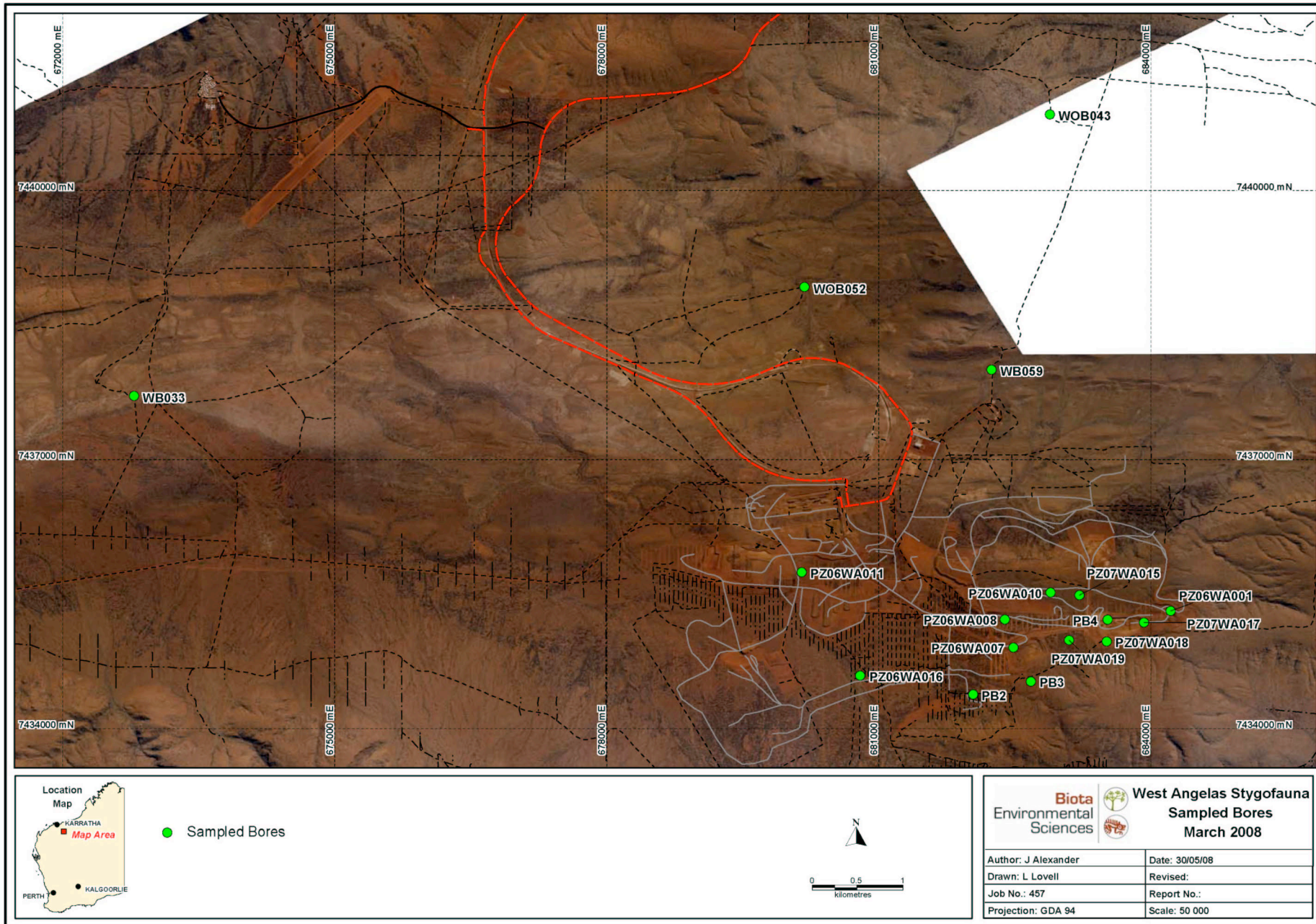


Figure 2.1: Location of bores sampled around Deposit A aquifer, West Angelas.

## 3.0 Results

### 3.1 Survey Results

As can be seen in Table 3.1, no stygofauna were recorded from any of the fifteen bores sampled in the West Angelas Deposit A aquifer (23°10'45"S, 118°47'5"E). This is consistent with the isolated nature and location of the aquifer and the proximity to the operational mine area (see Section 4.0).

**Table 3.1: Results, location (MGA datum, zone 50), effort and dates of bores sampled from Deposit A.**

Date Sampled	Bore Name	Hauls	Specimen	Comment
5/03/08	PB2	3	-	Rusty sediment
5/03/08	PB4	3	-	Organic matter, cloudy sample
5/03/08	PZ06WA007	3	-	Rusty sediment, cloudy sample
4/03/08	PZ06WA010	3	-	Clear Sample
4/03/08	PZ06WA011	3	-	Cloudy sample
5/03/08	PZ06WA016	3	-	Clear sample
5/03/08	PZ07WA015	3	-	Clear sample
4/03/08	PZ07WA017	3	-	Clear sample
4/03/08	PZ07WA018	3	-	Clear sample
4/03/08	PZ07WA019	3	-	PVC particles, Sandy sediment
5/03/08	WB033	3	-	Cloudy sample
5/03/08	WOB043	3	-	Organic matter
5/03/08	WOB052	3	-	Clear sample

### 3.2 Subterranean Fauna Habitats

The Deposit A aquifer is described by Woodward-Clyde (1998) as variably permeable and is surrounded by lower permeability material that acts to partially limit the horizontal spread of the aquifer (Ecologia 2000). Recharge to the aquifer predominantly comes from rainfall events and subsequent infiltration from creek flows and flooding and to a lesser extent, from other aquifers.

These geological and hydrological characteristics are consistent with the lack of stygofauna collected during the survey.

## 4.0 Conclusions

This report demonstrates the fulfillment by the proponent to Commitment 7 to complete sampling and identification of stygofauna species within areas where groundwater drawdown from abstraction and mine dewatering is predicted at West Angelas Deposit A.

No stygofauna were recorded from any of the bores sampled and this result is consistent with expected outcomes of sampling from within a aquifer of low connectivity located in close proximity to active mining operations.

Given these findings, there appears to be no value in expending additional effort and resources in any further sampling for stygofauna from the confined Deposit A ore body aquifer. However, a wider review of stygofauna monitoring activities at West Angelas is currently underway however, and further data will continue to be collected on this fauna from areas of core habitat in the locality.

## 5.0 References

- Biota Environmental Sciences (2004). West Angelas Stygofauna sampling 2003. Unpublished report prepared for Robe River Mining Co. Pty. Ltd. Perth.
- Danielopol D. L., Gibert J. and Stanford J.A. (1994). Groundwater Ecology. Academic Press, INC. San Diego, California.
- Greenslade P.J.M. (1983). Adversity Selection and the Habitat Templet. *American Naturalist* 1983. Vol. 122, pp. 352.
- Humphreys, W. F., Wilkens H., and Culver D.C. (2000). *Ecosystems of the World; Subterranean Ecosystems*. Elsevier Science B.V. Amsterdam, Netherlands.
- Humphreys, W. F. (1999). Relict stygofaunas living in sea salt, karst and calcrete habitats in arid northwestern Australia contain many ancient lineages. *The other 99% The conservation and biodoveristy of Invertebrates*: 219-227.
- Marmonier, P., P. Vervier, Gibert, J., and Dole-Oliver MJ. (November 1993). Biodiversity in Ground Waters. *TREE* 8(11).
- Watts, C. H. S. and Humphreys W. F. (1999). Three new genera and five new species of Dytiscidae (Coleoptera) from underground waters in Australia: *Rec. South Australian Museum (Adelaide)* 32 : 121-142)121-142.