



Rockwater
P R O P R I E T A R Y L I M I T E D

STYGOFAUNA SAMPLING FOR
THE CENTRAL WEST COAL
PROJECT

AVIVA CORPORATION LIMITED

OCTOBER 2007

REPORT FOR
AVIVA CORPORATION LIMITED

335.1/07/01

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EXECUTIVE SUMMARY

Aviva Corporation Limited (Aviva) is investigating development of the Central West Coal Deposit (the project) located about 10 to 20 km south of Eneabba, Western Australia. The development will require construction of an open pit to extract coal from the Cattamarra Coal Measures and dewatering operations, as mining will extend below the water table.

Sampling for stygofauna in the vicinity of the Central West Coal Deposit was undertaken in January and May 2007 to identify whether stygofauna are present and whether any conservation significant species are likely to be impacted by the implementation of Aviva's proposal. In total, the sampling programme yielded 45 samples from 30 bores using stygofauna haul nets. Sedimentary rocks of both the superficial aquifer and the underlying Cattamarra Coal Measures, of Jurassic age, were sampled.

No fauna were recorded from the deep aquifer. Six of the fifteen bores sampled in January 2007 contained invertebrate fauna, with only three of these containing aquatic species. The aquatic fauna recovered from the bores included Crustacea (Copepoda), Acariformes (Prostigmata) and Diptera (Muscidae) with only one bore containing a recognized groundwater-dependent taxon; the probable stygophile cyclopoid copepod *Australoeucyclops* n. sp. 1. The taxon is not restricted to groundwater in the Eneabba region, having been recorded previously from the Swan Coastal Plain at Yanchep (Eberhard, 2004) and from the Leeuwin-Naturaliste region. Eight of the 30 bores sampled in May 2007 contained invertebrate fauna, comprising one terrestrial and four aquatic species. The aquatic fauna included an ostracod, a syncarid and a nematode not collected in January 2007, and additional specimens of the cyclopoid copepod *Australoeucyclops* n. sp. 1. Terrestrial invertebrates recorded from bores at Eneabba included Psocoptera, Collembola, Hemiptera, Isoptera and Coleoptera.

The most significant taxon recorded by the survey was an undescribed bathynellid syncarid, which are known obligate groundwater taxa (stygobites). The species is also a potential short-range endemic. An assessment of the conservation significance of the bathynellid syncarid is constrained by the limited knowledge of Bathynellidae in the region and can not be undertaken until the taxon is formally described.

The fauna identified from the shallow aquifer above the Central West Coal Deposit will be directly impacted by development of an open pit to extract the coal resource. A hydrogeological investigation is currently being conducted and will provide additional information on the effect of the project on stygofauna habitat. The formal EIA process



will identify any additional potential impacts to the deep and shallow aquifers that may occur should the project proposal be implemented.

INTRODUCTION

Aviva Corporation Limited (Aviva) is investigating development of the Central West Coal Project located about 10 to 20 km south of Eneabba and immediately west of the Brand Highway. The development will require construction of an open pit to extract coal from the Cattamarra Coal Measures and dewatering operations, as mining will extend below the water table.

Rockwater Pty Ltd was commissioned by Aviva to conduct a stygofauna survey in the vicinity of the proposed Central West Coal Deposit for the purpose of identifying whether stygofauna are a relevant environmental factor for the project and to identify any conservation significant species within aquifers likely to be impacted by the implementation of Aviva's proposal.

The project will be referred for formal environmental impact assessment (EIA) under Section 38 of the Environmental Protection Act (1986). Sampling for stygofauna is required during the EIA process because development of the project has potential to impact on groundwater levels and/or groundwater quality in the vicinity of the mine.

The Environmental Protection Authority (EPA) has issued specific guidance for the consideration of stygofauna during EIA in Western Australia (EPA, 2003, 2007). The methodology applied to this investigation was developed in accordance with the 2003 EPA guidance statement (the 2007 Draft Guidance Statement 54a was issued subsequent to the commencement of the sampling programme) and considers the requirements of the EPA for assessment of stygofauna as a relevant environmental factor for the project. It involves collecting a sample set that is representative of aquifers affected by the project including an appropriate spread of sampling sites across the project area. The stygofauna investigation was designed in conjunction with a hydrogeological investigation of the Central West Coal Project, so that bores being constructed for groundwater monitoring would be suitable for stygofauna sampling. No new bores were installed solely for stygofauna sampling. The proposed sampling programme was reviewed and approved by the Department of Environment and Conservation (DEC) prior to being implemented. The following report presents the results of the investigation.



METHODOLOGY

The stygofauna sampling programme was undertaken in two phases and included existing bores and newly constructed groundwater monitoring bores in the vicinity of the proposed Central West Coal Project. The first phase of the programme involved sampling fifteen existing bores centred on the coal deposit. These included six farm bores, three disused production bores from a nearby decommissioned mineral sands mine (Iluka Resources Limited) and three pairs of deep piezometers installed by Aviva in the proposed pit area. Sampling was undertaken in the period 30 January to 2 February, 2007.

A second round of sampling was conducted in May 2007 and included most bores sampled during round 1. The exception being production bore EWP25, which was equipped with a small pump for stock watering. In addition, eleven of thirteen monitoring bores installed during a programme of test drilling in the vicinity of the deposit in November 2006 were sampled for stygofauna. These were suitable for stygofauna sampling following a resting period of six months after installation, to allow the bores to settle. All newly constructed bores were 'developed' following installation, meaning any contaminants were removed and water flow into the bore was improved. A total of 30 bores were sampled during phase 2.

Each bore was sampled as summarised below:

- prior to sampling, measure water level and basic water quality (including salinity, pH, dissolved oxygen and temperature);
- record bore depth and other construction details where available;
- collect biological samples using stygofauna sampling nets; and
- preserve samples in 100 % ethanol.

Stygofauna sampling nets with filter mesh sizes 50 µm and 150 µm and collar diameters of 47 to 147 mm were selected to accommodate the anticipated range of bore-casing diameters. Each net consists of a steel collar that supports a filter mesh, tapering to a hollow brass weight. A clear polycarbonate vial with bottom removed and replaced with 50 µm filter mesh was screwed into the brass weight to collect animals filtered by the 50 µm and 150 µm sampling nets. Nets were suspended by a carabineer and three trace wires attached to the steel collar.

Sampling nets were lowered into bores using fishing braid on a reel until they reached the bottom of the borehole where they were agitated to disturb sediment and any animals that may be present. Each biological sample was taken using four net-hauls of the stygofauna



sampling nets, made up of two hauls of each of the 50 µm and 150 µm sampling nets. For any equipped bores, a pumped water sample was filtered through a 50 µm net. Samples were stored in 120 mL polycarbonate vials and preserved using 100% (absolute) ethanol. To avoid contamination between sites, the sampling nets were thoroughly washed with a decontaminant solution and then rinsed with distilled water. All samples were forwarded to specialist stygofauna biologists for sorting and identification at the end of each phase of the sampling programme.

RESULTS

Sorting and Identification of individual specimens was undertaken by Dr Stefan Eberhard. Dr Eberhard's lab results and a brief letter report accompanying the data for each sampling phase are provided in Appendix 1.

The locations of sites sampled during the 2007 stygofauna sampling programme at the Central West Coal Project are shown in Figure 1. All sites are likely to be within the zone of influence of groundwater-level drawdown due to dewatering of the proposed open pit.

In total 45 samples were taken from 31 sites, with both the superficial aquifer and underlying Cattamarra Coal Measures being sampled. With the exception of Collembola which are terrestrial epigeans (surface dwelling), no invertebrates were recovered from the deep bores in the Cattamarra Coal Measures. Invertebrate fauna recorded by phases 1 and 2 of the 2007 sampling programme are presented in Table 1. The results of sampling from the superficial aquifer (shallow bores) are discussed for each phase of the sampling programme by invertebrate groups.

The 15 bores sampled during phase one yielded aquatic fauna from three sites, including Crustacea (Copepoda), Acariformes (Prostigmata) and Diptera (Muscidae) with only one bore, EFB1, containing a recognized groundwater-dependent taxon. Although currently undescribed, the cyclopoid copepod *Australoeucyclops* n. sp. 1 recovered from bore EFB1 is not restricted to groundwater in the Eneabba region. It has been recorded previously from the Swan Coastal Plain at Yanchep (Eberhard, 2004) and from the Leeuwin-Naturaliste region.

Acariformes and Dipteran collections, each recorded from one bore in February, were facultative groundwater dwelling taxa (stygophiles) i.e. not restricted to the groundwater environment. Terrestrial invertebrates recovered from the samples including Collembola, Hemiptera, Isoptera and Coleoptera are not considered further.



Table 1. List of taxa recorded from the Central West Coal Project, their groundwater dependence, conservation status and occurrence across sampling sites.

TAXON	Groundwater dependence*	Conservation status	SITE CODE																									COMMENTS					
			CWO11P	CWO10P	CWO13P	CWO12P	CWO15P	CWO14P	CWO35P	CWO36P	CWO39P	CWO40P	CWO41P	CWO42P	CWO43P	CWO44P	CWO45P	CWO48P	CWO49P	EFB1	EFB10	EFB11	EFB2	EFB3	EFB4	EFB5	EFB6		EFB7	EFB8	EFB9	EWP21	EWP24
CRUSTACEA																																	
Malacostraca																																	
Copepoda																																	
Australoeucyclops n. sp	A ₁	W																	1													1 specimen dissected on slide, 2 specimens in alcohol	
Cyclopoid copepodid (juv.)	A ₂	W																	1														
Ostracoda																																	
Cypridae sp.																																	
Sarscypridopsis sp. (?ochracea)	N ₁	W																		1												Dead on Collection	
Syncarida																																	
Bathynellidae sp.1	A ₃	X																			1												
UNIRAMIA																																	
Collembola	N	-														1	1								1					1	Terrestrial, not stygofauna		
INSECTA																																	
Isoptera																																	
Isoptera sp. (terr. Ep.)	N	-	1																													Terrestrial, not stygofauna	
Diptera																																	
Muscidae sp. (terr. Ep.)	N	-																						1								Larvae, not stygofauna	
Coleoptera																																	
Coleoptera sp. (terr. Ep.)	N	-																			1	1										Terrestrial, not stygofauna	
Psocoptera																																	
Psocoptera sp (terr. Ep.)	N	-																		1												Dead on Collection	
Hemiptera sp. (terr. Ep.)	N	-																												1		Terrestrial	
NEMATODA																																	
Nematoda sp.1	U	X	1																								1						
ACARIFORMES																																	
Prostigmata	N	-																					1									1 Adult, not stygobitic	
Trombidioidea	N	-																						1								1 Larva, not stygobitic	
TOTAL TAXA			0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	1	1	2	1	4	0	0	1	0	0	0	0	2	

Legend/Explanation of Codes

- A Recognised stygobite (groundwater dependence confirmed)
- N Taxon not confined to the groundwater environment (stygophile)/ Non-stygol taxon (terrestrial or surface aquatic habitat)
- U uncertain dependence on groundwater
- W Taxon locally common and/or of widespread distribution
- X Conservation status unknown
- * Numerical identifier in subscript for Figure 1

Sampling for stygofauna during phase two included 30 bores. Invertebrate fauna was recovered from 9 bores, although only four bores contained aquatic invertebrates. The aquatic fauna recorded included an ostracod, a nematode and a syncarid not recorded previously in phase one. In addition, the copepod *Australoeucyclops* n. sp. 1 was recorded at bore EFB1 where it had been recorded previously in February, along with a cyclopoid copepodid which is likely a juvenile specimen of the same taxon (S. Eberhard, pers. comm.). A terrestrial epigeal (surface-dwelling) species (Psocoptera) was also recorded.

Nematodes were collected from two bores, EFB7 and CW010P, in May 2007. The taxonomy of the Nematoda in Western Australia is too poorly described to comment on a specimen sampled from bore CW010P. The EPA's draft technical appendix pertaining to stygofauna (EPA, 2007) acknowledges the limitations of taxonomy for Nematoda in Western Australia. Identification to species level is generally required to understand an individual's ecological dependence on groundwater and to assess its conservation significance; an exception being the Syncarida, which are all obligate groundwater taxa (stygobites).

The bathynellid syncarid, Bathynellidae sp. 1, recorded from bore EFB2 in May 2007 is a known stygobite meaning it is restricted to the groundwater environment. This taxon is likely to have a restricted distribution range and consequently, is likely to warrant higher conservation significance. For EIA purposes it should be treated as a potential short-range endemic species. The taxonomy and distribution of the bathynellids and other Syncarida from Western Australia is very poorly known. While several species of parabathynellids have recently been described from the Kimberley and Yilgarn, no bathynellids from the southwest have been described (Eberhard, 2007b). Given that the Eneabba specimen is a new taxon, an assessment of its conservation significance is constrained by the limited knowledge of Bathynellidae in the region.

The four ostracod specimens collected from EFB11 in May 2007 were sent to Dr Ivana Karanovic in Tasmania for further taxonomic verification. The specimens were identified as *Sarscypridopsis* sp. (Family Cypridae, Subfamily Cypridopsinae) but further identification to species level was not possible, due to the specimens being disintegrated. It is possible that they belong to *Sarscypridopsis ochracea* which is not an obligate groundwater dwelling taxon (stygobite). If this taxon is a new species, it is not likely to be a short-range endemic as Dr Karanovic has recorded the same form in surface waters and wells in the Murchison region, Pilbara region and in the eastern states.



SUMMARY AND RECOMMENDATIONS

Sampling for stygofauna was undertaken from 31 bores over two seasons (mid summer and late autumn) in the vicinity of the Central West Coal Deposit near Eneabba, Western Australia. Forty five samples in total were collected. Both the sandy superficial aquifer and underlying Cattamarra Coal Measures were sampled although no stygofauna was recovered from the deeper formation. The most significant taxon recorded by the survey was an undescribed bathynellid syncarid, which are known obligate groundwater taxa (stygobites). The species is also a potential short-range endemic.

The superficial aquifer from which the undescribed bathynellid syncarid was recorded overlies the Central West Coal Deposit and as such, the fauna identified from the aquifer will be directly impacted by the development of Aviva's Central West Coal Deposit.

The taxonomy of the bathynellids from Western Australia is very poorly known; there have been no bathynellids described from the southwest. The bathynellid syncarid recorded at the site has not been recorded elsewhere to date and without being formally described, it is not possible to assess the conservation significance of this taxon.

Sampling work undertaken by the WA Museum in the Eneabba area (Laurentiis, Pesce *et al* 2001) identified stygofauna (copepods, bathynellids and oligochaetes) from 3 of 13 bores sampled, all of which were either in or underlying the Tamala limestone. Although the geology of the Eneabba area reported by Laurentiis *et al* (2001) differs from the superficial sands reported here, it is recommended that the bathynellid specimen recovered from bore EFB2 be compared with the WA Museum's 2001 bathynellid specimen(s), as this is the nearest known location of a syncarid collection to the project area.

Subsequent to the comparison of syncarid specimens from the WA Museum's 2001 collections with Aviva's 2007 specimen, a regional sampling programme should be designed and implemented to investigate the distribution of the undescribed bathynellid syncarid recorded from the project area. Regional sampling should be undertaken in the saturated superficial formations (sands) west of the Gingin Scarp within 10 to 20 km of the project site. Prior to commencement of any further sampling, the results of the sampling programme (Phases 1 and 2) should be discussed with the DEC.



Dated: 18 October 2007

Rockwater Pty Ltd

**N C P Evelegh
Principal Environmental Scientist**

REFERENCES

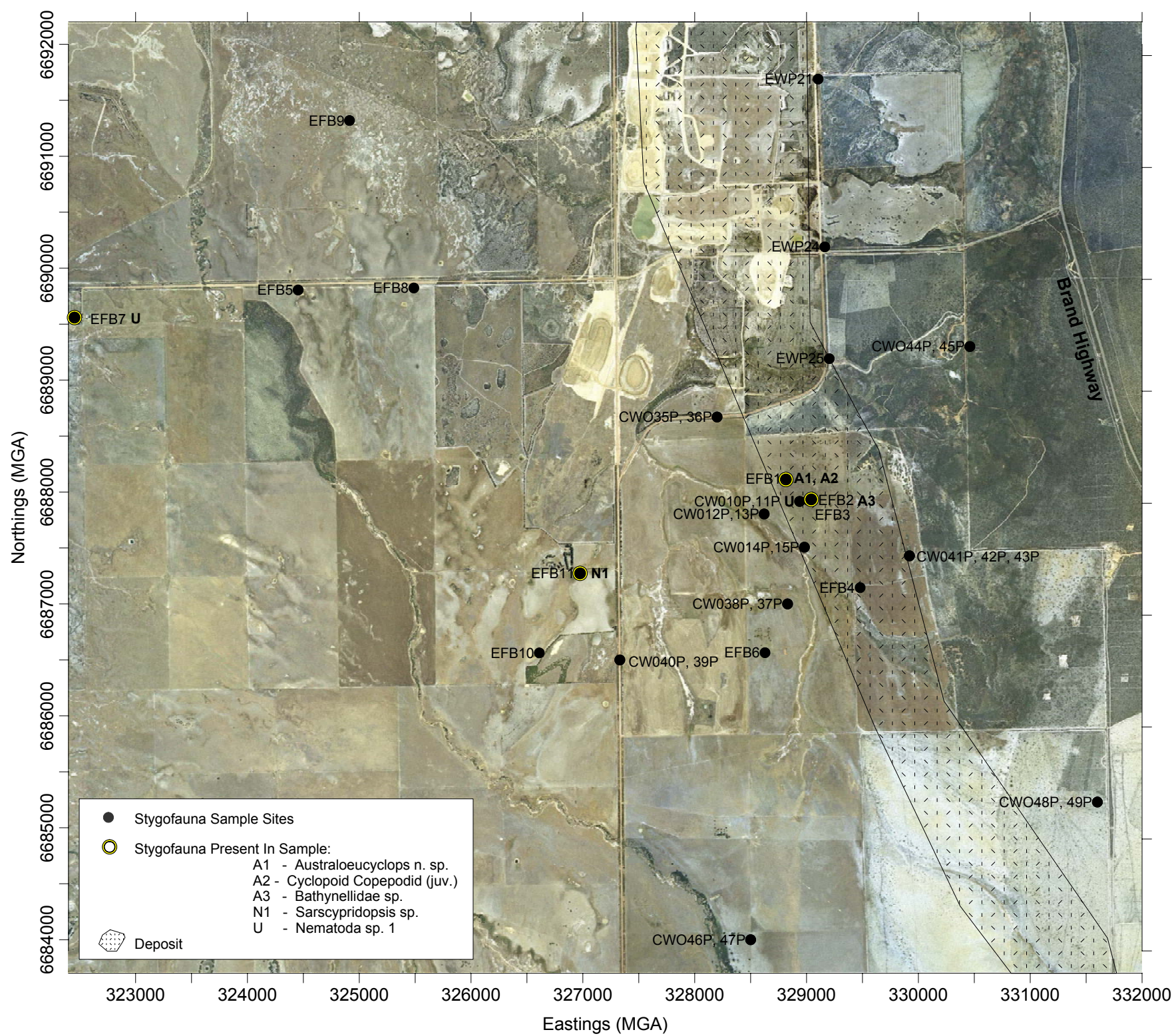
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- Laurentiis, P. D., Pesce, G. L. and Humphreys, W. F. (2001). Copepods from ground waters of Western Australia, VI. Cyclopidae (Crustacea: Copepoda) from the Yilgarn Region and the Swan Coastal Plain. *Records of the Western Australian Museum* Supplement **64**: 115–131.



FIGURES



Figure 1



I://335.1/Surfer/Aviva Stygo Locality1.srf

CLIENT: Aviva Corporation
 PROJECT: Eneabba Stygofauna Sampling
 DATE: October 2007
 Dwg. No: 335.1/07/1-1

STYGOFAUNA SAMPLING
 LOCALITY PLAN & RESULTS



APPENDIX 1





Subterranean Ecology

Scientific Environmental Services

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Nick Evelegh
Rockwater Pty Ltd
Perth, WA

Re: Eneabba Stygofauna Survey January-February 2007

Dear Nick,

Please see overleaf (and attached as Excel spreadsheet) the results of the sorting and identification of the 18 vials from 16 sites collected from Eneabba January-February 2007.

Invertebrate fauna was recovered from six of the 16 sites sampled. At three sites the fauna comprised terrestrial species, and only three sites (EFB1, EFB3, EFB4) contained aquatic species.

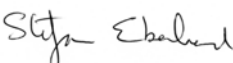
The aquatic taxa recorded included Crustacea (Copepoda), Acariformes (Prostigmata), and Diptera (Muscidae).

The cyclopoid copepod *Australoeucyclops* n. sp. 1 collected at Eneabba is the same undescribed species as recorded in the Yanchep Caves and from limestone springs in the Leeuwin-Naturaliste region (T. Karanovic pers. comm., Eberhard 2004). The genus *Australoeucyclops* includes one other described species, *A. karaytugi* Karanovic recorded from the surface pool of a spring in the Pilbara (Karanovic 2006).

None of the Acariformes were obviously stygomorphic (showing physical adaptations to subterranean life). Muscid dipterans have aquatic larval stages while the adults are terrestrial winged insects.

None of the identified taxa appear to be restricted to groundwater in the Eneabba region.

Yours Sincerely,


Dr Stefan Eberhard
Subterranean Ecology

References

Eberhard, S.M. (2004) Ecology and hydrology of a threatened groundwater-dependent ecosystem: the Jewel Cave karst system in Western Australia. PhD thesis Murdoch University.

<http://wwwlib.murdoch.edu.au/adt/browse/view/adt-MU20051010.141551>

Karanovic, T. (2006) Subterranean copepods (Crustacea, Copepoda) from the Pilbara Region in Western Australia. *Records of the Western Australian Museum Supplement* No. 70: 1-239.

Eneabba Stygofauna Survey January-February 2007

Subterranean Ecology specimen identifications April 2007

Site name	Easting	Northing	Date	Taxon 1	Identification	No. spec.	Lab No.	Slide No.	Comments
AMW1 d (CW011P)			01-Feb-07	NIL FAUNA					
AMW15 (CW010P)			31-Jan-07	Isoptera			na		terrestrial, not stygofauna, not collected
AMW2 (CW012P)			01-Feb-07	NIL FAUNA					
AMW2 (CW013P)			01-Feb-07	NIL FAUNA					
AMW35			31-Jan-07	NIL FAUNA					
AMW3d (CW015P)			31-Jan-07	NIL FAUNA					
EF85			01-Feb-07	NIL FAUNA					
EFB1	328819	6687117	31-Jan-07	Copepoda: Cyclopoida	<i>Australoeucyclops</i> n. sp. 1	1	seLN1 31	seS064	1 spec dissected on slide, 2 spec in alcohol
EFB2	329040	6687930	31-Jan-07	Coleoptera	Gen et sp. Indet.	1	na		terrestrial, not stygofauna, not collected
EFB5			02-Feb-07	NIL FAUNA					
EFB6	329013	6687927	02-Feb-07	NIL FAUNA					
EWP21			01-Feb-07	NIL FAUNA					
EWP24			02-Feb-07	NIL FAUNA					
EWP25			02-Feb-07	Collembola	Gen et sp. Indet.		na		terrestrial, not stygofauna, not collected
				Hemiptera	Gen et sp. Indet.		na		terrestrial, not collected
Ex Windmill 3 (EFB3)	329013	6687927	31-Jan-07	Acariformes: Prostigmata	Eupodidae?	1	seLN1 10		1 adult, not stygobitic
Ex Windmill 4 (EFB4)	329479	6687145	01-Feb-07	Acariformes: Trombidioidea	Gen et sp. Indet.	1	seLN1 09		1 larva, not stygobitic
				Coleoptera	Gen et sp. Indet.	4	na		terrestrial, not stygofauna, not collected
				Collembola	Gen et sp. Indet.	1	na		terrestrial, not stygofauna, not collected
				Diptera: Muscidae	Gen et sp. Indet.	2	na		larvae, not stygofauna, not collected



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Nick Evelegh
Rockwater Pty Ltd
Perth, WA

Re: Eneabba Stygofauna Samples Batch 2 collected May 2007

Dear Nick,

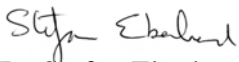
Please see overleaf the results of the sorting and identification of the 2nd batch of samples (28 sites) collected from Eneabba May 2007. For ease of comparison (also in attached Excel spreadsheet), the taxa list includes all species from both sample events.

Twenty-one invertebrate specimens comprising five taxa were recovered from eight of the 28 sites sampled. One of these taxa (Psocoptera) was a terrestrial epigeic (terr. Ep) species, the other four were aquatic. The aquatic fauna included ostracods and syncarids not collected in round one, plus additional specimens of the probable stygophile (Sp) copepod *Australoeucyclops* n. sp. 1 collected previously. The bathynellid syncarids are stygobites (Sb). The taxonomy of the bathynellids (cf. parabathynellids) is very poorly known in Western Australia. While several species of parabathynellids have recently been described from the Kimberley and Yilgarn, no bathynellids from southwest WA have been described.

The ostracods, which may be candonids, may also be stygobitic (Sb). The nearest known location for a described stygobitic candonid, *Acondona memoria* Karanovic is the Brockman River. If the collection site (EFB11) lies within the zone of influence of the project proposal then further identification of the candonid ostracod will require specialist taxonomic input, which can be sought if requested. The taxonomy of the Nematoda is too poorly described to comment on their degree of groundwater dependence.

For EIA purposes the stygobitic morpho-species (viz. the syncarids and ?candonid) collected at Eneabba should be treated as potential short-range endemic species, and the copepod as a local population.

Yours Sincerely,


Dr Stefan Eberhard
Subterranean Ecology

16th July 2007

Eneabba Stygofauna Samples Batch 2 May 2007: **Subterranean Ecology** specimen identifications July 2007

Batch 2 May 2007													
Phylum	Class	Order	Identification	site	AMW1d	AMW1s	AMW2d	AMW2s	AMW3d	AMW3s	CW035P	CW036P	
				date	2/05/2007	2/05/2007	2/05/2007	2/05/2007	2/05/2007	2/05/2007	3/05/2007	3/05/2007	
Nematoda			Nematoda sp. 1 (EN)		N	1	N	N	N	N	N	N	
Chelicerata			Acarina (terr. Ep.)		L		L	L	L	L	L	L	
Uniramia		Collembola	Collembola (terr. Ep.)		N		N	N	N	N	N	N	
	Insecta	Isoptera	Isoptera sp.(terr. Ep.)										
		Diptera	Muscidae sp. (terr. Ep.)		F		F	F	F	F	F	F	
		Coleoptera	Coleoptera sp. (terr. Ep.)		O		O	O	O	O	O	O	
		Psocoptera	Psocoptera sp. (terr. Ep.)		U		U	U	U	U	U	U	
			Hemiptera sp. (terr. Ep.)		I		I	I	I	I	I	I	
Crustacea	Malacostraca	Syncarida	Bathynellidae sp. 1 (EN) (Sb)		D		D	D	D	D	D	D	
		Copepoda	<i>Australoeucyclops</i> n. sp. (Sp)										
			Cyclopoid copepodid (juv.)										
		Ostracoda	?Canonidae sp. (Sb?)										
			Vial tracking numbers		Batch 2 May 2007								
Phylum	Class	Order	Identification	site	AMW1d	AMW1s	AMW2d	AMW2s	AMW3d	AMW3s	CW035P	CW036P	
				date	2/05/2007	2/05/2007	2/05/2007	2/05/2007	2/05/2007	2/05/2007	3/05/2007	3/05/2007	
Nematoda			Nematoda sp. 1 (EN)			seLN426							
Chelicerata			Acarina (terr. Ep.)										
Uniramia		Collembola	Collembola (terr. Ep.)										
	Insecta	Isoptera	Isoptera sp.(terr. Ep.)										
		Diptera	Muscidae sp. (terr. Ep.)										
		Coleoptera	Coleoptera sp. (terr. Ep.)										
		Psocoptera	Psocoptera sp. (terr. Ep.)										
			Hemiptera sp. (terr. Ep.)										
Crustacea	Malacostraca	Syncarida	Bathynellidae sp. 1 (EN) (Sb)										
		Copepoda	<i>Australoeucyclops</i> n. sp. (Sp)										
			Cyclopoid copepodid (juv.)										
		Ostracoda	Ostracoda										
			tot vials			1							

Eneabba Stygofauna Samples Batch 2 May 2007: **Subterranean Ecology** specimen identifications July 2007

Identification	EFB10	EFB11	EFB2	EFB3	EFB4	EFB5	EFB6	EFB7	EFB8	EFB9	EPW21	EWP24
	4/05/2007	4/05/2007	2/05/2007	2/05/2007	3/05/2007	3/05/2007	2/05/2007	2/05/2007	3/05/2007	3/05/2007	4/05/2007	4/05/2007
Nematoda sp. 1 (EN)				N		N	N	1	N	N	N	N
Acarina (terr. Ep.)				L		L	L		L	L	L	L
Collembola (terr. Ep.)				N		N	N		N	N	N	N
Isoptera sp.(terr. Ep.)												
Muscidae sp. (terr. Ep.)				F		F	F		F	F	F	F
Coleoptera sp. (terr. Ep.)				O	1	O	O		O	O	O	O
Psocoptera sp. (terr. Ep.)	D.O.C.			U		U	U		U	U	U	U
Hemiptera sp. (terr. Ep.)				I		I	I		I	I	I	I
Bathynellidae sp. 1 (EN) (Sb)			4	D		D	D		D	D	D	D
<i>Australoecyclops</i> n. sp. (Sp)												
Cyclopoid copepodid (juv.)												
?Canonidae sp. (Sb?)		D.O.C.										
Vial tracking numbers												
	EFB10	EFB11	EFB2	EFB3	EFB4	EFB5	EFB6	EFB7	EFB8	EFB9	EPW21	EWP24
	4/05/2007	4/05/2007	2/05/2007	2/05/2007	3/05/2007	3/05/2007	2/05/2007	2/05/2007	3/05/2007	3/05/2007	4/05/2007	4/05/2007
Nematoda sp. 1 (EN)								seLN428				
Acarina (terr. Ep.)												
Collembola (terr. Ep.)												
Isoptera sp.(terr. Ep.)												
Muscidae sp. (terr. Ep.)												
Coleoptera sp. (terr. Ep.)												
Psocoptera sp. (terr. Ep.)	seLN431											
Hemiptera sp. (terr. Ep.)												
Bathynellidae sp. 1 (EN) (Sb)			seLN427									
<i>Australoecyclops</i> n. sp. (Sp)												
Cyclopoid copepodid (juv.)												
		seLN432										
tot vials	1	1	1					1				

APPENDIX 2



Appendix 2- Water Quality Data Bore Details

Bore	Date	Bore Depth	Aquifer	Screened Interval	Diameter (mm)	Easting (WGS 84)	Northing	Water Level	Casing Hgt	Temp	DO%	DO	pH	SPCond	Salinity	Comments
		(m bgl)		(m bgl)				(m (btc))	(m (agl))	C	Sat	mg/L	Units	mS/cm	g/l TDS	
CW014P	31.1.07	12	shallow	6 - 12	50	328981	6687507	1.06	0.6	24.51	40.6	3.33	6.33	4.984		URS bore
CW015P	31.1.07	34.3	deep	28.3 - 34.3	50	328764	6687953	0.73	0.78	23.32	21.2	1.75	7.13	10.8	6.13	URS bore
EFB1	31.1.07	21.84	n/a	n/a	100	328819	6688117	8.18	0.26	24	75.8	6.38	5.46	0.2969	0.19	old farm bore
CW010P	31.1.07	22	shallow	18-22	100	329081	6688068	11.855	0.79	23.34	62.7	5.32	5.57	0.4135	0.2647	URS bore
CW011P	31.1.07	96	deep	90-96	100	329074	6688069	8.55	0.74	22.78	59.7	5.0	6.93	8.024	5.135	URS bore
EFB2	31.1.07	29.6	n/a	n/a	90 mm	329040	6687930	10.12	0.6	23.21	22.1	1.89	5.83	0.7766	0.497	old farm bore
EFB3	31.1.07	27.37	n/a	n/a	100	329013	6687927	9.62	0.22	22.41	13.3	1.15	7.06	1.091	0.6985	old farm bore
CW013P	1.2.07	84	deep	78 - 84	50	328621	6687804	0.72	0.8	22.32	49.2	4.06	7.34	15.33	9.821	URS bore
EFB4	1.2.07	27.22	n/a	n/a	100	329479	6687145	5.7	0.12	22.64	4.5	0.39	7.67	1.342	0.8586	old farm bore
EWP21	1.2.07	107	deep	49.97-103.83*	200	329100	6691686	5.05	0.42	22.98	38.8	3.31	7.04	2.98	1.9	* over 3 intervals
EWP25	1.2.07	134	deep	59.15-130.83*	200	329198	6689189	4.52	0.09	23.21	26.5	2.21	6.54	4.66	2.92	*over 3 intervals
CW012P	1.2.07	30	shallow	24 - 30	50	328621	6687804	0.81	0.82	22.25	61.2	5.27	7.12	3.11	1.99	URS bore
CW010P	1.5.07	22	shallow	18-22	100	329081	6688068	11.73	0.82	22.47	18.5	1.61	6.63	0.412	0.264	URS bore
CW011P	1.5.07	96	deep	90-96	100	328938	6687916	8.53	0.74	22.6	18.4	1.54	7.15	7.89	0.5055	URS bore
CW014P	1.5.07	12	shallow	6 - 12	50	328981	6687507	7.51	0.6	22.94	17.8	1.5	6.39	5.28	0.03382	URS bore
CW015P	1.5.07	34.3	deep	28.3 - 34.3	50	328764	6687953	5.31	0.78	23.66	7.5	0.55	7.23	10.47	6.866	URS bore
CW012P	1.5.07	30	shallow	24 - 30	50	329119	6687661	13.87		22.31	40.3	3.46	6.99	3.086	1.969	URS bore
CW013P	1.5.07	84	deep	78 - 84	50	328621	6687804	12.3	0.8	22.3	7.1	0.59	7.2	15.18	9.71	URS bore
CW040P	1.5.07	42	deep	36 - 42	50	328819	6687129	1.04	0.5	24.22	58.6	4.8	6.7	5.529	3.537	Rockwater bore
CW041P	1.5.07	16	shallow	10 - 16	50	328822	6687129	1.58	0.51	24.67	57.9	4.72	4.88	4.652	2.978	Rockwater bore
CW038P	1.5.07	36	shallow	30 - 36	50	330290	6689217	8.3	0.67	22.9	14	1.2	6.62	1.53	0.981	Rockwater bore
EFB5	2.2.07	65.55	n/a	n/a	90	324454	6689805	artesian	0	22.76	7.5	0.63	7.31	5.58	3.58	old farm bore
EFB6	2.2.07	26.07	n/a	n/a	130	328628	6686564	8.51	0.34	24.05	17.2	1.43	5.88	3.5	2.22	old farm bore
EWP24	2.2.07	92	deep	37.62-88.83	200	329163	6690191	5.04	0.55	24.73	37.3	3.07	6.69	2.77	1.78	*over 4 intervals
EFB7	3.5.07	n/a	n/a	n/a	100	322453	6689564	n/a	n/a	19.62	32	2.87	7.74	3.961	2.535	equipped bore; 40L pumped sample
EFB8	3.5.07	n/a	n/a	n/a	n/a	325488	6689823	artesian	0	22.96	20.6	1.72	7.3	5.5	3.516	old farm bore; 40 L sample taken
EFB5	4.5.07	65.55	n/a	n/a	90	324454	6689805	artesian	0	21.6	8.3	0.17	7.42	4.838	3.11	old farm bore
EFB10	4.5.07	18.5	n/a	n/a	100	326610	6686562	3.35	0.5	24.61	18.7	1.56	7.1	0.416	0.266	old farm bore
EFB9	4.5.07	47.96	n/a	n/a	100	324913	6691319	artesian	0.36	24.4	6.8	0.56	7.35	5.319	3.409	old farm bore
EFB11	4.5.07	21.55	n/a	n/a	80	326971	6687273	1.55	0.2	24.34	14.8	1.21	7.5	5.739	3.672	old farm bore
CW035P	4.5.07	48	deep	42-48	50	328221	6688637	1.63	0.91	23.52	46.9	3.9	6.48	5.83	3.73	Rockwater bore
CW036P	4.5.07	25	shallow	18-24	50	328224	6688637	2.94	0.64	24.13	15.6	1.28	5.83	7.061	4.519	Rockwater bore
EWP21	4.5.07	107	deep	49.97-103.83*	200	329103	6691689	5.14	0.42	22.18	30.9	2.65	7.34	2.959	1.894	*over 3 intervals
EFB4	4.5.07	27.22	n/a	n/a	100	329479	6687145	5.7	0.12	22.95	8.4	0.72	7.8	1.337	0.856	old farm bore
EWP24	4.5.07	92	deep	37.62-88.83	200	329163	6690191	5.04	0.34	24.09	38.5	3.2	7.19	2.727	1.745	*over 4 intervals
CW043P	4.5.07	30	shallow	29-30	50	330024	6687361	1.75	0.96	22.72	43.4	3.67	5.83	3.071	1.969	Rockwater bore
CW042P	4.5.07	87	deep	73-79	50	330023	6687363	1.75	0.96	22.94	11.9	11.01	6.53	3.293	2.108	Rockwater bore
CW049P	4.5.07	30	shallow	22-28	50	331676	6685257	25.08	0.77	21.56	55.7	4.88	5.65	1.418	0.907	Rockwater bore
CW048P	4.5.07	54	deep	38-44	50	331678	6685256	24.97	0.71	21.52	36.2	3.12	5.54	1.322	0.846	Rockwater bore
CW045P	4.5.07	24	shallow	18-24	50	328541	6684141	8.67	0.76	23.14	33.5	2.84	5.53	2.346	1.5	Rockwater bore
CW044P	4.5.07	48	deep	37-43	50	328541	6684139	8.73	0.6	23.16	28.2	2.39	5.51	2.4	1.3	Rockwater bore

n/a = not available



Rockwater
P R O P R I E T A R Y L I M I T E D

**STYGOFAUNA SAMPLING FOR
THE CENTRAL WEST COAL
PROJECT**

JULY 2008

**REPORT FOR
AVIVA CORPORATION LIMITED**

(335.1/08/01)

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EXECUTIVE SUMMARY

Aviva Corporation Limited (Aviva) is investigating development of the Central West Coal Deposit (the project) located about 10 to 20 km south of Eneabba, Western Australia. The development will require construction of an open pit to extract coal from the Cattamarra Coal Measures and dewatering operations, as mining will extend below the water table.

A programme of stygofauna sampling was undertaken in the vicinity of the project between January 2007 and March 2008 over four seasons to identify whether stygofauna are present and whether any conservation significant species are likely to be impacted by the implementation of Aviva's proposal. A total of 96 samples were collected for assessment.

Both the superficial aquifer and the underlying Cattamarra Coal Measures, of Jurassic age, were sampled. No fauna was recovered from the deep aquifer bores known to be screened in the Cattamarra Coal Measures, however the construction details and integrity of bore casings for many of the farm bores sampled were unknown, meaning that it was not always possible to determine which aquifer was being sampled.

Phase 1 of the investigation yielded 45 samples from 31 bores using stygofauna nets and recorded six aquatic invertebrate taxa including Crustacea (Copepoda, Ostracoda, Syncarida), Acariformes (Prostigmata), Diptera (Muscidae) and Nematoda. A second sampling phase conducted in 2008 yielded 51 samples from 30 bores using a combination of pumping and net hauling. Six aquatic groups were recorded in Phase 2 including the Oligochaeta, Syncarida and Nematoda sampled during Phase 1; and Oligochaeta (two additional taxa), Platyhelminthes, Ceratopogonidae, Chironomidae, and Amphipoda not sampled previously.

Fourteen aquatic taxa in total were recorded. The only recognised stygobitic taxon (obligate groundwater inhabitant) recorded by the sampling programme was the undescribed syncarid Bathynellidae sp. 1. The bathynellid syncarid was recorded from one bore on two of the four sampling occasions. It is possible that a bathynellid collected from a bore screened in the superficial aquifer and underlain by the Cattamarra Coal Measures aquifer approximately 50 km to the northwest of the project area represents the same taxon as the bathynellid specimens from bore EFB2. Given the sampling intensity employed for the investigation, the aquifers of the project area are not considered to contain a diverse stygobitic fauna.

The Cattamarra Coal Measures aquifer will be mined to extract coal in the vicinity of bore EFB2 where the bathynellid syncarid was recorded. Although the distribution and conservation status of this taxon is unknown, it is unlikely to be restricted to the



Cattamarra Coal Measures aquifer in the immediate project area. There is no evidence to suggest that the lithology of the formation in the vicinity of bore EFB2 is unique; meaning that suitable habitat within the aquifer potentially exists to the north and south of the project area. The Cattamarra Coal Measures extends from near Cervantes in the south to Mount Hill in the Shire of Greenough. If the superficial aquifer is in hydraulic connection with the Cattamarra Coal Measures, as is suggested by groundwater investigations for the project (Rockwater, 2008), it is possible that the local stygofauna populations will be dispersed throughout both aquifers (although not abundantly) where suitable habitat exists.

1 INTRODUCTION

Aviva Corporation Limited (Aviva) is investigating development of the Central West Coal Project located about 10 to 20 km south of Eneabba and immediately west of the Brand Highway (Figure 1). The development will require construction of an open pit to extract coal from the Cattamarra Coal Measures and dewatering operations, as mining will extend below the water table. Sampling for stygofauna is required during the environmental impact assessment (EIA) process because development of the project has potential to impact on groundwater levels and/or groundwater quality in the vicinity of the mine.

In early 2007 Rockwater Pty Ltd was commissioned by Aviva to conduct a stygofauna survey in the vicinity of the proposed Central West Coal Deposit for the purpose of identifying whether stygofauna are a relevant environmental factor for the project, and to identify any conservation significant species within aquifers likely to be impacted by the implementation of Aviva's proposal.

The EPA has issued specific guidance for the consideration of stygofauna during EIA in Western Australia (EPA, 2003, 2007). The methodology applied to the first phase of the investigation was developed in accordance with the 2003 EPA guidance statement (the 2007 Draft Guidance Statement 54a was issued subsequent to the commencement of the sampling programme) and considers the requirements of the EPA for assessment of stygofauna as a relevant environmental factor for the project. It involved collecting a sample set that is representative of aquifers affected by the project including an appropriate spread of sampling sites across the project area. The stygofauna investigation was designed in conjunction with a hydrogeological investigation of the Central West Coal Project, so that bores being constructed for groundwater monitoring would be suitable for stygofauna sampling. No new bores were installed solely for stygofauna sampling. The sampling programme was reviewed and approved by the Department of Environment and Conservation (DEC) prior to being implemented.

The project was referred to the Environmental Protection Authority (EPA) in September 2007 for formal EIA under Section 38 of the Environmental Protection Act (1986) and in October 2007 the EPA set the level of assessment at Public Environmental Review (PER).

The results of the first phase of the stygofauna sampling programme were supplied to the Department of Environment and Conservation (DEC) in late 2007 at which time a second phase of sampling was discussed and planned. The aim of the second sampling phase was to undertake additional sampling of bores in the vicinity of the project, focussing outside the pit area, to identify any significant taxa from additional sites. The following report presents the results of the investigation.

2 LOCAL SETTING AND AQUIFERS SAMPLED

The project area lies west of the Gingin Scarp, on the gently-sloping Eneabba Plain. Geologically, it is situated in the northern Perth Basin, within the Cadda Terrace, which contains a thick sequence of Permian to Late Jurassic sedimentary rocks. A detailed geological summary of the area is given by Mory and Lasky (1996).

The predominant sub-cropping unit in the project area is the Cattamarra Coal Measures which is about 500 m thick and is of Early Mid-Jurassic age. The Cattamarra Coal Measures comprises fine- to coarse-grained sandstone interbedded with dark carbonaceous claystone and siltstone, and seams of coal up to 11 m thick (Mory and Lasky, 1996). Rockwater (2008) provides a detailed summary of the hydrogeology of the project area. The formation occurs to the east of the Beagle Fault system, except north of Leeman, where it subcrops on the Beagle Ridge. The Cattamarra Coal Measures extends from near Cervantes in the south to north of Dongara. The most northern outcrop of the formation is at Mount Hill in the Shire of Greenough.

The main aquifer that will be dewatered during mining is the area of Cattamarra Coal Measures bounded by the Warradarge and Peron Faults (Figure 2). Groundwater levels in the Cattamarra Coal Measures at the Central West Coal Project generally vary from about 50 to 65 m AHD and slope down to the northwest at a low gradient. East of the Warradarge Fault, the Yarragadee aquifer sub-crops.

The superficial formations form a composite aquifer system, known as the superficial aquifer, which overlies the Mesozoic aquifers west of the Gingin Scarp. At the base of the Gingin Scarp the aquifer is thin and discontinuous and with a large portion of the formation unsaturated (Figure 3). Elsewhere, the phreatic surface closely matches the

potentiometric surface of the Cattamarra Coal Measures suggesting that the two aquifers are in hydraulic connection (Rockwater 2008).

3 METHODOLOGY

The stygofauna sampling programme was undertaken in two phases and included existing bores and newly constructed groundwater monitoring bores in the vicinity of the proposed Central West Coal Project. Each phase consisted of two rounds of field sampling for stygofauna.

The first phase of the programme involved collecting 45 samples over two seasons. Initially, fifteen existing bores centred on the coal deposit were sampled. These included six farm bores, three disused production bores from a decommissioned mineral sands mine nearby (Iluka Resources Limited) and three pairs of deep piezometers installed by Aviva in the proposed pit area. Sampling was undertaken in the period 30 January to 2 February, 2007. A second round of sampling was conducted in May 2007 and included most bores sampled during round 1. The exception being production bore EWP25, which was equipped with a small pump for stock watering. In addition, eleven of thirteen monitoring bores installed during a programme of test drilling in the vicinity of the deposit in November 2006 were sampled for stygofauna. These were suitable for stygofauna sampling following a resting period of six months after installation, to allow the bores to settle. All newly constructed bores were 'developed' following installation, meaning any contaminants were removed and water flow into the bore was improved. A total of 31 bores were sampled during round 2.

Following assessment of the 2007 results and discussions with regulatory authorities, a second phase of sampling was planned and implemented. The aim of the 2008 programme (phase 2 sampling) was to identify the undescribed bathynellid syncarid collected in round 1 from additional sites. Sampling focussed on regional bores within approximately 10 km of the project area. The sampling was undertaken in two rounds; over the periods 12 to 15 February and 24 to 28 March. Twenty-nine bores from surrounding farms and two nature reserves, Lake Logue Nature Reserve and South Eneabba Nature Reserve, were sampled. In addition, the farm bore which yielded the undescribed bathynellid syncarid during phase 1 was sampled on each successive sampling occasion in an attempt to collect additional material for vouchering and further taxonomic work.

The first round of sampling in 2008 involved seventeen bores in the area surrounding the coal deposit, and one farm bore centred on the deposit. These included fourteen farm bores, nine of which were windmill equipped, two monitoring bores from Iluka Resources Limited's (Iluka) decommissioned Eneabba West Mine and one Department of Agriculture and Food monitoring bore. Five of these bores were both

netted and pumped. Two of the bores sampled in February 2008 had been previously sampled in the 2007 stygofauna sampling programme; bores EFB2 and EFB7.

The second sampling round for 2008 included 20 bores, 13 of which had not previously been sampled. Six of these were farm bores (three were windmill equipped), thirteen were Iluka's decommissioned Eneabba West Mine monitoring bores and one was a disused Iluka production bore. Nine of the 20 bores were both netted and pumped in March 2008.

Each bore was sampled as summarised below:

- prior to sampling, measure water level and basic water quality (including salinity, pH, dissolved oxygen and temperature);
- record total depth and other bore details where available;
- collect biological samples using stygofauna sampling nets and/or pump; and
- preserve samples in 100 % ethanol.

Water quality was measured using a Hydrolab minisonde multiparameter probe on a 30 m cable. The probe was lowered down the bore casing to one metre below the water level and was held until readings stabilised before measurements were taken.

Stygofauna sampling nets with filter mesh sizes 50 µm and 150 µm and collar diameters of 40 to 147 mm were selected to accommodate the anticipated range of bore-casing diameters. Each net consists of a steel collar that supports a filter mesh, tapering to a hollow brass weight. A clear polycarbonate vial with bottom removed and replaced with 50 µm filter mesh was screwed into the brass weight to collect animals filtered by the 50 µm and 150 µm sampling nets. Nets were suspended by a carabiner and three trace wires attached to the steel collar.

Sampling nets were lowered into bores using a reel of fishing braid until they reached the bottom of the borehole where they were agitated to disturb sediment and any animals that may be present. Each biological sample was taken using either four (2007) or six (2008) net-hauls of the stygofauna sampling nets, made up of equal hauls of each of the 50 µm and 150 µm sampling nets. The number of net hauls per sample was increased in 2008 after consultation with the Department of Environment and Conservation. For bores with a diameter of 50 mm or greater, a sample was pumped from approximately one metre above the bottom of the bore hole using a Grundfos MP1 pump and then filtered through a 50 µm net. Bores were pumped after netted samples had been taken. Where possible, the amount of water pumped was calculated to be at least three times the volume of the bore hole. As the volume of windmill equipped bores could not be calculated, a sample of at least 300 L was pumped using the existing pumping infrastructure and filtered. For any bores equipped with submersible pumps, a water sample of at least 300 L was pumped and filtered through a 50 µm net.

Samples were stored in 120 mL polycarbonate vials and preserved using 100% (absolute) ethanol. To avoid contamination between sites, the sampling nets were thoroughly washed with a decontaminant solution and then rinsed with distilled water. All samples were forwarded to specialist stygofauna biologists for sorting and identification at the end of each sampling round. Specialist taxonomists were consulted on specific stygofauna groups as required.

4 RESULTS

4.1 SAMPLING AND IDENTIFICATION OF SPECIMENS

Sampling for stygofauna was undertaken from 58 bores over four seasons; mid summer and late autumn in 2007 and late summer and mid-autumn 2008. A total of 96 samples were collected; the 2007 sampling programme yielded 45 samples from 31 bores using net hauling alone, and the 2008 sampling programme yielded 51 samples from 29 bores using a combination of pumping and net hauling. The locations of sites sampled during the 2007/08 stygofauna sampling programme for the Central West Coal Project are shown in Figure 1. Both the superficial aquifer and sedimentary rocks of the underlying Cattamarra Coal Measures, of Jurassic age, were sampled.

Sorting and identification of individual specimens was undertaken by Subterranean Ecology. The lab results and a brief letter report provided by Dr Stefan Eberhard for each sampling phase are provided in Appendices 1a, and b.

The available details of all bores sampled during phases 1 and 2 of the programme are presented in Appendices 2a and 2b for 2007 and 2008 respectively, together with water quality data collected at each site.

Results from the 2007 sampling rounds are presented in a separate report (Rockwater, 2007) and a summary of relevant findings is included herewith. A total of 45 samples were taken from 31 sites in 2007, with both the superficial aquifer and underlying Cattamarra Coal Measures being sampled. Invertebrate fauna recorded by the 2007 sampling programme are presented in Table 1. With the exception of Collembola which are terrestrial epigeans (surface dwelling), no invertebrates were recovered from the deep bores known to be screened in the Cattamarra Coal Measures.

Table 1: List of taxa recorded from the Central West Coal Project, their groundwater dependence, conservation status and occurrence across sampling sites for 2007 sampling

TAXON	Groundwater dependence*	Conservation status	SITE CODE																									COMMENTS					
			CWO11P	CWO10P	CWO13P	CWO12P	CWO15P	CWO14P	CWO35P	CWO36P	CWO39P	CWO40P	CWO41P	CWO42P	CWO43P	CWO44P	CWO45P	CWO48P	CWO49P	EFB1	EFB10	EFB11	EFB2	EFB3	EFB4	EFB5	EFB6		EFB7	EFB8	EFB9	EWP21	EWP24
CRUSTACEA																																	
Malacostraca																																	
Copepoda																																	
Australoeucyclops n. sp	A ₁	W																			1												
Cyclopoid copepodid (juv.)	A ₂	W																		1													
Ostracoda																																	
Cypridae sp.																																	
<i>Sarscypridopsis</i> sp. (?ochracea)	N ₁	W																				1											
Syncarida																																	
Bathynellidae sp.1	A ₃	X																					1										
UNIRAMIA																																	
Collembola	N	-															1	1						1							1	Terrestrial, not stygofauna	
INSECTA																																	
Isoptera																																	
Isoptera sp. (terr. Ep.)	N	-		1																												Terrestrial, not stygofauna	
Diptera																																	
Muscidae sp. (terr. Ep.)	N	-																							1							Larvae, not stygofauna	
Coleoptera																																	
Coleoptera sp. (terr. Ep.)	N	-																					1	1								Terrestrial, not stygofauna	
Psocoptera																																	
Psocoptera sp (terr. Ep.)	N	-																			1											Dead on Collection	
Hemiptera sp. (terr. Ep.)	N	-																													1	Terrestrial	
NEMATODA																																	
Nematoda sp.1	U	X		1																								1					
ACARIFORMES																																	
Prostigmata	N	-																							1							1 Adult, not stygobitic	
Trombidioidea	N	-																														1 Larva, not stygobitic	
TOTAL TAXA				0	2	0	0	0	0	0	0	0	0	0	0	0	1	1	2	1	1	2	1	4	0	0	1	0	0	0	0	2	

Legend/Explanation of Codes

- A Recognised stygobite (groundwater dependence confirmed)
- N Taxon not confined to the groundwater environment (stygophile)/
Non-stygol taxon (terrestrial or surface aquatic habitat)
- U uncertain dependence on groundwater
- W Taxon locally common and/or of widespread distribution
- X Conservation status unknown
- * Numerical identifier in subscript for Figure 1

Thirteen invertebrate taxa were recovered from eleven of the 45 samples taken in 2007 which included six aquatic taxa. The aquatic invertebrates included an undescribed stygobitic bathynellid syncarid Bathynellidae sp. 1, the stygophile cyclopoid copepod *Australoeucyclops* n. sp. 1 (including juveniles of this taxon), the stygophile ostracod *Sarscypridopsis* sp., Acariformes (stygophiles), Insecta (aquatic dipteran larva) and an undescribed nematode. The most significant group recorded in 2007 was the bathynellid syncarid. The sites at which each taxon was recorded are shown in Figure 1. Eight terrestrial taxa were also found in the 2007 sampling programme including Uniramia (Collembola), Insecta (Isoptera, Coleoptera, Psocoptera, Hemiptera), Acariformes (Prostigmata, Trombidioidea) and Ostracoda.

The 2008 sampling programme (phase 2) yielded invertebrate fauna from 20 of the 51 samples (17 of 30 sites sampled). The invertebrate fauna recorded by phase 2 sampling are presented in Table 2 and Figure 1. In total there were 81 specimens from 13 taxonomic groups, with five taxa (Oligochaeta, Platyhelminthes, Ceratopogonidae, Chironomidae and Amphipoda) not recorded during previous sampling in 2007. Ceratopogonidae, Chironomidae and Amphipoda specimens were recorded from bores not sampled during 2007. Oligochaeta were recorded from 6 sites in 2008, one of which (EFB2) had been sampled during 2007.

Seventeen bores were sampled in February 2008 (round 3); five bores were pumped and netted, nine bores were pumped using the existing pumping infrastructure and three bores could only be sampled with nets. Eight invertebrate taxa were recorded from five of the bores. Four of these taxa were aquatic (Amphipoda, Oligochaeta, Platyhelminthes and Nematoda) and the remaining four were terrestrial (Ceratopogonidae, Chironomidae, Psocoptera and Acarina). An oligochaete specimen recorded from bore EFB2 could not be identified further and was assigned the morphospecies Oligochaeta sp. 1. The Amphipoda specimen recorded from bore EFB15 was identified as *Austrochiltonia subtenuis*, an epigeal species widespread throughout Southern Australia.

Ceratopogonidae and Chironomid larvae found in bores EFB14 and EFB15 are aquatic larvae from terrestrial insects, completing only part of their lifecycle in stygal habitats (stygoxenes) and having terrestrial adult forms. Acariformes which were collected from EFB14, EFB15 and EFB22 are facultative groundwater dwelling taxa (stygophiles) and are not restricted to groundwater environments. The Psocoptera was a terrestrial species.

Table 2: List of taxa recorded from the Central West Coal Project, their groundwater dependence, conservation status and occurrence across sampling sites for 2008 sampling

TAXON	Groundwater dependence*	Conservation status	SITE CODE																										COMMENTS					
			BH1	B1	EFB2	EFB7	EFB12	EFB13	EFB14	EFB15	EFB16	EFB17	EFB18	EFB19	EFB20	EFB21	EFB22	EPVT69	EWM2	EWM10	EWM11	EWM12	EWM13	EWM21	EWP25	EWP30	LI5FOB	LI6D		LT01D	NR1	NR2	NR3	
ACARIFORMES																																		
Acarina (terrestrial)	N	-							1	1									1	1														
AMPHIPODA																																		
Austrochiltonia subtenuis (epigeal)	N	W								1																								
CRUSTACEA																																		
Syncarida																																		
Bathynellidae sp.1	A ₃	X			1																													
INSECTA																																		
Ceratopogonidae larvae (surface)																																		
Ceratopogonidae larvae (surface)	N	-								1																								
Chironomid larvae (surface)	N	-							1																									
Psocoptera (terrestrial)	N	-			1																				1	1	1						LI5FOB Dead on Collection	
Hemiptera (terrestrial)	N	-																							1	1								
NEMATODA																																		
Nematoda sp.1	U ₁	X												1					1							1								
OLIGOCHAETA																																		
Oligochaeta Sp. 1	U ₂	X		1	1																													
Oligochaeta Sp. 2	U ₃	X																							1									
Oligochaeta Sp. 3	U ₄	X											1													1	1							
PLATYHELMINTHE																																		
Platyhelminthe Planarian sp.	U ₅	X																																
UNIRAMIA																																		
Collembola (terrestrial)	N	-																											1					
TOTAL TAXA	10		0	1	3	0	0	0	2	3	0	0	1	1	0	1	1	0	0	1	0	0	1	0	3	4	2	0	1	1	1			

Legend/Explanation of Codes

- A Recognised stygobite (groundwater dependence confirmed)
- N Taxon not confined to the groundwater environment (stygophile)/ Non-stygol taxon (terrestrial or surface aquatic habitat)
- U uncertain dependence on groundwater
- W Taxon locally common and/or of widespread distribution
- X Conservation status unknown
- * Numerical identifier in subscript for Figure 1

Round four of the 2008 programme (March) sampled 20 bores, with nine being both pumped and netted. Seven species were recovered from 12 bores, including 4 aquatic invertebrate groups (Bathynellidae, Oligochaeta, Platyhelminthes and Nematoda). The bathynellid syncarid was recorded from bore EFB2 and is the same taxon sampled previously from the bore. Oligochaeta were reported from nine bores (Eberhard 2008), however in June 2008 the oligochaete specimens were reviewed and separated into three morpho-species and one additional taxon was found to be a Planarian (Platyhelminthes). The oligochaete previously recorded at EFB2 in February 2008 (Oligochaeta sp. 1) was recorded from monitoring bore B1, approximately nine kilometres to the north (Figure 1), in March. Oligochaeta sp. 2 was recorded from bore EWP30, a decommissioned production bore approximately 2.2 km east of the proposed pit. Oligochaeta sp. 3 was recorded from farm bore EFB19 west of the planned pit and two observation bores, LI5FOB and LI6D, on Lake Logue. The Planarian was recorded from two bores in the Lake Logue Nature Reserve (NR2 and NR3) and one bore (EWM21) on the western margin of the South Eneabba Nature Reserve. Terrestrial Hemiptera (also found in EWP30) and Psocoptera (also found in LI6D and EWP30) were recovered from bore LI5FOB on Lake Logue and terrestrial Acarina and Collembola were found in EPVT69 and NR1 respectively.

4.2 COMPARISON OF NET AND PUMP SAMPLING METHODS

Nineteen of the bores sampled during the sampling programme were sampled on two occasions. In addition, bore EFB2 was sampled on all four sampling rounds. Eleven of the bores sampled on two occasions contained invertebrate fauna from at least one sample with six bores recording aquatic taxa. Only two bores recorded stygofauna on the second sampling occasion that had not been sampled previously. These were bore EFB19 (Oligochaeta) and bore CWO10P (Nematoda). Excluding terrestrial invertebrates which are not part of the groundwater fauna, bore EFB2 yielded bathynellid syncarids from netted samples in rounds 2 and 4, and oligochaetes from a pumped sample in round 3.

Eleven sites were subjected to both pumping and net sampling by phase two of the sampling programme, with three bores sampled in both February and March 2008. Table 3 compares the abundance and diversity of pumped and netted samples. Excluding accidentals (terrestrial taxa), which are not part of the groundwater fauna, the netted samples generally yielded higher abundances and a greater number of taxa than the pumped samples. On only two occasions was a taxon collected in a pumped sample that had not been recorded in the net sample at that site; a nematode recorded in bore LI5FOB on Lake Logue and an oligochaete from bore EFB2. Thirty eight individuals and six taxa were found in the net samples compared to 11 individuals and three taxa in the respective pumped samples.

Table 3: Comparison of diversity and abundance of aquatic invertebrates from netted and pumped samples taken from bores in 2008

	Bore	Netted Sample		Pumped Sample	
		Number of Individuals	Number of Taxa	Number of Individuals	Number of Taxa
February	EFB2	0	0	1	1
	EFB16	0	0	0	0
	EFB20	20	1	0	0
	EPVT69	0	0	0	0
	LT01D	0	0	0	0
March	EFB2	1	1	0	0
	EFB20	0	0	0	0
	EPVT69	0	0	0	0
	EWP30	0	0	2	1
	LI5 FOB	2	1	8	1
	LI6D	7	1	0	0
	NR1	0	0	0	0
	NR2	1	1	0	0
NR3	7	1	0	0	
	TOTAL	38	6	11	3

4.3 REVIEW OF SYNCARIDA SPECIMENS COLLECTED AT ENEABBA

Sampling work undertaken by the WA Museum in the Eneabba area (Laurentiis, Pesce *et al* 2001) identified bathynellids from a bore which was screened in the superficial aquifer above the Cattamarra Coal Measures. Those collections are the nearest reported locations of bathynellid syncarids to the project area. Of particular interest is Bathynellidae collection BES 5962 from bore LS26D, approximately 50 km to the northwest (Figure 5). The specimens are apparently on loan overseas, being reviewed by taxonomists who are describing the Western Australian members of the family. Consequently, comparison of the Eneabba specimens with those from the WA Museum was not possible. The WA Museum collections are likely to be unavailable for a considerable period.

Three specimens of the Eneabba bathynellid (two juvenile and one adult) were forwarded to Dr Brenton Knott at the University of Western Australia (UWA) for examination and further taxonomic description. The head, thorax and pleotelson of a juvenile specimen were dissected and mounted in lactic acid for morphological examination. The mounted material was examined under high power using a compound microscope, photographs were taken and specimens were compared with other Bathynellidae specimens from Western Australia within the UWA collections.

Plates 1 to 3 show photographs of the mounted sections of the bathynellid. The following comments on the images were provided by Dr Knott. Plate 1 shows the pleotelson (the very last body segment) with a telsonic projection (left) and two uropods. Plate 2 shows the row of spines on the second segment of the uropod. Plate 3 shows the head and first few body sections of the thorax. The first and second antennae are clearly visible and the beginning of the exopodite (a secondary branch of the second segment of the limb) can be seen (out of focus). The presence/absence of an exopodite on the second antenna is a diagnostic feature of the family.

Dr Knott concluded that the three specimens he reviewed represented the same species; likely to be a new species from an undescribed genus. Groundwater bathynellids (Family Bathynellidae) likely to be from the same genus have previously been recorded in shallow calcrete aquifers of the Yilgarn region of Western Australia (B. Knott *pers. comm.*).

4.4 ASSESSMENT OF DRAWDOWN IMPACTS

Aviva's Central West Coal Project will require dewatering of the brackish to saline water of the Cattamarra Coal Measures aquifer over the life of the mine to enable mining to occur. Numerical modelling of the Cattamarra Coal Measures aquifer was undertaken to predict water-level drawdown and the required dewatering pumping for Aviva's mining proposal (Rockwater 2008).

For 30 years of dewatering the model calculated that the drawdown of groundwater levels as a result of the pit dewatering would be less than 0.5 m at distances of 13.3 km north of the mine and 12.6 km south of the mine area. The modelled groundwater-level drawdown contours in the Cattamarra Coal Measures aquifer after 30 years of dewatering are shown in Figure 3 together with stygofauna sampling results. The current geological understanding indicates that all sites sampled by the investigation, with the exception of bores LI6D, LI5FOB, EFB7 and EPVT69, are likely to be within the zone of influence of groundwater-level drawdown due to dewatering of the proposed open pit (Figure 4).

The aquifer from which the bathynellid syncarids were recorded at bore EFB2 will be directly impacted by the planned path of the mine pit as the coal resource is extracted. Other stygal taxa likely to be directly impacted within the pit area include *Australoeucyclops* n. sp. 1, Nematoda sp. 1 and Oligochaeta sp. 1.

Groundwater level drawdown in the superficial aquifer and Cattamarra Coal Measures surrounding the pit as a result of pit dewatering also has potential to impact on stygofauna habitat (Figure 4). All taxa recorded by the investigation will be impacted

to some extent by the dewatering of the open pit. Two of the Oligochaeta were recorded at bores on Lake Logue that are outside the zone of influence of groundwater level drawdown from pit dewatering. The third Oligochaeta was recorded from a disused Yarragadee production bore (EWP30) to the east of the Warradarge Fault where modelled drawdown is negligible. Nematoda sp. 1 was recorded from bore EFB7 to the west of the pit and outside the impact zone.

5 DISCUSSION

Fourteen aquatic invertebrate taxa in total were recorded by the stygofauna sampling programme; five of these (36%) were taxa not confined to the groundwater environment (stygophiles), three (21%) are considered stygoxenes (comprising aquatic larvae of terrestrial insects) and five (36%) are currently not able to be assessed as their dependence on groundwater is unclear due to limitations in taxonomy for these groups (Oligochaeta, Nematoda and Platyhelminthes). Stygobitic taxa are those restricted to groundwater with morphological adaptations for subterranean life (Hancock, Boulton and Humphreys 2005). There was only one known stygobitic taxon recorded by the investigation; the undescribed Syncarida, Bathynellidae sp. 1 (Order Bathynellacea, Family Bathynellidae). The bathynellid was recorded from bore EFB2 in May 2007 and again in March 2008.

From a conservation perspective, the bathynellid syncarid is the most significant taxon recorded by the sampling programme for the Central West Coal Project. All syncarids are restricted to the groundwater environment and many have restricted distribution ranges. For EIA purposes, the bathynellid syncarid should be treated as a potential short-range endemic species (Eberhard 2008). Given that the Eneabba specimen is a new taxon, an assessment of its conservation significance is constrained by the limited knowledge of the Bathynellidae in Western Australia.

The taxonomy and distribution of the bathynellids and other Syncarida from Western Australia are very poorly known. While several species of parabathynellids have recently been described from the Kimberley and Yilgarn, no bathynellids from the southwest have been described (Eberhard, 2008). Many of the Bathynellidae specimens from the WA Museum's Crustacean Collection are currently on loan either overseas or interstate as there is work being undertaken on the group (W. Humphreys pers. comm.). Consequently, the specimens collected from the project area cannot be compared with other Bathynellidae collections from the Eneabba area. It is possible, given the restricted distribution ranges of syncarids generally, that a bathynellid collected from a bore screened in the superficial aquifer and underlain by the Cattamarra Coal Measures aquifer approximately 50 km to the northwest represents the same taxon as the bathynellid specimens from the project area.

In the project area, the bathynellid syncarid is probably widespread (but not abundantly) within the upper Cattamarra Coal Measures aquifer system, at least within the immediate aquifer, and its distribution is likely to extend to other Cattamarra Coal Measures aquifers in the region that are not hydraulically connected (i.e. bounded by faults). In the vicinity of the pit, the superficial formations are largely unsaturated, however suitable habitat for stygofauna may exist in the superficial aquifer system above the Cattamarra Coal Measures elsewhere, given that the two aquifers are likely to be in hydraulic connection.

The disjunct sub-crop areas of the Cattamarra Coal Measures that occur to the north and south of the project area (between Greenough Shire and Cervantes respectively) are likely to contain similarly prospective habitat for stygofauna to that sampled in the vicinity of the project. Unless the Cattamarra Coal Measures aquifer in the vicinity of the project is unique, the inherent fauna of the aquifer is likely to have dispersed through similar habitat in adjacent sub-crop areas of the Cattamarra Coal Measures.

In the vicinity of bore EFB2, the planned mine pit will extend to a depth of approximately 120 m, meaning a portion of the local habitat of the undescribed bathynellid syncarid will be directly impacted by the proposal. Numerical modelling of the Cattamarra Coal Measures aquifer has shown that groundwater level drawdown would be less than 0.5 m at distances of 13.3 km north of the mine and 12.6 km south of the mine area. Potential boundaries to drawdown in the local aquifer include the Warradarge and Peron Faults to the east and west of the project respectively, and a possible sub-crop of the Yarragadee Formation approximately four kilometres to the north of the planned mine pit.

Although currently undescribed, the cyclopoid copepod *Australoeucyclops* n. sp. 1 recorded from bore EFB1 in the vicinity of the pit is not restricted to the Eneabba region as it has been recorded previously from the Swan Coastal Plain at Yanchep (Eberhard, 2004) and from the Leeuwin-Naturaliste region.

The taxonomy of groundwater oligochaetes in Western Australia is poorly described and distributions are poorly known. Groundwater Oligochaeta have generally been found to be widespread in distribution (Eberhard 2008). Given the regional extent of the aquifers sampled, it is likely that the Oligochaeta recorded are more widely distributed than the sites sampled by this programme. The Planarian taxon could not be identified further as the taxonomy of Platyhelminthes in Western Australia is poorly described.

The taxonomy of the Nematoda in Western Australia is too poorly described to comment on a specimen sampled from the Eneabba bores. The limitations of taxonomy for Nematoda in Western Australia are well recognised (EPA, 2007).

Identification to species level is generally required to understand an individual's ecological dependence on groundwater and to assess its conservation significance; an exception being the Syncarida, which are all obligate groundwater taxa (stygobites).

The four ostracod specimens collected from EFB11 in May 2007 were sent to Dr Ivana Karanovic in Tasmania for further taxonomic verification. The specimens were identified as *Sarscypridopsis* sp. (Family Cypridae, Subfamily Cypridopsinae) but further identification to species level was not possible, due to the specimens being disintegrated. It is possible that they belong to *Sarscypridopsis ochracea* which is not a stygobitic taxon. If this taxon is a new species, it is not likely to be a short-range endemic as Dr Karanovic has recorded the same form in surface waters and wells in the Murchison region, Pilbara region and in eastern Australia (Eberhard, 2008).

The results of the combined net and pump sampling contrast with previous surveys (e.g. Hancock, 2006) in that the net-hauling method yielded a greater number of specimens and taxa than the pumped samples. On only two occasions was a taxon collected in a pumped sample which had not been recorded in the net sample at that site. It is possible that the centrifugal pump used to sample the bores affected the results in that impeller-driven pumps may potentially cause damage to larger animals such as Amphipods and Isopods. This is considered unlikely because fragments of larger animals were not identified in the pumped samples.

The construction details for many of the regional farm bores were not available during the sampling programme and only limited construction details of several equipped bores were attained directly from pastoralists. During field sampling, the depths of all of the open bores sampled were measured in metres below ground level (m bgl). With the exception of EFB5 (65.55 m bgl) and EFB9 (47.96 m bgl) the depths of all of the farm bores sampled by phase 1 of the programme were less than 30 m bgl. Construction details for one of three pairs of deep piezometers (CWO12P) installed by Aviva in the proposed pit area near EFB1, EFB2 and EFB3 showed the superficial aquifer to extend to a depth of 30 m. As the depths of the screened interval(s) for farm bores in the vicinity were unknown, they were initially assumed to be screened in the superficial aquifer if the total depth of the bore was less than 30 m.

For regional bores sampled by the programme where the construction details were not available, it was not always possible to differentiate between the aquifers being sampled. Bore EFB2 is a farm bore constructed for stock watering purposes. It is of interest because an undescribed bathynellid syncarid was recorded from the bore. The bore was measured to have a depth of 29.6 m with a static water level (SWL) of 10.16 m btc and is approximately 100 m east of bores CW010P and CW011P. Groundwater modelling for the region (Rockwater, 2008) suggests that the superficial formations extend to depths of 1 – 10 m in the proposed pit area, with underlying Cattamarra

Coal Measures. The SWL in CW011P (Figure 1) is 8 m btc and in CW010P about 12 m btc, and both bores are approximately 2 m higher than EFB2. Therefore, EFB2 is most likely to be screened within the same region as CW010P, which lies within the upper Cattamarra Coal Measures, but this can only be verified if the construction details for EFB2 are provided. Similar problems have been encountered by previous studies in the area (e.g. Laurentiis *et al* 2001), with many of the older farm bores having unknown construction details, but it is known that the Cattamarra Coal Measures extends west from the Warradarge faults to the eastern edge of the Beagle Ridge. Overlying the Eneabba Formation, the Cattamarra Coal Measures are made up of fluvial sandstones interbedded with partly carbonaceous siltstone and shale (NACC, 2002).

6 SUMMARY AND RECOMMENDATIONS

Sampling for stygofauna at the Central West Coal Deposit near Eneabba, Western Australia was undertaken from 58 bores over two seasons in 2007 (mid summer and late autumn) and two seasons in 2008 (late summer and mid-autumn). Ninety-six samples in total were collected. Both the sandy superficial aquifer and underlying Cattamarra Coal Measures aquifer were sampled. The only stygobitic taxon recorded by the survey was an undescribed bathynellid syncarid, Bathynellidae sp. 1. This was the most significant taxon recorded as it is a potential short-range endemic. It is implied by available lithological logs for bores constructed nearby that the bathynellid was recorded in the upper Cattamarra Coal Measures aquifer. Given the sampling intensity employed for the investigation, the aquifers of the project area are not considered to contain a diverse stygobitic fauna.

The Cattamarra Coal Measures will be mined to extract coal in the vicinity of bore EFB2 at which the bathynellid syncarid was recorded. Although the distribution and conservation status of this taxon is unknown, it is unlikely to be restricted to the Cattamarra Coal Measures aquifer in the immediate project area. There is no evidence to suggest that the lithology of the formation in the vicinity of bore EFB2 is unique; meaning that suitable habitat within the aquifer potentially exists both to the north and south of the project area. The Cattamarra Coal Measures extends from near Cervantes in the south to Mount Hill in the Shire of Greenough. The superficial formation near the planned mine pit is largely unsaturated, however, elsewhere it is shown to be in hydraulic connection with the underlying Cattamarra Coal Measures, suggesting that the superficial aquifer may also provide suitable habitat for local stygofauna populations.

It is recommended that the bathynellid specimens recovered from bore EFB2 be lodged with the WA Museum as they are undertaking a research project into the



taxonomy and phylogeny of Bathynellacea in Australia and a request for specimens has recently been circulated.

Dated: 29 July 2008

Rockwater Pty Ltd



N C P Eveleigh
Principal Environmental Scientist

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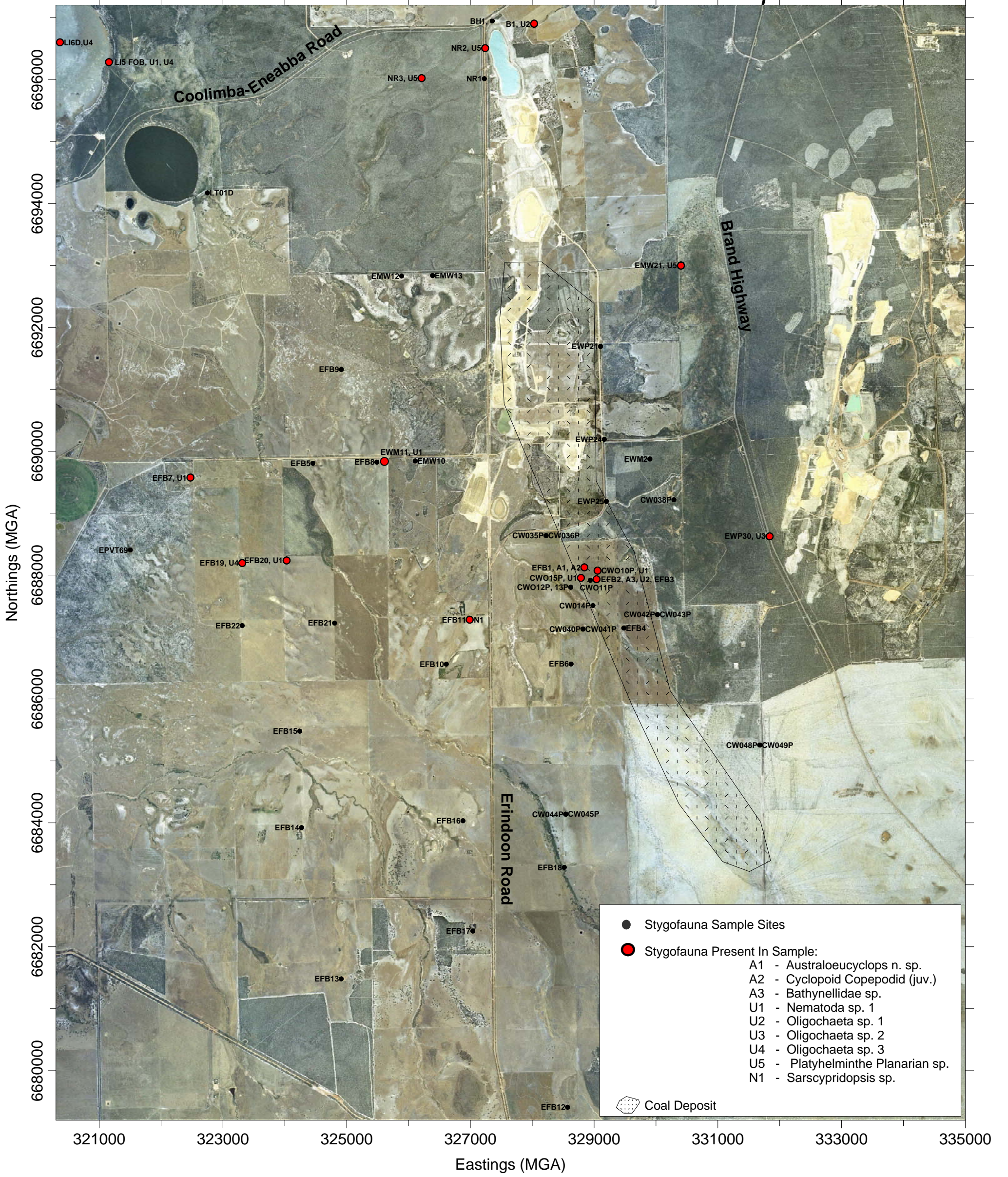
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FIGURES



Eneabba

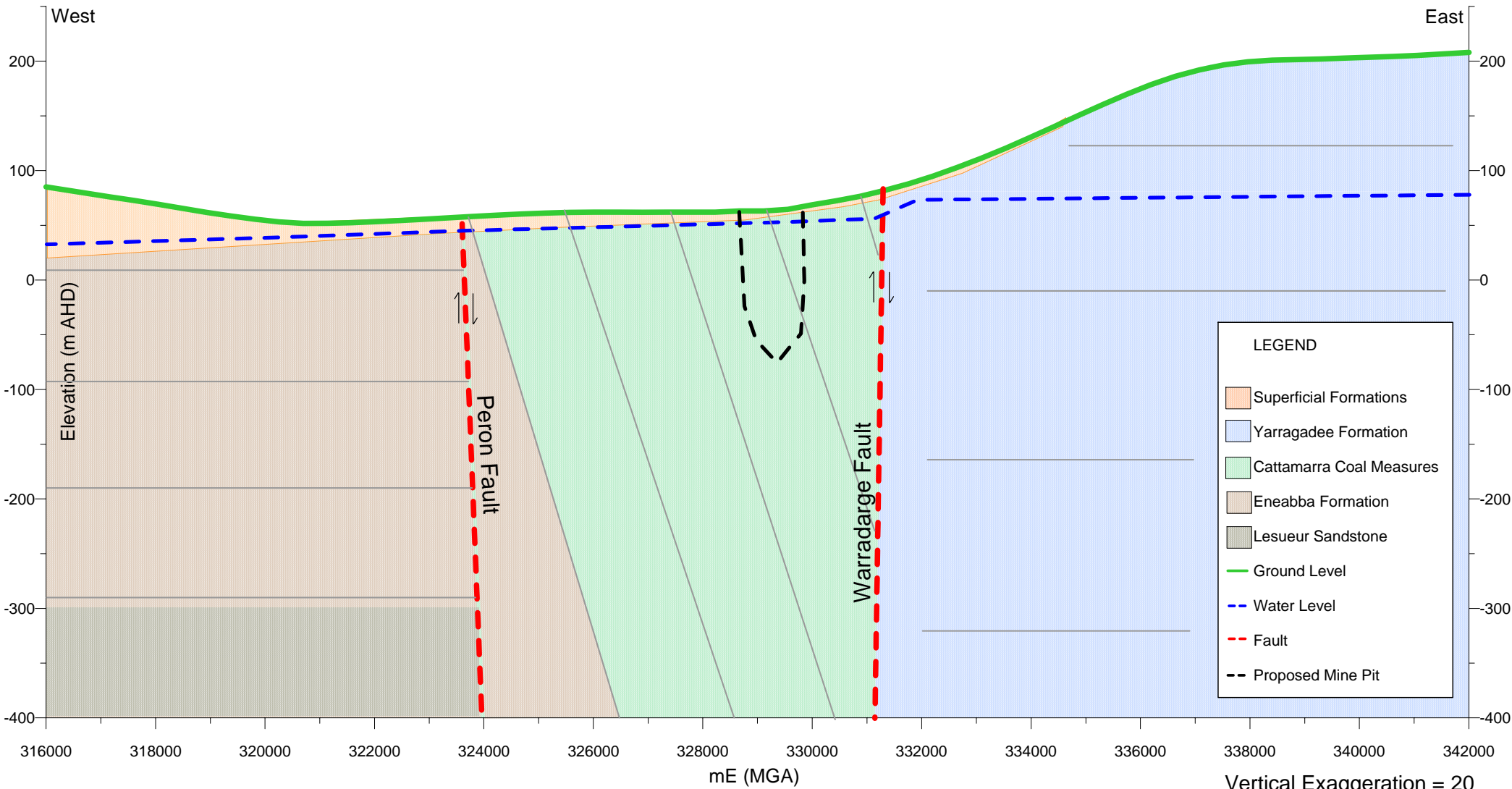


I:/335.1/2008 Surfer/Aviva Stygo Locality2.srf

CLIENT: Aviva Corporation
 PROJECT: Central West Coal Deposit Stygofauna Sampling
 DATE: June 2008
 Dwg. No: 335.1/08/1-1

STYGOFAUNA SAMPLING LOCALITY PLAN & RESULTS

Figure 2

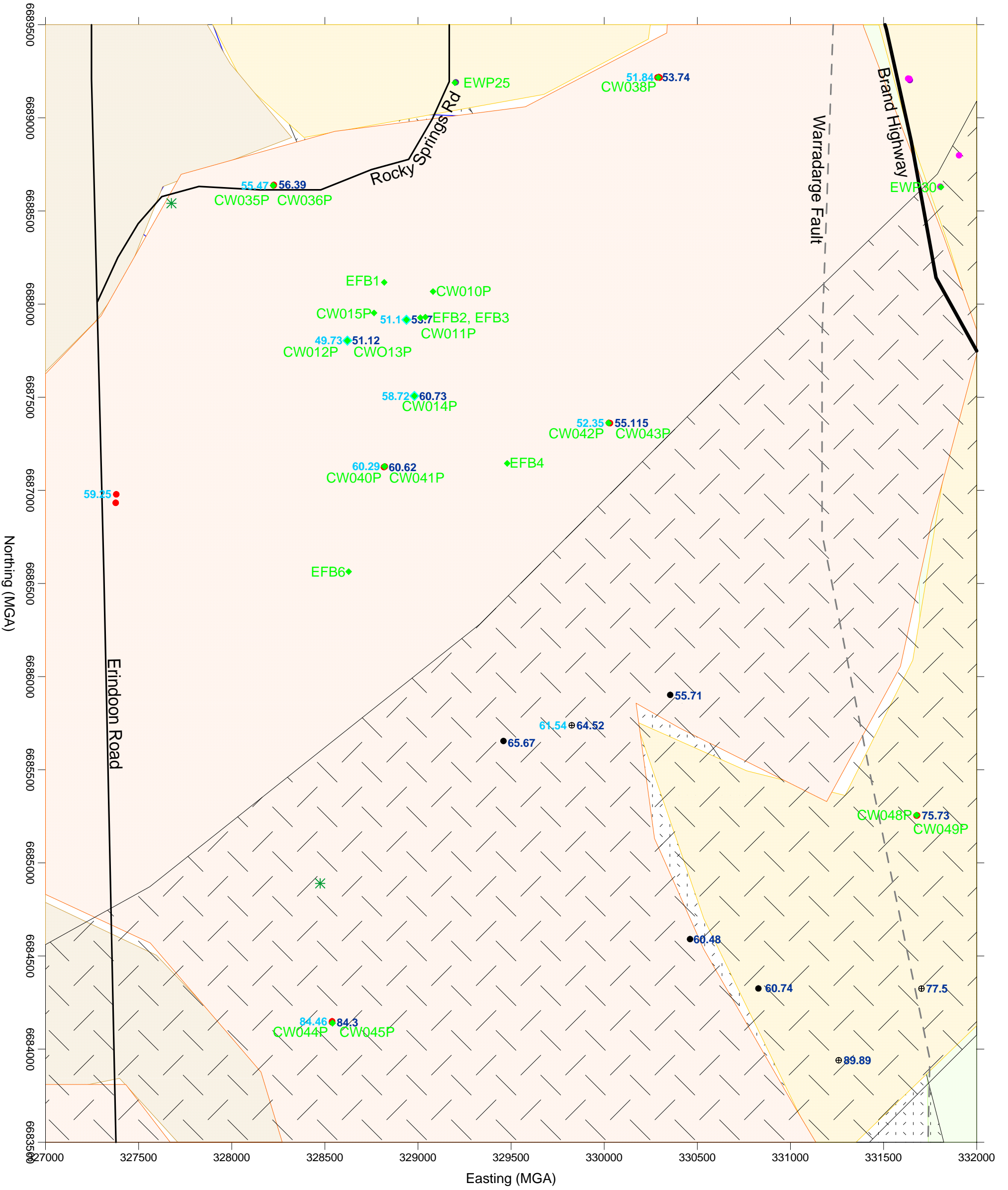


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Client : Aviva Corporation Limited
 Project : Central West Coal Deposit Stygofauna Sampling
 Date : June 2008
 Dwg No : 335.0/08/1-2

GENERALISED WEST-EAST
 CROSS-SECTION
 ALONG 6,688,000 mN

FIGURE 3



335.1/2008/Surface/Aviva Water Level with Geology.srf

SUPERFICIAL AQUIFER SATURATION (Central Pit Area)

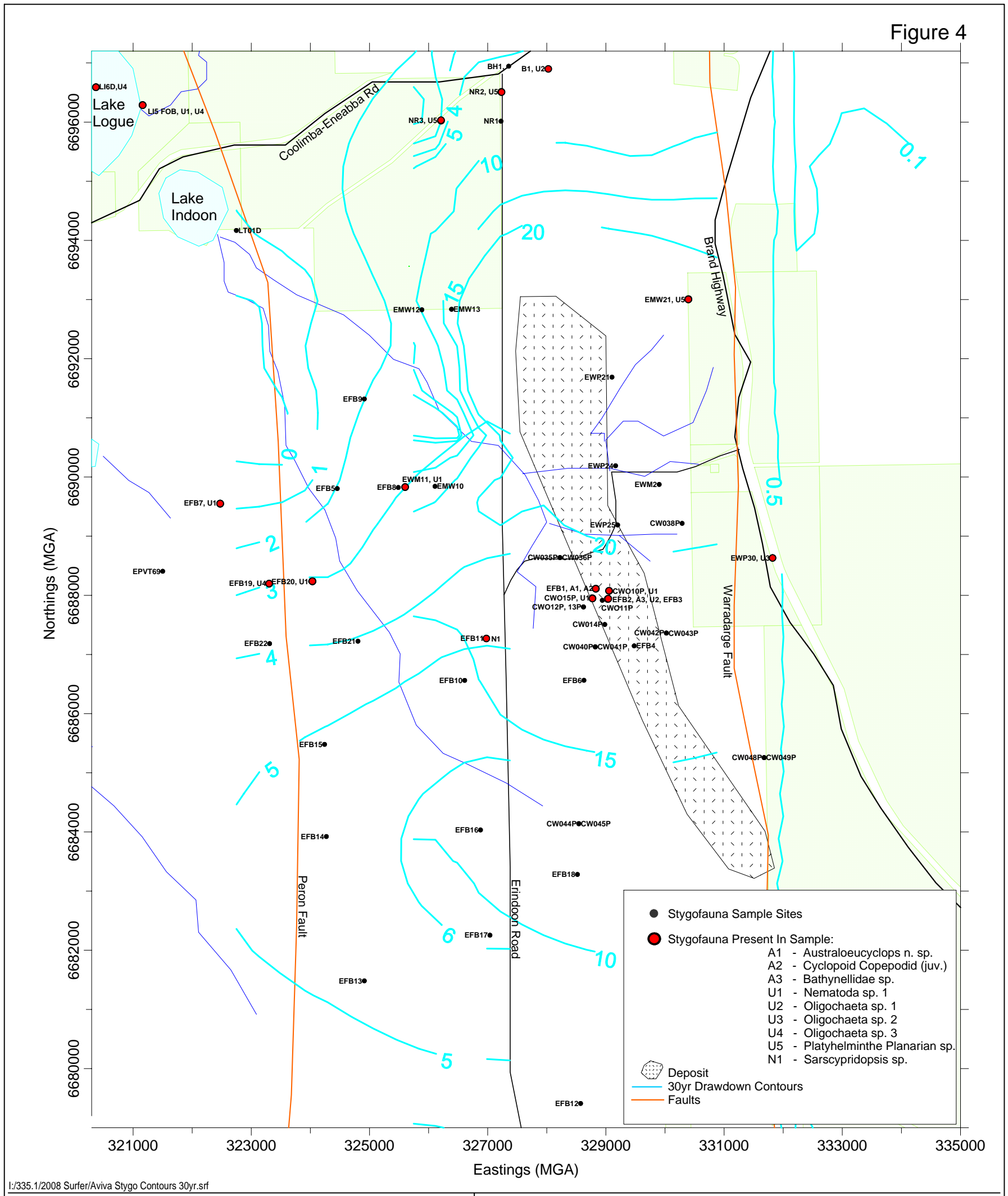


LEGEND

- Rockwater Production Bores (2007)
- ⊕ Rockwater Monitoring Bores (2007)
- Proposed Rockwater Dewatering Bore (2007)
- ⊕ Proposed Rockwater Monitoring Bore (2007)
- Rockwater Monitoring Bores (2006)
- Iluka Eneabba Monitoring Bores
- Iluka Eneabba Production Bores
- ◆ URS Monitoring Bores (2005)
- ◆ Bores sampled in the 2007/8 Stygofauna sampling program
- Unsat. Superficial Aquifer
- Laterite
- Guildford
- Bassendean
- Pit Deposit
- 65.56 Deep Aquifer Water Level
- 35.25 Shallow Aquifer Water Level

CLIENT: Aviva Corporation
 PROJECT: Central West Coal Deposit Stygofauna Sampling
 DATE: June 2008
 Dwg. No: 335.1/08/1-3

Figure 4



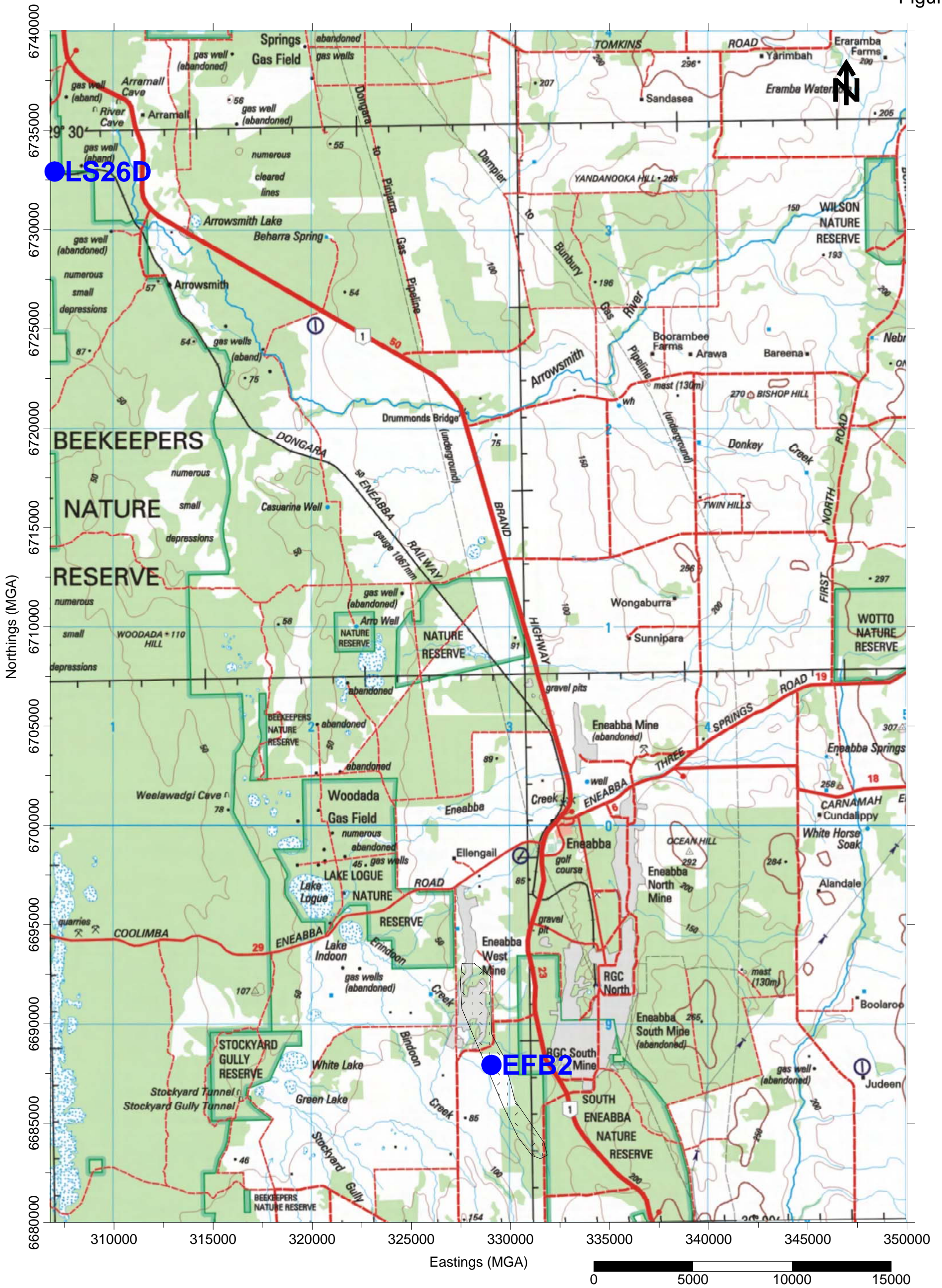
I:/335.1/2008 Surfer/Aviva Stygo Contours 30yr.srf

CLIENT: Aviva Corporation
PROJECT: Central West Coal Project Stygofauna Sampling
DATE: June 2008
Dwg. No: 335.1/08/1-4

STYGOFAUNA SAMPLING RESULTS WITH 30 YEAR DRAWDOWN CONTOURS
adapted from Rockwater (2008)

Rockwater Pty Ltd

Figure 5



I:/335.1/2008 Surfer/Aviva Stygo Locality of LS26D.srf

CLIENT: Aviva Corporation
 PROJECT: Central West Coal Deposit Stygofauna Sampling
 DATE: June 2008
 Dwg. No: 335.1/08/1-5

STYGOFUNA SAMPLING
 LOCALITY OF BATHYNELLIDAE COLLECTIONS
 (BORES EFB2 and LS26D)

COLOUR PLATES





Plate 1 - Bathynellidae sp. 1, bottom uropod with exopodite



Plate 2 - Bathynellidae sp. 1, uropod with 4 teeth on 2nd article

335-1/2008Surfer/Plates1-2.srf

CLIENT: Aviva Corporation
PROJECT: Central West Coal Deposit
Stygofauna Sampling
DATE: July 2008
Dwg. No: 335.1/08/1-Plates 1-2

Plates 1 and 2



Plate 3 - Bathynellidae sp.1, top 2nd antenna with exopodite on article 2

335-1/2008Surfer/Plate 3.srf

CLIENT: Aviva Corporation
PROJECT: Central West Coal Deposit
Stygofauna Sampling
DATE: July 2008
Dwg. No: 335.1/08/1-Plate 3

Plate 3

APPENDIX 1





Subterranean Ecology

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Nick Evelegh
Rockwater Pty Ltd
Perth, WA

Re: Eneabba Stygofauna Survey January-February 2007

Dear Nick,

Please see overleaf (and attached as Excel spreadsheet) the results of the sorting and identification of the 18 vials from 16 sites collected from Eneabba January-February 2007.

Invertebrate fauna was recovered from six of the 16 sites sampled. At three sites the fauna comprised terrestrial species, and only three sites (EFB1, EFB3, EFB4) contained aquatic species.

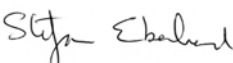
The aquatic taxa recorded included Crustacea (Copepoda), Acariformes (Prostigmata), and Diptera (Muscidae).

The cyclopoid copepod *Australoeucyclops* n. sp. 1 collected at Eneabba is the same undescribed species as recorded in the Yanchep Caves and from limestone springs in the Leeuwin-Naturaliste region (T. Karanovic pers. comm., Eberhard 2004). The genus *Australoeucyclops* includes one other described species, *A. karaytugi* Karanovic recorded from the surface pool of a spring in the Pilbara (Karanovic 2006).

None of the Acariformes were obviously stygomorphic (showing physical adaptations to subterranean life). Muscid dipterans have aquatic larval stages while the adults are terrestrial winged insects.

None of the identified taxa appear to be restricted to groundwater in the Eneabba region.

Yours Sincerely,


Dr Stefan Eberhard
Subterranean Ecology

References

Eberhard, S.M. (2004) Ecology and hydrology of a threatened groundwater-dependent ecosystem: the Jewel Cave karst system in Western Australia. PhD thesis Murdoch University.

<http://wwwlib.murdoch.edu.au/adt/browse/view/adt-MU20051010.141551>

Karanovic, T. (2006) Subterranean copepods (Crustacea, Copepoda) from the Pilbara Region in Western Australia. *Records of the Western Australian Museum Supplement* No. 70: 1-239.

Eneabba Stygofauna Survey January-February 2007

Subterranean Ecology specimen identifications April 2007

Site name	Easting	Northing	Date	Taxon 1	Identification	No. spec.	Lab No.	Slide No.	Comments
AMW1 d (CW011P)			01-Feb-07	NIL FAUNA					
AMW15 (CW010P)			31-Jan-07	Isoptera			na		terrestrial, not stygofauna, not collected
AMW2 (CW012P)			01-Feb-07	NIL FAUNA					
AMW2 (CW013P)			01-Feb-07	NIL FAUNA					
AMW35			31-Jan-07	NIL FAUNA					
AMW3d (CW015P)			31-Jan-07	NIL FAUNA					
EF85			01-Feb-07	NIL FAUNA					
EFB1	328819	6687117	31-Jan-07	Copepoda: Cyclopoida	<i>Australoeucyclops</i> n. sp. 1	1	seLN1 31	seS064	1 spec dissected on slide, 2 spec in alcohol
EFB2	329040	6687930	31-Jan-07	Coleoptera	Gen et sp. Indet.	1	na		terrestrial, not stygofauna, not collected
EFB5			02-Feb-07	NIL FAUNA					
EFB6	329013	6687927	02-Feb-07	NIL FAUNA					
EWP21			01-Feb-07	NIL FAUNA					
EWP24			02-Feb-07	NIL FAUNA					
EWP25			02-Feb-07	Collembola	Gen et sp. Indet.		na		terrestrial, not stygofauna, not collected
				Hemiptera	Gen et sp. Indet.		na		terrestrial, not collected
Ex Windmill 3 (EFB3)	329013	6687927	31-Jan-07	Acariformes: Prostigmata	Eupodidae?	1	seLN1 10		1 adult, not stygobitic
Ex Windmill 4 (EFB4)	329479	6687145	01-Feb-07	Acariformes: Trombidioidea	Gen et sp. Indet.	1	seLN1 09		1 larva, not stygobitic
				Coleoptera	Gen et sp. Indet.	4	na		terrestrial, not stygofauna, not collected
				Collembola	Gen et sp. Indet.	1	na		terrestrial, not stygofauna, not collected
				Diptera: Muscidae	Gen et sp. Indet.	2	na		larvae, not stygofauna, not collected



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Nick Evelegh
Rockwater Pty Ltd
Perth, WA

Re: Eneabba Stygofauna Samples Batch 2 collected May 2007

Dear Nick,

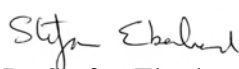
Please see overleaf the results of the sorting and identification of the 2nd batch of samples (28 sites) collected from Eneabba May 2007. For ease of comparison (also in attached Excel spreadsheet), the taxa list includes all species from both sample events.

Twenty-one invertebrate specimens comprising five taxa were recovered from eight of the 28 sites sampled. One of these taxa (Psocoptera) was a terrestrial epigeic (terr. Ep) species, the other four were aquatic. The aquatic fauna included ostracods and syncarids not collected in round one, plus additional specimens of the probable stygophile (Sp) copepod *Australoeucyclops* n. sp. 1 collected previously. The bathynellid syncarids are stygobites (Sb). The taxonomy of the bathynellids (cf. parabathynellids) is very poorly known in Western Australia. While several species of parabathynellids have recently been described from the Kimberley and Yilgarn, no bathynellids from southwest WA have been described.

The ostracods, which may be candonids, may also be stygobitic (Sb). The nearest known location for a described stygobitic candonid, *Acondona memoria* Karanovic is the Brockman River. If the collection site (EFB11) lies within the zone of influence of the project proposal then further identification of the candonid ostracod will require specialist taxonomic input, which can be sought if requested. The taxonomy of the Nematoda is too poorly described to comment on their degree of groundwater dependence.

For EIA purposes the stygobitic morpho-species (viz. the syncarids and ?candonid) collected at Eneabba should be treated as potential short-range endemic species, and the copepod as a local population.

Yours Sincerely,


Dr Stefan Eberhard
Subterranean Ecology

16th July 2007

Eneabba Stygofauna Samples Batch 2 May 2007: **Subterranean Ecology** specimen identifications July 2007

Identification	EFB10	EFB11	EFB2	EFB3	EFB4	EFB5	EFB6	EFB7	EFB8	EFB9	EPW21	EWP24
	4/05/2007	4/05/2007	2/05/2007	2/05/2007	3/05/2007	3/05/2007	2/05/2007	2/05/2007	3/05/2007	3/05/2007	4/05/2007	4/05/2007
Nematoda sp. 1 (EN)				N		N	N	1	N	N	N	N
Acarina (terr. Ep.)				L		L	L		L	L	L	L
Collembola (terr. Ep.)				N		N	N		N	N	N	N
Isoptera sp.(terr. Ep.)												
Muscidae sp. (terr. Ep.)				F		F	F		F	F	F	F
Coleoptera sp. (terr. Ep.)				O	1	O	O		O	O	O	O
Psocoptera sp. (terr. Ep.)	D.O.C.			U		U	U		U	U	U	U
Hemiptera sp. (terr. Ep.)				I		I	I		I	I	I	I
Bathynellidae sp. 1 (EN) (Sb)			4	D		D	D		D	D	D	D
<i>Australoecyclops</i> n. sp. (Sp)												
Cyclopoid copepodid (juv.)												
?Canonidae sp. (Sb?)		D.O.C.										
Vial tracking numbers												
	EFB10	EFB11	EFB2	EFB3	EFB4	EFB5	EFB6	EFB7	EFB8	EFB9	EPW21	EWP24
	4/05/2007	4/05/2007	2/05/2007	2/05/2007	3/05/2007	3/05/2007	2/05/2007	2/05/2007	3/05/2007	3/05/2007	4/05/2007	4/05/2007
Nematoda sp. 1 (EN)								seLN428				
Acarina (terr. Ep.)												
Collembola (terr. Ep.)												
Isoptera sp.(terr. Ep.)												
Muscidae sp. (terr. Ep.)												
Coleoptera sp. (terr. Ep.)												
Psocoptera sp. (terr. Ep.)	seLN431											
Hemiptera sp. (terr. Ep.)												
Bathynellidae sp. 1 (EN) (Sb)			seLN427									
<i>Australoecyclops</i> n. sp. (Sp)												
Cyclopoid copepodid (juv.)												
		seLN432										
tot vials	1	1	1					1				



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Nick Evelegh
Rockwater Pty Ltd
Perth, WA

Re: Eneabba Stygofauna Samples Batches 3 and 4 collected Feb and March 08

Nick,

The February and March batches comprised 51 samples, of which 20 samples contained invertebrates. Eighty-two invertebrate specimens belonging to 10 taxonomic groups were collected, including Oligochaeta, Nematoda, Acarina, Collembola, Psocoptera, Hemiptera, Ceratopogonidae, Chironomidae, Amphipoda, Syncarida. Four of these groups comprised terrestrial taxa (Acarina, Collembola, Psocoptera, Hemiptera) and were not members of the groundwater fauna. The six remaining aquatic groups were Oligochaeta, Nematoda, Ceratopogonidae, Chironomidae, Amphipoda, and Syncarida. The February and March surveys, which included numerous sites not sampled in earlier sampling conducted for this project, found four taxa not recorded at the earlier sampled sites (Oligochaeta, Ceratopogonidae, Chironomidae, Amphipoda).

The Ceratopogonidae and Chironomidae are aquatic larvae of terrestrial insects and not obligate inhabitants of groundwater. The Amphipoda were identified as *Austrochiltonia subtenuis* (Sayce) (Family Ceinidae) which is a common epigeal species and widely distributed in southern Australia. The Oligochaeta have not been further identified at this stage, however groundwater Oligochaeta generally display widespread distributions. The taxonomy of the Nematoda is too poorly described to comment on their degree of groundwater dependence.

A single syncarid specimen belonging to the family Bathynellidae was collected from the same bore (EFB2) which contained syncarids during the earlier sampling round. This species is clearly an obligate inhabitant of groundwater (stygobiont). The taxonomy of the bathynellids (cf. parabathynellids) is very poorly known in Western Australia. While several species of parabathynellids have recently been described from the Kimberley and Yilgarn, no bathynellids from southwest WA have been described. In the absence of published literature on syncarids from southwest WA, further identification of the bathynellid has not been attempted at this time, but assessment of its conservation status may be facilitated by comparison with other specimens collected from the region. For example, Laurentiis et al. (2001) mention bathynellids from bore LS26 in the Eneabba region, however this material is currently with taxonomists overseas (W. Humphreys pers. comm.).



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The cyclopoid copepod *Australoencyclops* n. sp. 1 collected during the earlier sampling phases at Eneabba appears to have some degree of association with groundwater. The specimens were identified by Dr Tom Karanovic who determined it is the same undescribed species as recorded in the Yanchep Caves and from limestone springs in the Leeuwin-Naturaliste region (T. Karanovic pers. comm., Eberhard 2004). The genus *Australoencyclops* includes one other described species, *A. karaytugi* Karanovic recorded from the surface pool of a spring in the Pilbara (Karanovic 2006).

Earlier surveys collected an ostracod which was identified by Dr Ivana Karanovic as *Sarscypridopsis* sp. The specimens were disintegrated so could not be identified to species level, but it may belong to *S. ochracea* Sars, 1924. The genus and this species is not a stygobiont, and if it is a new species it is not likely to be a short-range endemic, as Dr Karanovic has recorded the same form in surface waters and wells in the Murchison, Pilbara, and eastern Australia.

The Excel spreadsheet sent by email contains the taxa x site data for all samples to date, including the last two batches collected in February and March 2008.

Some brief comments are worth making on the different sampling methods used during the February and March surveys. About 10 sites were subjected to both net hauling and pumping. Overall the net haul samples collected more specimens (24 cf 13 individuals) than the pump samples, and only at one site did the pumping collect a taxon (Nematoda) that was not collected by net hauling. These results contrast with some other studies which have found that a combination of net hauling and pumping may be the most efficient approach, however the success of pumping may also be strongly influenced by the type of pump used and the pumping rate. Nonetheless, the net hauling and pumping results from Eneabba tend to reinforce the conclusion that the sampled aquifers do not support a highly diverse stygobiontic community.

Sincerely,

Dr Stefan Eberhard
Subterranean Ecology

30th April 2008

References

Eberhard, S.M. (2004) Ecology and hydrology of a threatened groundwater-dependent ecosystem: the Jewel Cave karst system in Western Australia. PhD thesis Murdoch University.

<http://www.lib.murdoch.edu.au/adt/browse/view/adt-MU20051010.141551>

Karanovic, T. (2006) Subterranean copepods (Crustacea, Copepoda) from the Pilbara Region in Western Australia. *Records of the Western Australian Museum Supplement* No. 70: 1-239.

Laurentiis, P.D., Pesce, G.L. et al. (2001) Copepods from groundwaters of Western Australia VI Cyclopidae (Crustacea: Copepoda) from the Yilgarn Region and the Swan Coastal Plain. *Records of the Western Australian Museum Supplement* No. 64: 243-257.

Appendix 1b: Eneabba 2008 Stygofauna Sampling Programme Results

Eneabba	FEBRUARY 2008 sampling										
	labno	1	2	3	4	5	6	7	8	9	10
site		NR1	Barara1 pumped	Amboseli	Barara3 600r	Barara2	Langford 2	EPVT69 pum	EPVT69	EFB2 pumpe	EFB2 net
date		12/02/2008	13/02/2007	13/02/2008	13/02/2008	13/02/2008	13/02/2008	13/02/2008	13/02/2008	14/02/2008	14/02/2008
collembola		N	N	N			N	N	N		
terrestrial hemiptera		I	I	I			I	I	I		
Acarina		L	L	L	1	5	L	L	L		
terrestrial Isoptera											
Muscidae larvae		F	F	F			F	F	F		
terrestrial beetle		O	O	O			O	O	O		
terrestrial Psocoptera		U	U	U			U	U	U		2
Nematoda		N	N	N			N	N	N		
Syncarida		D	D	D			D	D	D		
Cyclopoida											
Ostracoda											
Platyhelminthe Planarian sp.											
Oligochaeta sp 1											1
Oligochaeta sp 2											
Oligochaeta sp 3											
Chironomid larvae (surface)						2					
Amphipoda (epigean)					4						
ceratopogonidae larvae (surface)					1						
		81									
LAB NO.s											
site		NR1	Barara1 pumped	Amboseli	Barara3 600r	Barara2	Langford 2	EPVT69 pum	EPVT69	EFB2 pumpe	EFB2 net
date		12/02/2008	13/02/2007	13/02/2008	13/02/2008	13/02/2008	13/02/2008	13/02/2008	13/02/2008	14/02/2008	14/02/2008
collembola											
terrestrial hemiptera											
Acarina					LN1039	LN1032					
terrestrial Isoptera											
Muscidae larvae											
terrestrial beetle											
terrestrial Psocoptera											LN1035
Nematoda											
Syncarida											
Cyclopoida											
Ostracoda											
Platyhelminthe Planarian sp.											
Oligochaeta sp 1											LN1031
Oligochaeta sp 2											
Oligochaeta sp 3											
Chironomid larvae (surface)						LN1032					
Amphipoda (epigean)					LN1037						
ceratopogonidae larvae (surface)					LN1038						

Appendix 1b: Eneabba 2008 Stygofauna Sampling Programme Results

Eneabba											
	11	12	13	14	15	16	17	18	19	20	21
site	Coopers1	Cooper1 pum	Cooper2 Pum	EFB7	LT01D	LT01D pump	EWP25	Springvale1	Springvale1	Springvale2	Whites
date	14/02/2008	14/02/2008	14/02/2008	13/02/2008	14/02/2008	14/02/2008	14/02/2008	15/02/2008	15/02/2008	15/02/2008	15/2/20088
collembola	N	N	N	N	N	N	N	N		N	
terrestrial hemiptera	I	I	I	I	I	I	I	I		I	
Acarina	L	L	L	L	L	L	L	L		L	1
terrestrial Isoptera											
Muscidae larvae	F	F	F	F	F	F	F	F		F	
terrestrial beetle	O	O	O	O	O	O	O	O		O	
terrestrial Psocoptera	U	U	U	U	U	U	U	U		U	
Nematoda	N	N	N	N	N	N	N	N	20	N	
Syncarida	D	D	D	D	D	D	D	D		D	
Cyclopoida											
Ostracoda											
Platyhelminthe Planarian sp.											
Oligochaeta sp 1											
Oligochaeta sp 2											
Oligochaeta sp 3											
Chironomid larvae (surface)											
Amphipoda (epigean)											
ceratopogonidae larvae (surface)											
LAB NO.s											
site	Coopers1	Cooper1 pum	Cooper2 Pum	EFB7	LT01D	LT01D pump	EWP25	Springvale1	Springvale1	Springvale2	Whites
date	14/02/2008	14/02/2008	14/02/2008	13/02/2008	14/02/2008	14/02/2008	14/02/2008	15/02/2008	15/02/2008	15/02/2008	15/2/20088
collembola											
terrestrial hemiptera											
Acarina											LN1034
terrestrial Isoptera											
Muscidae larvae											
terrestrial beetle											
terrestrial Psocoptera											
Nematoda									LN1036		
Syncarida											
Cyclopoida											
Ostracoda											
Platyhelminthe Planarian sp.											
Oligochaeta sp 1											
Oligochaeta sp 2											
Oligochaeta sp 3											
Chironomid larvae (surface)											
Amphipoda (epigean)											
ceratopogonidae larvae (surface)											

Appendix 1b: Eneabba 2008 Stygofauna Sampling Programme Results

Eneabba		March 2008 sampling									
	22	Rockwater la	1	2	3	4	5	6	7	8	9
site	Sheans		EPVT69 pum	Sheans	Whites	Springvale2	NR2 net	NR2 pumped	NR1 net	NR1 pumped	NR3 net
date	15/02/2008		24/03/2008	24/03/2008	24/03/2008	24/03/2008	25/03/2008	25/03/2008	25/03/2008	25/03/2008	25/03/2008
collembola	N									1	
terrestrial hemiptera	I		N		N	N		N	N		
Acarina	L		I		I	I		I	I		
terrestrial Isoptera			L		L	L		L	L		
Muscidae larvae	F										
terrestrial beetle	O		F		F	F		F	F		
terrestrial Psocoptera	U		O		O	O		O	O		
Nematoda	N		U		U	U		U	U		
Syncarida	D		N		N	N		N	N		
Cyclopoida			D		D	D		D	D		
Ostracoda											
Platyhelminthe Planarian sp.							1				7
Oligochaeta sp 1											
Oligochaeta sp 2											
Oligochaeta sp 3				1							
Chironomid larvae (surface)											
Amphipoda (epigean)											
ceratopogonidae larvae (surface)											
LAB NO.s											
site	Sheans										
date	15/02/2008										
collembola											
terrestrial hemiptera											
Acarina											
terrestrial Isoptera											
Muscidae larvae											
terrestrial beetle											
terrestrial Psocoptera											
Nematoda											
Syncarida											
Cyclopoida											
Ostracoda											
Platyhelminthe Planarian sp.							seLN1042				LN1048
Oligochaeta sp 1											
Oligochaeta sp 2											
Oligochaeta sp 3				LN1046							
Chironomid larvae (surface)											
Amphipoda (epigean)											
ceratopogonidae larvae (surface)											

Appendix 1b: Eneabba 2008 Stygofauna Sampling Programme Results

Eneabba											
	10	11	12	13	14	15	16	17	18	19	20
site	NR3 pumped	BH1	B1	EWM11	EWM10	EWM12	EWM13	EWM21	EFB2 net	EFB2 pumpe	LI5FOB net
date	25/03/2008	25/03/2008	25/03/2008	26/03//2008	26/03//2008	26/03//2008	26/03//2008	26/03//2008	26/03//2008	26/03//2008	27/03/2008
collembola											
terrestrial hemiptera	N	N			N	N	N			N	1
Acarina	I	I			I	I	I			I	
terrestrial Isoptera	L	L			L	L	L			L	
Muscidae larvae											
terrestrial beetle	F	F			F	F	F			F	
terrestrial Psocoptera	O	O			O	O	O			O	D.O.C.
Nematoda	U	U		2	U	U	U			U	
Syncarida	N	N			N	N	N		1	N	
Cyclopoida	D	D			D	D	D			D	
Ostracoda											
Platyhelminthe Planarian sp.								1			
Oligochaeta sp 1			4								
Oligochaeta sp 2											
Oligochaeta sp 3											2
Chironomid larvae (surface)											
Amphipoda (epigean)											
ceratopogonidae larvae (surface)											
LAB NO.s											
site											
date											
collembola											
terrestrial hemiptera											
Acarina											
terrestrial Isoptera											
Muscidae larvae											
terrestrial beetle											
terrestrial Psocoptera											
Nematoda				LN1045							
Syncarida									LN1047		
Cyclopoida											
Ostracoda											
Platyhelminthe Planarian sp.								LN1049			
Oligochaeta sp 1			LN1040								
Oligochaeta sp 2											
Oligochaeta sp 3											LN1052
Chironomid larvae (surface)											
Amphipoda (epigean)											
ceratopogonidae larvae (surface)											

Appendix 1b: Eneabba 2008 Stygofauna Sampling Programme Results

Eneabba									
	21	22	23	24	25	26	27	28	29
site	LI5FOB pum	LI6D net	LI6D pumped	Springvale1 r	Springvale1 r	EPVT69 net	EWM2	EWP30 net	EWP30 pumped
date	27/03/2008	27/03/2008	27/03/2008	27/03/2008	27/03/2008	27/03/2008	28/03/2008	28/03/2008	28/03/2008
collembola									
terrestrial hemiptera			N	N	N		N		1
Acarina			I	I	I	1	I		
terrestrial Isoptera			L	L	L		L		
Muscidae larvae									
terrestrial beetle			F	F	F		F		
terrestrial Psocoptera		3	O	O	O		O	1	
Nematoda	8		U	U	U		U		
Syncarida			N	N	N		N		
Cyclopoida			D	D	D		D		
Ostracoda									
Platyhelminthe Planarian sp.									
Oligochaeta sp 1									
Oligochaeta sp 2									2
Oligochaeta sp 3		7							
Chironomid larvae (surface)									
Amphipoda (epigean)									
ceratopogonidae larvae (surface)									
LAB NO.s									
site									
date									
collembola									
terrestrial hemiptera									
Acarina									
terrestrial Isoptera									
Muscidae larvae									
terrestrial beetle									
terrestrial Psocoptera		LN1051						LN1043	
Nematoda	LN1041								
Syncarida									
Cyclopoida									
Ostracoda									
Platyhelminthe Planarian sp.									
Oligochaeta sp 1									
Oligochaeta sp 2									LN1044
Oligochaeta sp 3		LN1050							
Chironomid larvae (surface)									
Amphipoda (epigean)									
ceratopogonidae larvae (surface)									

APPENDIX 2



Appendix 2a: Water Quality Data and Bore Details, 2007

Bore	Date	Bore Depth	Aquifer	Screened Interval	Diameter (mm)	Easting	Northing	Water Level	Casing Hgt	Temp	DO%	DO	pH	SPCond	Salinity	Salinity	Comments
		(m bgl)		(m bgl)		(WGS 84)		m (btc)	m (agl)	C	Sat	mg/L	Units	mS/cm	ppt	g/l TDS	
CW014P	31.1.07	12	shallow	6 - 12	50	328981	6687507	1.06	0.6	24.51	40.6	3.33	6.33	4.984	2.73		URS bore
CW015P	31.1.07	34.3	deep	28.3 - 34.3	50	328764	6687953	0.73	0.78	23.32	21.2	1.75	7.13	10.8	6.14	6.13	URS bore
EFB1	31.1.07	21.84	n/a	n/a	100	328819	6688117	8.18	0.26	24	75.8	6.38	5.46	0.2969	0.14	0.19	old farm bore
CW010P	31.1.07	22	shallow	18-22	100	329081	6688068	11.855	0.79	23.34	62.7	5.32	5.57	0.4135	0.21	0.2647	URS bore
CW011P	31.1.07	96	deep	90-96	100	329074	6688069	8.55	0.74	22.78	59.7	5.0	6.93	8.024	4.49	5.135	URS bore
EFB2	31.1.07	29.6	n/a	n/a	90	329040	6687930	10.12	0.6	23.21	22.1	1.89	5.83	0.7766	0.4	0.497	old farm bore
EFB3	31.1.07	27.37	n/a	n/a	100	329013	6687927	9.62	0.22	22.41	13.3	1.15	7.06	1.091	0.57	0.6985	old farm bore
CW013P	1.2.07	84	deep	78 - 84	50	328621	6687804	0.72	0.8	22.32	49.2	4.06	7.34	15.33	8.92	9.821	URS bore
EFB4	1.2.07	27.22	n/a	n/a	100	329479	6687145	5.7	0.12	22.64	4.5	0.39	7.67	1.342	0.71	0.8586	old farm bore
EWP21	1.2.07	107	deep	49.97-103.83*	200	329100	6691686	5.05	0.42	22.98	38.8	3.31	7.04	2.98	1.6	1.9	* over 3 intervals
EWP25	1.2.07	134	deep	59.15-130.83*	200	329198	6689189	4.52	0.09	23.21	26.5	2.21	6.54	4.66	2.5	2.92	*over 3 intervals
CW012P	1.2.07	30	shallow	24 - 30	50	328621	6687804	0.81	0.82	22.25	61.2	5.27	7.12	3.11	1.68	1.99	URS bore
CW010P	1.5.07	22	shallow	18-22	100	329081	6688068	11.73	0.82	22.47	18.5	1.61	6.63	0.412		0.264	URS bore
CW011P	1.5.07	96	deep	90-96	100	328938	6687916	8.53	0.74	22.6	18.4	1.54	7.15	7.89		0.5055	URS bore
CW014P	1.5.07	12	shallow	6 - 12	50	328981	6687507	7.51	0.6	22.94	17.8	1.5	6.39	5.28		0.03382	URS bore
CW015P	1.5.07	34.3	deep	28.3 - 34.3	50	328764	6687953	5.31	0.78	23.66	7.5	0.55	7.23	10.47		6.866	URS bore
CW012P	1.5.07	30	shallow	24 - 30	50	329119	6687661	13.87		22.31	40.3	3.46	6.99	3.086		1.969	URS bore
CW013P	1.5.07	84	deep	78 - 84	50	328621	6687804	12.3	0.8	22.3	7.1	0.59	7.2	15.18		9.71	URS bore
CW040P	1.5.07	42	deep	36 - 42	50	328819	6687129	1.04	0.5	24.22	58.6	4.8	6.7	5.529		3.537	Rockwater bore
CW041P	1.5.07	16	shallow	10 - 16	50	328822	6687129	1.58	0.51	24.67	57.9	4.72	4.88	4.652		2.978	Rockwater bore
CW038P	1.5.07	36	shallow	30 - 36	50	330290	6689217	8.3	0.67	22.9	14	1.2	6.62	1.53		0.981	Rockwater bore
EFB5	2.5.07	65.55	n/a	n/a	90	324454	6689805	artesian	0	22.76	7.5	0.63	7.31	5.58	3.08	3.58	old farm bore
EFB6	2.5.07	26.07	n/a	n/a	130	328628	6686564	8.51	0.34	24.05	17.2	1.43	5.88	3.5	1.89	2.22	old farm bore
EWP24	2.5.07	92	deep	37.62-88.83	200	329163	6690191	5.04	0.55	24.73	37.3	3.07	6.69	2.77	1.51	1.78	*over 4 intervals
EFB7	3.5.07	n/a	n/a	n/a	100	322453	6689564	n/a	n/a	19.62	32	2.87	7.74	3.961		2.535	equipped bore; 40L pumped sample
EFB8	3.5.07	n/a	n/a	n/a	n/a	325488	6689823	artesian	0	22.96	20.6	1.72	7.3	5.5		3.516	old farm bore; 40 L sample taken
EFB5	4.5.07	65.55	n/a	n/a	90	324454	6689805	artesian	0	21.6	8.3	0.17	7.42	4.838		3.11	old farm bore
EFB10	4.5.07	18.5	n/a	n/a	100	326610	6686562	3.35	0.5	24.61	18.7	1.56	7.1	0.416		0.266	old farm bore
EFB9	4.5.07	47.96	n/a	n/a	100	324913	6691319	artesian	0.36	24.4	6.8	0.56	7.35	5.319		3.409	old farm bore
EFB11	4.5.07	21.55	n/a	n/a	80	326971	6687273	1.55	0.2	24.34	14.8	1.21	7.5	5.739		3.672	old farm bore
CW035P	4.5.07	48	deep	42-48	50	328221	6688637	1.63	0.91	23.52	46.9	3.9	6.48	5.83		3.73	Rockwater bore
CW036P	4.5.07	25	shallow	18-24	50	328224	6688637	2.94	0.64	24.13	15.6	1.28	5.83	7.061		4.519	Rockwater bore
EWP21	4.5.07	107	deep	49.97-103.83*	200	329103	6691689	5.14	0.42	22.18	30.9	2.65	7.34	2.959		1.894	*over 3 intervals
EFB4	4.5.07	27.22	n/a	n/a	100	329479	6687145	5.7	0.12	22.95	8.4	0.72	7.8	1.337		0.856	old farm bore
EWP24	4.5.07	92	deep	37.62-88.83	200	329163	6690191	5.04	0.34	24.09	38.5	3.2	7.19	2.727		1.745	*over 4 intervals
CW043P	4.5.07	30	shallow	29-30	50	330024	6687361	1.75	0.96	22.72	43.4	3.67	5.83	3.071		1.969	Rockwater bore
CW042P	4.5.07	87	deep	73-79	50	330023	6687363	1.75	0.96	22.94	11.9	11.01	6.53	3.293		2.108	Rockwater bore
CW049P	4.5.07	30	shallow	22-28	50	331676	6685257	25.08	0.77	21.56	55.7	4.88	5.65	1.418		0.907	Rockwater bore
CW048P	4.5.07	54	deep	38-44	50	331678	6685256	24.97	0.71	21.52	36.2	3.12	5.54	1.322		0.846	Rockwater bore
CW045P	4.5.07	24	shallow	18-24	50	328541	6684141	8.67	0.76	23.14	33.5	2.84	5.53	2.346		1.5	Rockwater bore
CW044P	4.5.07	48	deep	37-43	50	328541	6684139	8.73	0.6	23.16	28.2	2.39	5.51	2.4		1.3	Rockwater bore

n/a = not available

Appendix 2b: Water Quality Data and Bore details 2008

Bore	Date	Time	Bore Depth (m bgl)	Aquifer	Screened Interval (m bgl)	Diameter (mm)	Easting (WGS 84)	Northing (WGS 84)	Water Level m (btc)	Casing Hgt m (agl)	Temp C	DO%	DO	pH	SPCond	Salinity
												Sat	mg/L	Units	mS/cm	ppt
NR1	12/02/2008	17:32	41.14		4-39.7	50	327225	6696014	7.225	0.88	24.1	74.5	6.16	5.38	3.64	2
EFB13	13/02/2008	10:45	29.26		2-26.2	100	324912	6681482	18.29	-	23.52	54.8	4.64	6.1	4.194	2.3
EFB12	13/02/2008	11:15	100.584			100	328571	6679410	65.62	-	25.82	73.5	6.16	5.43	1.846	1
EFB15	13/02/2008	12:10	30			142	324240	6685480	5	-	24.15	21.1	1.78	6.01	6.944	3.9
EFB14	13/02/2008	12:54	13.716			100	324270	6683923	6.096	-	25.5	60	4.9	5.82	4.568	2.5
EFB18	13/02/2008	14:30				142	328518	6683281		-	22.84	38.2	3.33	5.8	4.646	2.5
EFB7	13/02/2008	15:00				100	322453	6689564		-	25.1	42.1	3.59	7.06	4.092	2.2
EPVT69	13/02/2008	15:38	27.8			142	321502	6688406	Artesian	0.44	22.3	4.6	0.39	6.82	3.786	2.1
EFB2	14/02/2008	9:34	27.37			9.28	329037	6687929	9.28	0.64	22.79	50.1	4.28	4.95	0.574	0.3
EFB16	14/02/2008	12:45	15.82			84	326879	6684034	Artesian	0.43	22.4	9.4	0.8	5.58	3.841	2.1
EFB17	14/02/2008	14:20	24.4			130	327038	6682254	11.62		24.11	74.1	6.2	5.58	3.532	1.9
LT01s	14/02/2008	17:40	5.64			50	322748	6694169	2.63		26.47	15.1	1.21	6.28	14.66	8.5
LT01D	14/02/2008	17:45	17.97			50	322748	6694169	2.88		25.98	49	3.7	6.17	29.96	11.2
EFB20	15/02/2008	7:48	30.33			90	324004	6688235	Artesian	0.33	25.64	23	1.92	7.09	10.35	5.9
EFB21	15/02/2008	10:20	10.16			100	324804	6687225	6.66	0.24	27.09	49.5	4.02	6.68	8.533	4.8
EFB22	15/02/2008	11:13	21.4			100	323311	6687184	4.57	0.19	25.8	41.9	3.44	6.03	3.204	1.7
EFB19	15/02/2008	12:21					323289	6688198			22.64	43.4	3.68	6.24	6.646	3.7
EPVT69	24/03/2008	2:59	27.8			142	321502	6688406	Artesian	0.44	22.3	4.6	0.39	6.82	3.786	2.1
EFB19	24/03/2008	4:55					323289	6688198			22.64	43.4	3.68	6.24	6.646	3.7
EFB22	24/02/2008	17:35	21.4			100	323311	6687184	4.57	0.19	25.8	41.9	3.44	6.03	3.204	1.7
EFB21	24/02/2008	18:31	10.16			100	324804	6687225	6.66	0.24	27.09	49.5	4.02	6.68	8.533	4.8
NR2	25/03/2008	9:06	40.23			50	327211	6696508	6.925	0.95	-	-	-	-	-	-
NR1	25/03/2008	10:52	41.14		4-39.7	50	327225	6696014	7.225	0.88	24.1	74.5	6.16	5.38	3.64	2
NR3	25/03/2008	12:42	41.25			50	326183	6696024	5.45	1.08	-	-	-	-	-	-
BH1	25/03/2008	2:45	31.74			50	327354	6696945	7.61	0.68	-	-	-	-	-	-
B1	25/03/2008	18:45	25.24			50	328004	6696899	4.6	0.65	-	-	-	-	-	-
EWM11	26/03/2008	8:48	6.33			44	325603	6689832	3.04	0.53	-	-	-	-	-	-
EMW10	26/03/2008	10:50	20.08			44	326108	6689843	1.43	0.65	-	-	-	-	-	-
EMW12	26/03/2008	12:58	20.16			44	325887	6692827	2.52	0.59	-	-	-	-	-	-
EMW13	26/03/2008	13:35	15.7			44	326388	6692836	4.97	0.58	-	-	-	-	-	-
EMW21	26/03/2008	14:38	14.24			44	330376	6692997	9.2	0.71	-	-	-	-	-	-
EFB2	26/03/2008	16:29	27.37			9.28	329037	6687929	9.28	0.64	22.79	50.1	4.28	4.95	0.574	0.3
LI5 FOB	27/03/2008	11:16	7.0			80	321159	6696290	3.16	0.76	-	-	-	-	-	-
LI6D	27/03/2008	12:26	15.7			50	320392	6696597	6.93	0.78	-	-	-	-	-	-
EFB20	27/03/2008	3:49	30.33			90	324004	6688235	Artesian	0.33	25.64	23	1.92	7.09	10.35	5.9
EWM2	28/03/2008	7:02	20.46			44	329901	6689874	9.94	0.79	-	-	-	-	-	-
EWP30	28/03/2008	10:05				220	331809	6688629	18.55	0.34	-	-	-	-	-	-