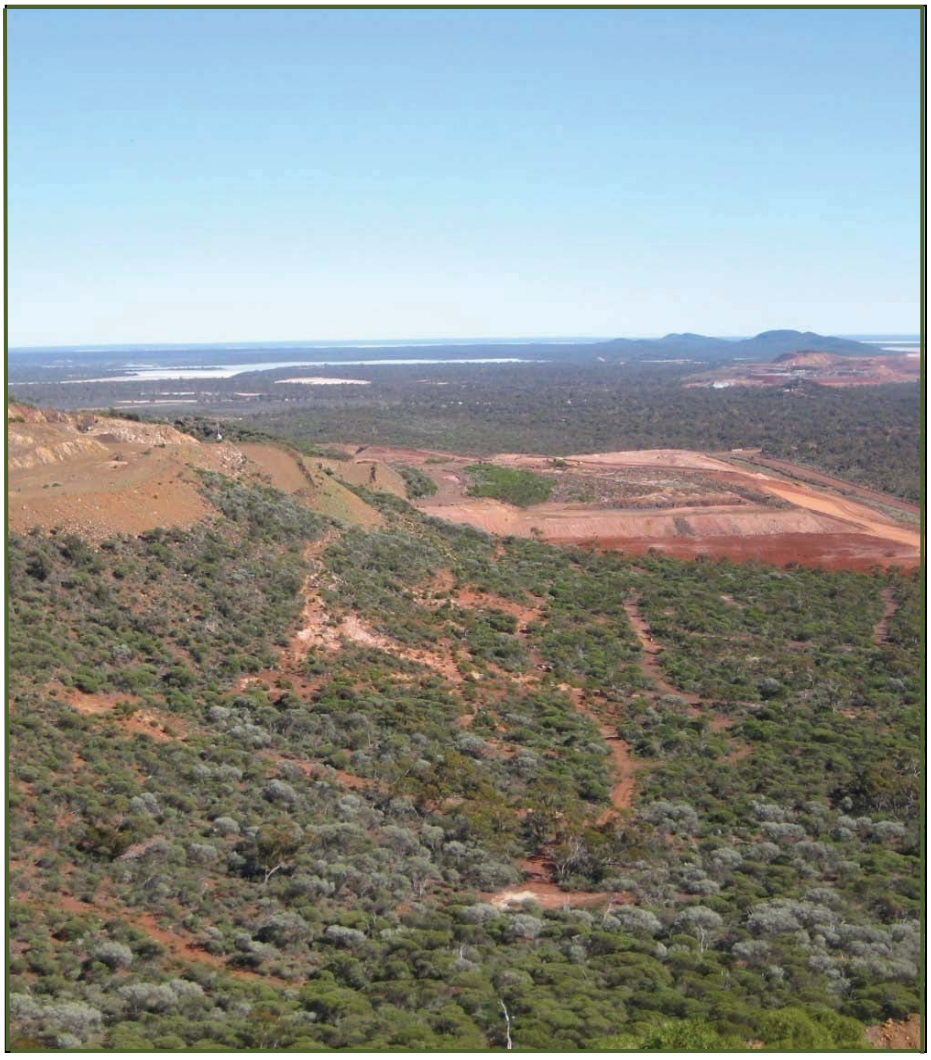
Troglofauna survey at Koolyanobbing



Prepared for
Portman Ltd
by Bennelongia Pty Ltd

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Report 2008/49

Troglofauna survey at Koolyanobbing

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Executive Summary

This report provides the results of a troglofauna survey at Portman Ltd's proposed mine sites in B and C Deposit (proposed B and C Pits) at Koolyanobbing, which is located approximately 50 km north of Southern Cross in the Yilgarn region of Western Australia. Portman is seeking environmental approval to mine B and C Deposits.

The purpose of this survey was to document the troglofaunal community at the proposed mine sites and assess the potential impacts of the proposed mines on troglofauna.

A total of 141 troglofaunal animals were collected during the survey. The surveyed area supports a troglofauna community that has typical diversity for arid parts of Western Australia, comprising 19 possible species that represent 10 Orders of invertebrates including slaters, millipedes, centipedes, spiders, silverfish, beetles, symphylans, cockroaches, bristletails and bugs.

There appears to be little risk to the survival of troglofaunal species from mining C Deposit (Pit C) and low risk from mining B Deposit (B Pit). All but two species recorded within the proposed mine pits are also found outside the mine pits. The species apparently restricted to the pits, *Mecistocephalus* sp. B1 at C Pit and Atelurinae sp. B3 at B Pit, are known only from singleton records, which convey little information about the distribution of the species. It is likely both species occur more widely, with the currently known distribution being an artefact of their low abundance.

The distributions of the other species of troglofauna present in B and C Deposits provided no evidence that the communities are tightly restricted. Species occurring at multiple bores were also found outside the two deposits. While there has been little previous troglofauna investigation in the local area, morphological identifications suggest that at least 10 of the 19 species (44% of troglofauna taxa collected) have ranges extending to Mt Jackson, approximately 80 km north of the Koolyanobbing deposits.

Contents

1.0 Introduction

The Koolyanobbing mine site is located approximately 50 km to the north of the town of Southern Cross in the Yilgarn region of Western Australia (WA) (Figure 1.1). Mining in the area originally commenced at A deposit in 1950. BHP obtained the leases for the Koolyanobbing mine in 1960 and mined both A and D deposits until 1983, when the mine was closed because of closure of the Kwinana Blast Furnace. Control of the deposits then reverted to the State Government. In 1992, Portman Ltd successfully applied for the rights to redevelop the Koolyanobbing iron ore deposits and mining commenced in July 1994 in A, D and K Pits.

In November 2002, Portman submitted an *Addendum to Notice of Intent Koolyanobbing Upgrade Project* (Portman 2002) to facilitate the opening of B and C Pits, and the construction of associated stockpiles and waste rock dumps. Portman now proposes to expand the B and C Pits and associated WRD beyond those areas approved under the 2002 NOI addendum. Mining in B and C Pits is expected to be completed in 2011 and 2014, respectively.

The facilities and infrastructure at the Koolyanobbing mine site currently comprise:

- Three open cut pits (A, D and K);

- Waste rock dumps adjacent to the pits;
- Crushing and screening plant;
- Ore stockpiles;
- Rail loop and train load-out facility;
- Power station;
- Accommodation for mine management personnel; and
- A 1200 m gravel airstrip, located adjacent to A Pit.

The layout of existing infrastructure at the Koolyanobbing mine site is shown in Figure 1.1.

As part of the environmental impact assessment of developing mines at B and C Deposits, the impacts of on troglofauna have been examined. Troglofauna are air-breathing subterranean animals that occur in underground cavities and small fissures above the water table. Nearly all troglofauna fauna are invertebrates, although troglofaunal reptiles have been recorded in Western Australia (Aplin 1998). Troglofauna are a focus of environmental assessment because many troglofauna are likely to be short range endemics and there is relatively little information about their distribution. The distribution of troglofauna is likely to be more restricted than stygofauna (Biota 2006; Eberhard et al 2008).

The objectives of this troglofauna survey at Pit B and Pit C were:

1. To document the troglofaunal species present within the areas to be impacted by mining at Pit B and Pit C;
2. To assess the conservation status and significance of the troglofauna communities at Pit B and Pit C and their constituent species.

2.0 Local Geology

The occurrence of troglofauna is strongly influenced by geology. Troglofauna require small subterranean voids for habitat and connectivity of these voids is important to enable troglofauna to move around below ground. In addition, there must be some surface connections so that nutrient can infiltrate into troglofauna habitat. Geological features such as dykes and valleys may act as barriers to troglofauna dispersal and lead to species having highly restricted ranges.

B and C deposits are both hematite-goethite iron ore deposits developed within a locally extensive banded iron formation unit that extends for some 50 km along the Koolyanobbing Range. Both B and C deposits are characterised by the replacement of the original banded iron formation by hematite and goethite in structurally favourable positions. The banded iron formation is bounded on either side by massive mafic volcanic rocks. B and C deposits have very similar geology to surround iron ore deposits within the southern Koolyanobbing Range such as A, D, F, G, I and J with all of these deposits hosted within the same continuous banded iron formation unit.

3.0 Troglofauna of the Region

Troglofauna are widespread in Western Australia, although until recently they were studied only in caves. Surveys in the wider landscape in the last few years, mostly achieved through sampling uncased bores, have revealed a variety of troglofaunal spiders and other arachnids, millipedes and centipedes, and various insects. They are now known from the Kimberley (Harvey et al. 2008) to the South-West (Biota 2005a), with hotspots in the Pilbara, Cape Range and Barrow Island (Harvey, 1993; Biota 2005b).

Troglofauna have been collected above the watertable in calcretes of the Yilgarn, with the groups collected including palpigrads (Barranco & Harvey 2008), pseudoscorpions (Edward & Harvey 2008), spiders (Platnick 2008) and isopods (S. Taiti in litt.). Troglofaunal pseudoscorpions and, probably, isopods have been collected from Yilgarn banded iron formation (Biota 2007). The habitats that troglofauna occupy within banded iron formation are still being determined but it is inferred that they utilise the fissures and voids associated with weathering and enrichment of the ore as well as occupying any voids created by faulting.

4.0 Methods

Troglofauna were surveyed within the impact footprint of the proposed mine pits at B and C Deposits (hereafter referred to as B and C Pits) and several nearby deposits of similar geology that were sampled to provide information on the wider distribution of the troglofauna species occurring in B and C Pits. These reference areas were D, E, F, I and J Deposits, located between 0.3 km and 8 km to the east of Pits B and C (Figure 4.1 and 4.2). Information from a comparable troglofauna survey at Mt Jackson (Bennelongia 2008b) was also used to assist assess the risk to troglofauna at B and C Pits.

Troglofauna survey was conducted in accordance with the principles laid out in EPA Guidance Statements Nos 54 and 54a (EPA 2003, 2007).

4.1 Sampling effort

A total of 52 impact bores (23 bores within Pit B and 29 within Pit C) were sampled twice for troglofauna. The first sampling round occurred in February and the second in August 2008 (Table 4.1), providing 46 and 58 samples for Pit B and Pit C, respectively. Guidelines recommend 60 samples should be taken from an impact area and that sampling events should be separated by at least 3 months. Both B and C Pits are small and could easily be regarded as a single impact area, so sampling effort was considered to be adequate (see Figure 4.1). The impact zone of each pit was considered to include the mine void and all area with 100 m of the proposed pit boundary.

Reference samples were collected in Deposits D, E, F, I and J along the same ridge at a maximum distance of 8 km from the proposed mine pits (Table 4.1, Figure 4.2). A total of 51 reference samples were collected during one round of sampling in August 2008.

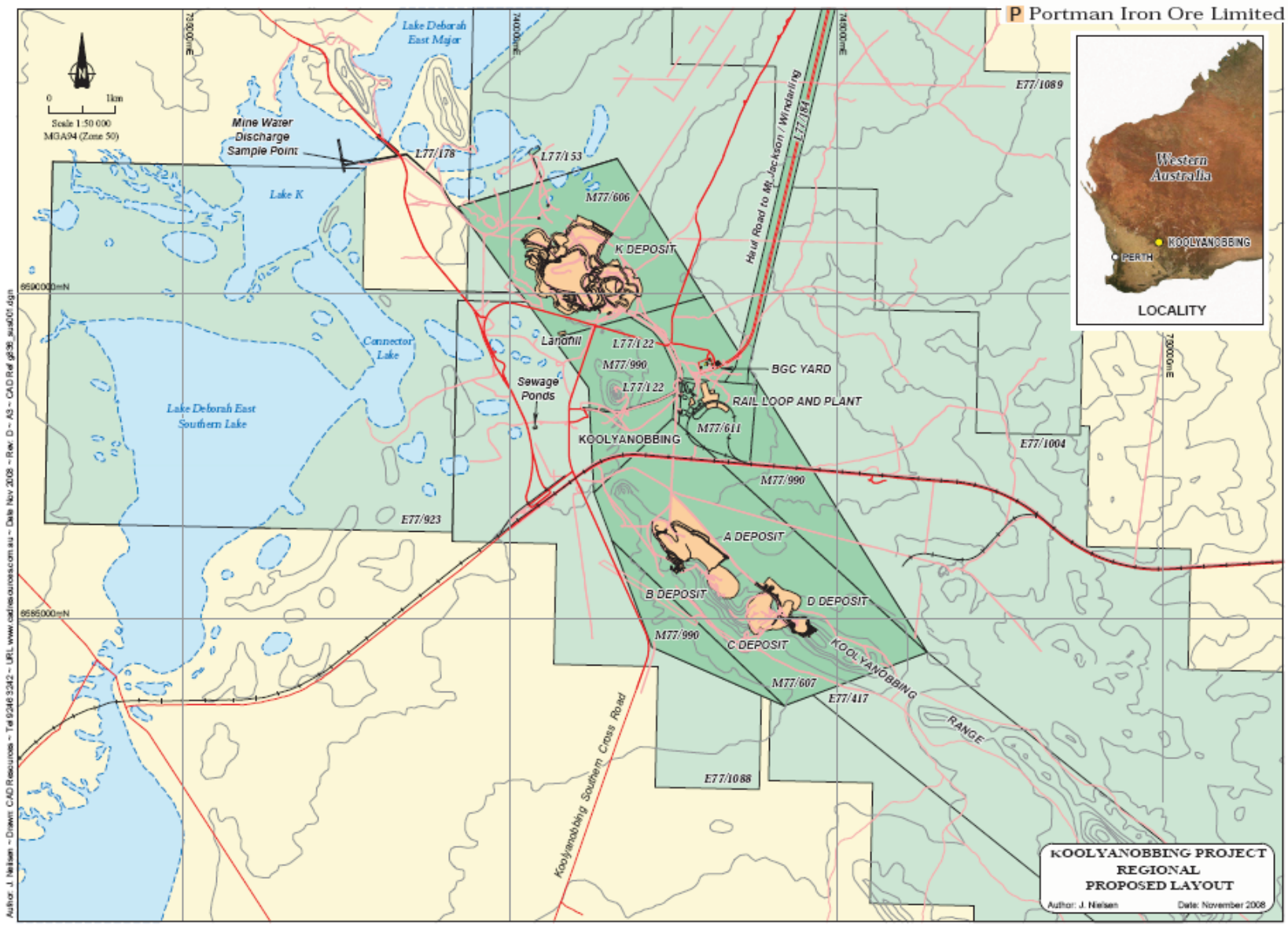

Figure 1.1. Location of current and proposed mine pits and associated infrastructure at Portman's Koolyanobbing mine site

Table 4.1. Numbers of samples collected from the Koolyanobbing study site. *Impact* (Pit B, Pit C) and *Reference* (Deposits D, E, F, I, J). Samples consisted of scraping and a trapping event with 1 or 2 traps. S trap, one trap; D trap, two traps (shallow and deep)

		First Round			Second Round			
	Survey Area	**Scrapes**	**S Trap**	**D Traps**	**Scrapes**	**S Trap**	**D Traps**	**Total samples**
Impact	Pit B	*23*	*15*	*8*	*23*	*16*	*7*	*46*
	Pit C	*29*	*21*	*8*	*29*	*21*	*8*	*58*
Reference	D Deposit	*11*	*7*	*3*	-	-	-	*11*
	E Deposit	*2*	*1*	*1*	-	-	-	*2*
	F Deposit	*30*	*21*	*9*	-	-	-	*30*
	I Deposit	*7*	*4*	*3*	-	-	-	*7*
	J Deposit	*1*	*1*	-	-	-	-	*1*
						Reference total		*51*

4.2 Sampling Methods

In summary, two sampling methods were employed:

1. Scraping occurred immediately prior to setting traps. A small, reinforced stygofauna net was lowered to the bottom of the bore (or watertable) and dragged back to the surface along the bore walls. This was repeated four times, with the aim of scraping any troglofauna on the walls into the net. After each haul, the contents of the net were transferred to a 250 ml vial and preserved in 100% ethanol.
2. Trapping of troglofauna occurred using traps measuring 270 x 70 mm, with holes drilled in the sides of the PVC, and with an open top end and closed bottom. They were baited with moist leaf litter sterilised by microwaving and lowered on cord to within several metres of the watertable or base of the bore. In every fourth bore, a second trap was set mid-way down the bore. Bores were closed off at the top while traps were in place to minimise ingress of surface invertebrates, although invertebrates inhabiting the surface layers of soil still comprised the bulk of animals caught in traps. Traps were retrieved using the attached cord and their contents (including leaf litter) were emptied into a zip-lock bag and road freighted to the laboratory in Perth.

4.3 Sample Sorting and Species Identification

Preserved scrapes from each bore were sorted under a dissecting microscope, after elutriation to separate animals from heavier sediment and sieving into size fractions using 250, 90 and 53 µm mesh sieves to remove litter and improve searching efficiency.

Troglofauna caught in traps were extracted from leaf litter using Berlese funnels under incandescent lamps. The aim was to make troglofauna and soil animals move out of the litter into the base of the funnel, which contained 100% ethanol as a preservative (EPA 2007). After about 72 hours, the ethanol and its contents were removed and sorted under a dissecting microscope. Litter from each funnel was also examined under a microscope for any remaining live or dead animals.

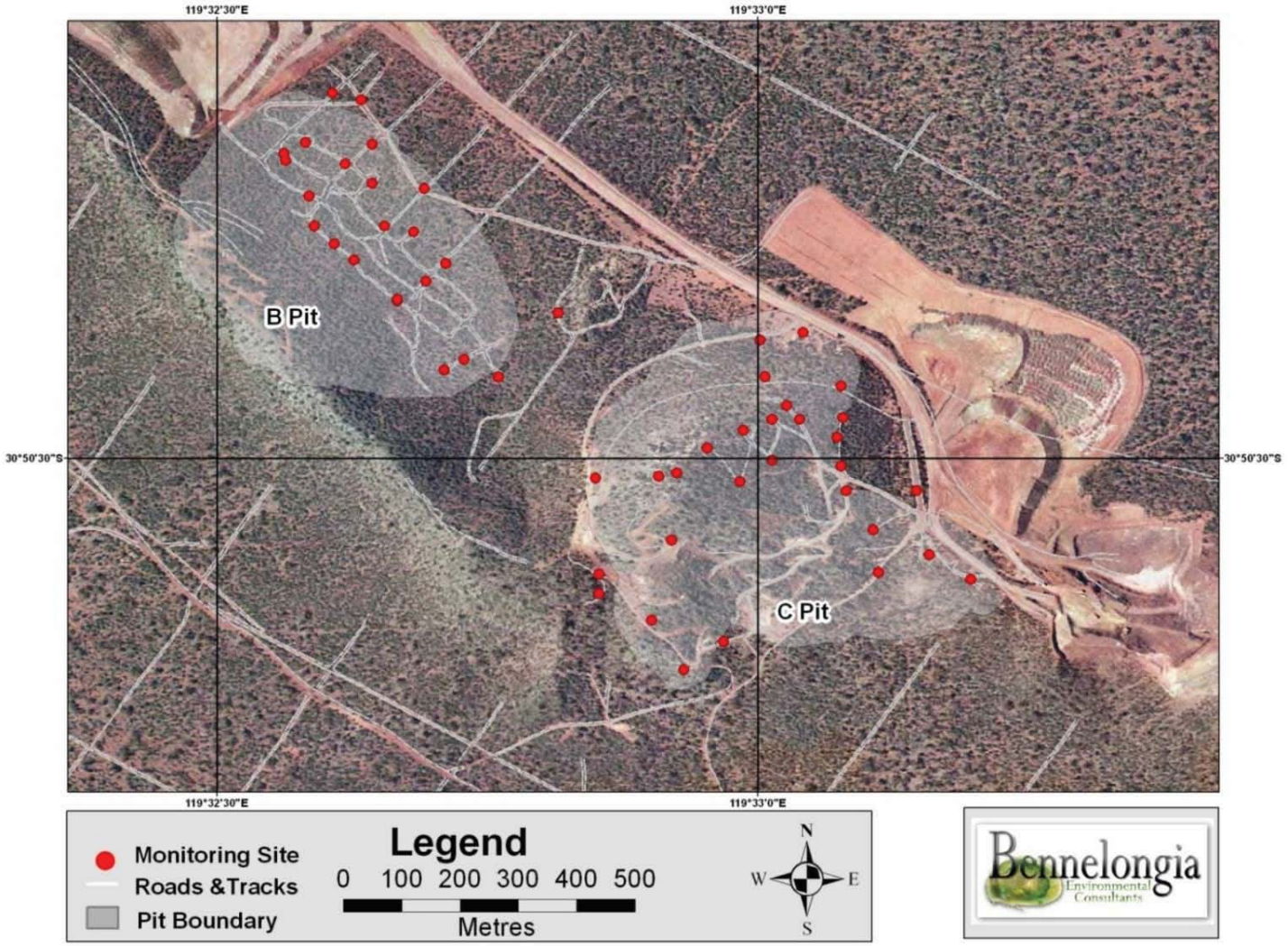

Figure 4.1. Bores sampled for troglofauna at Pit B and Pit C, Koolyanobbing. Note that sites outside the pit are less than <100 m from pit boundary and are considered impact

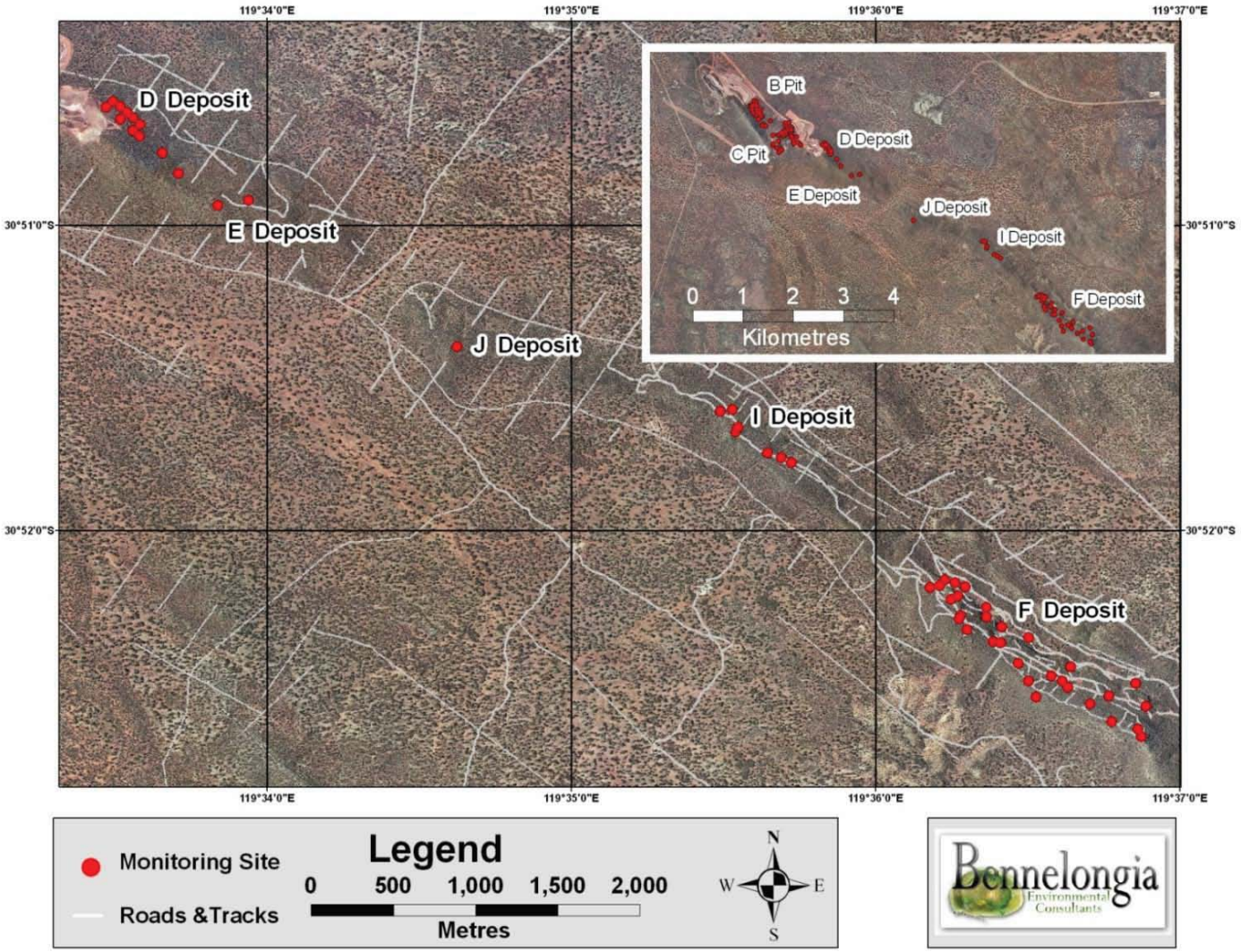

Figure 4.2. Bores sampled for troglofauna at Deposits D, E, J, I, F at Koolyanobbing. Inset: Deposits D, E, J, I, F in relation to Pit B and Pit C

All animals were picked out of the samples and checked for possession of troglomorphic characters. Surface and soil-dwelling species were identified only to Order level. Troglofauna were, as far as possible, identified to species or morphospecies level, unless damaged, juvenile or the wrong sex for identification (as stipulated by EPA 2007). Identifications were made under dissecting and compound microscopes and animals were dissected as necessary. Unpublished and informal taxonomic keys were used to assist identification of taxa for which no published keys exist. Representative animals will be lodged with the Western Australian Museum once the assessment process has been completed.

4.4 Personnel

Fieldwork was undertaken by Mike Scanlon, Jim Cocking, Andrew Trotter, Brad Scanlon and Peter Cocking. Sorting was done by Megan Phillips, Jane McRae, Mike Scanlon, Jim Cocking, Heather McLetchie and Andrew Trotter. Identifications were made by Jane McRae. Where necessary, identifications were confirmed by specialist taxonomists.

5.0 Results

5.1 Troglofauna at the Study Site

A total of 141 troglobitic animals were collected during the survey (Table 5.1). The troglofauna community comprised possibly 19 species (Table 5.1) of 10 Orders, representing a troglofauna community of typical complexity for arid parts of Western Australia. Four or five species of slaters, two species of millipedes, centipedes, spiders, silverfish and beetles and one species of symphylan, cockroach, bristletail and bug were present (Table 5.1, Figures 5.1). The most frequently found and numerous species were the slaters Philosciidae sp B4, *Buddelundia* sp. B1 and Trichorhinae sp. B2. (Table 5.1, Figure 5.1).

Nine species were recorded from with the impact zone of the proposed mine pits (Figure 5.2) and 14 species were recorded in reference areas. Troglofauna diversity was 2.5 times higher in reference areas than the impact zone with 0.11 and 0.27 species per sample, respectively. The highest yielding area was F Deposit, where 11 species were recorded at a rate of 0.37 species per sample. In comparison, the richer of the two impact zones, C Pit, contained only 7 species at a capture rate of 0.12 species per sample. Only three animals were collected from B Pit, representing two species with a capture rate of 0.04 species per sample.

Of the possible 19 troglofauna species recorded during the study, nine were collected only as singletons (one animal, one bore) (Table 5.1). The number of singletons recorded equated to a rate of 5.96 singletons per 100 samples across all sampling. This is similar to the figure of 5.04 returned for a troglofauna study at nearby Mount Jackson (Bennelongia 2008a). Four of the nine singleton taxa were recorded from impact bores, namely *Mecistocephalus* sp. B1**,** Atelurinae sp. B3, Blattidae sp. and Curculionidae sp. B4 (Table 5.1). The beetle Curculionidae sp. B4 has also been recorded at Mount Jackson Range 80 km away, as was Polyxenida sp. B1, a millipede which was only recorded from two bores inside B Pit at Koolyanobbing. The silverfish Atelurinae sp. B3 is only known from an impact bore are B Pit. The centipede, *Mecistocephalus* sp. B1, and cockroach Blattidae sp. are known only from impact bores at C Pit. Five singleton species were also found in the reference sampling areas, namely Juliforma sp. B2, Araneomorphae sp. B8, Japygidae sp. B8, Meenoplidae sp. and Pselaphinae sp. B3 (Table 5.1).

Table 5.1. Troglofauna at Koolyanobbing, showing number of animals collected of each species. J1-J5 = Mount Jackson sampling sites

	Impact				Reference			Other Occurrences
	Pit B	**Pit C**	**D Deposit**	**E Deposit**	**F Deposit**	**I Deposit**	**J Deposit**	**Mt Jackson**
Millipede								
Polyxenida sp. B1	2							J1
Juliforma sp. B2			1					
Centipede								
Mecistocephalus sp. B1		1						
Australoschendyla sp. B3					3			
Spider								
Araneomorphae sp. B4		2				1		J1, J5
Araneomorphae sp. B8						1		
Slater								
Philosciidae					2			
Philosciidae sp. B4		41	7		4	34		J1, J5
Troglarmidillo sp. B1					5			J5
Buddelundia sp. B1					12	1		
Trichorhinae sp. B2		1			9	1	1	J1, J4, J5
Symphla								
Hanseniella sp. B3			1		1			J1, J4, J5
Bristle-tail								
Japygidae sp. B8					1			
Silverfish								
Hemitrinemura sp. B2		1			1	1	1	
Atelurinae sp. B3	1							
Cockroach								
Blattidae sp. [1]		1						
Bug								
Meenoplidae sp.					1			
Beetle								
Curculionidae sp. B4		1						J1
Pselaphinae sp. B3					1			
Total number of animals	3	48	9	0	40	39	2	
Number of species	2	7	3	0	11	6	2	

[1] Possibly troglobytic

5.2 Troglofauna Distribution

The distribution of troglofauna along the Koolyanobbing Range suggests considerable habitat connectivity between the sites surveyed (Figure 4.2, Table 5.2). Two species of slater, Philosciidae sp B4 and Trichorhinae sp. B2 were recorded from C Pit through to F Deposit, a distance of approximately 7

km (Figure 1.1, Table 5.2). The less abundant *Hemitrinemura* sp. B2, a silverfish, appears to have the same range as Philosciidae sp B4 and Trichorhinae sp. B2 (Figure 1.1 and 1.2, Table 5.1). It appears that the ranges of some species extend well beyond the surveyed sites. Based on morphological identification, seven of the 18 species (44%) were also recorded at 80 km away at Mount Jackson Range (Table 5.1). The wide-ranging slaters at Koolyanobbing, Philosciidae sp B4 and Trichorhinae sp. B2, were found at multiple deposits in the Mount Jackson Range (Table 5.1).

The low abundance of troglofauna in B Pit made it difficult to document species composition (Table 5.1, Table 5.2) and to draw conclusions about the distribution of the this troglofauna community. There is little evidence that the community in Pit B is the same as, or similar to, that in Pit C but the proximity of the two Pits and the widespread ranges of the species in Pit C make it likely they share a similar community.

5.3 Sampling Completeness and Efficiency

Troglofauna communities are difficult to document fully because a high proportion of species occur in low abundance. This pattern of low abundance was very evident at Koolyanobbing, where the most abundant third of species accounted for 87% of all troglofaunal animals found and the least abundant third only 4% (Figure 5.4). As the number of animals collected increases, extra species are likely to be added onto the right hand side of the graph in Figure 5.1. Delineating the distributions of these species will require further, usually extensive, sampling.

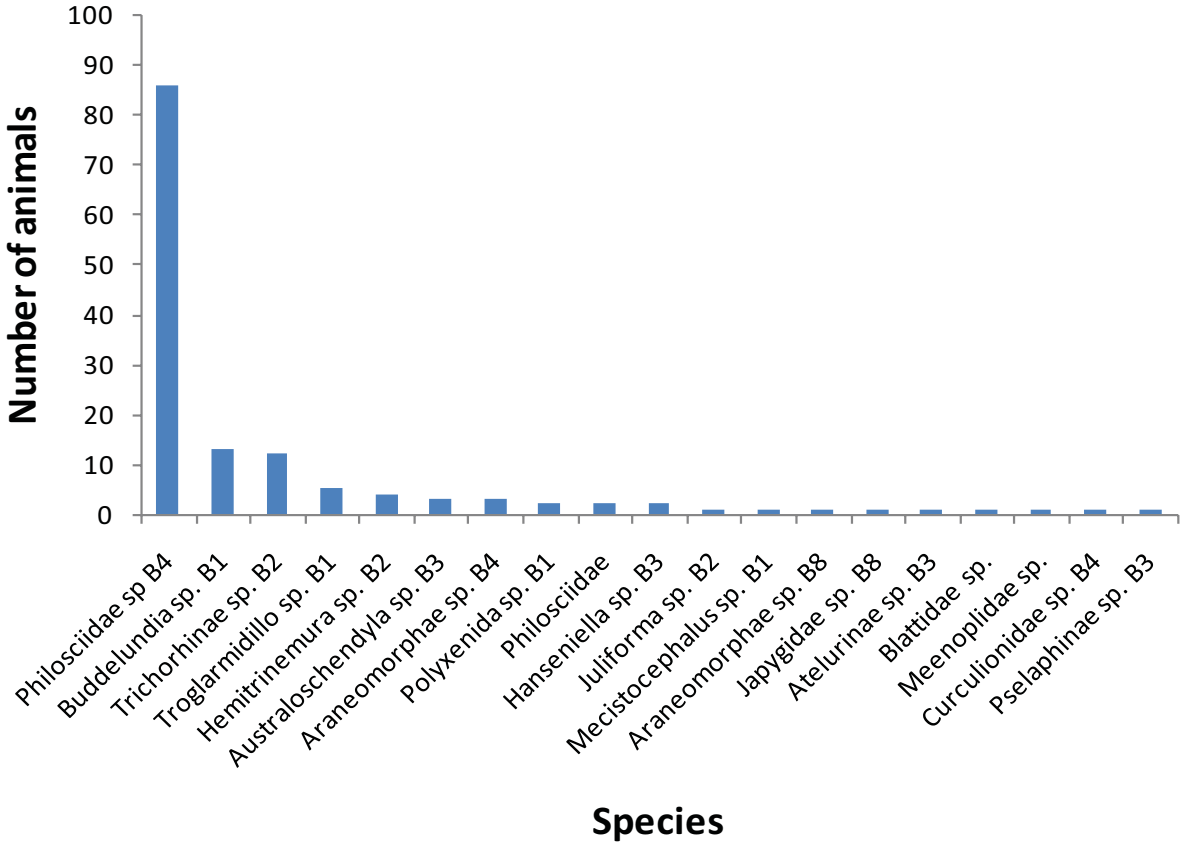

Figure 5.1. Capture abundance each troglofauna species within Koolyanobbing Range

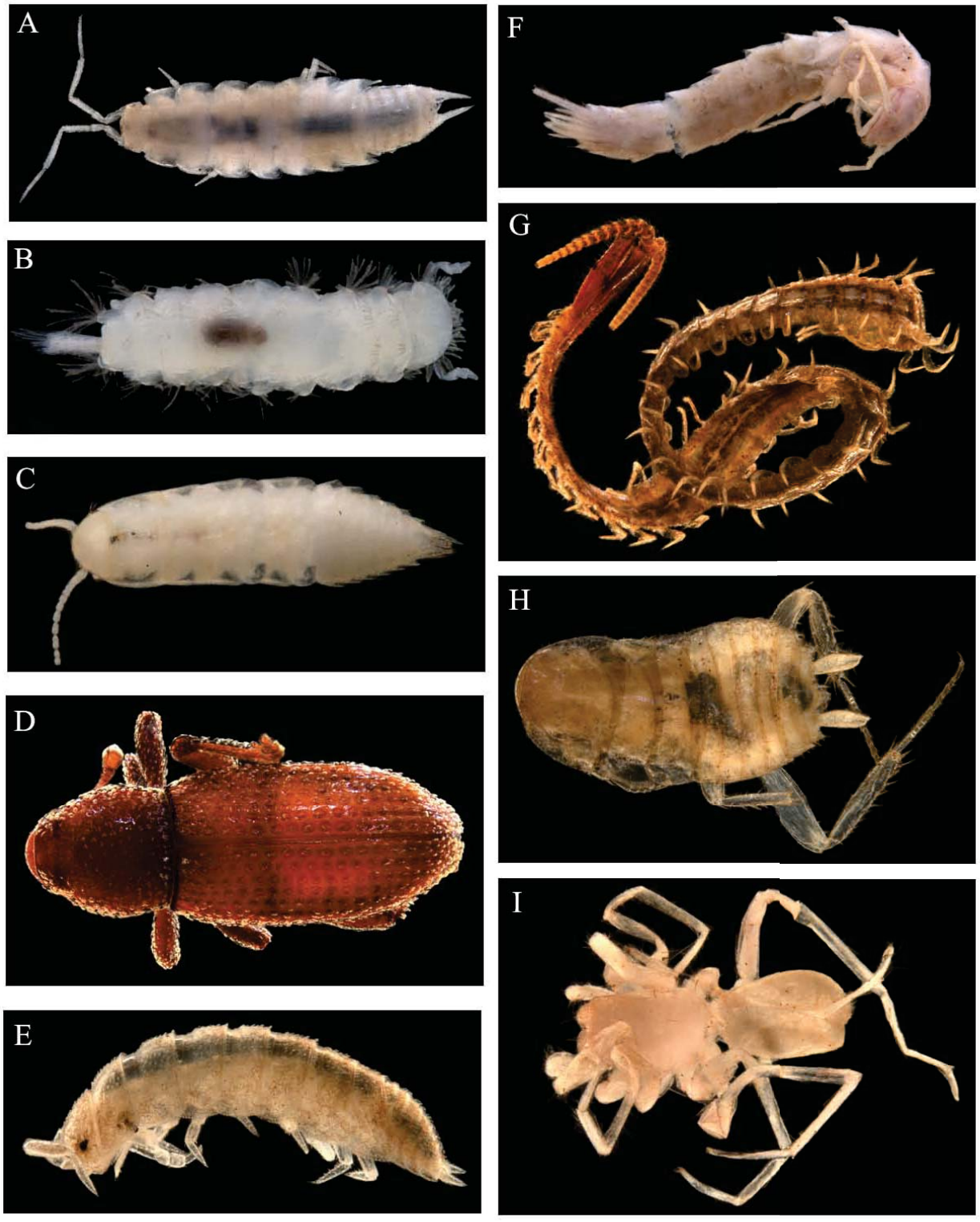

Figure 5.2. Troglofauna species recording from the proposed mine pits at Koolyanobbing. A, Philosciidae sp. B4; B, Polyxenida sp. B1; C, Atelurinae sp. B3; D, Curculionidae sp. B4; E, Trichorhinae sp. B2; F, Hemitrinemura sp. B2; G, *Mecistocephalus* sp. B1, H, Blattidae sp.; I, Araneomorphae sp. B4

Table 5.2. Troglofauna distribution at Koolyanobbing. Sites are grouped geographically and displayed left to right (see Figure 4.2 for locations). Number of animals collected at a site is shown (number of bores yielding in parentheses). Note that D and E Deposit are grouped, as are I and J Deposit, owing to their close proximity to each other

	B-Pit	C-Pit	D-E Deposit	I-J Deposit	F Deposit
Polyxenida sp. B1	2(2)				
Juliforma sp. B2			1		
Mecistocephalus sp. B1		1			
Australoschendyla sp. B3					3(1)
Araneomorphae sp. B4		2(2)		1	
Araneomorphae sp. B8				1	
Philosciidae					2(2)
Philosciidae sp. B4		41(6)	7(3)	34(3)	4(4)
Troglarmidillo sp. B1					5(2)
Buddelundia sp. B1				1	12(2)
Trichorhinae sp. B2		1		2(2)	9(6)
Hanseniella sp. B3			1		1
Japygidae sp. B8					1
Hemitrinemura sp. B2		1		2(2)	1
Atelurinae sp. B3	1				
Blattidae sp.[1]		1			
Meenoplidae sp. B1					1
Curculionidae sp. B4		1			
Pselaphinae sp. B3					1
Number of samples	**46**	**58**	**13**	**8**	**30**
Number of bores	**23**	**29**	**13**	**8**	**30**

[1] Possibly troglobytic

The overall capture rate of troglofauna at Koolyanobbing was 0.91 animals per sample. There was considerable variability in capture rate among study areas. The capture rate was very low in B Pit at 0.07 animals per sample, while C Pit returned 0.83 animals per sample. In the reference areas, capture rates were: D Deposit 0.82, E Deposit 0, F Deposit 1.33, I Deposit 5.57, and J Deposit 2.0. Much of the variability could be explained by the low sample size for E, I and J Deposits. The combined capture rate for the 51 reference samples was 1.76, which was greatly elevated by the 34 Philosciidae sp B4 captured from one bore in I Deposit.

5.4 Species Determinations and Troglobitic Assignment

We have classified the bug Meenoplidae sp. B1 as troglofauna because some members of the family occur in caves, where they are troglofauna (Humphreys 2008). However, many members of the family are inquiline and occur in termite mounds. Meenoplidae sp. is name given to Meenoplidae that are recorded as nymphs. Adult specimens are required to further the taxonomic classification.

Blattidae sp. is a name given to a Blattidae cockroach that was recorded as a nymph. This specimen has reduced eyes and is possibly troglofauna; however, the troglobitic assignment is tentative and adults are required to complete the taxonomic identification and determination of species habits.

6.0 Discussion

6.1 Troglofauna Abundance, Detection and Distribution

In marked contrast to some previous troglofauna work (e.g. Biota 2006 in the Robe Valley in the Pilbara), there was only modest evidence of species being tightly restricted to the proposed mine areas At Koolyanobbing. All but two confirmed troglobitic species that were recorded within the proposed mine pits are recorded from beyond the pit boundary. These two species were singletons, namely, the centipede *Mecistocephalus* sp. B1 at C Pit and the silverfish Atelurinae sp. B3 at B Pit. Note that because of the uncertainty about the status of the Blattidae sp. nymph it has not been treated as restricted troglofauna.

It appears very likely that *Mecistocephalus* sp. B1 extends beyond the proposed C Pit because:

- The pattern of occurrence of other troglofauna species at C Pit was wide-ranging, indicating that species are using the habitat connectivity to extend their ranges and *Mecistocephalus* sp. B1 is expected to conform with this pattern;
- There is considerable evidence of similar troglofauna habitat extending beyond the proposed mine pits (Section 2.0, Section 6.2);
- The singleton record of *Mecistocephalus* sp. B1 is more likely evidence of the species having low-abundance than very highly restricted occurrence;
- Curculionidae sp. B4, the other species apparently 'restricted' to the proposed C Pit according to current information, is known to occur much more widely at Mount Jackson 80 km away (Table 5.1); and
- The occurrence of five singleton species in the reference sampling areas indicates that low-abundance species occur throughout the study site and not just in proposed mine pits.

It is also likely that Atelurinae sp. B3 extends beyond the proposed B Pit for the same reasons as given above in relation to *Mecistocephalus* sp. B1 and C Pit although troglofauna were depauperate at B Pit and there is limited information on which to base the species component of an assessment of troglofauna at the deposit. Relevant information is that:

- The troglofauna community at B Pit consisted of only three animals of two species and is depauperate;
- Polyxenida sp. B1, the only other species recorded at B Pit is known to occur at Mount Jackson 80 km away (Table 5.1); and
- Apparently restricted species are frequently shown to be more widespread after intensive sampling in appropriate habitats in a range of seasons (Camacho & Valdecasas 2008).

It appears likely that *Mecistocephalus* sp. B1 and Atelurinae sp. B3 are low-abundance species with a range that will be defined only after very extensive sampling. Troglobitic singleton species of centipedes and silverfish have been recorded previously (Bennelongia, 2008a). The ability to detect subterranean fauna is inversely related to abundance (Eberhard et al. 2008), so that many more sampling events are required to collect species that occur in low numbers compared to abundant species. Only the distributions of abundant species are likely to have been documented well within the Koolyanobbing Range to date.

The troglofauna community at Koolyanobbing displays a typical species abundance pattern, with few relatively abundant species and a tail of singletons species that are likely to occur at very low density (Figure 5.1, Magurran & Henderson 2003). Defining the distributions of these singletons represents a perennial biological problem that requires much more extensive sampling than is required to characterise the community (Miller et al. 1989, Guisan et al. 2006). This is a level of sampling beyond that recommended routinely in Environmental Protection Authority guidelines (EPA 2007).

6.2 Troglofauna Distribution and Habitat

The distribution of species depends largely on the availability of habitat. In this study there is evidence of troglofauna habitat, similar to that in the proposed mine pits, extending along the range around to the south-east of the proposed pits. The diversity of troglofauna in the study area appeared to be almost three times greater outside the mine pits than within them (Table 5.1). Furthermore, 44% of the species recorded in the study area are known to have distributions extending well beyond the Koolyanobbing Range (Table 5.1). The continuity of the geology between the study site and the strata to the south-east make it likely that troglofauna habitat connectivity occurs between the mine pits (especially C Pit) and surrounding areas (Section 2.0). It is unlikely that the planned C Pit comprises a restricted area of habitat, unlike some previously studied sites e.g. Biota 2006 in the Robe Valley, Pilbara, where species were tightly restricted to single mesas.

The lower yields from impact bores at Koolyanobbing compared to their reference counterparts suggest lower troglofauna abundance and may indicate poorer troglofauna habitat exists within the proposed pits (particularly B Pit) than in surrounding areas. While there is no detailed information on geology and troglofauna habitat use to support the proposition, it appears likely that B Pit is an area of poor grade troglofauna habitat with connections to areas of better habitat. This would account for the very low troglofauna abundance at B Pit and yet the wide occurrence of one of the species present, the millipede Polyxenida sp. B1 (Table 5.1).

6.3 Species Determinations and Troglobitic Assignment

Troglofauna studies are in their infancy and a high proportion of the species collected from little surveyed regions are likely to be new. Consequently, some of the species identifications and troglobitic assignment in this report are preliminary. Identification and other taxonomic issues continue to be worked on and some of the assessments presented here may be revised in future as a result of this work. It is unlikely, however, that any advancement to taxonomic understanding will have major implications for the conservation of species inhabiting the proposed mine pits at Koolyanobbing.

7.0 Conclusion

The sampling effort on which this report was based represents a typical troglofauna survey by current standards. The following conclusions are drawn from the work:

- As a whole, the study site contains a typically diverse troglofauna community comprising 19 possible taxa. The species known to be present include slaters, millipedes, centipedes, spiders, silverfish, beetles, symphylan, cockroaches, bristletails and bugs.
- Results of the survey suggest there is little risk to the survival of any troglofaunal species from developing a mine at C Pit and low risk from mining at B Pit. All but two species recorded within the proposed mine pits are found outside of the pit boundary.

- The species apparently restricted to mine pits, *Mecistocephalus* sp. B1 at C Pit and Atelurinae sp. B3 at B Pit, are known from singleton records, which convey little information about the distribution of the species. It is likely both species occurs more widely, with the currently known distribution being an artefact of their low abundance.
- Distributions of troglofauna species occurring in C Pit suggest that the community at C Pit is not restricted. Five of the seven species present are known to be widespread and a sixth species (represented by a nymph identifiable only to family) belongs to a group that is usually widespread.
- Of the two troglofauna species collected from B Pit, one was widespread. It appears likely that B Pit is connected to other troglofauna habitat and that the community is widespread, though depauperate.

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Appendices

Appendix 1: Bores Sampled at Koolyanobbing

Site name	Bore code	Latitude	Longitude
Pit B	KBRC075	-30.83802778	119.5431667
Pit B	KBRC079	-30.83755556	119.5430833
Pit B	KBRC082	-30.83830556	119.5434722
Pit B	KBRC083	-30.83855556	119.5437778
Pit B	KBRC086	-30.83916667	119.5444444
Pit B	KBRC087	-30.83919444	119.5444444
Pit B	KBRC114	-30.84027778	119.5451667
Pit B	KBRC115	-30.84011111	119.5454722
Pit B	KBRC121	-30.837	119.5427222
Pit B	KBRC134	-30.84038889	119.546
Pit B	KBRC139	-30.83672222	119.5430278
Pit B	KBRC146	-30.83888889	119.5448889
Pit B	KBRC147	-30.83861111	119.5451944
Pit B	KBRC148	-30.83811111	119.5446944
Pit B	KBRC150	-30.83705556	119.5436389
Pit B	KBRC151	-30.83802778	119.54425
Pit B	KBRC153	-30.83744444	119.5448611
Pit B	KBRC154	-30.83736111	119.5440556
Pit B	KBRC155	-30.83688889	119.5426944
Pit B	KBRC003	-30.83938889	119.5469167
Pit B	KBUN004	-30.83675	119.5440556
Pit B	KBUN01	-30.83594444	119.5434444
Pit B	KBUN02	-30.83605556	119.5438889
Pit C	KCRC151	-30.83969444	119.5506944
Pit C	KCDD001	-30.84316667	119.5526389
Pit C	KCDD003	-30.84294444	119.5486667
Pit C	KCRC010	-30.84419444	119.5483611
Pit C	KCRC059	-30.84277778	119.5517778
Pit C	KCRC085	-30.84197222	119.5475
Pit C	KCRC086	-30.84083333	119.5504444
Pit C	KCRC090	-30.84216667	119.5524444
Pit C	KCRC115	-30.84194444	119.5484722
Pit C	KCRC118	-30.84188889	119.54875
Pit C	KDRC125	-30.84344444	119.5518611
Pit C	KCRC126	-30.84355556	119.5532778

Site name	Bore code	Latitude	Longitude
Pit C	KCRC129	-30.84052778	119.5512778
Pit C	KCRC130	-30.84216667	119.5513611
Pit C	KCRC131	-30.84177778	119.5512778
Pit C	KCRC132	-30.84133333	119.5512222
Pit C	KCRC133	-30.84102778	119.5513056
Pit C	KCRC135	-30.84105556	119.5506389
Pit C	KCRC136	-30.84105556	119.5502222
Pit C	KCRC138	-30.84169444	119.5502222
Pit C	KCRC139	-30.84122222	119.5497778
Pit C	KCRC144	-30.84497222	119.5488611
Pit C	KCRC145	-30.84452778	119.5494722
Pit C	KCRC148	-30.84347222	119.5475556
Pit C	KCRC149	-30.84377778	119.5475556
Pit C	KCRC153	-30.83980556	119.5500278
Pit C	KCRC154	-30.84038889	119.5501111
Pit C	KCRC157	-30.8415	119.5492222
Pit C	KCRC159	-30.84202778	119.5497222
D Deposit	KDRC0001	-30.84321667	119.5582
D Deposit	KDRC004	-30.8442	119.5585833
D Deposit	KDRC006	-30.84481667	119.5593
D Deposit	KDRC007	-30.84513333	119.55965
D Deposit	KDRC010	-30.84603333	119.5609167
D Deposit	KDRC012	-30.84716667	119.5617667
D Deposit	KDRC013	-30.843525	119.5585833
D Deposit	KDRC014	-30.84383333	119.5589833
D Deposit	KDRC015	-30.84411667	119.5592833
D Deposit	KDRC016	-30.84448333	119.5596833
D Deposit	KDRC025	-30.84355	119.5578167
E Deposit	KERCUNK01	-30.84891667	119.5639278
E Deposit	KERCUNK02	-30.84861667	119.5656167
F Deposit	KFDD03	-30.8757	119.61275
F Deposit	KFRC017	-30.87041667	119.6041
F Deposit	KFRC062	-30.87488333	119.60835
F Deposit	KFRC117	-30.87613333	119.6117167
F Deposit	KFRC130	-30.87521667	119.6105
F Deposit	KFRC188	-30.87488333	119.6101833
F Deposit	KFRC189	-30.8746	119.6096167
F Deposit	KFRC191	-30.87626667	119.6148
F Deposit	KFRC200	-30.8739	119.6078
F Deposit	KFRC206	-30.8728	119.6068167

Site name	Bore code	Latitude	Longitude
F Deposit	KFRC207	-30.87271667	119.6064167
F Deposit	KFRC219	-30.86975	119.60295
F Deposit	KFRC220	-30.87575	119.60875
F Deposit	KFRC222	-30.86936667	119.6037667
F Deposit	KFRC225	-30.8741	119.6106667
F Deposit	KFRC227	-30.86971667	119.6048833
F Deposit	KFRC228	-30.86951667	119.6043333
F Deposit	KFRC229	-30.87085	119.60605
F Deposit	KFRC230	-30.8714	119.60605
F Deposit	KFRC232	-30.87251667	119.60835
F Deposit	KFRC235	-30.87502222	119.6142167
F Deposit	KFRC237	-30.87191667	119.6069
F Deposit	KFRC239	-30.8713	119.60465
F Deposit	KFRC242	-30.87023333	119.6044833
F Deposit	KFRC246	-30.87708333	119.6129
F Deposit	KFRC247	-30.87146667	119.60455
F Deposit	KFRCUNK01	-30.87791667	119.6145333
F Deposit	KFRCUNK02	-30.8775	119.61435
F Deposit	KFRCUNK03	-30.86968333	119.6035
F Deposit	PHF123	-30.87206667	119.6049833
I Deposit	KIRC002	-30.86128333	119.5923167
I Deposit	KIRC003	-30.86101667	119.5924333
I Deposit	KIRC009	-30.86241667	119.59405
I Deposit	KIRC013	-30.86268333	119.5948
I Deposit	KIRC014	-30.86295	119.5953833
I Deposit	KIRC018	-30.86005	119.5921167
I Deposit	KIRC021	-30.86013333	119.5914667
J Deposit	KJRC002	-30.85661667	119.5770333