A detailed description of each species including behavior, habitat preferences and distribution is provided in Outback Ecology (2012).

4.3.1. Threatened Species

There are eight threatened fauna species (as defined under the EPBC Act or the WC Act) that have the potential to occur within the Study area: Night Parrot (*Pezoporus occidentalis*), Northern Quoll (*Dasyurus hallucatus*), Mulgara (*Dasycercus blythi*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*), Pilbara Olive Python (*Liasis olivaceus barroni*), Peregrine Falcon (*Falco peregrinus*) and Woma (*Aspidites ramsayi*) (**Table 3**).

Table 3: Threatened fauna species potentially occurring within the Study area

Common name (*Scientific name*)	**Likelihood**	**Conservation Status**		**No of previous surveys recorded**	**No. of database searches recorded**	**Reason for likelihood**
		EPBC Act[1]	**WC Act[2, 3]**			
Mammals						
Northern Quoll (*Dasyurus hallucatus*)	Confirmed	EN	S1	9	3	recorded within the Study area during previous surveys
Brush-tailed Mulgara (*Dasycercus blythi*)	Possible	VU	S1	6	2	recorded within the Study area during previous survey but not in habitats occurring within the Project footprint
Greater Bilby (*Macrotis lagotis*)	Possible	VU	S1	2	1	marginal habitat within Study area, recent records within surrounding region
Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*)	Confirmed	VU	S1	5	3	recorded within the Study area during previous surveys
Birds						
Night Parrot (*Pezoporus occidentalis*)	Possible	EN / M	S1	1	-	presence of apparently suitable habitat, recent records within surrounding region, rarely detected species
Peregrine Falcon (*Falco peregrinus*)	Likely	-	S4	6	2	presence of suitable habitat, recent records adjacent to Study area, patchily distributed
Reptiles						
Pilbara Olive Python (*Liasis olivaceus barroni*)	Very Likely	VU	S1	4	2	presence of suitable habitat, recent records adjacent to Study area
Woma (*Aspidites ramsayi*)	Possible	-	S4	1	-	presence of suitable habitat, recent records in surrounding region, patchily distributed species

4.3.2. Priority Species

Ten listed Priority species have the potential to occur within the Project footprint (**Table 4**). Five of these species were recorded within or near the Project footprint during previous surveys: Ghost Bat (*Macroderma gigas*), Spectacled Hare-wallaby (*Lagorchestes conspicillatus* subsp*. leichardti),* Western Pebble-mound Mouse (*Pseudomys chapmani*), Australian Bustard (*Ardeotis australis*) and Bush Stone-curlew (*Burhinus grallarius*). It is unknown whether the Spotted Ctenotus (*Ctenotus uber johnstonei*) or Pin-striped Finesnout Ctenotus (*Ctenotus nigrilineatus*) occur due to a paucity of data on these species.

Table 4: Priority species recorded or with the potential to occur within the Study area

Common name (*Scientific name*)	**Likelihood**	**Conservation Status**		**No of previous surveys recorded**	**No. of database searches recorded**	**Reason for likelihood**
		EPBC Act[1]	**WC Act**[2, 3]			
Mammals						
Ghost Bat (*Macroderma gigas*)	Confirmed	-	P4	8	2	recorded within the Study area during previous survey
Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*)	Confirmed	-	P3	3	2	marginal habitat within Study area, recorded within the Study area during previous survey
Western Pebble-mound Mouse (*Pseudomys chapmani*)	Confirmed	-	P4	11	2	recorded within the Study area during previous surveys
Long Tailed Dunnart (*Sminthopsis longicaudata*)	Possible	-	P4	1	-	presence of suitable habitat, few records in surrounding region, patchily distributed species
Lakeland Downs Mouse (*Leggadina lakedownensis*)	Likely	-	P4	3	1	presence of suitable habitat, several recent records in surrounding region, patchily distributed species
Mangrove Freetail-bat *(Mormopterus cobourgiana)*	Unlikely	-	P1	1	-	no suitable habitat within Study area
Birds						
Australian Bustard (*Ardeotis australis*)	Confirmed	-	P4	10	3	recorded within the Study area during previous survey
Bush Stone-curlew (*Burhinus grallarius*)	Confirmed	-	P4	8	3	recorded within the Study area during previous survey
Grey Falcon (*Falco hypoleucos)*	Possible	-	P4	3	2	presence of suitable habitat, recent records in surrounding region, patchily distributed species
Western Star Finch (*Neochima*	Possible	-	P4	3	-	presence of suitable habitat, few recent records in

Common name (*Scientific name*)	Likelihood	Conservation Status		No of previous surveys recorded	No. of database searches recorded	Reason for likelihood
		EPBC Act[1]	WC Act[2, 3]			
ruficauda subclarescens)						surrounding region
Eastern Curlew (*Numenius madagascariensis*)	Unlikely	-	P4	1	1	no suitable habitat within the Study area
Flock Bronzewing (*Phaps histrionica*)	Unlikely	-	P4	-	1	presence of suitable habitat, towards periphery of species range, patchily distributed species
Reptiles						
Ramphotyphlops ganei	Possible	-	P1	1	1	presence of suitable habitat, recent records in surrounding region, ecology and habitat preferences poorly known
Spotted Ctenotus *(Ctenotus uber johnstonei)*	Unknown	-	P2	4	-	few records for this species, ecology and habitat preferences poorly known
Pin-striped Finesnout Ctenotus *(Ctenotus nigrilineatus)*	Unknown	-	P2	1	1	few records for this species, ecology and habitat preferences poorly known

4.3.3. Migratory Bird Species

Migratory species are listed under the EPBC Act and international agreements. The database searches and literature review identified 26 migratory species that have the potential to occur within the Project footprint (**Table 5**). Of these, 24 were considered unlikely to occur within the Project footprint and are excluded from further consideration. The three migratory species with potential to occur were Fork-tailed Swift (*Apus pacificus*), Rainbow Bee-eater (*Merops ornatus*) and Night Parrot (*Pezoporus occidentalis*), described in Outback Ecology (2012).

Table 5: Migratory bird species recorded or with the potential to occur within the Project footprint

Common name (*Scientific name*)	Likelihood	Conservation Status		No of previous surveys recorded	No. of database searches recorded	Reason for likelihood
		EPBC Act[1]	WC Act[2]			
Common Sandpiper (*Actitis hypoleucos*)	Unlikely	M	S3	1	1	no suitable habitat within the Study area
Fork-tailed Swift (*Apus pacificus*)	Likely	M	S3	3	2	Aerial species, may occur within Study area
Cattle Egret (*Ardea ibis*)	Unlikely	M	S3	-	2	no suitable habitat within the Study area
Ruddy Turnstone (Arenaria interpres)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Curlew Sandpiper (*Calidris ferruginea*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Red-necked Stint (*Calidris ruficollis*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Long-toed Stint (*Calidris subminuta*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Greater Sand Plover (*Charadrius leschenaultii*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Oriental Plover (*Charadrius veredus*)	Unlikely	M	S3	-	2	no suitable habitat within the Study area
White-winged Black Tern (*Chlidonias leucopterus*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Eastern Reef Egret (*Egretta sacra*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Oriental Pratincole (*Glareola maldivareum)*	Unlikely	M	S3	-	2	no suitable habitat within the Study area
White-Bellied Sea Eagle (*Haliaeetus leucogaster*)	Unlikely	M	S3	-	2	no suitable habitat within the Study area
Barn Swallow (*Hirundo rustica*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Caspian Tern (*Hydroprogne caspia*)	Unlikely	M	S3	1	1	no suitable habitat within the Study area

Common name (*Scientific name*)	Likelihood	Conservation Status		No of previous surveys recorded	No. of database searches recorded	Reason for likelihood
		EPBC Act[1]	WC Act[2]			
Rainbow Bee-eater (*Merops ornatus*)	Confirmed	M	S3	12	3	recorded during previous surveys of the Study area
Eastern Curlew (*Numenius madagascariensis*)	Unlikely	M	S3	1	1	no suitable habitat within the Study area
Whimbrel (*Numenius phaeopus*)	Unlikely	M	S3	2	1	no suitable habitat within the Study area
Night Parrot (*Pezoporus occidentalis*)	Possible	EN / M	S1	1	-	presence of apparently suitable habitat, recent records within surrounding region, rarely detected species
Glossy Ibis (*Plegadis falcinellus*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Pacific Golden Plover (*Pluvialis fulva*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Lesser Crested Tern (*Thalasseus bengalensis*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area
Grey-tailed Tattler (*Tringa brevipes*)	Unlikely	M	S3	1	1	no suitable habitat within the Study area
Wood Sandpiper (*Tringa glareola*)	Unlikely	M	S3	1	1	no suitable habitat within the Study area
Common Greenshank (*Tringa nebularia*)	Unlikely	M	S3	1	1	no suitable habitat within the Study area
Marsh Sandpiper (*Tringa stagnatilis*)	Unlikely	M	S3	-	1	no suitable habitat within the Study area

5. POTENTIAL IMPACTS

5.1. Threatening Processes

Threatening processes relevant to the Pilbara bioregion have been identified during the Australian Natural Resources Audit (Australian Natural Resources Atlas 2009) and include feral predators, inappropriate fire regimes, grazing by introduced herbivores, and invasive weeds.

Threatening processes associated with the Project are categorised by having either direct or indirect impacts. Direct impacts of the Project include:

- habitat removal and modification; and
- inadvertent mortality, eg. collision with vehicles, drowning, poisoning.

Indirect impacts of the Project include:

- altered hydrology;
- noise and vibration;
- artificial light exposure;
- dust emissions;
- introduced flora; and
- introduced fauna.

5.2. Habitat Removal And Modification

Fauna habitat loss as a direct result of land clearing is considered one of the primary impacts on terrestrial fauna. Land clearance is listed as a Key Threatening Process under the EPBC Act. It is likely that sedentary fauna currently residing within areas to be cleared would be lost and more mobile fauna would be displaced.

Land clearing represents the most direct impact on habitats and fauna assemblages present within the Project footprint. Although mobile fauna may be able to avoid direct impact from operations, the degree of subsequent impact is dependent on the availability of suitable habitat elsewhere in the vicinity and the ability of species to disperse to these habitats. Nesting birds and their young may also be directly impacted. This potential impact can be reduced by timing of clearance activities to avoid nesting periods.

The development of the Project will result in the loss of approximately 178 ha of habitat via land clearance. This will impact on the five habitat types described in **Section 4.1** primarily through habitat removal. Of these habitat types, Spinifex Stony Plains, Rocky Foothills and Scree Slope habitat types will be subject to the greatest direct impact from clearance activities. While the extent of clearing in Drainage Line and Rocky Ridges and Gorges habitats is small, these habitat types are of high value in supporting conservation significant species (**Table 2, Figure 6**). Habitats are discussed below in terms of the degree, nature and implication of impacts on them.

5.2.1. Spinifex Stony Plain

Approximately 69.5 ha (39.0%) of the Project footprint lies in Spinifex Stony Plain habitat. The ability of this habitat to support fauna assemblages is linked to fire regime and the presence of large, mature hummocks of spinifex. This is a habitat element of importance to the conservation significant Bilby (Vulnerable - EPBC Act, Schedule 1 – WC Act), Spectacled Hare-wallaby (Priority 3) and Brush-tailed Mulgara (Priority 4). Although these species are more commonly associated with the Spinifex Sandplain habitat type, they have also been reported from Spinifex Stony Plain habitats. Conservation significant species that may also occur in this habitat included the Australian Bustard (*Ardeotis australis*), Bush Stone-curlew (*Burhinus grallarius*) and the Rainbow Bee-eater (*Merops ornatus*). Mounds of the Western Pebble-mound Mouse (*Pseudomys chapmani*) may be recorded where stony pebbles and gravel occur.

Spinifex Stony Plain habitat is widespread around the Project footprint and in the broader landscape (**Table 2, Figure 6**). This habitat type is well connected in the broader landscape and progressive clearing of vegetation is likely to allow fauna occurring within the proposed Project footprint to disperse to adjacent areas of equivalent habitat. Furthermore, as this habitat is extensive in the local area (2,689 ha in the Study area) and regional surrounds, removal or modification of 69.5 ha is considered a low impact on a regional scale.

5.2.2. Rocky Foothills;

Approximately 56.9 ha (31.9%) of the Project footprint occurs in Rocky Foothills habitat. The habitat consists of those hills that do not commonly feature ridges, caves and gorges and hence do not tend to possess microclimates that are favourable to fauna species. Conservation significant species that may occur within this habitat type include the Australian Bustard (*Ardeotis australis*), Bush Stone-Curlew (*Burhinus grallarius*) and the Western Pebble-mound Mouse (*Pseudomys chapmani*).

The Rocky Foothills habitat type forms part of the Capricorn land system, which is well represented throughout the surrounding landscape (**Table 2, Figure 6**). This habitat type is well connected in the broader landscape and progressive clearing of vegetation is likely to allow fauna occurring within the proposed Project footprint to disperse to adjacent areas of equivalent habitat. This habitat type is extensive in the local area (2,487 ha in the Study area) and the region. Removal or modification of 56.9 ha is considered a low impact on a regional scale.

5.2.3. Scree Slope

Approximately 48.9 ha (27.4%) of the Project footprint occurs in Scree Slope habitat. Scree Slope habitat forms part of the Capricorn land system, which is not typically utilised for pastoralism, resulting in much of this habitat remaining in good condition in the region (Van Vreeswyk *et al.* 2004). The conservation significant Western Pebble-mound Mouse (*Pseudomys chapmani*) is commonly detected in this habitat via its characteristic mounds (How *et al.* 1991). Other conservation significant species likely to occur within this habitat include the Australian Bustard (*Ardeotis australis*) and Rainbow Bee-eater (*Merops ornatus*).

This habitat type is extensive in the local area (1,416 ha in the Study area) and the region (**Table 2, Figure 6**). The removal or modification of 48.9 ha is considered a low impact on a regional scale.

5.2.4. Drainage Line

Drainage Line habitat consists of rivers, creeks and minor watercourses. It is subject to regular flooding, is typically less than 20 m in width and often supports a thin band of Eucalyptus and Acacia species as well as isolated groups of Melaleuca trees and sedges. Drainage Line habitat may support soft spinifex and buffel grass (*Cenchrus ciliaris* – an introduced weed), which is considered palatable to livestock, often leading to degradation from grazing (Van Vreeswyk *et al.* 2004).

Drainage Line habitat represents important habitat for fauna as it provides a range of microhabitats and a stable source of resources (How *et al.* 1991). More specifically, nectarivorous avifauna benefit from the flowering plants that line the banks of drainage lines (Burbidge *et al.* 2010) and mammal and reptile fauna may congregate around permanent water pools (How *et al.* 1991). In particular, amphibian species would be most likely to occur within this habitat type. The linear arrangement provides linkages between other more permanent sources of food and water (How *et al.* 1991) and the habitat is therefore important for allowing fauna to move throughout the landscape. For example, migratory bird species are known to use Drainage Line habitat as a conduit for movement (Bamford *et al.* 2008, Storr 1984).

Conservation significant species that may occur within this habitat type include the Northern Quoll (*Dasyurus hallucatus*), Australian Bustard (*Ardeotis australis*) and Bush Stone-curlew (*Burhinus grallarius*).

Approximately 2.5 ha (1.4%) of the Project footprint lies in this habitat type (**Table 2, Figure 6**). This habitat type is well connected in the broader landscape and progressive clearing of vegetation is likely to allow fauna occurring within the proposed Project footprint to disperse to adjacent areas of equivalent habitat. 215 ha of this habitat type was identified in the Study area. The habitat is of high value to fauna and not extensive in the landscape; however, the area lying within the footprint is small. The removal or modification of 2.5 ha is considered a low impact on a regional scale.

5.2.5. Rocky Ridges and Gorges.

Approximately 0.4 ha (0.25%) of the Project footprint lies in this habitat type, which occurs in patches in and near the Project footprint (**Table 2, Figure 6**). Rocky Ridges and Gorges is relatively uncommon habitat in the broader landscape as it is comprised specifically of those hills featuring outcropping ironstone, fallen boulders, caves, overhangs and crevices.

This habitat type is considered important for fauna and may support a number of species of conservation significance (Bamford Consulting Ecologists 2008, How *et al.* 1991). Ridge habitats provide important breeding habitat and nursery dens for the Northern Quoll (*Dasyurus hallucatus*) (DSEWPaC: Department of Sustainability Environment Water Population and Communities 2011, Hill and Ward 2010, How *et al.* 2009). Gorges provide shelter and water sources for habitat specific species such as the Pilbara Olive Python (*Liasis olivaceus barroni*). Deep, humid caves provide roost habitats for conservation significant bat species, the Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) and Ghost Bat (*Macroderma gigas*). On-ground reconnaissance suggests that much of the habitat within the Project footprint was of marginal quality for these species with deep, substantial caves required by these species for breeding largely absent. Should these species be making use of any minor caves within these areas, it is likely that they would be used as foraging or night roosts only (Outback Ecology 2012).

While this habitat is of high value to conservation significant fauna and is not well connected, there is at least 211 ha of this habitat in the immediate vicinity and the proposed clearing is small. The removal or modification of 0.4 ha is considered a low impact on a regional scale.

5.3. Inadvertent mortality

Transport of ore along the proposed access road would occur on a continuous basis (24 hours per day and seven days per week) for a mine life of eight years. In addition there would be daily light vehicle movements around the site and on the access road. Consequently, vehicle collisions may have a significant impact on local fauna assemblages. The proposed haul road bisects all five habitat types except Rocky Ridges and Gorges (**Figure 6**). Conservation significant species that typically forage at night within these habitats (eg. Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat, Spectacled Hare-wallaby, Brush-tailed Mulgara, Bush Stone-curlew, Australian Bustard) may be at risk when traversing the haul road.

The presence of open bodies of water, including an evaporation pond, sumps and uncovered containers presents a risk of drowning to vertebrate fauna if not properly managed or regularly monitored. Improper management of toxic substances, such as hydrocarbons or chemicals used in processing ore, can lead to individual mortalities.

Incidents of the above typically only involve individuals; however, the cumulative effect they have on small or isolated populations can be significant at a local scale. While the number of species potentially impacted is large, the impacts are restricted to local populations. Without appropriate mitigation actions during construction, operation and post-closure these impacts are likely to be low. With appropriate mitigation actions these could be reduced to a negligible level.

5.4. Indirect Impacts

5.4.1. Altered Hydrology

Availability of water and nutrients is the primary limiting factor in arid and semi-arid environments (James *et al.* 1995). The degree to which ecosystems depend on groundwater and retention of water after substantial rainfall varies with the particular structure and function of that ecosystem, which in turn are likely to vary over time (Hatton and Evans 1998). For example, floodplains, floodouts and riparian fringes are the most productive habitats in the landscape because soils are fertile and water supply is relatively continuous as a result of reliable run-on and accessible ground water.

The vast majority of ecosystems in the Pilbara region do not feature permanently accessible water and numerous species are associated with these relatively infertile parts of the landscape. However, small occurrences of productive, water dependent ecosystems are distributed within the region and these provide critical refuge and habitat for organisms in times of drought (James *et al.* 1995). These ecosystems are typically limited in their extent but they represent a key resource to a diversity of fauna, including vertebrate fauna (Murray *et al.* 2003).

Localised interruption of hydrological flows where the access road corridor bisects Drainage Line habitat may result in changes in water recharge and retention (Nevill *et al.* 2010). Removal of water from this habitat type, or a change in the timing, quantity, quality or distribution of water may impact negatively upon the Drainage Line ecosystem, thereby affecting the fauna assemblages that are dependent upon this habitat type.

5.4.2. Noise and Vibration

The construction of the access road is likely to generate short-term noise and vibration due to general operation of heavy machinery and vehicles. The use of the access road by road trains is anticipated to generate noise and vibration 24 hours per day for a period of eight years. The effects of noise on wildlife have been well studied, although responses vary depending on the species and on the age and sex of the individual animal (for comprehensive summaries see Larkin *et al.* 1996, Radle 2007).

General responses to noise, across a wide variety of animal species, range from interruptions in feeding and resting behaviour to complete abandonment of a habitat area. Noise may lead to reduced population densities in small mammals, nest failure and decreased population densities in birds and abandoning of roost sites and a reduced hunting efficiency in bats due to disturbance of their echolocation system (Slabbekoorn and Ripmeester 2008). Constant levels of noise also interfere with species communication, via acoustic interference (Parris and Schneider 2009). Species that may be especially at risk of disturbed communication are those that use calls to communicate over larger distances, such as the conservation significant Bush Stone-curlew (*Burhinus grallarius*) which is known to occur in the Project footprint.

5.4.3. Artificial Light Exposure

The Project is likely to result in an increase in exposure of fauna to artificial light. Artificial light from night time construction, operation and haulage activities may have detrimental effects on resident bird, mammal and reptile species. It may interfere with biological and behavioural activities that are governed by the length of day or photoperiod, including reproduction, dormancy, foraging and migration (Bradshaw and Holzapfel 2007, Le Corre *et al.* 2002). Bird *et al.* (2004) found that nocturnal mice exposed to artificial light exploited fewer food patches compared to mice exposed to areas of less light, while nocturnal frogs exposed to artificial light have been known to suspend normal feeding and reproductive behaviour (Harder 2002).

Light pollution has also been shown to interfere with timing of songbird choruses, potentially leading to reduction in breeding success or survival (Miller 2006). Excessive light is likely to have an adverse effect on the natural foraging behaviour of bats, in particular the Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) which is attracted to artificial light sources (DSEWPaC 2012).

5.4.4. Dust Emissions

The development and operation of the Project will create dust emissions due to construction, haulage and general traffic activities. Dust emissions may affect surrounding vegetation. High levels of dust have been associated with a reduction in plant growth and productivity, resulting in degradation of the overall ecosystem and an increased risk of disease in plants (Farmer 1993). Dust has also been linked to changes in soil chemistry and the structure of vegetation communities (Farmer 1993). This reduces the quality of fauna habitats and is likely to impact on faunal assemblages within the area, due to a reduction in food resource availability and shelter.

Dust may directly pollute water bodies, such as waterpools in Drainage Line habitat, by increasing turbidity or potentially altering water chemistry. This would affect fauna and flora dependent on these water sources.

5.4.5. Introduced Flora

Environmental weeds may be brought in by mobile equipment during construction and operation of the access road. Weed invasion is widely recognised as having a negative impact on fauna species, as it can fundamentally alter the composition and structure of native vegetation communities (Cowie and Werner 1993, Gordon 1998). Invasion by non-native species typically results in declines in native plant species richness but the response of fauna may be more complicated with individual invasions potentially resulting in increase, decrease or no-change scenarios for different assemblages (Grice 2006). For example, both Smyth et al. (2009) and Binks et al. (2005) found that even at low densities, Buffel Grass (*Cenchrus ciliaris*) affected the composition of ground vegetation, birds and ant fauna, leading to declines in some species.

5.4.6. Introduced Fauna

Introduced fauna (both herbivorous and predatory) cause fundamental changes to ecosystems, and have lead to the decline and extinction of many species in Australia (Abbott 2002, Burbidge and McKenzie 1989, Ford *et al.* 2001, Short and Smith 1994). Of the 19 Key Threatening Processes to native ecosystems and species listed under the EPBC Act, 11 are concerned with introduced flora and fauna.

Project activities may provide additional resources or habitat (eg. food scraps, fresh water, buildings) that may attract and support a greater abundance of feral animals in the area, which in turn may adversely impact on populations of native fauna. Of concern would be an increase in the size of the local population of Feral Cats (*Felis catus*), which are not only a predator of the Northern Quoll (*Dasyurus hallucatus*) but also directly compete for food resources and habitat requirements with this and other species. Introduced predators may also be attracted to the Project area as a result of the scavenging opportunities generated by the presence of road kill along roads.

5.4.7. Indirect Impacts – Summary

The potential impacts described in the section above are varied and have implications for a range of species, including many conservation significant species. The cumulative effect on small or isolated populations can be significant at a local scale and without mitigation actions the impacts would be considered low. At a regional scale, however, the impacts would be considered negligible. If appropriate mitigation actions are undertaken during construction, operation and post-closure then populations of vertebrate fauna are likely to recover to current levels some years following closure and the above indirect impacts are likely to be negligible.

5.5. Impacts On Terrestrial Vertebrate Faunal Assemblages

Database search findings, a review of relevant literature within the surrounding region, and previous surveys in or near the Study area indicated that it is possible that up to of 392 terrestrial vertebrate fauna species occur within the Project footprint, including 53 mammals (44 native), 211 birds, 116 reptiles, five fish and seven amphibian species (Outback Ecology 2012). Review of previous surveys conducted within the Study area suggests that a total of 151 terrestrial vertebrate fauna species may occur within the Study area, including 27 mammals (22 native), 83 birds, 34 reptiles, five fish and two amphibian species.

The majority of these species form assemblages that occur across a variety of the habitats present within and surrounding the footprint. These assemblages are similar to those found in the surrounding landscape, as determined by previous surveys. Land clearance is likely to result in the direct loss of individuals during initial clearance activities; however, those assemblages occurring across a range of habitats or those occurring in widespread habitats are unlikely to be significantly impacted by the Project. Impacts to fauna assemblages may be reduced by considering the timing of land clearing activities and other proposed works.

5.6. Impacts On Species Of Conservation Significance

Based on habitat preference or observed occurrence there are 20 species of fauna of conservation significance that possibly, are likely, very likely or known to occur in the Study area (**Section 4.3**; **Table 6**). It is unknown whether the Spotted Ctenotus (*Ctenotus uber johnstonei*) or Pin-striped Finesnout Ctenotus (*Ctenotus nigrilineatus*) occur in the area.

As the habitat is contiguous between the Project area and the Study area, since the vertebrate species identified are mobile on the scale of the Study area and using the precautionary principle, it is assumed that any species confirmed present in the Study area was also present in the Project footprint.

Predetermined categories (**Table 7**) were used to rank the likely impacts of the Project on these fauna, from both local and regional perspectives (**Table 8**). Impacts were ranked based on the assumption that no management actions or mitigation strategies were to be implemented. The species in this section have been assessed in approximate order of conservation significance and level of impact (highest to lowest).

Recommended management actions and strategies to manage the impacts of the Project on conservation significant fauna are also recommended (**Table 8**). The level of impact on conservation significant fauna is likely to be reduced should the recommended actions and strategies be implemented. More general management recommendations for fauna habitats and native fauna assemblages are provided later in this report (**Section 6**).

Table 6: Species of conservation significance potentially occurring in the Study area

Common name (*Scientific name*)	**Likelihood**	**Conservation Status**	
		EPBC Act	**WC Act**
Northern Quoll (*Dasyurus hallucatus*)	Confirmed	EN	S1
Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*)	Confirmed	VU	S1
Pilbara Olive Python (*Liasis olivaceus barroni*)	Very Likely	VU	S1
Bilby (*Macrotis lagotis*)	Possible	VU	S1
Brush-tailed Mulgara (*Dasycercus blythi*)	Possible	VU	S1
Peregrine Falcon (*Falco peregrinus*)	Likely	-	S4
Woma (*Aspidites ramsayi*)	Possible	-	S4
Ramphotyphlops ganei	Possible	-	P1
Spectacled Hare-wallaby (*Lagorchestes conspicillatus leichardti*)	Possible		P3
Ghost Bat (*Macroderma gigas*)	Confirmed	-	P4
Long Tailed Dunnart (*Sminthopsis longicaudata*)	Possible	-	P4
Lakeland Downs Mouse (*Leggadina lakedownensis*)	Likely	-	P4
Western Pebble-mound Mouse (*Pseudomys chapmani*)	Confirmed	-	P4
Australian Bustard (*Ardeotis australis*)	Confirmed	-	P4
Grey Falcon (*Falco hypoleucos)*	Possible	-	P4
Bush Stone-curlew (*Burhinus grallarius*)	Confirmed	-	P4
Fork-tailed Swift (*Apus pacificus*)	Likely	M	S3
Rainbow Bee-eater (*Merops ornatus*)	Confirmed	M	S3
Night Parrot (*Pezoporus occidentalis*)	Possible	EN, M	S1
Star Finch (Western) (*Neochima ruficauda*)	Possible	-	P4

EPBC Act: EN – Endangered, VU – Vulnerable, M – Migratory
WC Act: S1 – Schedule 1 Rare or likely to go extinct, Schedule 3 - DEC Priority List, P1 – Priority 1, P3 – Priority 3, P4 – Priority 4

Table 7: Ranking criteria for Project impacts on fauna of conservation significance

Impact	Description	
	Localised impact (in the Project footprint or surrounding 10 km)	**Regional impact (in the surrounding 150 km)**
Negligible	No perceived effect on population	No perceived effect on species
Minimal	No population decline expected	No species decline expected
Low	Short-term population decline expected within Application Area (recovery expected after life of the Project)	Short-term species decline expected within the region (recovery expected after life of the Project)
Moderate	Permanent population decline expected – no perceived threat to population persistence	Permanent species decline expected – no perceived threat to regional conservation status of species
High	Permanent population decline expected – persistence of local population threatened	Permanent species decline expected – resulting in a change in conservation status of species
Extreme	Local population extinction likely	Regional extinction likely

Table 8: Impacts on conservation significant species and suggested management actions

<table>
<tr><th rowspan="2">Common name</th><th rowspan="2" colspan="2">Species name</th><th colspan="2">Conservation status</th><th rowspan="2">Likelihood of occurrence in Project footprint</th></tr>
<tr><th>EPBC[1]</th><th>In WA[2]</th></tr>
<tr><td>Northern Quoll</td><td colspan="2">Dasyurus hallucatus</td><td>EN</td><td>S1</td><td>Confirmed</td></tr>
<tr><td colspan="2">Localised impact: LOW
• Optimal habitat for the Northern Quoll comprises deep gullies and gorges, often with permanent water; a small amount of this habitat type (Rocky Ridges and Gorges) occurs within the Project footprint. Drainage Line habitat may also support permanent residents with denning sites in tree hollows
• The Scree Slopes, Rocky Foothills (and to a lesser degree Spinifex Stony Plains) habitat types in the Project footprint are unlikely to support permanent residents of this species but do represent suitable foraging habitat
• Clearing of the Project footprint would result in loss of 0.4 ha of potential denning/shelter habitat. The remainder of the Project footprint (177.9 ha) may be considered foraging habitat
• Alteration of the quality of Drainage Line habitat may have implications for the quality of adjacent foraging habitat
• There is increased potential for road kill of individuals during night-time hours
• Impacts on behaviour of local populations due to dust, noise and light emissions</td><td colspan="2">Regional impact: MINIMAL
• Extent of habitat within Project footprint (0.4 ha) is small relative to available habitat in the Study area (211 ha) and wider region
• Potential Northern Quoll habitat identified within the Project footprint is not well-connected with the surrounding landscape
• Clearing associated with the Project will directly impact habitat identified as optimal for supporting populations of Northern Quolls (Rocky Ridges and Gorges)</td><td colspan="2">Suggested management actions
• Create and implement a Significant Species Management Plan that contains specific management actions for the Northern Quoll
• Maintain refugia in Rocky Ridges and Gorges habitat
• Facilitate egress by Northern Quolls along linear habitats bisected by the proposed access road through construction of culverts and fencing
• Monitor the outcome of any egress measures installed, using appropriate techniques in accordance with DEC and the Commonwealth Department of Sustainability, Environment, Water, Population and Communities guidelines (eg. periodic monitoring using motion-sensor cameras for the life of the Project)
• Install egress matting in evaporation pond and keep all fluid containers lidded
• Remove or reduce traffic and lower speed limits of traffic in Project area during night-time
• Monitor and control feral animals and feral predators
• Educate site personnel and contractors regarding the conservation status of the Northern Quoll
• Report any incident that results in injury to or death of a Northern Quoll to the DEC and retain specimens (frozen) for further examination by the DEC and the WA Museum</td></tr>
<tr><td>Pilbara Leaf-nosed Bat</td><td colspan="2">Rhinonicteris aurantia</td><td>VU</td><td>S1</td><td>Confirmed</td></tr>
<tr><td colspan="2">Localised impact: MINIMAL
• The Pilbara Leaf-nosed Bat roosts in abandoned shafts of the Lalla Rookh mine, 10 km northeast of the Project, and individuals would be expected to forage widely within the Project footprint (Outback Ecology 2012). Caves in the Rocky Ridges and Gorges habitat type may be used by the species for foraging but not for roosting
• There is potential for road kill of individuals during night operations
• Artificial light may influence Pilbara Leaf-nosed Bats, as they are likely to be attracted to light sources</td><td colspan="2">Regional impact: NEGLIGIBLE
• Impacts may result in individual deaths and a small amount of localised foraging habitat loss. Foraging habitat within the Project footprint is small relative to available foraging habitat in the wider region</td><td colspan="2">Suggested management actions
• To reduce the impact of artificial light on this species during the night, position lights to illuminate areas such as pathways and roads, rather than the habitat and night sky
• Educate personnel and contractors regarding the conservation status of the Pilbara Leaf-nosed Bat
• Remove or reduce, and/or lower speed limits of, nocturnal traffic in Project area (especially between dusk and midnight)
• Any incident that results in injury to or death of a Pilbara Leaf-nosed Bat should be reported to the DEC and specimens should be retained (frozen) for further examination by the DEC and the WA Museum (WAM)</td></tr>
</table>

<table>
<tr><th>Common name</th><th>Species name</th><th colspan="2">Conservation status</th><th>Likelihood of occurrence in Project footprint</th></tr>
<tr><td>Pilbara Olive Python</td><td>Liasis olivaceus barroni</td><td>VU</td><td>S1</td><td>Very Likely</td></tr>
<tr><td colspan="2">Localised impact: MINIMAL
• Optimal habitat for the Pilbara Olive Python comprises deep gullies and gorges, with permanent water; a small amount of this habitat type (Rocky Ridges and Gorges and Drainage Line) occurs within the Project footprint
• Alteration of the quality of Drainage Line habitat within the Project footprint may have implications for the quality of adjacent Drainage Line habitat and water sources that this species relies upon
• There is increased potential for road kill of individuals during night-time hours, especially where access road infrastructure intersects Drainage Line habitat</td><td colspan="2">Regional impact: NEGLIGIBLE
• Although it is patchily distributed, the Pilbara Olive Python is widespread across the Pilbara
• Although optimal habitat for the Pilbara Olive Python occurs at intermittent, isolated locations, it is not uncommon in the wider region
• Localised habitat loss will occur in the Drainage Line habitat type, but the extent of this habitat type within the Project footprint (2.5 ha) is small relative to available habitat within the Study Area (215 ha) and the wider region</td><td>Suggested management actions
• Minimise removal of, and interference with the hydrology of, Drainage Line and Rocky Ridge and Gorges habitats
• Remove or reduce traffic and lower speed limits of traffic in Project area during night-time, especially in Drainage Line habitat
• Educate site personnel and contractors regarding the conservation status of the Pilbara Olive Python
• Any incident that results in injury to or death of a Pilbara Olive Python should be reported to the DEC, and specimens should be retained (frozen) for further examination by the DEC and the WAM
• When encountered in areas close to infrastructure, authorised snake handlers should relocate Pilbara Olive Pythons to undisturbed areas of suitable habitat</td></tr>
<tr><td>Woma</td><td>Aspidites ramsayi</td><td></td><td>S4</td><td>Possible</td></tr>
<tr><td colspan="2">Localised impact: MINIMAL
• There is increased potential for road kill of individuals, particularly during night-time hours, but also during the day
• There will be some localised habitat loss for the Woma, with direct mortality possible</td><td colspan="2">Regional impact: NEGLIGIBLE
• Habitat within Project footprint is small relative to available habitat in the wider region
• The species is thought to be widespread in the Pilbara region, and it is the south-western (Wheatbelt) population that is thought to be rare</td><td>Suggested management actions
• Low speed limits of daytime traffic in the Project area
• Remove or reduce nocturnal traffic and lower speed limits of nocturnal traffic in Project area
• Educate site personnel and contractors regarding the conservation status of the Woma
• When encountered in areas close to infrastructure, authorised snake handlers should relocate Womas to undisturbed areas of suitable habitat</td></tr>
<tr><td>Spectacled Hare-wallaby</td><td>Lagorchestes conspicillatus leichardti</td><td></td><td>P3</td><td>Confirmed</td></tr>
<tr><td colspan="2">Localised impact: MINIMAL
• There is increased potential for road kill of individuals, particularly during night-time hours, but also during the day
• Potential habitat loss (i.e. Spinifex Stony Plains habitat – marginal for this species) is minimal and suitable habitats are well represented outside the Project footprint</td><td colspan="2">Regional impact: NEGLIGIBLE
• This species has dispersal capability sufficient to remove itself from the Project area when necessary
• Habitat within Project footprint is small relative to available habitat in the wider region</td><td>Suggested management actions
• Minimise clearing of old-growth spinifex habitats within the Project area
• Implement fire management where possible, ie reduce the scale, frequency and intensity of fires within spinifex habitat
• Monitor and control feral animals and feral predators
• Lower speed limits of daytime traffic in areas of suitable habitat for this species
• Remove or reduce, and/or lower speed limits of nocturnal traffic in areas of suitable habitat for this species
• Educate site personnel and contractors regarding the conservation status of the Spectacled Hare-wallaby
• Report sightings of this species to the DEC</td></tr>
<tr><td>Australian Bustard</td><td>Ardeotis australis</td><td></td><td>P4</td><td>Confirmed</td></tr>
<tr><td colspan="2">Localised impact: LOW
• There is increased potential for road kill of individuals, particularly during daytime hours, but also during the night
• Potential habitat loss is minimal and suitable habitats are well represented outside the Project footprint</td><td colspan="2">Regional impact: MINIMAL
• This species is relatively common within the Pilbara region
• This species has dispersal capability sufficient to remove itself from the Project area when necessary
• Habitat within Project footprint is small relative to available habitat in the wider region</td><td>Suggested management actions
• Educate site personnel and contractors regarding the conservation status of the Australian Bustard
• Implement measures to reduce road kill
• Lower speed limits of daytime traffic in the Project area
• Remove or reduce, and/or lower speed limits of nocturnal traffic in Project area</td></tr>
<tr><td>Bush Stone-curlew</td><td>Burhinus grallarius</td><td></td><td>P4</td><td>Confirmed</td></tr>
<tr><td colspan="2">Localised impact: LOW
• There is increased potential for road kill of individuals, particularly during night operations
• Potential for localised disturbance near operations in the Application Area due to noise</td><td colspan="2">Regional impact: MINIMAL
• Overall habitat loss is likely to be negligible
• There is suitable habitat available in the wider surrounds of the project
• Connectivity of habitat will allow for ready movement of individuals between the Project footprint and the surrounding area</td><td>Suggested management actions
• Educate site personnel and contractors regarding the conservation status of the Bush Stone-curlew
• Implement measures to reduce road kill
• Remove or reduce, and/or lower speed limits of, nocturnal traffic in Project area</td></tr>
<tr><th>Common name</th><th>Species name</th><th colspan="2">Conservation status</th><th>Likelihood of occurrence in Project footprint</th></tr>
<tr><td>Western Pebble-mound Mouse</td><td>Pseudomys chapmani</td><td></td><td>P4</td><td>Confirmed</td></tr>
</table>

<table>
<tr><td colspan="2">Localised impact: MINIMAL</td><td colspan="2">Regional impact: NEGLIGIBLE</td><td colspan="2">Suggested management actions</td></tr>
<tr><td colspan="2">• The Western Pebble-mound Mouse presumably has low ability to disperse ahead of clearing activities (even progressive clearing)
• Mounds are scattered within suitable habitat in the Study area, and it is assumed that the likelihood of individual mounds being cleared is low</td><td colspan="2">• Habitat within Project footprint is small relative to available habitat in the wider region
• The species is widespread in suitable habitat outside of the Project footprint</td><td colspan="2">• Avoid clearing of pebble-mounds
• Record location and status (ie active or inactive) of mounds encountered
• Demarcate mounds encountered and educate site personnel as to their importance</td></tr>
<tr><td>Ghost Bat</td><td>Macroderma gigas</td><td></td><td></td><td>P4</td><td>Confirmed</td></tr>
<tr><td colspan="2">Localised impact: MINIMAL</td><td colspan="2">Regional impact: NEGLIGIBLE</td><td colspan="2">Suggested management actions</td></tr>
<tr><td colspan="2">• The Project is likely to result in clearing of habitat used by this species for foraging but not for roosting
• There is potential for road kill of individuals during night operations
• There is risk of entanglement of Ghost Bats in barbed-wire fencing, if this is used during construction or operation of the Project</td><td colspan="2">• Impacts may result in individual deaths and a small amount of localised foraging habitat loss. Foraging habitat within the Project footprint is small relative to available foraging habitat in the wider region</td><td colspan="2">• To reduce the impact of artificial light on this species, position lights to illuminate designated areas such as pathways and roads, rather than the habitat and night sky
• Educate site personnel and contractors regarding the conservation status of the Ghost Bat
• Remove or reduce, and/or lower speed limits of nocturnal traffic in areas of suitable habitat for this species
• Avoid use of barbed wire; alternatives are suggested by MOLHAR Pty Ltd (2007)
• Any incident that results in injury to or death of a Ghost Bat should be reported to the DEC, and specimens should be retained (frozen) for further examination by the DEC and the WAM</td></tr>
<tr><td>Bilby</td><td>Macrotis lagotis</td><td></td><td>VU</td><td>S1</td><td>Possible</td></tr>
<tr><td colspan="2">Localised impact: MINIMAL</td><td colspan="2">Regional impact: NEGLIGIBLE</td><td colspan="2">Suggested management actions</td></tr>
<tr><td colspan="2">• There is increased potential for road kill of individuals, particularly during night-time hours, but also during the day
• Potential habitat loss (i.e. Spinifex Stony Plains habitat – marginal for this species) is minimal and suitable habitats are well represented outside the Project footprint</td><td colspan="2">• This species has dispersal capability sufficient to remove itself from the Project area when necessary
• Mortality due to localised impacts will represent a negligible decline in the species within the region
• Habitat within the Project footprint is small relative to available habitat in the wider region
• Habitat is well connected, which would support re-colonisation by individuals after the life of the Project</td><td colspan="2">• Minimise clearing of old-growth spinifex habitats within the Project footprint
• Perform pre-clearing searches for burrows of the Bilby and perform exclusion trapping and translocation, where appropriate
• Implement fire management where possible, ie reduce the scale, frequency and intensity of fires within spinifex habitat
• Monitor and control feral animals and feral predators
• Lower speed limits of daytime traffic in the Project area
• Remove or reduce traffic and lower speed limits of traffic in Project area during night-time
• Educate site personnel and contractors regarding the conservation status of the Bilby, and train personnel to recognise the distinctive burrows of this species
• Report sightings of this species or its burrows to the DEC</td></tr>
<tr><td>Brush-tailed Mulgara</td><td>Dasycercus blythi</td><td></td><td>VU</td><td>P4</td><td>Possible</td></tr>
<tr><td colspan="2">Localised impact: MINIMAL</td><td colspan="2">Regional impact: NEGLIGIBLE</td><td colspan="2">Suggested management actions</td></tr>
<tr><td colspan="2">• Mulgara burrows were observed in Spinifex Sandplain habitat adjacent to the Project footprint (Outback Ecology 2012). Spinifex Stony Plains is considered marginal habitat for this species. 69.5 ha of this habitat type will be modified or removed
• There is potential for road kill of individuals, particularly during night-time hours</td><td colspan="2">• The Project is toward the northern edge of the western extremity of the distribution of the Brush-tailed Mulgara (Van Dyck and Strahan 2008)
• Mortality due to localised impacts will represent a negligible decline in the species within the region
• Habitat within the Project footprint is small relative to available habitat in the wider region
• Habitat is well connected, which would support re-colonisation by individuals after the life of the Project
• Recovery of regional population could be expected following conclusion of the Project</td><td colspan="2">• Minimise clearing of old-growth spinifex habitats within the Project footprint
• Perform pre-clearing searches for burrows of the Brush-tailed Mulgara and perform exclusion trapping and translocation as appropriate
• Implement fire management where possible, ie reduce the scale, frequency and intensity of fires within spinifex habitat
• Monitor and control feral animals and feral predators
• Lower speed limits of daytime traffic in the Project area
• Remove or reduce traffic and lower speed limits of traffic in Project area during night-time
• Educate site personnel and contractors regarding the conservation status of the Brush-tailed Mulgara, and train personnel to recognise the distinctive burrows of this species
• Report sightings of this species or its burrows to the DEC</td></tr>
</table>

<table>
<tr><td>Long-tailed Dunnart</td><td>Sminthopsis longicaudata</td><td></td><td>P4</td><td>Possible</td></tr>
<tr><td colspan="2">Localised impact: NEGLIGIBLE
• This species is patchily distributed in arid rocky areas and has been recorded from flat topped hills, plateaus, granite outcrops and rocky scree slopes. Clearing of Rocky Foothills and Scree Slope habitat types make up 105.8 ha. These habitat types are extensive in the landscape and well connected locally. Impacts from removal or modification of habitat are likely to be minimal.</td><td>Regional impact: NEGLIGIBLE
• Connectivity of habitat will allow for ready movement of individuals between the Project and the wider region</td><td colspan="2">Suggested management actions
• None</td></tr>
<tr><td>Peregrine Falcon</td><td>Falco peregrinus</td><td></td><td>S4</td><td>Likely</td></tr>
<tr><td colspan="2">Localised impact: NEGLIGIBLE
• Although the species may forage widely over the Project area, the area is unlikely to contain many suitable nest sites (optimal nesting locations are cliff faces, none of which are within the Project area; tree hollows may also be used)
• The Peregrine Falcon is unlikely to be solely reliant on the foraging habitats provided by the Project area</td><td>Regional impact: NEGLIGIBLE
• Foraging and nesting habitat is widespread across the Pilbara region
• The Peregrine Falcon is widespread across much of Australia, and the Project area comprises only a small portion of its range</td><td colspan="2">Suggested management actions
• Minimise destruction of mature trees with hollows, or potential to bear hollows, whenever possible
• Report sightings of this species to the DEC</td></tr>
<tr><td>Lakeland Downs Mouse</td><td>Leggadina lakedownensis</td><td></td><td>P4</td><td>Likely</td></tr>
<tr><td colspan="2">Localised impact: NEGLIGIBLE
• Many habitats within the Project footprint are capable of supporting this species, but there is only an outside chance of its occurrence within the Project footprint</td><td>Regional impact: NEGLIGIBLE
• Habitat within Project footprint is small relative to available habitat in the wider region</td><td colspan="2">Suggested management actions
• Implement fire management where possible, ie reduce the scale, frequency and intensity of fires within spinifex habitat
• Monitor and control feral animals and feral predators
• Report sightings of this species to the DEC</td></tr>
<tr><td>A species of blind snake</td><td>Ramphotyphlops ganei</td><td></td><td>P1</td><td>Possible</td></tr>
<tr><td colspan="2">Localised impact: NEGLIGIBLE
• Ramphotyphlops ganei is thought to be associated with moist gorge and gully habitats. Only a small amount of habitat within the Project footprint is suitable for this species
• Clearing impacts to this habitat type are likely to be minimal</td><td>Regional impact: NEGLIGIBLE
• No regional impact upon this species is expected</td><td colspan="2">Suggested management actions
• None</td></tr>
<tr><td>Grey Falcon</td><td>Falco hypoleucos</td><td></td><td>P4</td><td>Possible</td></tr>
<tr><td colspan="2">Localised impact: NEGLIGIBLE
• The Grey Falcon has not been previously reported in the Study area
• This is a wide-ranging species that is unlikely to be dependent on habitat within the Project footprint</td><td>Regional impact: NEGLIGIBLE
• Overall habitat disturbance for this species is likely to be negligible</td><td colspan="2">Suggested management actions
• None</td></tr>
<tr><td>Fork-tailed Swift</td><td>Apus pacificus</td><td>M</td><td>S3</td><td>Likely</td></tr>
<tr><td colspan="2">Localised impact: NEGLIGIBLE
• The Fork-tailed Swift is almost entirely aerial; it is therefore not expected to be reliant on habitat within the Project footprint</td><td>Regional impact: NEGLIGIBLE
• No significant impact on this species is expected</td><td colspan="2">Suggested management actions
• None</td></tr>
<tr><td>Rainbow Bee-eater</td><td>Merops ornatus</td><td>M</td><td>S3</td><td>Confirmed</td></tr>
<tr><td colspan="2">Localised impact: NEGLIGIBLE
• The Rainbow Bee-eater is known to be widespread and common throughout the Project footprint and surrounds
• The species occupies a wide variety of habitats within the region</td><td>Regional impact: NEGLIGIBLE
• Widespread and common throughout the region
• No significant impact on this species is expected</td><td colspan="2">Suggested management actions
• None</td></tr>
</table>

<table>
<tr><td>Night Parrot</td><td>Pezoporus occidentalis</td><td>EN, M</td><td>S1</td><td>Possible</td></tr>
<tr><td colspan="2">Localised impact: NEGLIGIBLE
• The habitat of the Night Parrot consists of Triodia grasslands in stony or sandy environments. The impact to Spinifex Stony Plains habitat is considered low</td><td colspan="2">Regional impact: NEGLIGIBLE
• There is suitable habitat available in the wider surrounds of the project
• Connectivity of habitat will allow for ready movement of individuals between the Project footprint and the surrounding area</td><td>Suggested management actions
• None</td></tr>
<tr><td>Star Finch (Western)</td><td>Neochmia ruficauda subclarescens</td><td>-</td><td>P4</td><td>Possible</td></tr>
<tr><td colspan="2">Localised impact: NEGLIGIBLE
• This species occurs in lush, green woodland vegetation along temporary or permanent water courses, the margins of swamps or in green crops. Removal or modification of Drainage Line habitat is considered minimal</td><td colspan="2">Regional impact: NEGLIGIBLE
• There is suitable habitat available in the wider surrounds of the project
• Connectivity of habitat will allow for ready movement of individuals between the Project footprint and the surrounding area</td><td>Suggested management actions
• None</td></tr>
</table>

6. GENERAL MANAGEMENT RECOMMENDATIONS

The following broad management recommendations have been developed as a guide for mitigating the potential impacts of the Project to fauna habitat and native fauna assemblages in general. Management recommendations specific to fauna of conservation significance are listed above (**Section 5.6**).

6.1. Project Design

- During Project design, consider options for aligning infrastructure footprints and clearing for construction so as to avoid or minimise clearing of habitats that are known to or have been identified as likely to support conservation significant species and are not well represented in the landscape, i.e. Drainage Line and Rocky Ridges and Gorges.
- Artificial lighting should be designed to illuminate designated operations areas and limit illumination of the surrounding landscape. Ensure that transport and haulage routes are designed to avoid inadvertent illumination of important habitat features such as riverine pools and substantial rocky outcrops. Consider the principles behind methods used for protecting marine turtles from light impacts (EPA 2010; although methods themselves differ, the principles are consistent between aquatic and terrestrial environments).

6.2. Land Disturbance and Clearing Activities

- Where practicable, minimise land disturbance and clearing activities in habitat known to or likely to support species of conservation significance, such as Drainage Line, Rocky Ridges and Gorges and long unburnt Spinifex habitat containing mature spinifex hummocks.
- Minimise and manage impacts to natural surface hydrology to ensure the quality of Drainage Line habitat is maintained and to minimise potential for waterbirds to be attracted to artificial water sources. Roads and borrow pits should be designed to minimise hydrological impacts.
- Undertake clearing progressively over time to allow fauna to disperse to other suitable habitats within the surrounds. Dispersal can also be facilitated by retaining corridors or linkages (eg. culverts underneath roads in key habitat areas) so that individuals can move between remaining habitat patches. Consider timing of clearing activities to reduce the impact on nesting birds (i.e. avoid clearing during the end of the wet season and immediately after)
- Clearing boundaries should be demarcated in the field by environmental personnel.
- Stockpile cleared vegetation, topsoil and oversize waste overburden separately to ensure maximum reuse of these resources in subsequent rehabilitation.

6.3. Project Operation

- Prepare and implement a Significant Species Management Plan for fauna of conservation significance that likely to be impacted by the Project and for which specific management actions may mitigate impacts. Species should include Northern Quoll, Pilbara Olive Python, Spectacled Hare-wallaby, Western Pebble-mound Mouse and Bilby.

- implement dust suppression measures to reduce the effects of dust on vegetation and hence on fauna habitats and assemblages. This should include management of vehicle speed on unsealed roads.
- prepare and implement a weed management strategy to prevent the spread of existing weed species and the establishment of new weeds.
- conduct monitoring and control of feral animals in participation with surrounding land managers such as pastoralists and DEC. Additional management measures to prevent the increase of feral species numbers and control the attraction of any new feral species to the Project should be implemented, including proper hygiene practices and appropriate disposal of waste.
- prepare and implement a strategy for prevention of unplanned fires, which should include all vehicles being fitted with fire extinguishers and all personnel being trained in their use.
- prepare and implement a fire management strategy to reduce the scale, frequency and intensity of fires within fauna habitats (especially Spinifex Stony Plain habitat).
- educate personnel and implement measures to minimise road kill, especially for nocturnal species or those prone to vehicle collisions (eg. reduce the speed and times at which vehicles travel and/or erecting fences, barriers or alternative routes for fauna in strategic areas where fauna are known to cross major transport routes).
- install egress devices (eg. matting) in sumps and pond where egress may be impaired. Ensure that inside walls of pond are ramped. Keep all fluid containers covered. Regularly monitor open bodies of water and construct and maintain fences as required.
- keep all toxic substances confined to hazardous goods storage areas in appropriate containers.
- investigate strategies to reduce impacts of high frequency traffic on fauna and barriers to fauna dispersal created by the access road corridors.

6.4. Rehabilitation and Closure

- Implement a progressive rehabilitation and closure plan to ensure disturbed areas are rehabilitated as soon as practicable.
- reconstruct linkages among fragmented fauna habitats.

7. CONCLUSION

The Project will impact vertebrate faunal assemblages on a local scale (i.e. within the Project area or surrounding 10 km) through direct loss of fauna during land clearing, loss of habitat and indirect impacts.

The project footprint comprises approximately 178.3 hectares with some additional clearing potentially required for the development of associated infrastructure. Habitats encompassed by the Project footprint are generally well represented within the Study area and the wider region so impacts of the project are not likely to be significant. The greatest area of habitat to be cleared will be from Spinifex Stony Plain (69.5 ha), although this represents a low proportion of habitat present within the vicinity of the Project.

The Project will directly impact on small areas of Rocky Ridge and Gorge habitat and Drainage Line habitat, with 0.4 ha and 2.5 ha to be removed, respectively. Conservation significant fauna species recorded from these habitats as part of previous surveys within the Study area and surrounds include the Northern Quoll (*Dasyurus hallucatus*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*), Pilbara Olive Python (*Liasis olivaceus barroni*) and Ghost Bat (*Macroderma gigas*) and it is assumed that these habitats support these species. Although these habitats are uncommon in the landscape, the limited amount of habitat to be removed suggests that the development of the Project is likely to have a minimal impact on these and other species at a localised scale (i.e. within the surrounding 10 km). The exception to this is the Northern Quoll, for which impacts are considered to be low (short-term decline expected with recovery expected after the life of the Project).

At the local scale, assuming no actions are undertaken to mitigate risks, the likely impact on individual conservation significant species is negligible, minimal or low (the latter rating for the Northern Quoll only). At the regional scale the impact on each species is either negligible or minimal.

Impacts to vertebrate fauna can be significantly mitigated and management recommendations are provided. Important recommendations include:

- preparation and implementation of a Significant Species Management Plan for fauna of conservation significance that are likely to be impacted by the Project;
- designing the project so as to minimise the footprint and alterations to hydrology in important habitat types (Drainage Line and Rocky Ridges and Gorges);
- implementation of clearing protocols, including progressive clearing to allow egress by mobile fauna and boundary checking to minimise accidental clearing;
- progressive rehabilitation to maximise rehabilitation success and minimise impacts associated with cleared areas; and
- management of traffic, especially reduced speed limits at night.

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APPENDIX 6: TARGETED TERRESTRIAL SRE INVERTEBRATE FAUNA ASSESSMENT (OUTBACK ECOLOGY 2012C)





Venturex Resources

Sulphur Springs Copper - Zinc Project

Targeted Terrestrial SRE Invertebrate Fauna Assessment

November 2012

Outback Ecology Services
1/71 Troy Terrace
Jolimont WA 6014
Ph: +61 (08) 9388 8799
Fax: +61 (08) 9388 8633
admin@outbackecology.com

Targeted Terrestrial SRE Invertebrate Fauna Assessment

Distribution:

Company	Copies	Contact Name
Venturex Resources Limited	1 (electronic)	Ian Suckling, Andrew Robertson

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Executive Summary

Venturex Resources Limited commissioned Outback Ecology to conduct a Targeted Terrestrial short-range endemic (SRE) invertebrate fauna assessment for the proposed Sulphur Springs Copper - Zinc Project. The Project is located approximately 57 kilometres (km) west of Marble Bar in the Pilbara region of Western Australia.

The Project will comprise the underground development of the Sulphur Springs Copper Zinc deposit, processing of ore at an onsite concentrate plant and haulage of concentrate from Sulphur Springs to Port Hedland via road train for export. Ore mined at the Venturex owned Whim Creek and Mons Cupri Projects will also be hauled to Sulphur Springs for processing. Development within the Project area will include a processing plant, tailings storage facility, evaporation pond ROM pad, access roads, workshops, borrow pit, offices, camp and air strip.

The Project footprint is expected to be approximately 178.3 ha in size. It is understood that this footprint includes all major infrastructure associated with the Project, however additionally clearing may be required outside the footprint during construction. Some areas within this footprint have been previously been cleared by CBH Resources during their exploration phase.

This report documents the results of a desktop study and a targeted terrestrial SRE invertebrate fauna assessment conducted over Venturex tenements and neighbouring tenements surrounding the Project (herein referred to as the Study area). The Study area covered an area of 27,425 hectares and was assessed via targeted searching and habitat mapping between 22 and 25 January 2012.

Previous biological work at Sulphur Springs by Biota in August 2006 resulted in the collection of a SRE pseudoscorpion *Feaella* 'PSE007' (previously *Feaella* sp. 'Sulphur Springs') from Drainage Line habitat. Additional work carried out by Outback Ecology in 2011 identified drainage features in the vicinity of the Project as forming potential SRE habitats as they have sheltered areas of vegetation that were uncommon in the surrounding area. Other potential SRE habitats identified by Outback Ecology in 2011 were Rubble Piles and Ficus Groves, however these habitats were considered unlikely to be impacted by the Project.

Consequently, the specific objectives of this targeted SRE assessment were to:

- assess the occurrence and likely distribution of terrestrial SRE invertebrate fauna within drainage habitats in the Study area;
- identify, describe and map drainage habitats in the Study area;
- assess survey findings in the context of regional comparisons with available data from the surrounding area and other localities within the Pilbara bioregion; and
- assess the potential impacts of the Project on any terrestrial SRE invertebrate fauna and their associated habitat identified within the Study area.

The field survey involved targeted searching for invertebrate fauna at 13 sites within the Study area. Habitat assessments were also conducted at these and an additional three survey sites. The targeted survey of SRE groups within the Study area yielded a total of 153 specimens from 13 species. Terrestrial snails were the most numerous group to be collected (64 specimens from five identifiable species), followed by aquatic snails (38 specimens from two species), millipedes (29 specimens from two identifiable species), slaters (20 specimens from three identifiable species), pseudoscorpions (one specimen) and mygalomorph spiders (one specimen). From this survey and previous survey work, four SRE species have been identified from the Study area, comprising:

- the millipede *Antichiropus* 'DIP005' (formally 'abydos');
- the millipede *Antichiropus* 'DIP034';
- the slater *Buddelundia* sp. 11; and
- the pseudoscorpion *Feaella* 'PSE007'.

Based on the desktop assessment, nine additional species were considered to have medium potential to occur in the Study area. This consideration is based on the proximity of records, the availability suitable habitat and the connectivity of habitat with the Study area.

Of the four SRE species collected within the Study area, only the millipede *Antichiropus* 'DIP005' has been collected within the Project footprint. This species has also been collected outside of the Project footprint within the Study area and at regional sites 12 km southwest of the Project. Although this species is likely to have a distribution that aligns with sheltered habitats in the vicinity of Sulphur Springs, the occurrence of this species at regional sites suggests that the Project is unlikely to pose a long term conservation risk to *Antichiropus* 'DIP005'. Provided that secondary impacts to habitats are minimised, the Project is also unlikely to pose a long term conservation risk to the other three species as they were not collected within the Project footprint.

The only known specimen of pseudoscorpion *Feaella* 'PSE007' was collected by Biota during a survey in 2006. No further specimens of *Feaella* 'PSE007' have been found despite two subsequent surveys which have aimed to better understand the distribution of this species.

Habitat assessments of the drainage features within the Study area identified five types of drainage habitat:

- Gorge;
- Creek Line;
- Riverine;
- Drainage Line; and
- Floodplain.

The Gorge and Creek Line habitats were considered to have high potential for supporting SRE species on the basis of the habitats forming sheltered microhabitats or by forming habitat isolates. Riverine habitat was considered to have medium potential to support SRE species.

The construction of the Project will result in the loss of approximately 2.73 ha of drainage habitat comprising 1.49 ha (1.3 km) of Gorge, 0.08 ha of Creek Line and 0.63 ha of Riverine habitats present in the Study area. These habitats will primarily be impacted through the construction of of the site access road. There also exists the potential for runoff from the site access road to cause sediment loading of the Gorge and Creek Line habitats in the vicinity and downstream of the access road. The natural hydrology of the Gorge and Creek Line may also make the access road susceptible to erosion during high rainfall events which may cause direct and downstream impacts to drainage habitats. Although these habitats are known to occur in other locations in the Study area, they are of limited extent and not well connected in the surrounding landscape. All other drainage habitats in the Study area were considered to have a low potential to support SRE species.

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1. INTRODUCTION

1.1. Project Location And Description

Venturex Resources Limited (Venturex) commissioned Outback Ecology to undertake a targeted terrestrial short-range-endemic (SRE) invertebrate fauna assessment of the proposed Sulphur Springs Copper - Zinc Project (the Project). The Project is located approximately 57 kilometres (km) west of Marble Bar in the Pilbara region of Western Australia (WA, **Figure 1**).

The Project footprint is expected to be approximately 178.3 ha in size (**Figure 2**). It is understood that this footprint includes all major infrastructure associated with the Project, however additionally clearing may be required outside the footprint during construction. Some areas within this footprint have been previously been cleared by CBH Resources during their exploration phase.

The Project will comprise the underground development of the Sulphur Springs Copper-Zinc deposit, processing of ore at an onsite concentrate plant and haulage of concentrate from Sulphur Springs to Port Hedland via road train for export. Ore mined at the Venturex owned Whim Creek and Mons Cupri Projects will also be hauled to Sulphur Springs for processing. Development within the Project area will include a processing plant, tailings storage facility (TSF), evaporation pond, ROM pad, access roads, workshops, borrow pit, offices, camp and air strip.

The Study area for this assessment encompasses a 27,425 hectare (ha) parcel of land which surrounds the Project (**Figure 2**). The Study area covers tenements held by Venturex and neighbouring tenements held by other resource companies.

Previous biological work at Sulphur Springs by Biota in August 2006 resulted in the collection of a SRE pseudoscorpion *Feaella* 'PSE007' (previously *Feaella* sp. 'Sulphur Springs') from a Drainage line. Additional work carried out by Outback Ecology (2011b) identified drainage features as forming potential SRE habitat as they had sheltered areas of vegetation that were uncommon in the surrounding area. These areas were identified as potentially being at risk from the Project. Consequently, this targeted SRE survey and habitat assessment of drainage features was undertaken within the vicinity of the Project and at regional sites to assess the potential impacts of the Project on SRE fauna and habitat.

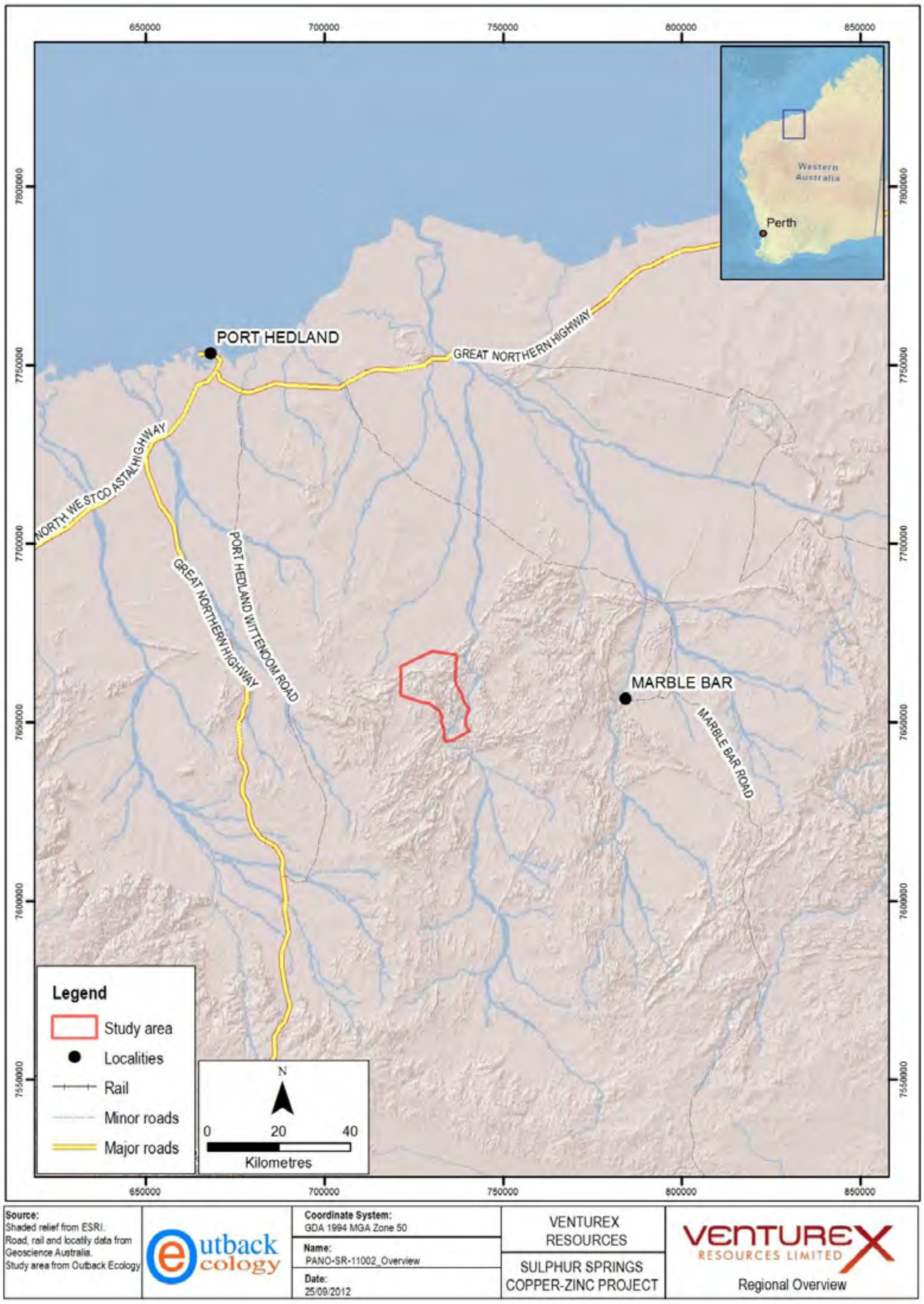

Figure 1: Regional location of the Study area

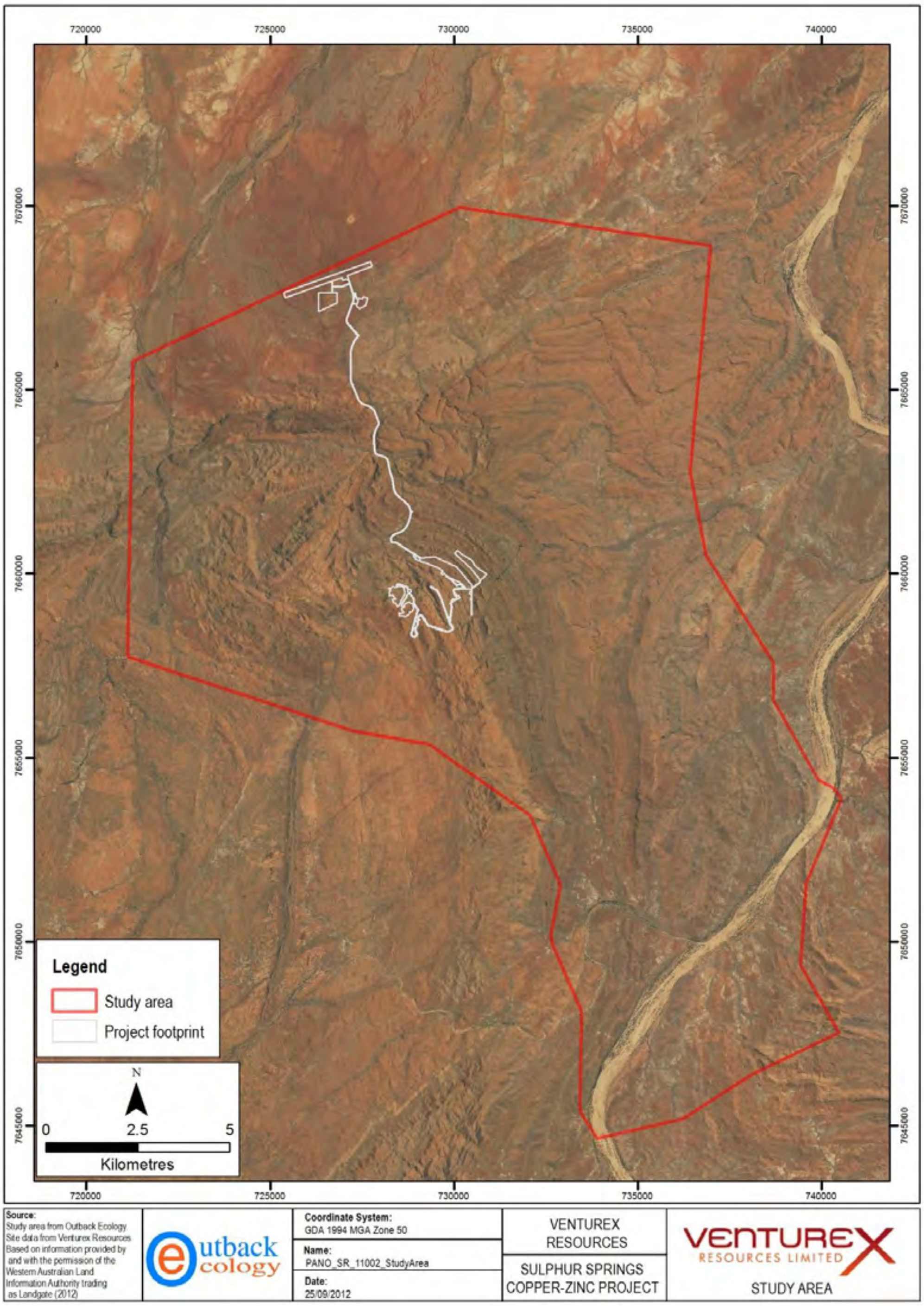

Figure 2: The Study area and Project footprint

1.2. Report Scope And Objectives

This report documents the results of a targeted terrestrial SRE invertebrate fauna assessment conducted over the Study area between 22 and 25 January 2012. For local and regional context, this report also presents a summary of terrestrial SRE invertebrate fauna surveys previously conducted in the Study area and surrounds.

The objectives of this targeted SRE assessment are to:

- assess the occurrence and likely distribution of terrestrial SRE invertebrate fauna within drainage habitats in the Study area;
- identify, describe and map drainage habitats in the Study area;
- assess survey findings in the context of regional comparisons with available data from the surrounding area and other localities within the Pilbara bioregion; and
- assess the potential impacts of the Project on any terrestrial SRE invertebrate fauna and their associated habitat identified within the Study area.

The targeted terrestrial SRE invertebrate fauna survey was designed and conducted in accordance with the:

- Western Australia (WA) Environmental Protection Authority (EPA) Guidance No. 20, *Sampling of Short-range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (Environmental Protection Authority 2009);
- EPA Guidance No. 56, *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (Environmental Protection Authority 2004); and
- EPA Position Statement No. 3, *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (Environmental Protection Authority 2003).

Field Code Changed

For a summary of the existing environment, including biogeographic region, climate, land systems and land use, please refer to the Sulphur Springs Copper Zinc Project Level 1 Fauna Survey (Outback Ecology 2011b).

2. MATERIALS AND METHODS

The methods used to assess the presence of terrestrial SRE invertebrate fauna and habitat during this assessment include database searches and a literature review (**Section 2.1**); and a targeted terrestrial SRE invertebrate fauna survey (**Section 2.2**).

2.1. DESKTOP STUDY

A search of relevant databases and a literature review was undertaken prior to the field survey in order to:

- determine the SRE taxa that have been previously collected in the region;
- facilitate the identification of SRE habitat within the Study area; and
- assist with the assessment of the conservation significance of the invertebrate species collected.

The results of the database search and literature review are presented in **Section 3.3**.

2.1.1. Database Searches

A database search was undertaken to provide a list of SRE invertebrate species that have previously been recorded or have the potential to occur within the Study area. The central point used for the database search was 50 K 741617 E 7674906 S.

- Western Australian Museum (WAM) Arachnid and Millipede Database (Western Australian Museum 2011) (square search area 200 x 200 km);
- NatureMap database (Department of Environment and Conservation 2012a) (40 km radius search area);
- Threatened and Priority Fauna Database (Department of Environment and Conservation 2012b) (square search area 200 x 200 km); and
- The Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act Protected Matters Database (Department of Environment Water Heritage and the Arts 2012) (square search area 100 x 100 km).

It should be noted that at present, WAM is only able to conduct database searches for SRE spiders, scorpions, pseudoscorpions and millipedes; and not snails or slaters.

2.1.2. Literature Review

To gain an understanding of terrestrial invertebrate SRE fauna recorded within the Study area and wider surrounds, a literature review was undertaken of previous SRE invertebrate fauna surveys conducted within a 100 km radius of the Study area. A radius of 100 km was used on the basis of a SRE species being loosely defined as having a distribution of less than 10 000 km^2 (Harvey 2002).

The surveys that fall within a 100 km radius of the Study area that were reviewed as part of this study include:

- Abydos DSO Project: Terrestrial Short Range Endemic Invertebrate Fauna Assessment (Outback Ecology 2012a)
- Sulphur Springs Copper-Zinc Project: Level 1 Terrestrial Fauna Survey (Outback Ecology 2011b)
- Mt Dove DSO Project: Terrestrial Short-range Endemic Invertebrate Fauna Assessment(Outback Ecology 2011a);
- Giralia Resources NL Mount Webber Iron Ore Project Short-Range Endemic Invertebrate Fauna Survey (ecologia 2011);
- Turner River Hub Project: Terrestrial Short-range Endemic Invertebrate Fauna Baseline Survey(Outback Ecology 2011c);
- Wodgina DSO Project Stage 2: Targeted Terrestrial Snail Survey (Outback Ecology 2010);
- Abydos Direct Shipping Iron Ore Project: Terrestrial Fauna Assessment (Bamford Consulting Ecologists 2009);
- Wodgina DSO Project Terrestrial Short-range Endemic Invertebrate Fauna Assessment (Outback Ecology 2009);
- RGP5 Rail Duplication Project: Chichester Deviation: Short-range Endemic Invertebrate Fauna Survey and Targeted Survey for the Trapdoor Spider, *Aurecocrypta* sp.(ecologia 2008);
- A Report on the Trapdoor Spider *Aurecocrypta* sp. from the Chichester Range(Raven 2008);
- Panorama Project: Mine Site and Haul Road Corridor Targeted Fauna Survey (Biota 2007a);
- Sulphur Springs Project: Mine Site and Haul Road Corridor Targeted Fauna Survey, Prepared for CBH Resources Ltd (Biota 2007b); and
- Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage B Rail Corridor and Mine Areas (Biota 2005).

Of these surveys, the Study area overlies much of the area surveyed for the Sulphur Springs Project: Mine Site and Haul Road Corridor Targeted Fauna Survey (Biota 2007a) and the Sulphur Springs Copper Zinc Project: Level 1 Terrestrial Fauna Assessment (Outback Ecology 2011b). Additionally, the Study area lies adjacent to the area surveyed for the Abydos DSO Project: Terrestrial Short Range Endemic Invertebrate Fauna Assessment (Outback Ecology 2012a). These surveys are discussed in greater detail below.

Biota (2007a) Sulphur Springs Project: Mine Site and Haul Road Corridor Targeted Fauna Survey

This Level 2 survey was conducted to assess the Mine Site and Haul Road Corridor associated with the Sulphur Springs project in August-September 2006. Survey methods for invertebrate fauna included targeted searching and dry pitfall trapping.

The Study area encompassed three broad habitat types:

- a narrowly incised valley supporting mid-dense to dense riparian vegetation and small to medium sized pools and low stony hills vegetated with *Triodia* hummock grasslands.

- the “ridges, hills and upper slopes” slopes land unit with cobbled and stony substrates (with some bedrock exposures), vegetated primarily with *Triodia* hummock grasslands and scattered *Corymbia hamersleyana* as defined by Trudgen (2006), formed a broad valley floor at the northern and southern extremities of the valley.
- the “stony plains” land unit with cobbled and stony mantles over shallow red loamy substrates, vegetated primarily with *Triodia* hummock grasslands and scattered Acacia as defined by Trudgen (2006), formed a broad valley floor at the northern and southern extremities of the valley.

Invertebrate taxa prone to short-range endemism collected during the survey included terrestrial snails, mygalomorph spiders and pseudoscorpions. Species collected that potentially represented SRE species included the pseudoscorpion *Feaella* ‘PSE007’ (reported as *Feaella* sp. ‘Sulphur Springs’), the snail *Rhagada* sp. ‘Sulphur Springs’ and six specimens of a mygalomorph spider from the family Barychelidae that were not identified to species.

The six mygalomorph spider specimens have been since identified as *Aurecocrypta* `chichester` which is not considered to be a SRE species (Raven 2008). The snail *Rhagada* sp. ‘Sulphur Springs’ was informally separated from the species *Rhagada richardsonii* (described from Depuch Island which occurs 155 km west of the Study area) through genetic work completed by Biota (2007a). Morphological differences between the type specimens of *Rhagada richardsonii* and the specimens of Sulphur Springs appear to support this separation (**Appendix D**; Cory Whisson pers comm. May 2012). The specimens from Sulphur Springs most closely resemble a larger widespread form which has been collected from the Oakover River, Nullagine and Strelley River (**Appendix D**). The eastern branch of the Strelley River passes through the Study area. Based on this distribution, it appears unlikely that this species has a restricted distribution.

The only species collected during the survey still considered to represent a potential SRE is the pseudoscorpion *Feaella* ‘PSE007’. The specimen was collected beneath slate like rock on the south face of a low cliff adjacent to a narrowly incised ephemeral Drainage Line (Biota 2007b).

Biota (2007b) recommended that additional survey work be undertaken to delineate distribution and habitat of *Feaella* sp. 'PSE007' and that additional taxonomic work should be undertaken to resolve the identity of the specimen. As a result, additional survey work was undertaken with the assistance of Dr Mark Harvey from the WA museum in October 2007. The survey was unsuccessful in collecting additional specimens of *Feaella* sp. ’PSE007’.

Outback Ecology (2011b) Sulphur Springs Copper Zinc Project: Level 1 Fauna Assessment

In June 2011, Outback Ecology conducted a terrestrial fauna desktop study and reconnaissance survey of the Sulphur Springs Project. During this survey Rocky Ridges and Gorges and Drainage Lines were identified as potential SRE habitats, with Rubble Piles and Ficus Groves representing habitat isolates that may support SRE species.

Drainage Line habitat encompasses a considerable proportion of the Study area and was found to align with the only recorded location of the specimen *Feaella* sp. 'PSE007' collected by Biota (2007a). It was recommended that a targeted terrestrial invertebrate SRE survey for *Feaella* sp. 'PSE007' be conducted during the period of peak rainfall for the area to gain a better understanding of the species distribution and identify other potential habitats for *Feaella* sp. 'PSE007' outside of proposed impact areas.

Outback Ecology (2012a) Abydos DSO Project: Terrestrial Short Range Endemic Invertebrate Fauna Assessment

Atlas Iron Limited commissioned Outback Ecology to conduct a SRE invertebrate fauna assessment of the Abydos Direct Shipping Iron Ore Project which is located approximately 7 km west of the Study area. Two surveys were conducted from 28 March to 28 July 2010. Sampling methods included wet pitfall trapping, targeted searching and leaf litter and soil collection.

The surveys yielded a total of 1,453 invertebrate specimens from 43 species. Of these, six species were considered to be SRE comprising: the scorpion *Aops* 'pilbara'; the pseudoscorpion *Tyrannocthonius* 'near aridus'; the Slaters *Buddelundia* sp. 11 and *Buddelundia* sp. 18; the camaenid snail ?Gen. nov. sp. nov.; and the millipede *Antichiropus* 'DIP005' (reported as 'abydos').

During the survey, eight broad habitat types were identified from within the Study area. Gorge habitat was identified as having high potential to support SRE species, because it forms cool, sheltered habitats that were isolated from similar habitats in the surrounding landscape. Ridge habitat (i.e. southerly or easterly aspect), Gully and Riverine habitats were considered to have medium potential to support SRE species, as they also formed sheltered habitat isolates, however they were generally more exposed than the Gorge habitat.

2.2. Terrestrial SRE Invertebrate Fauna Field Survey

The field survey was conducted in accordance with the EPA Guidance Statement No 20 (Environmental Protection Authority 2009) and after consultation with specialists from DEC and the WAM. Recommendations and information given by the specialists was incorporated into the survey design.

2.2.1. Survey Timing

The Sulphur Springs targeted terrestrial SRE invertebrate fauna survey involved targeted searching and leaf litter collection from the 22 to 25 January 2012.

2.2.2. Weather Conditions

Eleven days prior to the field survey (12 January 2012), Tropical Cyclone Heidi crossed the Pilbara coast causing significant rainfall in the region. The rainfall caused flooding of major roadways and river crossings and subsequent road closures (Bureau of Meteorology 2012).

Field Code Changed

The records from Marble Bar, Port Hedland and Strelley weather stations were considered for this survey, and are located 58 km east, 92 km north west and 78 km north west of the Study area, respectively. The Marble Bar and Port Hedland weather stations record both temperature and rainfall, whereas, only rainfall is recorded at Strelley. Despite this, information from Strelley is useful in providing a regional context, given the localised nature of rainfall in the Pilbara bioregion.

During the survey, the daily maximum temperature recorded at Marble Bar ranged from 35.7ºC to 39.5ºC, while the minimum temperature ranged from 23.5ºC to 27.3ºC (Bureau of Meteorology 2012). A mean maximum temperature of 37.3ºC and a mean minimum of 25.1ºC over the survey period were recorded at Marble Bar which is slightly lower than the long-term average. In the six weeks prior to the survey, 166.8 mm of rain was recorded at Marble Bar, 167.04 mm at Port Hedland and 180.5 mm at Strelley Station (**Figure 3**). During the survey period, 16 mm of rain was recorded at Marble Bar; 0 mm of rainfall was recorded at Port Hedland and 0.5mm at Strelley Station (**Figure 3**). The rainfall recorded prior to and during the first survey was higher than the long-term average as a result of cyclone activity (Bureau of Meteorology 2012).

Field Code Changed

Field Code Changed

The survey was conducted between November and April which is the optimum time for invertebrate surveys in the Pilbara bioregion (Environmental Protection Authority 2009). The peak activity of SRE taxa generally coincides with the wet season, in particular with rainfall events (Environmental Protection Authority 2009). The high level of rainfall prior to and during the survey resulted in ideal timing for the collection of specimens from SRE taxa.

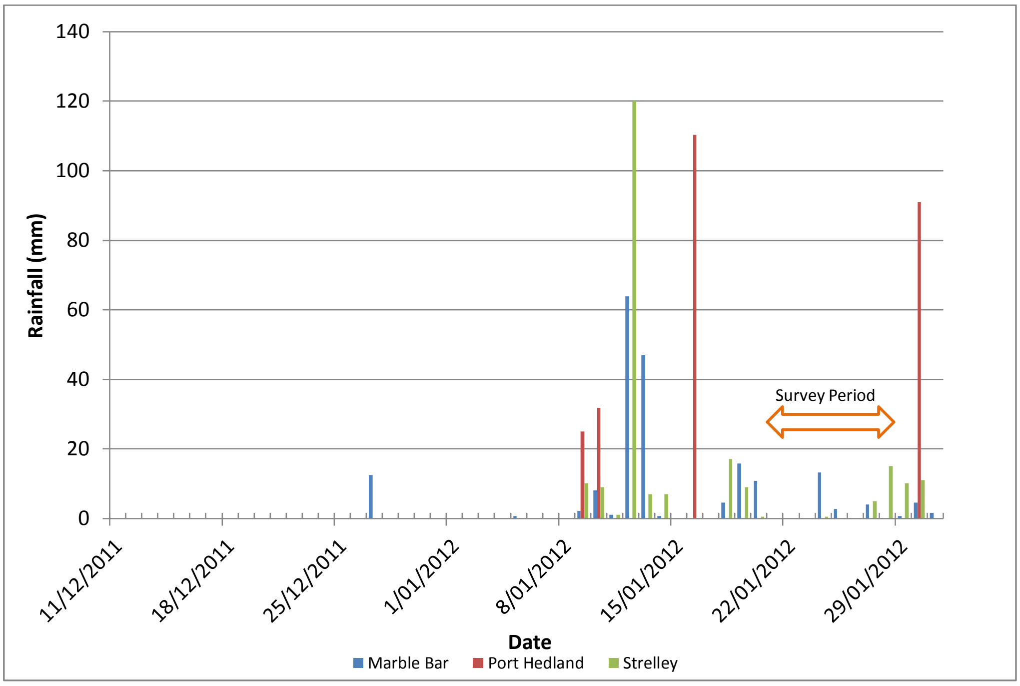

Figure 3: Rainfall recorded at Marble Bar, Port Hedland and Strelley weather station prior to and during the survey (Bureau of Meteorology 2012)

Field Code Changed

2.2.3. Survey Sites

Prospective survey sites were selected using satellite imagery prior to the survey. The actual survey sites selected were dependent on ground truthing and vehicle access at the time of the survey. Targeted searching, leaf litter collection and habitat assessments were conducted at a total of 13 survey sites. Habitat assessments were also conducted at an additional three survey sites to provide an adequate coverage of drainage habitats in the Study area (**Table 1** & **Figure 4**). Survey sites were located within Venturex, Atlas Iron, Zenith Minerals and Brockman Exploration tenements. Site descriptions for each of the survey sites assessed in the Study area are presented in **Appendix A**.

Table 1: Survey sites, habitat and survey methods within the Study area

Site	Habitat	Targeted searching	Leaf litter collection	Habitat assessment	Coordinates (GDA 94 MGA 50K)	
					Easting	Northing
1	Creek Line	X	X	X	728153	7660988
2	Riverine	X	X	X	727119	7665434
3	Creek Line	X	X	X	728695	7662229
4	Gorge	X	X	X	727956	7663270
5	Gorge	X	X	X	727931	7663990
6	Drainage Line	X	X	X	727205	7660204
7	Gorge	X	X	X	731862	7660742
8	Gorge	X	X	X	729692	7662604
9	Drainage Line	X	X	X	732605	7653429
10	Riverine	X	X	X	735640	7650327
11	Drainage Line	X	X	X	728244	7657541
12	Riverine	X	X	X	722249	7664139
13	Riverine	X	X	X	722113	7661781
HA01	Drainage Line			X	734403	7651623
HA02	Floodplain			X	727125	7666666
HA03	Gorge			X	722053	7662237

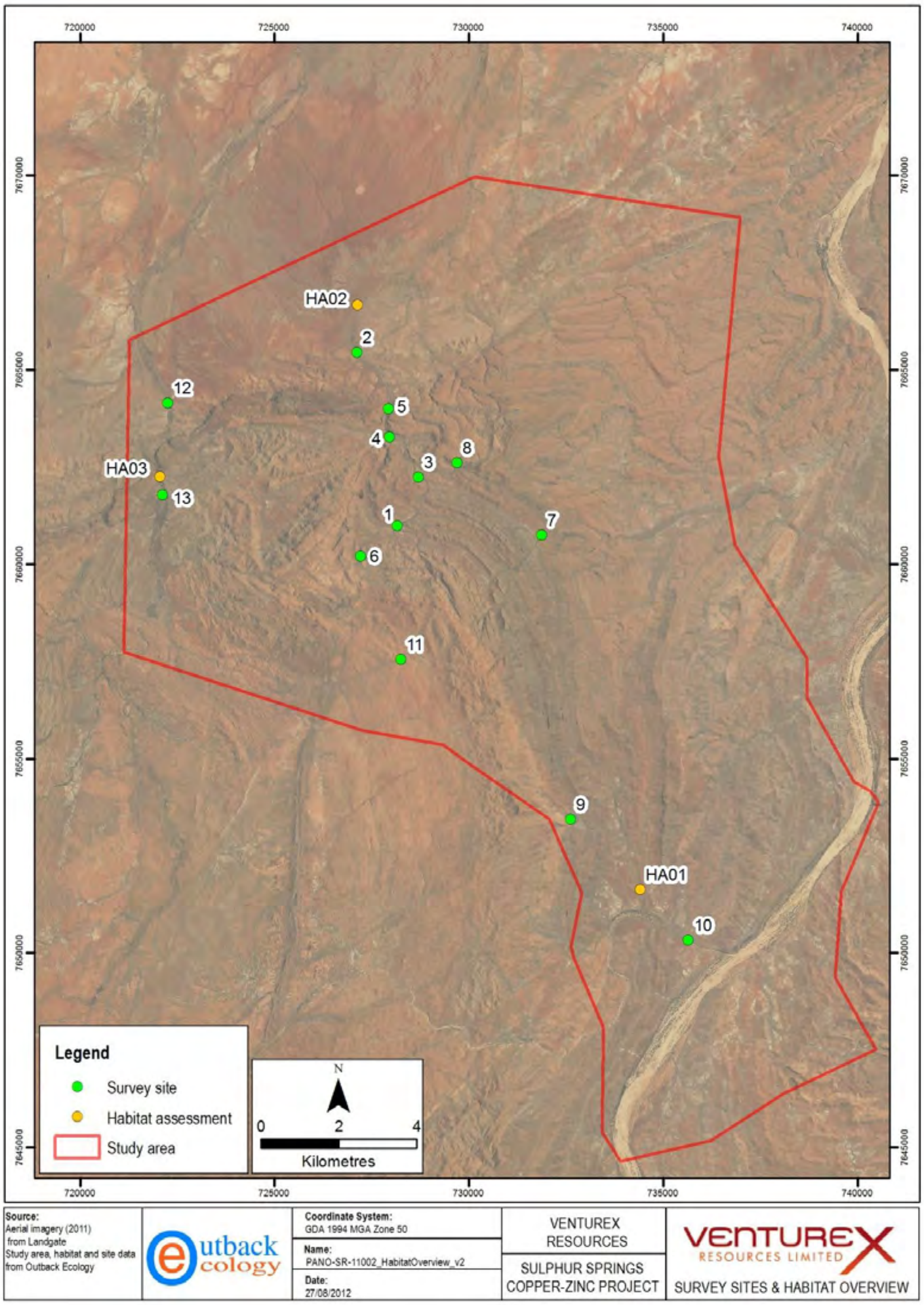

Figure 4: Survey site locations and habitats within the Study area

2.2.4. SRE Habitat Assessment

Potential terrestrial SRE habitats within the Study area were identified and assessed in terms of complexity, quality, connectivity and extensiveness within the landscape. A SRE habitat assessment was conducted for each potential SRE habitat unit identified within the Study area. This assessment entailed:

- establishment of habitat assessment reference sites of sufficient geographical spread and replication to characterise the extent of SRE habitat in the Study area; and
- compiling a standardised habitat assessment field sheet for each site. Assessments were made within a 50 m x 50 m area and the following information recorded: landscape position, outcropping, soil type, broad vegetation type, litter cover, existing disturbance, extensiveness and physical connectivity within the landscape.

Although there are no prescriptive guidelines for identifying SRE habitats, most prospective habitats tend to be those that are sheltered, isolated or both (Environmental Protection Authority 2009, Harvey 2002). Many SRE species are associated with sheltered environments that are pockets of relictual Gondwanan habitat. In the Pilbara, sheltered habitats include: deep gorges, ridges and slopes with south east facing aspects, drainage systems and fire refuge areas. Isolated habitats are more likely to support SRE species in comparison to extensive swathes of contiguous habitat. Habitat isolates in the Pilbara include individual *Ficus* trees and also mountains, outcrops and mesas surrounded by plains (Environmental Protection Authority 2009, Harvey 2002). Information collected from habitat assessments have been incorporated into the descriptions of each broad habitat in the Study area (**Section 3.1**).

2.2.5. Collection Techniques

Methods for the sampling and collection of targeted SRE taxa that were undertaken during this survey were aligned with those specified by the EPA (2009) and endorsed by invertebrate SRE specialists of the WAM and DEC (**Table** 2). These are described below.

Table 2: Summary of SRE sampling methods undertaken at each survey site

Sampling technique	Target group	Sampling effort	Total
Targeted searching	All groups	1.5 person hours at 13 sites	19.5 person hours
Leaf litter collection	All groups	3 samples at each of 13 sites	39 samples

Targeted Searching

Each site was searched for SRE invertebrates for one and a half person hours, resulting in a total of 19.5 hours of targeted searching within the Study area. Microhabitats searched included leaf litter, beneath logs, bark and rocks, crevices, at the bases of shrubs and trees and beneath Spinifex hummocks. Burrows suspected to be those of mygalomorph spiders or scorpions were excavated and the occupants if any, were collected.

Leaf Litter Collection and Tullgren Funnels

Three samples of leaf litter were collected from each site, with a total of 39 samples collected during the survey. The samples were collected by scraping back the top layer of litter to reveal the decomposition layer above the soil. Leaf litter samples were sealed in plastic bags and kept cool during fieldwork and subsequent transportation to the Outback Ecology laboratory. Tullgren funnels were used to extract invertebrates from the leaf litter samples. Tullgren funnels use light and heat generated above the sample to encourage the downward movement of invertebrates. Eventually the invertebrates exit the funnel and fall into a container of 100% ethanol. Leaf litter samples were left in the Tullgren funnels for at least 72 hours. After this time, the collection containers beneath the Tullgren funnels were examined for invertebrates using a dissecting microscope at six times magnification in the Outback Ecology laboratory. The leaf litter remaining in the funnels was searched for invertebrates using two times magnification.

2.2.6. Specimen Preservation

Mygalomorph spiders and scorpions had their third left leg removed and stored in 100% ethanol in a cryogenic tube and placed inside a larger vial with the remaining specimen stored in 75% ethanol. This allowed for the option of genetic testing if required. All other arthropod specimens were stored in 100% ethanol. Land snails were kept live in a state of aestivation by storing them in well ventilated, cool, dry containers.

2.2.7. Specimen Processing And Identification

Specimens belonging to taxa prone to short-range endemism were delivered to the WA Museum for registration and identification by specialist taxonomists (**Table 3**).

Table 3: Invertebrate taxonomists whom identified specimens collected from the Study area

Speciality	Taxonomist	Organisation
Spiders, pseudoscorpions and millipedes	Dr Mieke A. Burger Dr Catherine A. Car Mark A. Castalanelli Dr Mark S. Harvey	Western Australian Museum
Slaters	Dr Simon Judd	Independent consultant
Snails	Mr Corey Whisson	Western Australian Museum
Molecular Identification of millipedes	Mark A. Castalanelli Dr Mark S. Harvey	Western Australian Museum

2.2.8. SRE Survey Team And Licensing

The terrestrial SRE invertebrate fauna survey was conducted by:

Paul Bolton	B. Sc. (Marine Biology/Zoology) (Hons.)	Principal Environmental Scientist
Adele Scarfone	B.Sc. (Env. Sci. & Catchment Management)	Environmental Scientist

The survey was conducted under Licence to Take Fauna for Scientific Purposes (Regulation 17) – Licence No: SF008425

Date of issue: 24/01/2012
Valid from: 24/01/2012
Date of expiry: 23/01/2013

3. RESULTS

3.1. Terrestrial SRE Invertebrate Fauna Habitats

The Study area spans approximately 15 km from east to west, 22 km from north to south and covers approximately 27,425 ha in area. Drainage features were previously identified as having potential to support SRE species as they provide sheltered microhabitat that is uncommon in the surrounding landscape (Outback Ecology 2011b). The current survey assessed these drainage features and classified them into defined habitat types. These habitat types were then identified in the wider region both within and outside the Project footprint.

A total of five drainage habitat types were identified in the Study area: Gorge, Creek Line, Riverine, Drainage Line and Floodplain (**Table 4** & **Figure 5**). These habitats were categorised as having a high, medium or low potential for supporting SRE species on the basis of the habitats forming sheltered microhabitats or by forming habitat isolates (**Section 2.2.4**).

Table 4: Drainage habitats present in the Study area

Habitat	Potential for Supporting SRE taxa	Rationale for classification	Survey Site	Area (ha) in the Study area	Extent (%) of the Study area
Gorge	High	Gorges form cool, sheltered habitats that are isolated from similar habitats in the landscape. The dense vegetation results in an accumulation of leaf litter along the banks and around the bases of trees and rocks which provides habitat suitable for relictual invertebrate species.	Site 4 Site 5 Site 7 Site 8 HA03	80	0.3
Creek Line	High	Creek lines form sheltered habitats compared to the surrounding environment. The dense vegetation provides sheltered areas suitable to relictual invertebrate species.	Site 1 Site 3	8	< 0.1
Riverine	Medium	Rivers support large Eucalypts that provide both shade and accumulated leaf litter and contain higher levels of moisture when compared with the surrounding landscape (e.g semi-permanent pools).	Site 2 Site 10 Site 12 Site 13	967	3.5
Drainage Line	Low	Drainage lines in the Study area are typically exposed with limited sheltered areas. Moisture retention is relatively limited compared to Riverine habitat.	Site 6 Site 9 Site 11 HA01	95	0.4
Floodplain	Low	Floodplain forms an open and largely exposed habitat with the exception of scattered *Eucalyptus victrix* and *Melaleuca* sp. The similarity of this habitat with the surrounding environment suggests that the Floodplain is unlikely to support species with restricted ranges.	HA02	38	0.1
			TOTAL	**1,188**	**4.3**

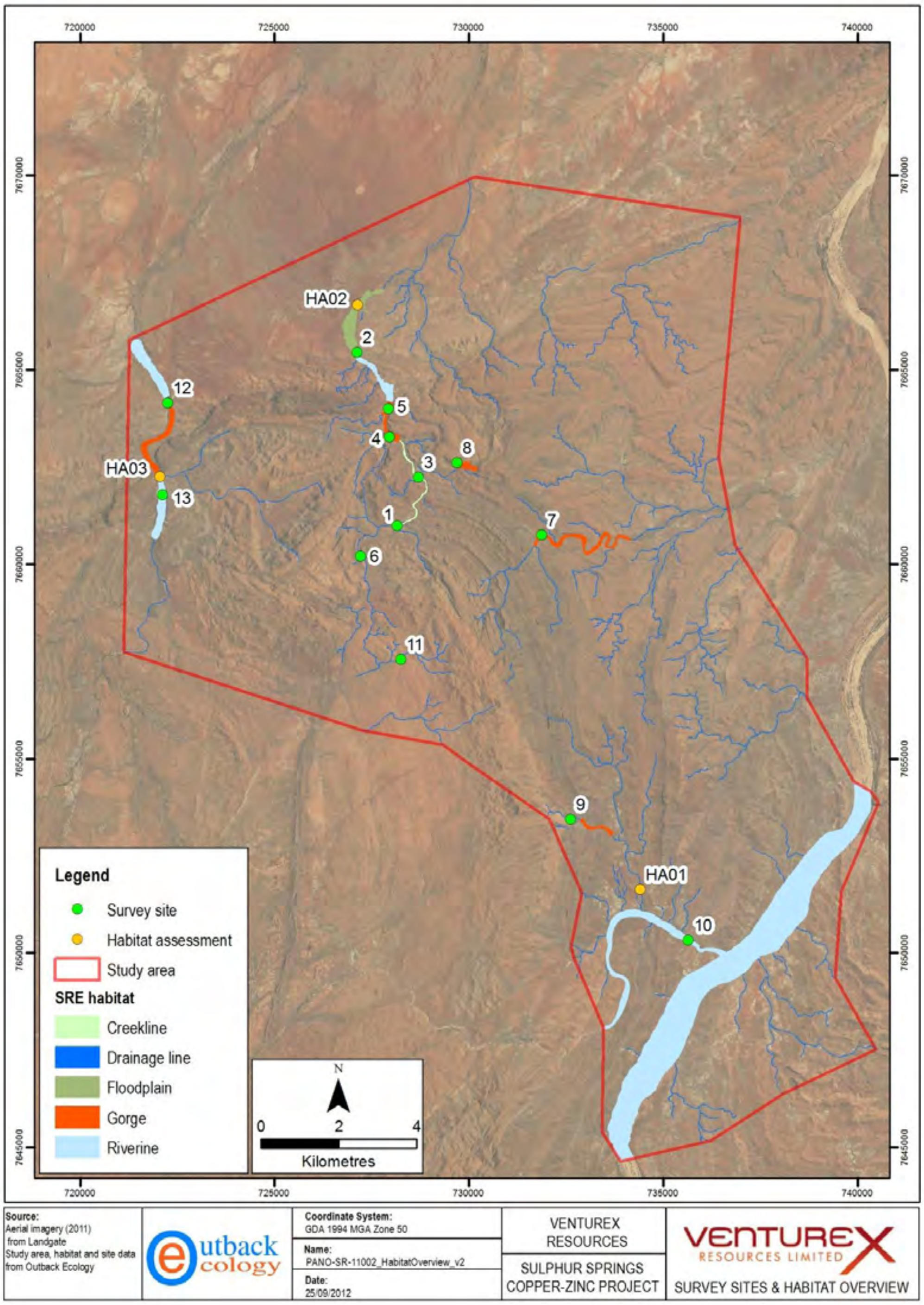

Figure 5: Potential SRE habitat in the Study area

3.1.1. Gorge

Gorges have a high potential to support SRE species because they form cool, sheltered habitats that are isolated from similar habitats in the surrounding landscape. The main Gorge in the Study area has been formed over time by erosion from flowing water, which has cut through the rock to form a narrow channel. This channel is subject to seasonal flooding with sections containing semi-permanent pools and springs of permanent flowing water. A total of five Gorges were located within the Study area. Each of these features represent habitat isolates in the landscape.

Vegetation in Gorge habitat is typified by an overstorey of *Eucalyptus victrix*, over a midstorey of *Acacia inaequilatera* and *Acacia tumida*; over an understory of *Melaleuca* sp., *Triodia* sp. and sedges. The presence of dense vegetation results in an accumulation leaf litter along the banks and around the bases of trees and rocks which provides habitat suitable for relictual invertebrate species. Substrate within Gorge habitat comprised rocks and alluvial sands.

Gorge habitat occurs in the west, central and south east portions of the Study area (**Figure 4**) and was assessed at survey sites 4, 5, 7, 8 and HA03 (**Appendix A**). The Gorge habitat covers an area of 80 ha which represents approximately 0.2 % of the Study area (**Table 4**).

3.1.2. Creek Line

Creek lines have a high potential to support SRE species because they form sheltered habitats compared to the surrounding landscape. The dense vegetation within this habitat also provides sheltered areas with potential to support SRE species. This habitat is subject to seasonal flooding and there is evidence of high water flow. Unlike Drainage Line habitat, the Creek Line habitat carries flowing water for longer periods after rainfall.

Vegetation in the Creek Line habitat was typified by a scattered overstorey of *Eucalyptus victrix*, *Acacia inaequilatera* and *Melaleuca* sp. over understorey of *Triodia* sp. Leaf litter had accumulated along the banks and around the bases of trees and rocks. Substrate within Creek Line habitat consisted of alluvial rocks and sands.

Creek Line habitat occurs in the central portion of the Study area (**Figure 4**) and was assessed at survey sites 1 and 3 (**Appendix A**). The Creek Line habitat covers an area of 8 ha which represents approximately 0.03 % of the Study area (**Table 4**).

3.1.3. Riverine

Rivers have a medium potential to support SRE species because they support large Eucalypt trees which provide both shade and leaf litter. Additionally, Riverine habitat retains moisture after rain events for longer periods than other habitats within the landscape. Furthermore, Riverine habitat commonly contains permanent and semi-permanent water pools, which are uncommon more widely.

Vegetation in Riverine habitat was typified by large *Eucalyptus camaldulensis* along the banks with scattered *Eucalyptus victrix* and *Melaleuca* sp., with understorey of *Triodia sp. and Cenchrus ciliaris*

(Buffel Grass). The substrate consisted of rocky river beds with alluvial sands and clays. These areas are generally degraded due to prolonged grazing by cattle.

Riverine habitat occurs in the west and south east portions of the Study area (**Figure 4**) and was assessed at survey sites 2, 10, 12 and 13 (**Appendix A**). Riverine habitat covers an area of 966 ha which represents approximately 3.52 % of the Study area (**Table 4**).

3.1.4. Drainage Line

Drainage lines in the Study area had a low potential to support SRE species as they formed a habitat that was exposed with limited sheltered areas. Unlike Creek Line habitat, the Drainage Line habitat carries water only briefly after rainfall. The Drainage Line habitats form the upper tributaries of the Study area.

Common vegetation in the Drainage Line habitat comprised a scattered over-storey of *Eucalyptus victrix* and *Melaleuca* sp., with understorey *of Triodia* sp. The substrate comprised of alluvial gravels and sands. Areas within this habitat were subjected to grazing by cattle.

The Drainage Line habitat occurs throughout the Study area (**Figure 4**) and was assessed at survey sites 6, 9, 11 and HA01 (**Appendix A**). The Drainage Line habitat covers an area of 95 ha which represents approximately 0.35 % of the Study area (**Table 4**).

3.1.5. Floodplain

Floodplain habitat has a low potential to support SRE species as it is exposed with limited shelter offered by landforms or vegetation. Floodplain habitat in the Study area is open with a number of minor channels. The water flows through this habitat rapidly after rainfall without forming pools or a permanent water source.

Common vegetation in the Floodplain habitat comprised isolated *Eucalyptus victrix* along some of the minor channels with and understorey of *Triodia* sp. Due to high water flow, leaf litter is largely removed from the area. The substrate is made up of alluvial sands and clays.

The Floodplain habitat occurs in the northern portion of the Study area (**Figure 4**) and was assessed at survey site HA02 (**Appendix A**). The Floodplain habitat covers an area of 38 ha which represents approximately 0.14 % of the Study area (**Table 4**).

3.2. Terrestrial SRE Invertebrate Fauna Species Recorded From The Study area

The targeted survey of the Study area yielded a total of 153 invertebrate specimens from 15 species (

Table 5). For brevity, the term “species” refers to both species and morphospecies. A number of specimens from each target group were not able to be identified to species level, as they were of an inappropriate sex or life stage.

Terrestrial snails were the most numerous of the groups collected, with 64 individuals collected from five identifiable species (

Table 5). This was followed by aquatic snails, millipedes, slaters, pseudoscorpions and mygalomorph spiders (

Table 5). A total of 113 specimens were collected through targeted searching and 40 through leaf litter or Tullgren sampling.

Table 5: Summary of invertebrates from SRE taxa collected during the targeted SRE survey

Target group	Number of specimens	Number of species
Mygalomorph spiders	1	1
Pseudoscorpions	1	1
Millipedes	29	2
Slaters	20	3
Terrestrial snails	64	5
Aquatic snails	38	2
TOTAL	**153**	**13**

Based on scientific knowledge at the time of this report, three of the species collected were considered potential SRE species:

- *Antichiropus* 'DIP005'
- *Antichiropus* 'DIP034'
- *Buddelundia* sp. 11

Table 6: SRE species collected from the Study area showing site, number of specimens and associated habitat

Habitat	Site	Number of SRE specimens collected		
		Antichiropus 'DIP005'	*Antichiropus* 'DIP034'	*Buddelundia* sp. 11
Gorge	Site 4	8	-	-
	Site 8	-	-	3
Creek Line	Site 1	10	-	-
	Site 3	9	-	4
Riverine	Site 2	2	1	-
Total		**29**	**1**	**7**

3.2.1. Mygalomorph Spiders

The single specimen of *Aname* sp. collected during the survey was not a male and therefore, it could not be identified to species level. The distribution and conservation status of many species of this genus are not well understood with some species having limited distributions (**Appendix B**). Since this specimen was not a male, it is not possible to establish whether it is a potential SRE species.

3.2.2. Pseudoscorpions

The single female specimen of *Indolpium* sp. collected during the survey could not be identified to species level. Since extremely similar specimens have been collected from other regions in Western Australia, it is considered unlikely that *Indolpium* sp. represents a SRE species (**Appendix B**).

3.2.3. Millipedes

Two millipede species collected during the survey - *Antichiropus* 'DIP005' *and Antichiropus* 'DIP034' - were considered SRE species (**Table 6**; **Appendix B**). Most species of the genus *Antichiropus* are considered SRE species and many have a species range of only a few hundred square kilometres (Harvey 2002, 2000).

The millipede *Antichiropus* 'DIP005' was represented by three male specimens collected from Creek Line habitat. Twenty six juvenile and female *Antichiropus* millipede specimens were also collected during the survey; however, these specimens could not be identified to species level using morphology because this can only be done using mature male specimens. To confirm the status of these individuals, Mitochondrial DNA (mtDNA) sequencing was used to compare the specimens with other millipedes collected nearby and in the surrounding region. Results of this analysis revealed that the juvenile and female *Antichiropus* specimens comprised two distinct species. One of these species was *Antichiropus* 'DIP005' which had been previously collected at the Abydos DSO Project (9 km south west of the Study area); the other species was *Antichiropus* 'DIP034' which had been collected at Marble Bar (65 km east of the Study area).

Antichiropus 'DIP005' was collected from Creek Line and Gorge habitats during this survey (**Table 6**) and from ridge (southerly or easterly aspect), Gorge and gully habitats during the Abydos DSO Project: Terrestrial Short Range Endemic Invertebrate Fauna Assessment (Outback Ecology 2012a). Since this species has been collected from a limited range in the Abydos and Sulphur Springs area, it is still considered a SRE species (**Appendix B** and **Appendix E**).

Antichiropus 'DIP034' was only collected from the Riverine habitat during the survey (**Table 6**), however it has also been previously collected from a disturbed areas in the vicinity of the Marble Bar Hotel (65 km east of the study area). Since this species has been collected from a limited range in the Sulphur Springs and Marble Bar area, it is also considered a SRE species (**Appendix E**).

3.2.4. Slaters

Seven specimens of the SRE slater *Buddelundia* sp. 11 were collected during the survey (**Plate 1**). These specimens were collected from Creek Line and Gorge habitats (**Table 6**). Other specimens of this species have been collected from regional locations including the Abydos DSO Project (9 km south west of the Study area), the Mt Webber DSO Project (30 km south of the Study area) and the McPhee Creek DSO project (85 km south east of the Study area). Although this species has been collected at a number of sites in the region, its range is still limited to within 10,000 km^2 and therefore is still considered an SRE species (**Appendix C**). Other non SRE species collected during the survey were *Buddelundia* sp.14 and *Laevophiloscia* sp.

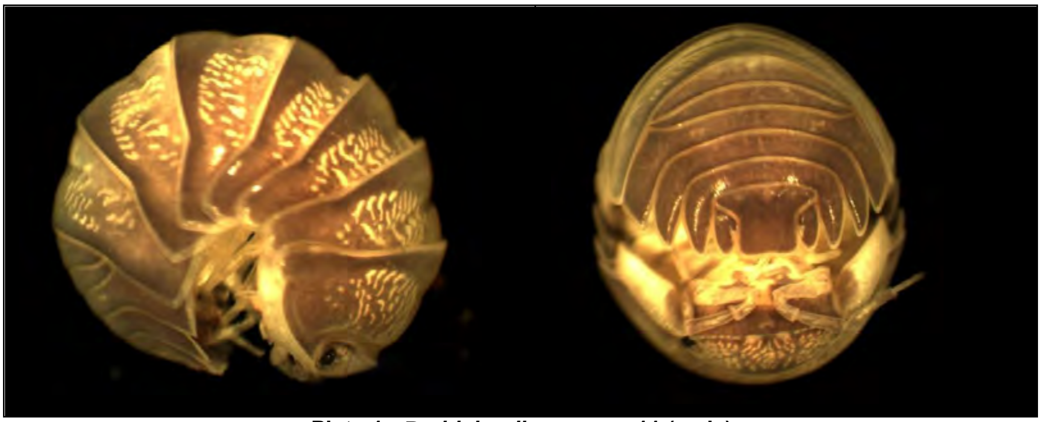

Plate 1: *Buddelundia* sp. nov. 11 (male)

3.2.5. Snails

None of the snails collected during the survey were considered to be SRE species as all are likely to represent species that have been collected more widely in the Pilbara and many are known from other locations in the state of Western Australia (**Appendix D**). The specimens identified as *Rhagada* cf. *richardsonii* (**Appendix D**) are likely to be the same species collected by Biota and identified as *Rhagada* 'Sulphur Springs' (Biota 2007a) (**Plate 2**).

Other species collected during the survey that were not considered SRE species included the terrestrial species: *Pupoides pacificus, Gastrocopta larapinta*, *Gastrocopta mussoni* and *Stenopylis coarctata*; and the aquatic species: *Gyraulus* sp. *Isidorella* cf. *egregia, Austropeplea* cf. *lessoni.*

Plate 2: *Rhagada* sp. 'Sulphur Springs' (photo: Roy Teale) (Biota 2007a).

3.3. SRE Species Previously Recorded From The Study Area And The Wider Region

The database searches and a literature review yielded a total of 26 SRE invertebrate species that have been collected within a 100 km radius of the Study area (**Table 7**, **Figure 6**, **Figure 7**). Of these 26 species, nine were considered to have medium potential to occur in the Study area while fourteen species were considered to have a low potential to occur in the Study area due to a lack of suitable habitat or lack of connecting habitat with the Study area. Two of the three remaining species were confirmed to occur in the Study area (*Antichiropus* 'DIP005' and *Buddelundia* sp. 11) during this survey (**Section 3.2**). Additionally, the pseudoscorpion *Feaella* 'PSE007' was collected in the Study area during a previous survey (Biota 2007b) but was not collected during the current survey.

Table 7: SRE invertebrate collection records yielded by database searches and literature review

SRE species	Group	Source	Habitat(s)	Potential for occurrence in the Study area	Reason for potential occurrence
Antichiropus \`DIP005\`	Millipede	• Abydos DSO Project (Outback Ecology 2012a)	• Ridge (southerly or easterly aspect) • Gorge • Gully	Confirmed	Species was collected from the Drainage Line habitat in the Study area at Site 1, 3 and 4.
Feaella \`PSE007\`	Pseudoscorpion	• Sulphur Springs Project (Biota 2007b)	• South facing cliff close to Drainage Line	Confirmed	Species was collected within the Study area by Biota in 2007.
Buddelundia sp. 11	Slater	• Turner River Hub Project (Outback Ecology 2011c) • Abydos DSO Project (Outback Ecology 2012a) • McPhee Creek DSO Project (Outback Ecology 2012b) • Mt Webber DSO Project (Outback Ecology 2012c)	• Gorge • Ridge (southerly or easterly aspect) • Gully • Ridge (northerly or westerly aspect)	Confirmed	Species was collected from two sites within the Study area.
Buddelundia sp. 18	Slater	• Abydos DSO Project (Outback Ecology 2012a) • McPhee Creek DSO Project (Outback Ecology 2012b)	• Gorge • Ridge (southerly or easterly aspect) • Gully • Ridge (northerly or westerly aspect)	Medium	Species has been collected from a number of locations across Pilbara. Closest records are from Abydos (199 specimens) approximately 6.7 km SW of the Study area. Similar habitat occurs in the Study area.
Aops ‘pilbara 2’	Scorpion	• Abydos DSO Project (Outback Ecology 2012a)	• Ridge (southerly or easterly aspect)	Medium	Species has been collected at Abydos (four specimens) located approximately 7 km W of the Study area. Habitat occurs within the Study area.
Tyrannocthonius ‘nr aridus’	Pseudoscorpion	• Abydos DSO Project (Outback Ecology 2012a) • Mt Dove DSO Project (Phase 1) (Outback Ecology 2011a)	• Ridge (southerly or easterly aspect) • Gully • Ridge (northerly or westerly aspect)	Medium	Species has been collected at Abydos 10 km SW (33 specimens) and at Mt Dove (two specimens) located 79 and 80 km N and NW of the Study area respectively. Similar

SRE species	Group	Source	Habitat(s)	Potential for occurrence in the Study area	Reason for potential occurrence
					habitat may occur in the Study area.
Barrowdillo sp. nov. 2	Slater	• Turner River Hub Project (Outback Ecology 2011c)	• Ridge (northerly or westerly aspect)	Medium	Similar habitat occurs in the Study area. Closest record is 44.1km SW of the Study area
Kwonkan `MYG200`	Mygalomorph Spider	• Giralia Mt Webber (ecologia 2011)	• South facing slope	Medium	Similar habitat occurs in the Study area. Closest record is 45 km SSE of the Study area.
Karaops sp. `Mt Webber`	Selenopid Spider	• Turner River Hub Project (Outback Ecology 2011c)	• Ridge (southerly or easterly aspect)	Medium	Similar habitat occurs in the Study area. Closest record is 45 km SSE of the Study area.
Karaops sp. 'Wodgina'	Selenopid Spider	• Turner River Hub Project (Outback Ecology 2011c)	• Calcrete Breakaway • Ridge (southerly or easterly aspect) • Gully • Ridge (southerly or easterly aspect)	Medium	Closest record is located 37 km SW of the Study area.
Gen. nov. sp. nov	Snail	• Abydos DSO Project (Outback Ecology 2012)	• Gorge • Ridge (southerly or easterly aspect)	Medium	Similar habitat occurs in the Study area. Closest record is 7 km.
Feaella 'PSE017'	Pseudoscorpion	• Turner River Hub Project (Outback Ecology 2011c)	• Riverine	Medium	Similar habitat occurs in the Study area. Closest record is 40 km SSW of the Study area
Karaops sp. 'Mt Dove`	Selenopid Spider	• Mt Dove DSO Project (Phase 1) (Outback Ecology 2011a)	• Ridge (southerly or easterly aspect)	Low	Species represented by a single record from a habitat isolate 78 km NW from the Study area.
Urodacus 'pilbara 13'	Scorpion	• Turner River Hub Project (Outback Ecology 2011c)	• Maritime grassland • Low Acacia heath with Spinifex	Low	Habitat does not occur in the Study area
Troglochernes 'sp. nov. 001'	Pseudoscorpion	• Mt Dove DSO Project (Phase 1) (Outback Ecology 2011a)	• Ridge (southerly or easterly aspect)	Low	Species represented by five records from a habitat isolate from 85 km NW of Study area
Antichiropus	Millipede	• WAM Database (Western	• South facing Gully	Low	Species is likely to have a very

SRE species	Group	Source	Habitat(s)	Potential for occurrence in the Study area	Reason for potential occurrence
`Chichester`		Australian Museum 2011)	Floor • Creek line		restricted distribution. Closest record 102km S of the Study area.
Aname 'MYG100'	Spider	• WAM Database (Western Australian Museum 2011)	• Spinifex plain	Low	Habitat does not occur in the Study area
Aname 'MYG103'	Spider	• WAM Database (Western Australian Museum 2011)	• Spinifex plain	Low	Habitat does not occur in the Study area
Aname 'MYG208'	Mygalomorph Spider	• Turner River Hub Project (Outback Ecology 2011c)	• Acacia, Spinifex sandplain	Low	Habitat does not occur in the Study area
Aname 'MYG209'	Mygalomorph Spider	• Turner River Hub Project (Outback Ecology 2011c)	• Acacia, Spinifex sandplain	Low	Habitat does not occur in the Study area
Synsphyronus 'PSE008'	Pseudoscorpion	• WAM Database (Western Australian Museum 2011)	• Granite Outcrop	Low	Habitat does not occur in the Study Area
Sundochernes 'PSE021'	Pseudoscorpion	• WAM Database (Western Australian Museum 2011)	• Granite Outcrop	Low	Habitat does not occur in the Study Area
Oratemnus 'PSE018'	Pseudoscorpion	• WAM Database (Western Australian Museum 2011)	• Granite Outcrop	Low	Habitat does not occur in the Study Area
Quistrachia turneri	Slater	• Turner River Hub Project (Outback Ecology 2011c)	• Granite Outcrop • Ridge (southerly or easterly aspect • Calcrete Breakaway	Low	Habitats are limited in the Study area. Closest collection record 70 km S of the Study Area.
Spherillo? sp.	Slater	• Turner River Hub Project ((Outback Ecology 2011c)	• Granite Outcrop	Low	Habitat does not occur in the Study Area
Buddelundia sp. 21	Slater	• Mt Dove DSO Project (Phase 1) (Outback Ecology 2011a)	• Ridge (southerly or easterly aspect)	Low	Habitat is limited in the Study Area. Closest collection record approximately 80 km NW of the Study area.

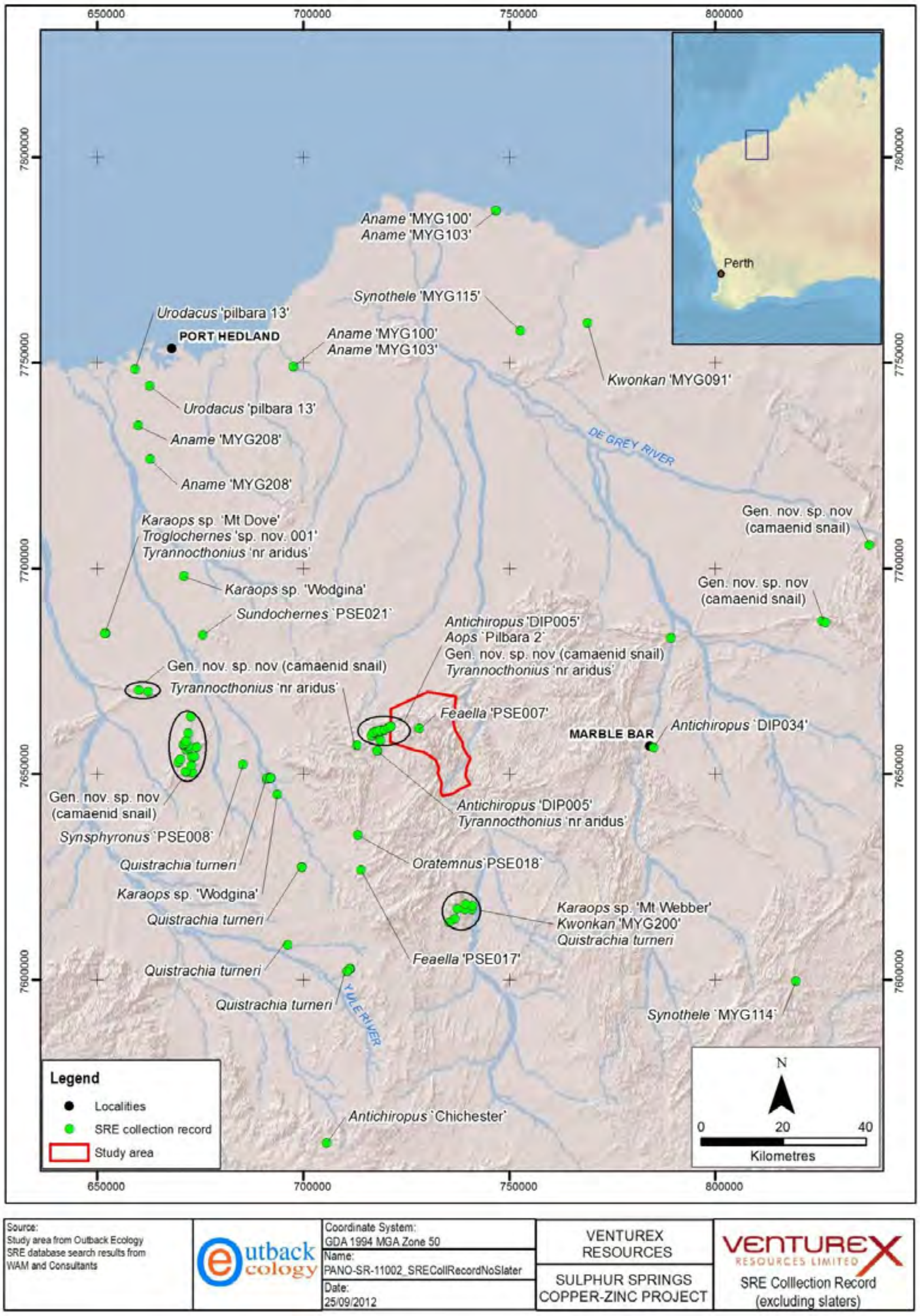

Figure 6: SRE Collection records yielded by database searches and literature review with reference to habitat distribution within the Study area and surrounds

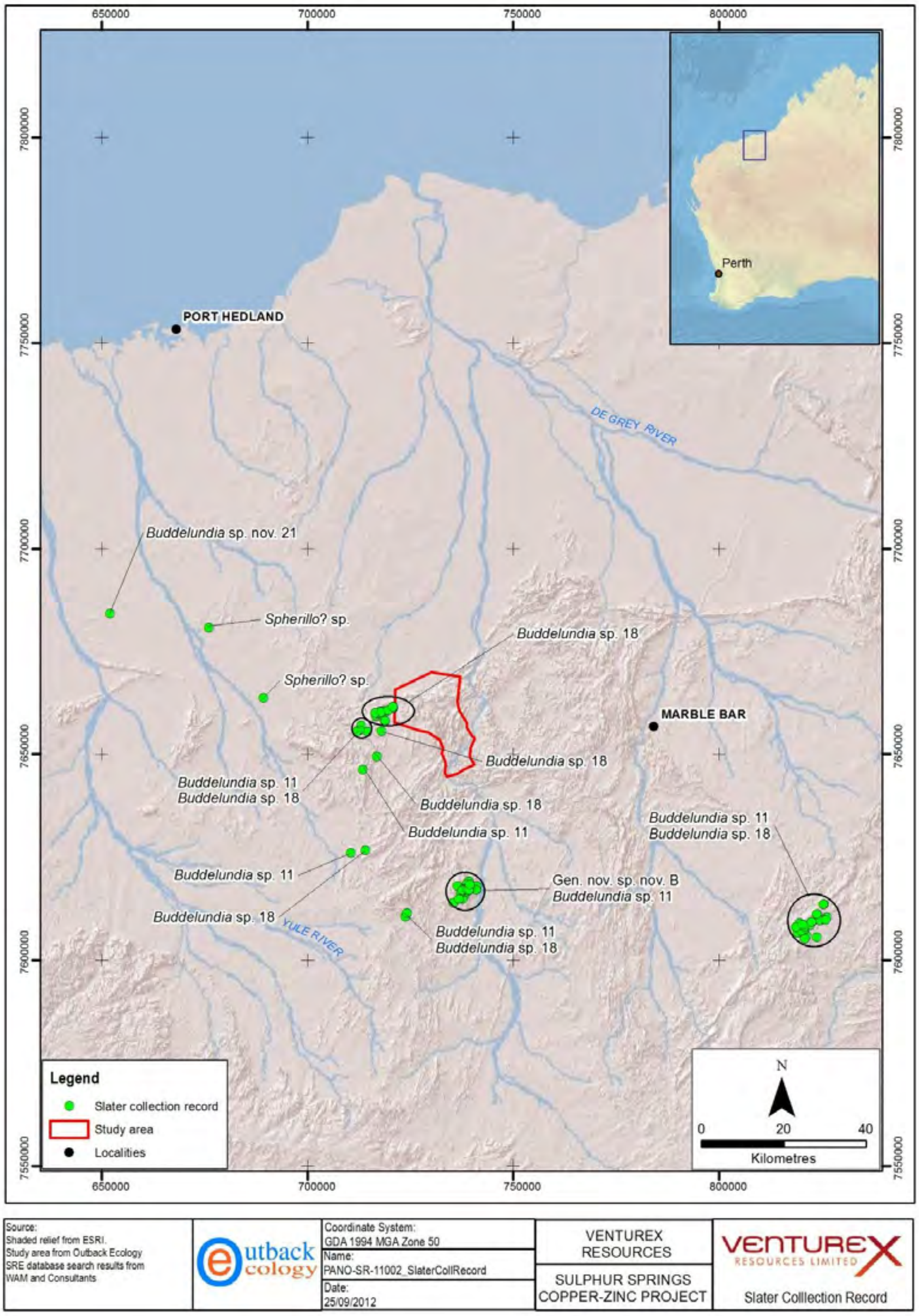

Figure 7: Collection records of slaters yielded by database searches and literature review with reference to habitat distribution within the Study area and surrounds

4. SURVEY LIMITATIONS AND CONSTRAINTS

A number of factors can influence the design and intensity of a SRE invertebrate fauna survey. The EPA (2004) lists possible limitations and constraints that can impinge on the adequacy of a survey (**Table 8**). All SRE invertebrate fauna surveys are limited to some degree by time and seasonal factors and in an ideal situation several surveys would be undertaken over a number of years during different seasons. Nevertheless, all potential limitations and constraints identified by the EPA (2004) were considered and satisfied.

Table 8: Summary of potential survey limitations and constraints

Aspect	Constraint?	Current survey
Competency/experience of consultants	no	Members of the survey team have had a combined experience in excess of six years undertaking SRE invertebrate fauna surveys of this kind in WA. Invertebrate specimens were identified by recognised taxonomic specialists.
Scope	no	Terrestrial SRE invertebrate fauna and habitat were assessed using established and standardised sampling techniques and habitat assessments.
Proportion of fauna identified, recorded and/or collected	no	The survey of the Study area yielded a total of 153 invertebrate specimens from 13 species belonging to taxa prone to short-range endemism. All specimens collected from groups prone to short range endemism in WA were submitted to the WAM or relevant specialists for identification. Whilst, all specimens were identified down to the lowest taxonomic level possible, it was not always possible to identify to species level if the taxonomy of the group was not well resolved or if the life stage or sex required for identification was not collected. The survey was designed to maximise the collection of specimens belonging to target groups; however, it is recognised that surveys across years and seasons may be necessary to collect the majority of species in an area.
Sources of information (e.g. previously available data as distinct from new data)	no	Data relevant to this survey was obtained via database searches (Section 2.1.1) and by undertaking a literature review (Section 2.1.2). The results from these database and literature reviews are presented in Section 3.3.
Proportion of task achieved, and further work which might be needed	no	Representative sites from all potential SRE habitats in the Study area were sampled using targeted searching and leaf litter collection. Specimens belonging to target SRE groups were collected from all 13 sampled sites. All specimens from target groups were identified by relevant taxonomic experts.
Timing, weather, season, cycle	no	Targeted searching was conducted during the optimum time for invertebrate surveys in the Pilbara (Environmental Protection Authority 2009). This was considered satisfactory given that the climatic conditions during the survey period were conducive to invertebrate activity. The temperature and during the survey was typical of the time of year however rainfall prior to the survey was higher than average due to cyclone activity (Section 2.2.2).

Aspect	Constraint?	Current survey
Disturbances	no	Evidence of grazing pressure from cattle was observed in the Drainage Line, Open Drainage Line, Riverine and Open Woodland habitats within the Study area. Vehicle access tracks impacted on the Gorge, Drainage Line and Floodplain (Habitat Assessment 1 Habitat Assessment 2). However, most of the area within these habitat considered to be important to SRE invertebrates was largely undisturbed.
Intensity	no	Targeted searching, soil and litter collection were employed at 13 sites. Additionally, habitat assessments were conducted at a further 3 survey sites. In total, the survey comprised 19.5 hours of targeted searching and the collection of 31 leaf litter samples.
Completeness	no	All potential SRE habitats within the Study area were adequately surveyed.
Resources	no	Resources were adequate to complete the survey. Survey participants were competent in the collection of invertebrates and identification of the habitats encountered during the survey.
Remoteness and access problems	partial	Due to flooding of access tracks in the Study area at the time of the survey, access by 4WD was slower than during previous visits to the area. As a result, the number of targeted search sites had to be reduced from 14 down to 13 sites. Coverage of the Study area by targeted searching was still adequate given the scale of proposed impacts.
Availability of contextual information	no	Contextual information on the occurrence of SRE species in the region was available and sourced through the WAM Database and through a literature review of regional SRE invertebrate fauna surveys. Additional information was also considered which included DEC's Threatened and Priority Fauna Database and DECs NatureMap database.

5. IMPACT ASSESSMENT

This section presents an assessment of the potential impacts of the Project on terrestrial SRE invertebrate fauna habitat and SRE species identified during field survey and also via the desktop study in accordance with requirements outlined by the EPA (2004, 2009). The primary objectives of this section are to describe the relevant threatening processes associated with the Project (**Section 5.1**), and to examine the likely impact of these threatening processes on SRE invertebrate fauna habitat (**Section 5.2**) and SRE species present in the Study area or immediate surrounds (**Section 5.3**).

5.1. Threatening Processes

Threatening processes specifically associated with the Project can be categorised as either direct or indirect impacts. Direct impacts primarily occur through land clearing whereas indirect impacts include inappropriate fire regimes, introduced flora and changes to surface hydrology (Environmental Protection Authority 2009), increased noise, vibration, artificial light, and impacts of dust. The threatening processes that are potentially associated with the development of the Project are discussed below.

5.1.1. Land Clearing

Land clearing is likely to be the threatening process that will have the largest impact on SRE invertebrate fauna and habitat. To develop the Project, land clearing will be required for a processing plant, TSF, evaporation pond, ROM pad, access roads, workshops, borrow pit, offices, camp and air strip.

The Project footprint is expected to be approximately 178.3 ha in size. It is understood that this footprint includes all major infrastructure associated with the Project, however additionally clearing may be required outside the footprint during construction. Some areas within this footprint have been previously been cleared by CBH Resources during their exploration phase.Land clearing will directly remove potential SRE invertebrate fauna habitat resulting in a reduction in available habitat and potentially habitat fragmentation. Short-range endemic invertebrate fauna species typically have poor powers of dispersal and are therefore unable to emigrate from land as it is being cleared. Land clearing will result in the loss of SRE individuals that occur within the Project footprint. The clearing of habitats with a high or medium potential to support SRE species (**Section 3.1**) should be limited where practicable.

5.1.2. Fire

The development and operation of the Project may alter the fire regime of the Study area. SRE invertebrate habitat such as cliffs, ridges and Gorges are often fire refuges (Environmental Protection Authority 2009) as they do not experience fire with the frequency of the surrounding landscape. Fire refuges in the Pilbara often support *Ficus* sp. trees and other fire intolerant vegetation, which are an important component of SRE habitats. Increasing fire frequency in fire refuges is likely to be detrimental to SRE species which have evolved in the absence of fire. The impact of inappropriate fire regimes may be reduced through the implementation of an appropriate fire management plan.

5.1.3. Introduced Flora

The Project may result in the introduction or spread of existing weeds in the Study area. Weeds may have a negative impact on SRE species as they can fundamentally alter the composition and structure of vegetation communities (Cowie and Werner 1993, Gordon 1998). Invasion by non-native species typically results in a decline in native plant species richness (Grice 2006). It is therefore important to implement management strategies to reduce the occurrence and spread of weeds during mining operations.

5.1.4. Changes To Surface Hydrology

The Project will impact upon drainage habitats in the vicinity of the Project, primarily through the construction of the access road (**Figure 5**). There exists the potential for runoff from the access road to cause sediment loading of the Gorge and Creek Line habitats in the vicinity and downstream of the access road. The natural hydrology of the Gorge and Creek Line may also make the access road susceptible to erosion during high rainfall events which may cause direct and downstream impacts to drainage habitats.

Drainage control structures may also affect the natural flow of water through drainage habitats. This may divert or interrupt the natural flow of water away from areas that were previously moist environments reducing the quality of SRE habitat and the health of vegetation occurring in these areas.

5.1.5. Noise And Vibration

Noise and vibration from the Project is likely to be associated with blasting, crushing and screening, haul trucks, road trains, diesel power generation and general machinery necessary for mine operation. Information on the potential effects of noise and vibration on SRE species is limited. A trial that tested the effect of exploration drilling on the SRE Shield-backed trapdoor spider has been conducted at Jack Hills in the Murchison by Crosslands Resources (Department of Mines and Petroleum 2010). In the trial, spiders were observed in their burrows while vibration simulating drilling was produced. Preliminary results suggest that the effects of vibration on spiders may be limited; however; the intrusion of the burrows by endoscopic camera may also have influenced spider behaviour. Raven (2008) suggests that vibrations created by blasting and heavy earthmoving equipment may actually attract spiders and other arachnids, which subsequently places these individuals at risk of direct contact with mining activities. Without further research, it is not possible to predict and quantify the noise and vibration impacts on SRE species.

5.1.6. Light

The operation of the Project and potential use of the access road during night-time hours could result in an increase in the exposure of SRE fauna to artificial light. Most SRE invertebrate fauna in the Pilbara are active during the hours of darkness and it is possible that artificial light will influence feeding and breeding behaviour. To reduce possible impacts of artificial light on SRE fauna, lighting should be designed to illuminate designated operations areas rather than the surrounding landscape.

5.1.7. Dust

The Project will potentially result in an increase in dust pollution resulting from the movement of light and heavy vehicles and the general use of equipment on site. Dust pollution may lead to the degradation of surrounding vegetation and high levels may reduce plant growth resulting in the degradation of the overall ecosystem and the increased risk of disease in plants. Adequate dust suppression measures should be implemented to reduce the effects of dust on potential SRE habitats and SRE species, particularly in the vicinity of the Gorge and Creek Line habitats

5.2. Impact on SRE Habitat

The construction of the Project will result in the loss of habitat. Habitat loss is listed as a key threatening process under the EPBC Act; however, it is recognised that this is a necessary and typical part of the development of the Project. The removal of SRE habitat within the Project footprint will result in the loss of the SRE populations that reside in those habitats.

Five drainage habitats were identified within the Study area. Of these habitats, the Gorge and Creek Line habitat were considered to have a high potential to support SRE species, whereas the Riverine habitat was considered to have a medium potential to support SRE species. The development of the access road component of the Project will impact all three of these habitat types and impacts to the many Drainage Lines that feed Gorge and Creek Lines are also likely to have an effect on these habitats.

The Gorge habitat has a high potential to support SRE species (**Section 3.1**). There were a total of five Gorges located within the Study area and each of these features formed a habitat isolate in the landscape. The development of the Project will directly impact one of these Gorges by removing 1.5 ha for 1.3 km along the Gorge for the construction of the access road (**Table 9**; **Figure 8**). Secondary impacts from the access road such as erosion and sedimentation may occur in the vicinity and downstream of the access road as a result of high volume water flow through the Gorge after periods of high rainfall. The other four Gorges in the Study area occur to the west, east and south east of the Project and comprise approximately 75.5 ha. These Gorges are unlikely to be impacted by the Project. Similar habitat also occurs beyond the Study area to the south west at the Abydos DSO Project (Outback Ecology 2012a). Because Gorges form habitat isolates and are of limited extent in the landscape, impacts to this habitat should be minimised as much as possible.

The Creek Line habitat has a high potential to support SRE species (Section 3.1). The development of the Project will result in the direct loss of approximately 0.08 ha of the Creek Line habitat for the construction of the access road where it crosses the Creek Line in one location (**Table 9**; **Figure 8**). This habitat was not identified elsewhere in the Study area. As this habitat is not well connected in the landscape and has a limited extent within the Study area, impacts to this habitat should be minimised where possible.

The Riverine habitat has medium potential to support SRE species (Section 3.1). The development of the Project will result in the loss of approximately 0.63 ha of the Riverine habitat for the construction of the access road (**Table 9**; **Figure 8**). Approximately 950 ha of this habitat is also known to occur to the west and south east of the Project within the Study area and is unlikely to be impacted by the Project. This habitat is extensive both within and outside the Study area in association with the Shaw River, however impacts to this habitat should be minimised where possible because of its medium potential to support SRE species and the potential to have downstream secondary impacts.

Table 9: The extent of drainage habitats within the proposed Project footprint

Drainage habitat	Area in Study area (ha)	Area in Project footprint (ha)
Gorge	80	1.49
Creek Line	8	0.08
Riverine	967	0.63
Drainage Line	95	0.13
Floodplain	38	0.41
Total	**1,188**	**2.73**

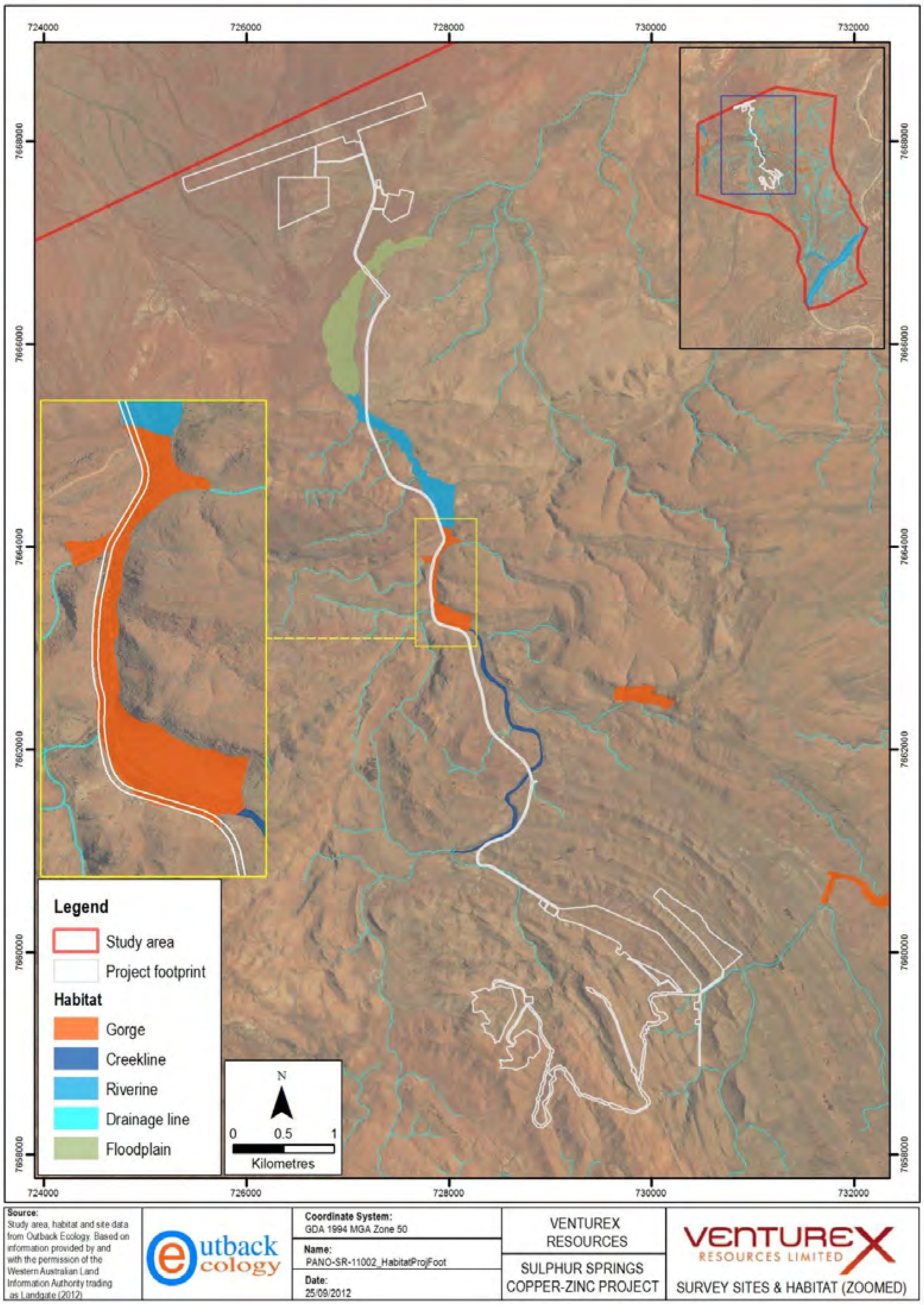

Figure 8: Drainage habitats in relation to the proposed Project footprint

5.3. Impact on SRE Species

Three SRE species were collected during the targeted SRE survey of the Study area (**Section 3.2**). Additionally, one species has been collected within the Study area during a survey by Biota (2007a) (**Section 3.3**).

Table 10: The distribution of SRE species and their habitat in relation to the Project footprint

SRE species	Records			Habitat(s) from which species were collected
	Project footprint	Study area (outside of Project footprint)	Regional (outside of Study area)	
Antichiropus DIP005	X	X	X	Gorge
				Creek Line
Antichiropus DIP34		X	X	Riverine
				Disturbed
Buddelundia sp. 11		X	X	Drainage Line
				Gorge
Feaella PSE007		X		Creek Line

5.3.1. *Antichiropus* 'DIP005'

The millipede *Antichiropus* 'DIP005' is a SRE species that was collected at one site within the Project footprint and three sites outside the Project footprint (**Table 10**; **Figure 9**). Within the Study area, *Antichiropus* 'DIP005' was collected from Gorge and Creek Line habitats which are considered to have a high potential to support SRE species. The development of the Project will remove 1.49 ha (1.3 km) of Gorge habitat and 0.08 ha of Creek Line habitat (**Table 9**). Although the Project will impact upon the Gorge and Creek Line where this species was collected; this species is also known to occur at another Gorge away from the Project footprint within the Study area. Additionally, this species is known to occur at six sites 9 km south west of the Study area at the Abydos DSO Project (**Figure 10**).

Although *Antichiropus* 'DIP005' is a SRE species that is likely to have a distribution that aligns with sheltered habitats in the vicinity of Sulphur Springs, the known distribution of this species extends outside of the footprint for the Project both locally and regionally. Consequently, the Project is unlikely to pose a long term conservation risk to *Antichiropus* 'DIP005'.

5.3.2. *Antichiropus* 'DIP034'

The millipede *Antichiropus* 'DIP034' is a SRE species collected at one site in Riverine habitat less than 100 m downstream of the access road component of the Project footprint (**Table 10**; **Figure 9**). The Riverine habitat has medium potential to support SRE species and 0.63 ha of this habitat occurs within the Project footprint (**Table 9**). Although the Project will impact upon the Riverine habitat where this species was collected; this species is also known to occur outside of the Study area at Marble Bar (65 km east of the Study area) (**Figure 10**).

Although *Antichiropus* 'DIP034' is a SRE species that is likely to have a distribution that aligns with sheltered habitats in the vicinity of Sulphur Springs, the distribution of this species extends outside of the footprint for the Project regionally. Consequently, the Project is unlikely to pose a long term conservation risk to *Antichiropus* 'DIP034'.

5.3.3. Buddelundia sp. 11

The slater *Buddelundia* sp. 11 is a SRE species collected at two sites during the survey outside of the Project footprint (**Table 10**; **Figure 12**). Within the Study area, *Buddelundia* sp. 11 was collected from Gorge and Creek Line habitats which are considered to have a high potential to support SRE species. The development of the Project will remove 1.49 ha (1.3 km) of Gorge habitat and 0.08 ha of Creek Line habitat (**Table 9**). *Buddelundia* sp. 11 has also been collected at a number of regional locations including the Abydos DSO Project, Mt Webber DSO Project and the McPhee Creek DSO Project as well as other locations.

Although *Buddelundia* sp. 11 has been collected from habitats that occur within the Project footprint, none of the specimens were collected from within the Project footprint. Additionally, *Buddelundia* sp. 11 is known to have a wide regional distribution from collection records from a number of other locations. Consequently, the Project is unlikely to pose a long term conservation risk to *Buddelundia* sp. 11.

5.3.4. *Feaella* PSE007

The pseudoscorpion *Feaella* PSE007 is a SRE species known from a single specimen collected outside the Project footprint habitat by Biota (2007a) (**Table 10**; **Figure 13**). This species was collected from Creek Line habitat which is considered to have a high potential to support SRE species. The Project will remove 0.08 ha of Creek Line approximately 1 km downstream of where the specimen of *Feaella* PSE007 was collected.

Only one specimen has been collected despite several surveys being conducted with the aim of collecting additional specimens, suggesting that the species is very cryptic and may only be active during certain climatic conditions. Given the Project will not impact the collection location of this species and given that impacts to the Creek Line habitat are limited, it appears unlikely that the Project will pose a long term conservation risk to *Feaella* PSE007.

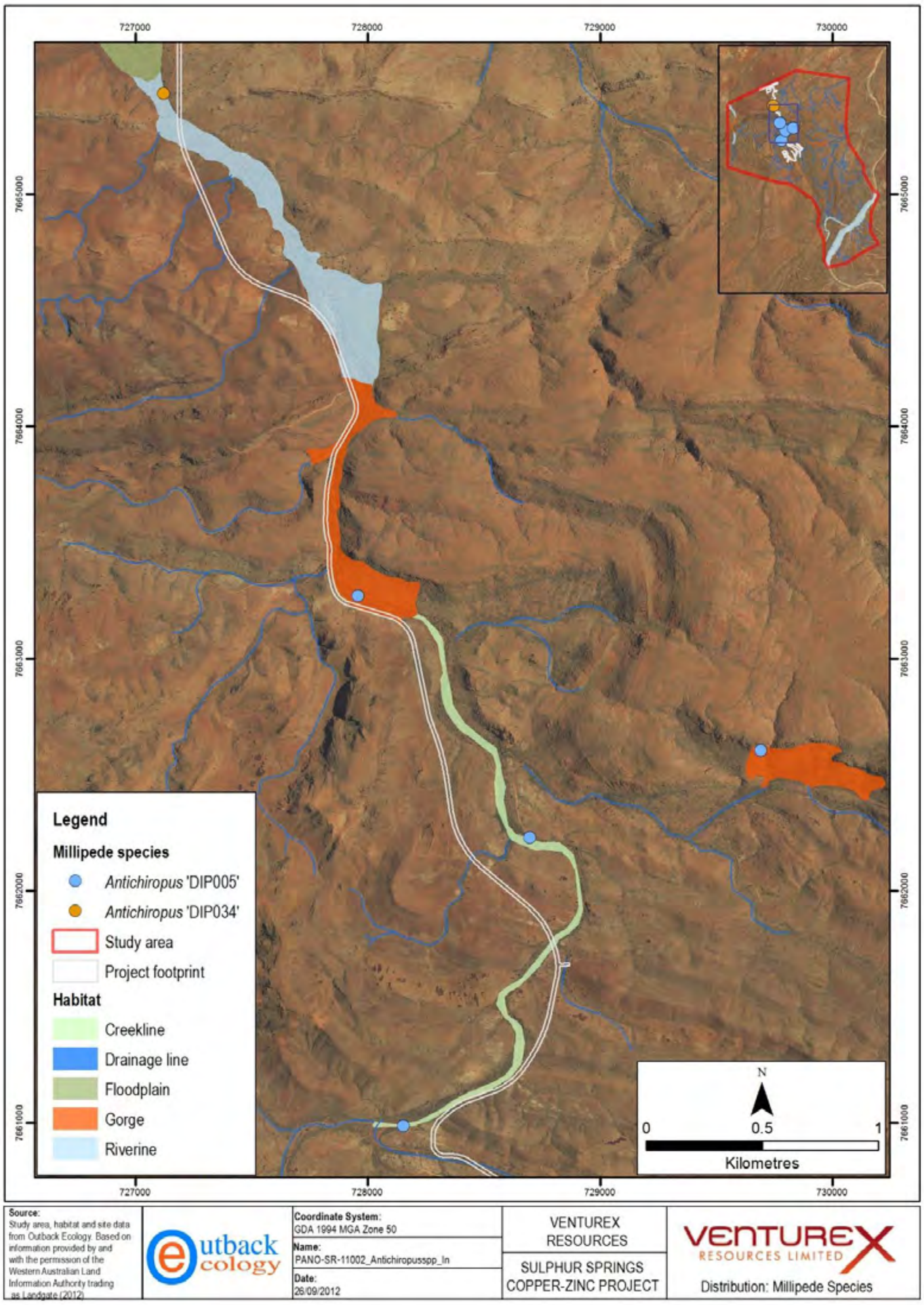

Figure 9: Collection locations of the millipede *Antichiropus* 'DIP005' and Antichiropus '034' with respect to habitat types within the Study area

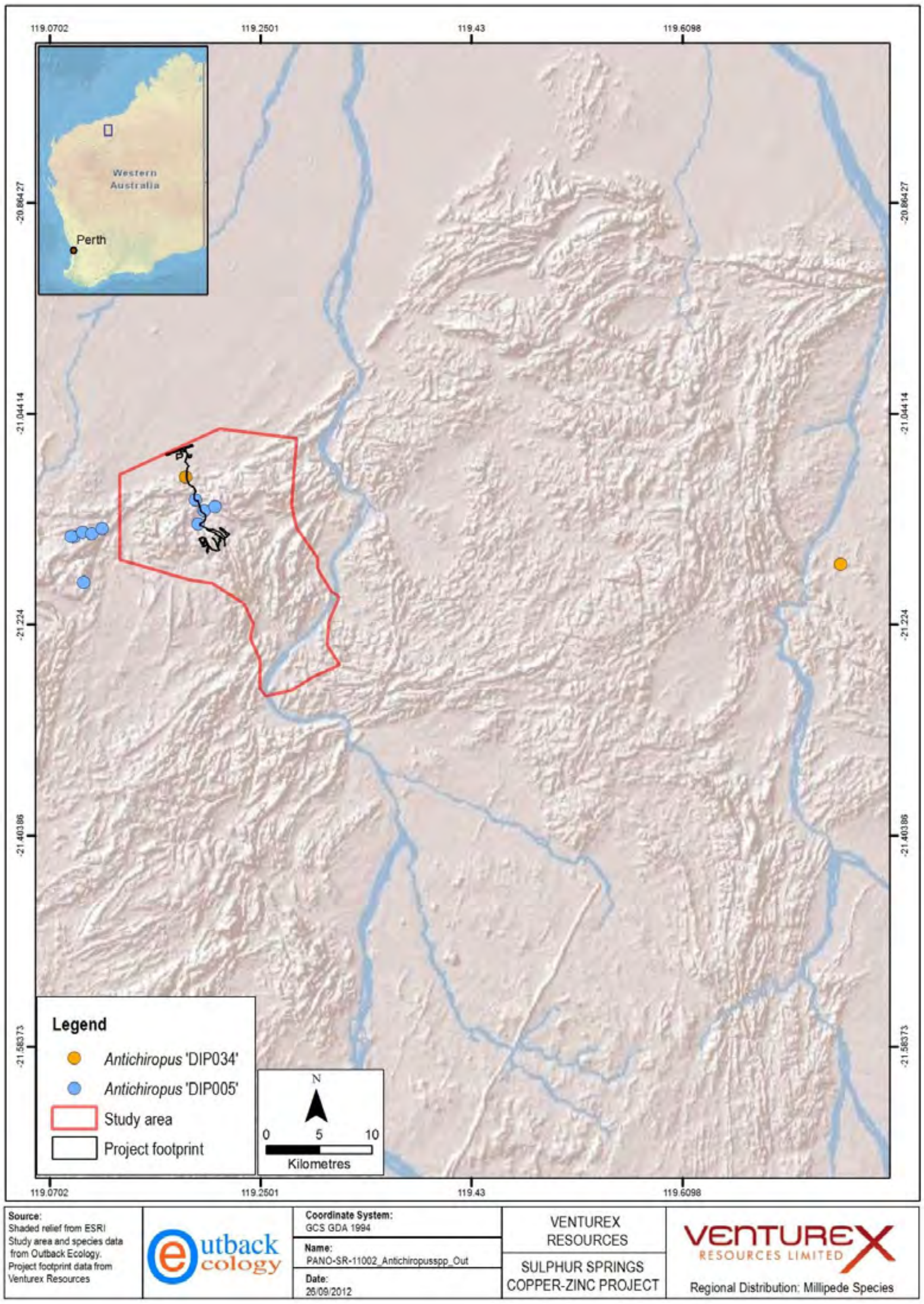

Figure 10: Distribution map of the millipede *Antichiropus* 'DIP005' and *Antichiropus* 'DIP034'

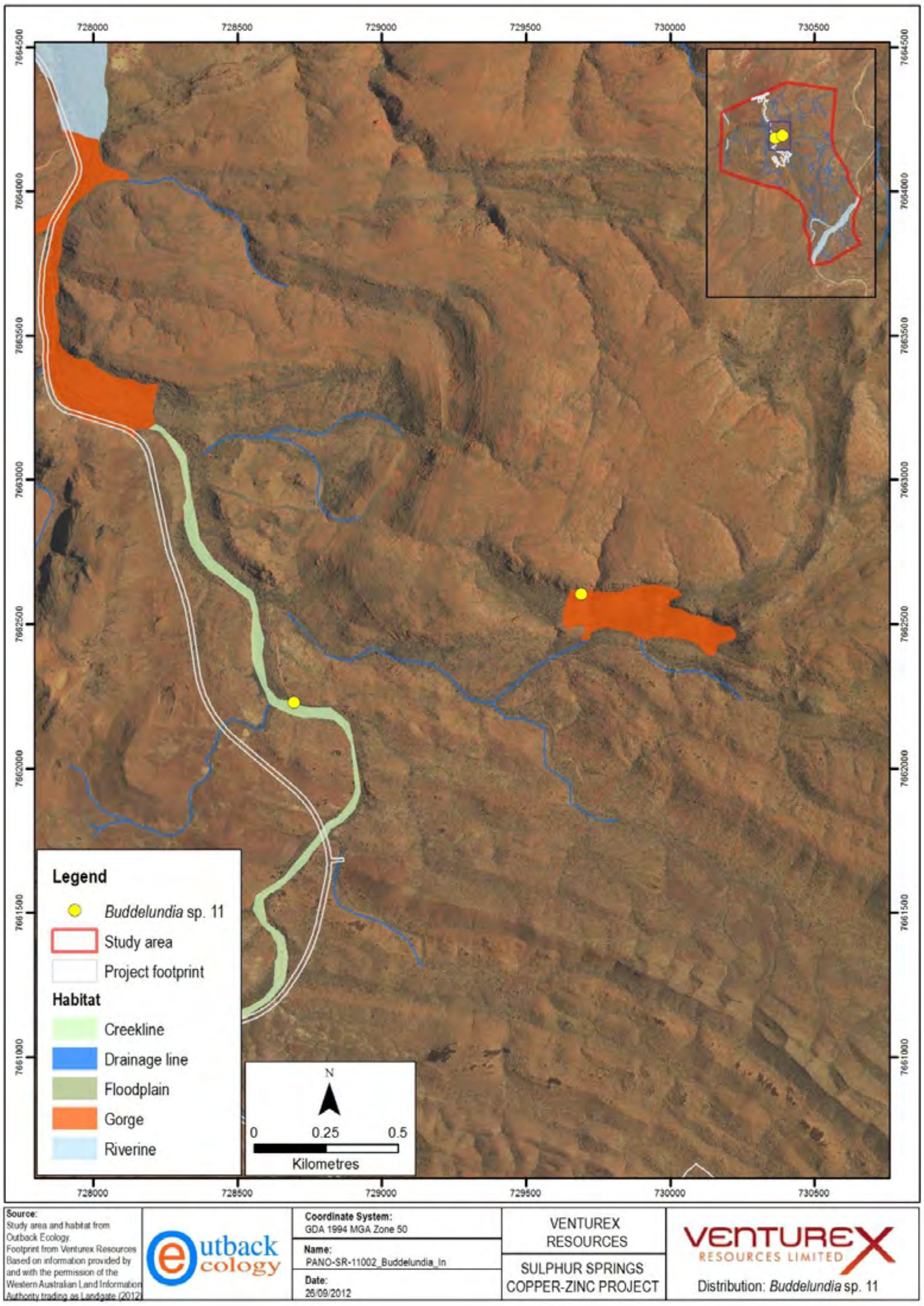

Figure 11: Collection records of the slater *Buddelundia* sp. 11 with respect to habitats within the Study area

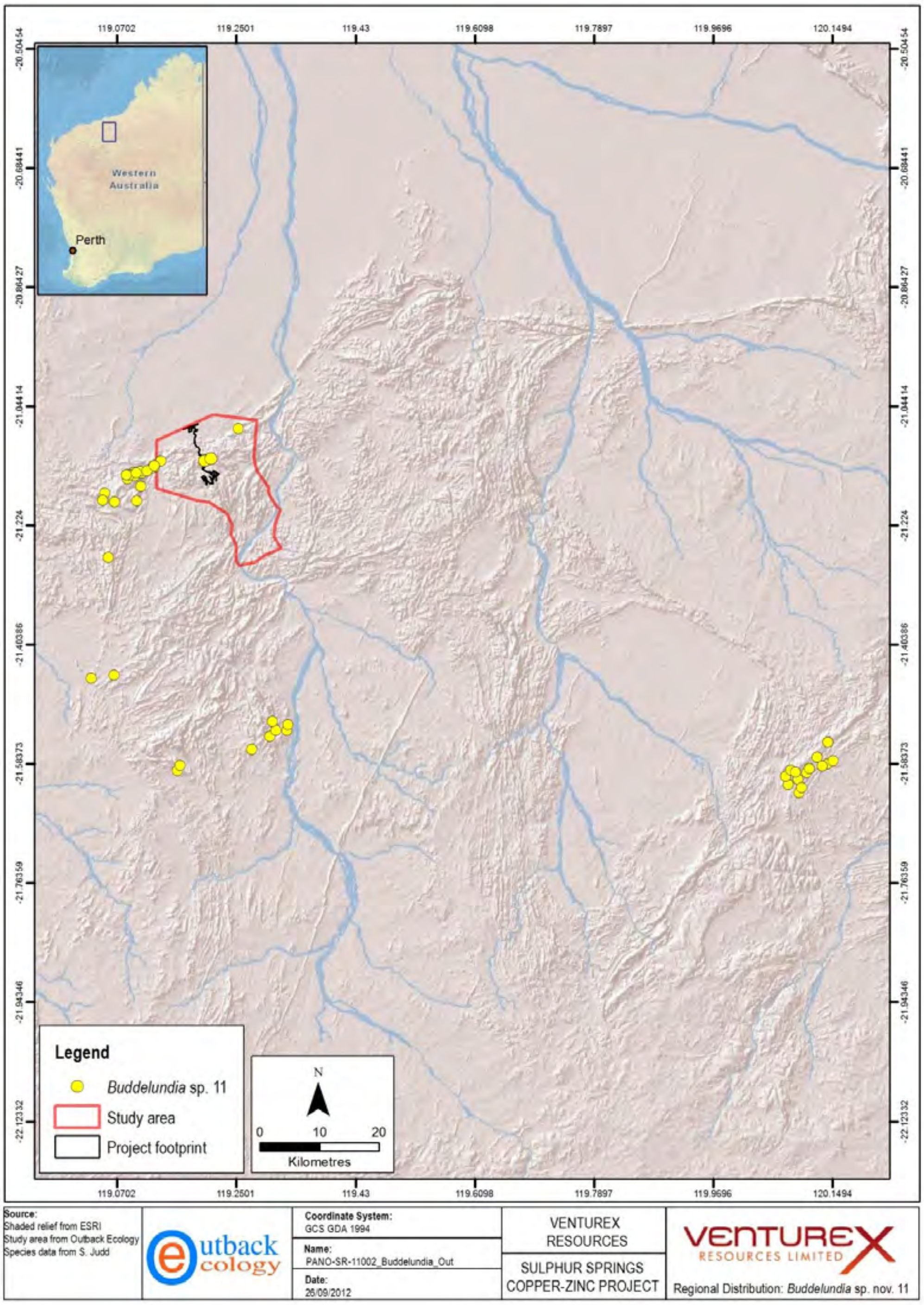

Figure 12: Regional distribution of the slater *Buddelundia* sp. 11

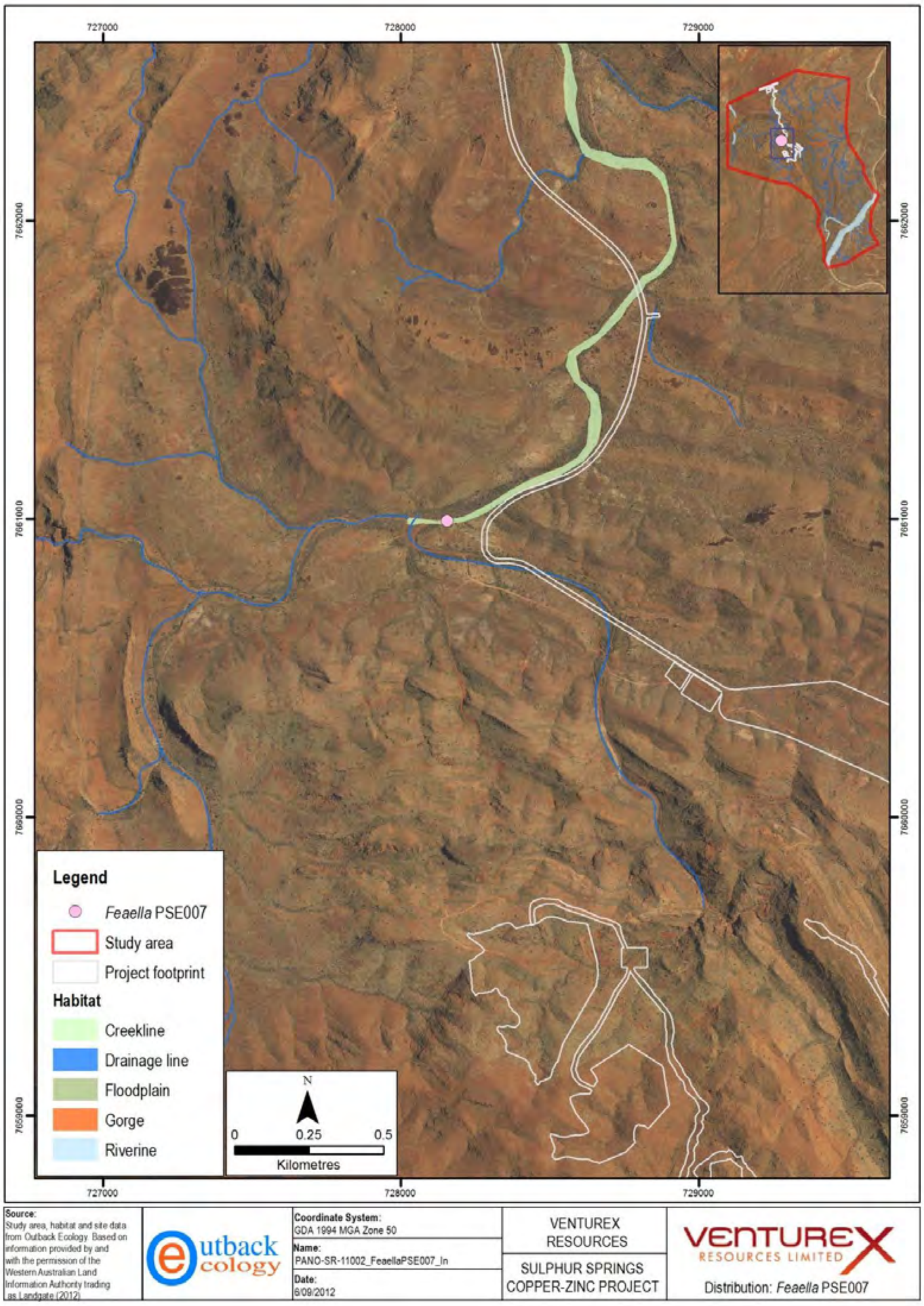

Figure 13: Collection records of the pseudoscorpion *Feaella* PSE007 with respect to habitats within the Study area

6. CONCLUSIONS

The Project will impact upon SRE species through the loss of individuals and habitat on a local scale through direct loss of individuals during clearing, loss of habitat and indirect impacts, particularly in the vicinity of the proposed mine access road.

The targeted survey of SRE groups within the Study area resulted in the collection of four SRE species:

- the millipede *Antichiropus* 'DIP005';
- the millipede *Antichiropus* 'DIP034',
- the slater *Buddelundia* sp. 11; and
- the pseudoscorpion *Feaella* 'PSE007'.

Based on the desktop assessment, nine additional species were considered to have medium potential to occur in the Study area based on the proximity of records, the availability suitable habitat and the connectivity of habitat with the Study area.

Of the four species collected within the Study area, only the millipede *Antichiropus* 'DIP005' has been collected within the Project footprint. However this species has also been collected outside of the Project footprint within the Study area and at regional sites 12 km southwest of the Project. Although this species is likely to have a distribution that aligns with sheltered habitats in the vicinity of Sulphur Springs, the occurrence of this species at regional sites suggests that the Project is unlikely to pose a long term conservation risk to *Antichiropus* 'DIP005'. Provided that secondary impacts to habitats are minimised, the Project is also unlikely to pose a long term conservation risk to the other three species as they were not collected within the Project footprint.

The Project footprint is expected to be approximately 178.3 ha in size. It is understood that this footprint includes all major infrastructure associated with the Project, however additionally clearing may be required outside the footprint during construction. Some areas within this footprint have been previously been cleared by CBH Resources during their exploration phase.

Habitat assessments of the drainage features within the Study area identified five types of drainage habitat:

- Gorge;
- Creek Line;
- Riverine;
- Drainage Line; and
- Floodplain.

The Gorge and Creek Line habitats were considered to have high potential for supporting SRE species and Riverine habitat was considered to have medium potential to support SRE species.

The construction of the Project will result in the loss of approximately 2.73 ha of drainage habitat. This will comprise 1.49 ha (1.3 km) of Gorge habitat, 0.08 ha of Creek line habitat and 0.63 ha of Riverine habitat present in the Study area. These habitats will primarily be impacted thought the construction of the mine access road. There also exists the potential for runoff from the access road to cause sediment loading of the Gorge and Creek Line habitats in the vicinity and downstream of the access road. The natural hydrology of the Gorge and Creek Line may also make the access road susceptible to erosion during high rainfall events which may cause direct and downstream impacts to drainage habitats. Although these habitats are known to occur in other locations in the Study area, they are of limited extent and not well connected in the surrounding landscape. All other drainage habitats in the Study area were considered to have a low potential to support SRE species.

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APPENDIX A
Site Descriptions

APPENDIX B

Arachnids and Diplopods from Sulphur Springs, Western Australia

APPENDIX C

Slaters of the Venturex Copper Zinc Project: Sulphur Springs

APPENDIX D

Non - Marine Molluscs from Sulphur Springs, Western Australia

Appendix E

Outback Ecology DNA Bar-coding Project (Antichiropus)

APPENDIX 7: SUBTERRANEAN FAUNA SURVEYS (SUBTERRANEAN ECOLOGY 2007A, 2007B AND 2007C)

Panorama Project
Subterranean Fauna Survey
Report 2

Prepared for

CBH Sulphur Springs Pty Ltd

Prepared by

Subterranean Ecology

Scientific Environmental Services

July 2007

Panorama Project
Subterranean Fauna Survey
Report 2

Subterranean Ecology
Scientific Environmental Services
ABN 61 973 518 568
11 Dillenia Way, Greenwood WA 6024, Australia
Phone: Int - 61 (0)8 9343 4141
Mobile: Int: 61 (0)401 436 968
Email: info@ subterraneanecology.com.au
www.subterraneanecology.com.au

Project No. 46

Prepared for: CBH Resources Pty Ltd

Prepared by: Subterranean Ecology

Date: July 2007

COVER: Sulphur Springs. Photo Subterranean Ecology.

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1. EXTENDED SUMMARY

This report documents an assessment of subterranean fauna undertaken for the Panoroma CBH Resources Sulphur Springs Project in the Pilbara region, Western Australia. The report documents the findings of two field surveys conducted for stygofauna (aquatic subterranean fauna) and two field survey conducted for troglofauna (terrestrial subterranean fauna), and assesses the distribution and conservation status of identified species in relation to potential impacts from mining activities.

Stygofauna

The first round of stygofauna sampling identified the occurrence of stygofauna in the project area (Subterranean Ecology 2006). This report recommended a second survey to adequately sample and identify the species found, and to assess their distribution and conservation status.

Survey effort for stygofauna involved two rounds of sampling undertaken in December 2006 and February 2007. Fifty-four (54) prospective sample sites were visited (eight sites were inaccessible for sampling), including bores, wells and springs. Sites were sampled using a combination of net hauling, trapping, pumping, and Karaman-Chappuis methods. Overall, the survey effort involved 74 sample events spread across 46 sites, of which 36 were located within the potential impact zone and 10 reference sites located outside the impact zone.

Stygofauna was detected at 20 (40 %) of the 461 sites sampled, and in seven of the eight topographic (sub) catchments sampled. Within the zone of mine influence, stygofauna was recorded from three of the six aquifers defined by Golder Associates. Stygofauna was collected from both deep and shallow groundwater habitats. The deep groundwater habitats comprised fractured-rock aquifers. Shallow groundwater habitats included alluvium and calcrete, and the hyporheos (porous interstitial) of springs and spring-brooks (Creek Spring in Sulphur Springs Creek).

The detected stygofauna comprised representatives of the major common groundwater taxa known in the Pilbara, including Crustacea (Amphipoda, Copepoda, Ostracoda, Isopoda), Acariformes, Nematoda and Oligochaeta. More than 1,161 individual specimens were retrieved from samples, with approximately 957 individuals identified to the level of species or the lowest taxonomic rank possible.

Twenty seven taxa were identified, of which 24 were found within the subcatchments of Sulphur Springs Creek, Minnieritchie Creek, Six Mile Creek or 'Lalla Rookh Creek'. Of these 24 taxa, 20 had distributions recorded further downstream in the catchments of the Shaw and East Strelley Rivers, and/or at regional scale of the Pilbara or greater.

The local distribution patterns of identified (morpho) species were consistent with predictions based on patterns of surface drainage and catchments. Taxa not detected or identified to species level because of taxonomic limitations are considered likely to display similar distributions related to local patterns in surface drainage and groundwater catchments.

The four taxa not collected or otherwise recorded in regional sampling were two species of Oligochaeta and two species of Nematoda. Groundwater Oligochaeta generally display widespread distributions. The taxonomy and distribution of Nematoda is poorly defined, however the collected taxa are considered likely to display similar distribution patterns to the other taxa collected during this survey.

In consideration of potential drawdown impacts to the conservation of stygofauna species, it is concluded on the basis of current available knowledge, that there is a low likelihood that any species will be threatened with extinction as a result of groundwater drawdown impacts from the mine development.

In consideration of potential drawdown impacts to the conservation of local populations inhabiting deep groundwater habitats, it is concluded on the basis of current available knowledge as at the printing of this report, that most of the deep groundwater habitat will be retained within the zone of fractured rocks that remain saturated below the limits of conceptual watertable drawdown.

In consideration of potential impacts to the conservation of local populations inhabiting shallow groundwater habitats in the springs and spring-brook in Sulphur Springs Creek, it is concluded that populations at this site may be adversely affected if the flow regime or water quality are affected.

The most important area sampled for stygofauna lies in Sulphur Springs Creek in the vicinity of bores SSWB36 to SSWB40, which is a local hotspot with 14 species recorded. In this area the natural seasonal variations in water levels recorded at these bores is +/- 4 m.

About 1.5 km upstream of this area is a spring and spring-brook, where stygofauna was recorded from shallow interstitial habitats in unconsolidated alluvial sediments of the creek bed. If groundwater pumping affects the discharge regime at this spring then the local populations of stygofauna here may be affected. The spring populations may also be affected by road construction activities such as sedimentation or pollutants.

Stygofauna was not detected in the pit and waste areas. The apparent absence of stygofauna in this area may be related to the groundwater quality which is acidic (pH range 2.8 to 4.8) and with low oxygen (DO < 0.5 mg/L).

Beyond the pit and waste areas, the evidence from drill logs and pump sampling (SSWB36, SSWB40) suggests that the major stygofauna habitat occurs in the fractured rocks below the superficial alluvium, where the saturated thicknesses range from an approximate minimum of 30 m (eg. SSWB40, SSWB41) to > 60 m (eg. SSWB36, SSWB22).

In addition to groundwater drawdown, other potential impacts include alteration to groundwater flow regime and water quality, pit salinisation, sedimentation and contaminated seepage from roads and other cleared surfaces, the TSF, plant equipment and infrastructure. These potential impacts may be localised but they need to be carefully managed considering the Creek Spring populations and stygofauna hotspot (SSWB36 to

SSWB40) are situated in Sulphur Springs Creek alongside the access road and immediately downstream of the TSF, plant and pit.

Further investigations that may be warranted prior to mine development include:

1. Baseline sampling at proposed new water supply bores;
2. Baseline sampling of bores in the area of the TSF;

Further investigations that may be warranted during mine operation include:

3. Monitoring drawdown and possible impacts on stygofauna populations;
4. Monitoring groundwater quality and possible contaminants in Sulphur Springs Creek;

Potential management activities to minimise impacts on stygofauna populations include, where practicable, minimise drawdown in areas of known populations. Standard precautions for protecting groundwater quality should be followed, including minimising sediment runoff, salinisation, contamination from seepage, infrastructure, and plant equipment.

Troglofauna

The preliminary desktop assessment suggested there was a low likelihood of occurrence of a troglobitic fauna community of potential conservation significance in the mine pit area. Field validation surveys were initiated in February 2007. Prior to this survey, troglofauna was not previously known from weathered volcanogenic massive sulphide (VMS), gossan, or other non-karstic or pseudo-karstic deposits (except vuggy pisolite in the Robe Valley), so the initial sampling approach was a pilot study aimed at establishing the likely presence or absence of troglofauna within the pit area. Following the pilot survey, a more intensive survey (phase 1) was initiated (May 2007) to determine if troglobitic species of conservation concern were present. Fifty-one traps were deployed in 18 drill holes spanning the range of different lithology in the mine pit area.

Invertebrates were collected from each of the 18 holes sampled. For both surveys, 1079 specimens comprising 23 morpho-species were collected. Most species collected were non-troglomorphic, and unlikely to be of potential conservation concern. One species, a cockroach (Blattodea) is a group known to include troglobitic representatives at Robe Valley and Cape Range. Ten specimens were collected from three holes (SSP19, SSP21, SSP23) situated close together on the western side of the valley and inside the proposed pit void. The specimens showed troglomorphologic characters suggesting they are fully adapted to subterranean life, including reduced pigment, reduced eyes, elongated antennae and appendages.

The specimens were compared with type specimens of subterranean cockroaches held at the Western Australian Museum. Based on gross morphology, the Sulphur Springs animals are clearly quite different to the highly troglomorphic *Nocticola flabella* Roth 1991 described from caves at Cape Range, and they also appear to be different from the other described species, *Nocticola brooksi* Roth 1995 recorded from caves in the Kimberley and Northern Territory. All of the Sulphur Springs specimens were immature nymphs, although for positive identification and description mature adults are needed for dissection of the genitalia.

To characterize the subsurface habitat for troglofauna in the proposed pit area, drill logs and diamond core photographs were examined for each of the holes sampled. Three sampled holes with major cavities did not contain invertebrate assemblages that were markedly more abundant or diverse than those in other holes with no cavities reported. The cavernous zone occurring at depth in the contact zone between overlying sediments (chert and polymict breccia) and the underlying sulphide lens appears to be isolated and disconnected from shallow surface weathering zones, with no intervening development of secondary permeability that might provide habitat connectivity between the potential deep and shallow subsurface habitats. The diamond core photographs that were examined displayed highly coherent lithologies with no indication of cavities, vugs, fracturing, or other significant voids in the profiles.

The troglomorphic cockroaches were collected from three holes (SSP19, SSP21, SSP23) situated close together (< 100 m apart) on the western side of the valley. The surface geology in this location is the upper chert, shale, sandstone and polymict breccia of the Kangaroo Caves Formation in the Sulphur Springs Group. The drill logs for these holes reported slightly weathered lithologies in the upper few metres (< 20 m) of profile, and increasing sulphide enrichment with depth, but no major cavity development was reported. Similarly, diamond core photographs from holes (SSD055, SSD074, SSD075, SSD085, SSD087) located < 100 m away showed highly compact lithologies, albeit with some shearing and fault structures, but no major air-filled cavities. The lithology at depth in this area does not appear to offer prospective habitat for troglofauna.

At the times of trap deployment and trap collection, two of the holes which contained cockroaches (SSP19, SSP21) contained standing water estimated to lie at about 20 m (SSP 19) and 30-40m (SSP21) below ground level. The upper lithology in these two holes comprised chert and shale, and in these holes the mineralized sulphide zone is intersected at depths > ca. 50m, viz., below standing water level. The cockroaches were collected in traps placed at depths of between 5 m and 25 m below the ground surface, and therefore must have colonized the traps from above the level of standing water in these holes.

At Sulphur Springs, the most plausible explanation for the observed occurrences of troglomorphic species, and troglofauna generally, is that the drill holes were colonised from the shallow subsurface (regolith and soil) and surface (epigean) zones. In the proposed pit area and extensively throughout the region, the regolith is well developed, and represents a prospective *shallow subsurface habitat* for invertebrates, including possible troglomorphic species. This terrain occurs widely throughout the ranges in the area, with unconsolidated colluvium sands, silts and gravels on outwash fans and on scree and talus slopes in pockets beneath the ridges of the George Creek and Sulphur Springs Groups. Prospective shallow subsurface habitats are not restricted to the VMS deposit or the proposed pit area, rather they are extensive and more or less continuous throughout the wider region. Given the continuity of this habitat, with no obvious barriers to dispersal or other geomorphic isolating mechanisms (cf. mesa landforms Robe Valley, Biota 2006), it is considered probable that the species assemblages sampled in the pit area are widely distributed in contiguous regolith habitats outside the pit impact zone.

Further investigations were warranted to verfiy the occurrence of troglofauna in *underground shallow medium* outside the proposed pit area. A field survey (phase 2) commenced in July 2007 with the aim of sampling as many holes as possible that could be located in similar geology and geomorphology outsidethe proposed pit void and mine site zone of influence. The phase 2 survey deployed traps in eleven holes found to be accessible which spanned two discrete but geologically contiguous areas in the Kangaroo Caves Formation (Kangaroo Caves and Bernts prospects) located seven and eleven kilometers southeast of the proposed mine site. Closer to the proposed mine site, all earlier constructed drill holes had been destroyed by natural processes of collapse, erosion, sedimentation and burial. This constrained the sampling coverage achievable.

At the completion of phase 2 the results will be examined to see if the species assemblages found in the region are similar or different to the assemblages found inside the pit area. If the assemblages found at Kangaroo Caves and Bernts are faunistically similar to those found inside the pit zone, then it is likely that no further assessment issues exist for troglofauna in relation to this project. If significant faunistic differences are evident, then further sampling may be warranted in prospective regolith habitats located closer to the proposed pit. This may necessitate drilling of shallow holes designed for sampling troglofauna in the regolith zone.

2. INTRODUCTION

2.1. Project background

CBH Sulphur Springs Pty Ltd (CBH) is planning to develop an open cut mine at its Sulphur Springs copper-zinc deposit in the Pilbara called the Panorama Project (Project). The Sulphur Springs deposit is located approximately 110 km southeast of Port Hedland within the Shire of East Pilbara. CBH plan to mine the ore by open-cut at the rate of 1.5 million tonnes per annum and process it through an on-site flotation plant to produce copper and zinc concentrates which will be transported to Port Hedland for shipment (CBH 2007). The Project has a nominal eight year life of mine.

As part of the environmental assessment process, Subterranean Ecology (Scientific Environmental Services) was contracted during November 2006 to conduct a preliminary survey for stygofauna (Subterranean Ecology 2006). This report identified the occurrence of stygofauna (aquatic subterranean fauna) in the Project area, and recommended a second survey to adequately sample and identify the species found, and to assess their distribution and conservation status in relation to potential impacts in the Project area and immediate surrounds. As part of the second survey, CBH requested Subterranean Ecology to also undertake an assessment and field survey for troglofauna (terrestrial subterranean fauna) in possible caves or voids within the Project pit area. The second field survey (stygofauna phase 2 and troglofauna pilot study) was undertaken in February 2007. A follow-up troglofauna survey (phase 1) was commenced in May 2007.

2.2. Scope of this report

This report documents the results of two phases of stygofauna survey, and two troglofauna surveys (pilot and phase 1).

The objectives of the work were to:

1. Adequately sample stygofauna in the Project area and surrounding lands to determine their occurrence and distribution in relation to the Project disturbance areas.

2. Undertake a pilot survey for troglofauna in possible caves or voids within the Project pit area, and if fauna was detected then undertake a follow-up survey (phase 1) to determine if troglomorphic species were present.

3. Identify collected specimens to species level, or the lowest taxonomic unit possible.

4. Assess the distribution and conservation status of species in relation to Project disturbance areas and potential impacts.

This survey was undertaken with reference to the Environmental Protection Authority (2003) Guidance for the assessment of environmental factors (in accordance with the Environmental Protection Act 1986) *Consideration of Subterranean fauna in* *groundwater and caves during environmental impact assessment in Western Australia. No. 54.* www.epa.wa.gov.au

2.3. Constraints and limitations

This study was limited to the requirements specified by the client and the extent of information made available to the consultant at the time of undertaking the work. Assessment of potential impacts was based on mine plans provided by CBH Resources (10th May 2007) and conceptual groundwater drawdown contours provided by Golder Associates (Technical Memorandum 19th April). It is noted that the hydrogeology of the area is complex, that additional bores are planned for water supply and monitoring, and further hydrogeological investigations will be undertaken prior to the project startup phase. Information not made available to this study, or which subsequently becomes available may alter the conclusions made herein.

3. DESKTOP REVIEW

3.1. Relevant legislation and guidance statement

Two State Acts and a Federal Act are relevant to the consideration of subterranean fauna in environmental impact assessment of this proposal:

Environmental Protection Act 1986,
Wildlife Conservation Act 1950;
Environment Protection and Biodiversity Conservation Act 1999.

In Western Australia, the objective of the Environmental Protection Authority (EPA 2003) in relation to subterranean fauna species is to ensure adequate protection of important habitats for these species. In accordance with the *Environmental Protection Act 1986*, the EPA Guidance Statement No. 54 (Subterranean fauna) provides the basis for the EPA's evaluation of development proposals subject to environmental impact assessment (EIA). The requirements of this Guidance represent the minimum level of information necessary to enable the assessment of subterranean fauna as an environmental factor.

The EPA also ensures that proposals do not potentially threaten the viability of any subterranean species, in accordance with the *Wildlife Conservation Act 1950.* This Act is administered by the Department of Conservation and Environment (DEC) who advises the EPA. The object of the *Wildlife Conservation Act 1950*, is 'to provide for the conservation and protection of wildlife', and it does not permit the Minister for the Environment to issue a license to take fauna where that taking might lead to extinction. Fauna species which are recognised as rare, threatened, or have high conservation value, may be specially listed under this Act via the *Wildlife Conservation (Specially Protected Fauna) Notice.*

The Federal *Environment Protection and Biodiversity Conservation Act 1999*, is relevant where certain threatened species and threatened ecological communities (TECs) listed under this Act may be impacted by a proposed action.

Panorama Project

Within the Project area there are no subterranean species or subterranean communities presently listed under the *Wildlife Conservation Act 1950* or the *EPBC Act 1999.*

3.2. Classification of subterranean fauna

Subterranean organisms are traditionally classified into three ecological-evolutionary categories originally proposed in the mid 1800s (see for example Camacho 1992, Trajano 2005):

Trogloxenes are regularly found in subterranean habitats, but must leave it during some period(s) to complete their life cycles (usually food requirements). Bats and cave crickets which shelter in caves during the day and forage for food outside caves at night are trogloxenes.
Troglophiles are facultative subterranean species which are able to complete their whole life cycles both in underground and epigean habitats, forming populations in both habitats, with individuals commuting between them and maintaining genetic flow between these populations (Trajano 2005).
Troglobites are obligate subterranean species that are restricted to subterranean environments and typically possess character traits related to subterranean existence (troglomorphisms) such as reduction to loss of eyes and dark pigmentation, and enhancement of non-optic sensory structures.

Previously these categories were applied to all subterranean fauna, but more recently distinction has been made between terrestrial and aquatic species. The term *troglofauna* embraces the three categories above and is used to define terrestrial subterranean fauna. The term *stygofauna* refers to aquatic subterranean fauna which may be similarly classified into three equivalent ecological-evolutionary categories, viz.: *Stygoxene, Stygophile,* and *Stygobite.* Several variations and sub-classifications of this scheme exist (see Camacho 1992).

Two other relevant categories in the ecological classification of subterranean fauna are:
Accidentals are epigean species which have wandered underground or fallen in accidentally. Populations may survive underground for a period of time but further generations are not established underground.
Edaphic species are soil dwelling species. *Edaphobites* are obligate soil dwelling species. The latter category frequently display similar morphological traits to troglobites, such as loss of eyes and pigmentation. Edaphobites are frequently found deeper underground in caves but their primary habitat is soil or regolith. Distinguishing edaphobites from troglobites may sometimes be difficult.

The terms *troglofauna* and *stygofauna* are often used as synonyms for *troglobites* and *stygobites* respectively. The distinction in terms, and application of the correct ecological classification, becomes important when assessing the conservation status of species and potential impacts. From a conservation biology perspective, troglobites and stygobites are usually of more concern because they are frequently short range endemic (SRE) species. Because of their restricted distribution, SREs are more vulnerable to extinction from a range of threatening processes including mining, groundwater pumping, and contamination. In assessing the environmental impact of projects on subterranean species it may become important to distinguish troglobites and stygobites from other ecological categories of subterranean fauna.

3.3. Overview of subterranean fauna habitats

Stygofauna

Stygofauna occupy groundwater across a diverse range of geologic / geomorphic settings, including karstic carbonate rocks, fractured rock aquifers, and porous unconsolidated sediments (eg. alluvium). They may be found in deep groundwater habitats tens to hundreds of metres below the surface, in addition to shallow groundwater habitats including springs and spring-brooks where groundwater discharges to the surface, also hyporheic and parafluvial setting (saturated sediments beneath and alongside surface water courses). Stygofauna are found in oxygenated groundwater ranging from fresh to brackish, but they may occur in salinities up to seawater (Humphreys 1999).

Troglofauna

Troglofauna are found in geologic / geomorphic environments with air-filled subsurface cavities that are humid and dark. A critical habitat requirement for troglobitic species is the maintenance of a high relative humidity because of their generally reduced cuticular impermeability (Howarth 1983).

Diverse troglobitic communities are usually recorded from caves in carbonate rocks which have been subject to karstification, such as those at Barrow Island and Cape Range (Humphreys 2000a). Until relatively recently it was thought that troglobites were more or less restricted to caves in karstic terrains, however in montane environments in Europe diverse troglomorphic faunae have been recorded from the zone of fractured rocks between the soil and non-calcareous bedrock, the so-called mileau souterrain superficiel (MSS) (Juberthie et al. 1980). Diverse troglobitic faunas have also been recorded from lava caves and smaller voids (mesocaverns) in fractured basalts in Hawaii (Howarth 1983) and the Canary Islands (Oromi and Martin 1992) for example. In Australia there has been little sampling of troglofauna in non-karstic terrains but troglobitic species have been recorded from lava caves in Queensland (Howarth 1988), dolerite talus caves in Tasmania (Eberhard *et al.* 1991), and vuggy pioslite ore in the Pilbara (Biota 2006). The emerging understanding is that species specialised to subterranean existence are not necessarily restricted to caves and karst but are more widely distributed and may potentially occur where suitable habitat exists (Eberhard and Humphreys 2003).

The nature and structure of cavity development is likely to be important in determining potential habitat for troglofauna. Open cavities or partially filled cavities may provide a habitable space for troglofauna, however cavities completely filled with sediment are unlikely to be potential habitat. Similarly, isolated or internally sealed cavities which have limited or no inter-connectivity with other cavities are unlikely to be suitable habitat. In this respect, isolated and disconnected cavities which do not form part of a larger integrated void system are not considered prospective habitat for troglofauna. Diverse subterranean faunas are typically found in habitat matrices where well developed secondary and/or tertiary (conduit) porosity enhances the circulation of water, gases, and nutrients, and allows animal movements. Shear and fracture zones where secondary porosity is well developed via open and integrated fracture systems represent potential troglofauna habitat, especially where permanent groundwater maintains a humidified environment in the unsaturated portion of the aquifer.

3.4. Existing knowledge (WA and Pilbara region)

Stygofauna

In Western Australia, stygofauna have been documented from most regions and areas including the Kimberley, Pilbara (Pilbara craton and Barrow Island), Carnarvon (Cape Range), Murchison, Goldfields, South West (Perth Basin and Leeuwin Naturaliste Ridge), South Coast (Albany and Nullarbor Plain). In the Pilbara region, sampling conducted in the last decade has revealed the Pilbara to be a globally significant hotspot for stygofauna diversity (Humphreys 2000b; Eberhard, Halse and Humphreys 2006). Stygofauna is widespread and occurs in a range of hydrogeological environments including karstic, fractured rock, vuggy CID and porous aquifers, in addition to springs, parafluvial and hyporheic environments (Eberhard *et al.* 2005).

Troglofauna

Troglofauna have been recorded predominantly from caves in karstified limestones in the Kimberley, Cape Range, Barrow Island, Perth Basin (eg. Eneabba, Jurien,Yanchep), the Leeuwin Naturaliste Ridge and the Nullarbor Plain. Beyond karst areas, there has been relatively little sampling effort, so there is limited knowledge about the occurrence of troglofauna in non-karstic environments. Recently however, rich troglobitic communities have been discovered in the humidified voids of pisolitic strata (Channel Iron Deposits CID) of mesa formations in the Robe River valley in the Pilbara (Biota 2006).

To date, rich troglobitic fauna communities have not been recorded in other geologic / geomorphic environments except karst and CID mesa formations. Other geologic / geomorphic environments that have been assessed and/or surveyed for troglofauna include, for example, gossans and banded iron formations (BIF) in the Murchison region. These surveys have been initiated as a component of environmetal impact assessment for mine development projects (eg. Biota 2007a,b). The results of other troglofauna surveys conducted in the Pilbara were not available to this review.

At Gossan Hill in the Murchison region, a desktop habitat assessment of geology and diamond drill cores did not identify any significant mesocaverns, consistent void spaces or vugs that might provide suitable microclimates and habitat for troglofauna. This was followed up with a field confirmation survey which was consistent with the desktop assessment and did not detect the presence of troglobitic fauna (Biota 2007a). Similarly at Gindalbie (Biota 2007b), the desktop assessment suggested a low probability that troglofauna occurred because the majority of drill cores showed no significant cavities, fractures, or vugginess below the superficial weathered zone. However, some drill cores showed evidence of cavities and vugs, and given the general lack of knowledge of troglofauna occurrence in these geologic / geomorphic environments, a targeted validation survey was initiated (Biota 2007b).

There is little existing knowledge on the occurrence and distribution of troglofauna in the Pilbara region. This reflects the limited sampling undertaken at only a few locations to date. Excluding the rich troglofaunas known at Barrow Island, Cape Range and Robe Valley, the WA Museum has few records of troglofauna in the Pilbara region. These records are limited to three taxa (two species of Pauropoda and one species of Hemiptera) from three bores at Turee Creek (West Angelas) and Millstream (WA Museum unpublished records). These taxa were collected incidentally during routine sampling for stygofauna.

On the Pilbara craton there are abundant carbonate rocks (Precambrian dolomites and Cainozoic limestones, calcretes) and frequently these have been subject to karstification, however there are few caves known which are large enough to be entered and sampled by humans. Most access for sampling subterranean fauna has been gained via bores and wells drilled for water supply. Consequently, most sampling of subterranean fauna in the Pilbara has been directed towards aquatic subterranean fauna (stygofauna) sampled using nets lowered into boreholes and wells.

Terrestrial taxa are sometimes collected in haul nets used for sampling stygofauna. These animals have either fallen into the water or are brushed off the walls of the borehole and collected in the haul net. Most often these animals are epigean species occurring incidentally or accidentally in the borehole, but sometimes they may include edaphobites and troglofauna.

Troglobitic fauna in mesa formations of vuggy pioslite ore (Channel Iron Deposits) in the Robe River valley was discovered by chance after a single schizomid specimen was collected in a haul net used for sampling stygofauna (Biota 2006). Subsequent sampling using specially designed traps revealed a diverse and significant troglobitic fauna, including species of Schizomida, Pseudoscorpionida, Araneae, Polydesmida, Scolopendrida, Diplura, Thysanura, and Blattodea. All of these species were new to science, and the general biogeographic pattern observed was for each mesa to contain its own suite of short range endemic (SRE) species. This pattern was verified in the schizomids using DNA molecular genetic techniques, which showed a phylogeographic structure consistent with the distribution and evolutionary history of the mesa formations (Biota 2006).

Biota's (2006) study of troglofauna in the Robe Valley mesas was significant because it revealed:

1. Diverse troglobitic fauna in the Pilbara craton,
2. Diverse troglobitic fauna in non-karstic rocks - vuggy pisolite ore (Channel Iron Deposits),
3. Multiple short range endemic (SRE) species of conservation significance,
4. Potential impacts from mining operations.

Biota's (2006) study concluded that the primary fauna habitat within mesas was the humidified pisolitic strata, and that maintenance of a humid microclimate within the mesas would be central to maintaining a suitable habitat.

For the broader Pilbara region, the implications of Biota's study are:

1. Troglofauna may occur in the unsaturated zone of non-karstic rocks such as vuggy pisolite (Channel Iron Deposits).
2. Potential troglofauna habitat may be inferred in any other rock type where secondary permeability is sufficiently developed to provide a suitably dark, stable and humidified air-filled habitat.
3. Troglobitic fauna is highly cryptic and difficult to detect, and survey requires a dedicated sampling program using specially designed traps.

3.5. Potential Impacts of Mining on Subterranean Fauna

The potential impacts of mining on subterranean fauna may be categorised as;

1. Direct impacts;
2. Indirect impacts (Hamilton-Smith and Eberhard 2000).

Direct impacts are the obvious destruction or degradation of habitat that occurs within the pit void and closely adjacent terrain, consequent upon the removal of rock or aquifer dewatering for example. On the other hand, indirect impacts tend to be less obvious and gradational, and thus more difficult to predict and manage because they may be exerted some distance away from the surface footprint area, or progressively expressed some time after mining has occurred. Examples include changes to hydrology, nutrient and microclimate regimes, contamination, reduced habitat area and population viability. The zone of influence for indirect impacts may be considerably larger than the area of the mine pit and surface footprint (waste rock, stockpiles, roads and infrastructure).

Potential indirect impacts of mining include:

1. Changes to surface hydrology affecting groundwater recharge regime, sedimentation, water quality (eg. beneath and proximal to waste rock dumps and stockpiles, roads and infrastructure);
2. Changes to subterranean microclimate in rock masses surrounding excavation pits (exposure to atmosphere of subsurface matrix and voids causing drying of habitat);
3. Changes to subterranean microclimate in the zone of influence of pit dewatering drawdown (drying of habitat);
4. Surface and groundwater contamination from plant equipment and infrastructure;
5. Reduction in organic inputs beneath areas cleared of vegetation and sealed surfaces;
6. Vibration disturbance from mining activities;
7. Reduced area of retained habitat which may fragment habitat and populations, and influence viable population sizes and increase risk of extinction through environmental changes over evolutionary time frames.

3.6. Geology and hydrogeology of the Project Area

The Sulphur Springs volcanogenic massive sulphide (VMS) zinc-copper deposit is located in the central eastern terrain of the Archaean Pilbara Crarton, which is a 3.45 to 2.85 Ga granite-greenstone complex unconformably overlain by the Late Archaean to Proterozoic volcanic-sedimentary succession of the Hamerlsey Basin . The Project area dominantly lies within the north-easterly trending tectonostratigraphic domain referred to as the Lalla Rookh – Western Shaw Corridor (LWSC). The LWSC comprises the following lithotectonic subdivisions which are considered important for this investigation (Golder 2006):

De Grey Goup – including the Lalla Rookh sandstone conglomerates, sandstone and shales.

George Creek Group – characterized by banded ironstone formation (BIF), basalts, cherts, interbedded sandstones (Paddy market Formation), shales and felsic volcanics.

Sulphur Springs Group – differentiated volcanics from basalt, dacites to rhyolite (Kangaroo Caves Formation), interbedded sandstones,cherts, breccias, and volcaniclastics.

Warragoona Group – dominantly mafic volcanics and volcanigenic sedimentary rocks, chert, carbonate, and BIF.

Granitoid rocks – plutonic and gneissic units underlying the LWSC.

Ferruginous duricrust including massive and pisoloitic laterite and ferruginous alluvium form a dissected laterite plateau or fringe typically atop the shales and BIF of the George Creek Group (Golder 2006).

Cainozoic geology is characterised by consolidated and unconsolidated colluvium and alluvium within outwash fans on scree slopes. Alluvial sheet deposits comprising silt, sand and pebble have been deposited on low gradient plains between the margins of creek flood plains and colluvial scree slopes. The Sulphur Springs Creek and North Shaw River channels contain unconsolidated silt, sand, coarse sand and gravel, which extend laterally forming flat flood plains (Golder 2006).

The hydrogeology has been partly investigated by Hydro-Resources (2002), and subsequently by Golder (2006). Groundwater occurs in fractures in the De Grey Group, George Creek Group (Paddy Market Formation), Sulphur Springs and Warragoona Volcanics. Groundwater also occurs within the weathering fringe and voids of the ore body and footwall fractured volcanics, and weathered granites and overlying alluvium in the vicinity of rivers and creeks. Groundwater discharge springs occur at the headwaters of Sulphur Springs Creek, and along the lower reaches of the creek. Numerous other springs have been identified in the area (Golder 2006).

The hydrogeology of the area is complex and heterogeneous in character, with six aquifers considered in the groundwater level drawdown assessment (Golder Associates Technical Memorandum 19th April 2007):

1. Cainozoic sediments and underlying Carlindi Granites;
2. Lalla Rookh sandstones;
3. Warrangoona Formation;
4. Corboy Formation, Paddy Market Siltstone and Honeyeater Basalts;
5. Lalla Rookh Fault Zone;
6. Mine sequence.

3.7. Previous studies

Stygofauna

No previous stygofauna sampling has been undertaken at the sites sampled by this survey (Eberhard, Halse & Humphreys 2006). A few scattered sites in the nearby region have been sampled as part of the DEC regional stygofauna survey (Eberhard *et al.* 2005). The results of the DEC survey are still to be published, however some taxonomic papers related to this survey have been published and these are referred to as appropriate.

Troglofauna

Surveys for troglofauna have not previously been undertaken in the Project area, and throughout the wider Pilbara region, only a few such surveys have recently been undertaken. At this point in time, the general paucity of background knowledge on troglofauna occurrence, distribution and habitat requirements, combined with major difficulties in adequately sampling this highly cryptic fauna, seriously constrains the ability to predict and assess the potential environmental impacts of particular projects on troglofauna. These general limitations in knowledge need to be taken into consideration.

3.8. Prospective subterranean habitats in the Project Area

Prospective habitats for subterranean fauna were reviewed using hydrogeology reports (Hydro-Resources 2002, Golder 2006), geology maps (GSWA 1:250,000), drill logs and diamond core photographs.

Stygofauna

In the mine pit and PAF waste area, prospective habitat includes fractured rocks and cavernous zones at depth in the weathered zone of the VMS deposit (gossan). However, groundwater quality in this area is not highly prospective for stygofauna, being acidic (pH range 2.8 to 4.8) with low oxygen (DO < 0.5 mg/L) (Hydro-Resources 2002, and this study). In the potential drawdown zones for pit dewatering and the water supply borefield, prospective habitats include fractured rock aquifers, alluvium, springs and spring-brooks. In these areas, groundwater quality is overall good (fresh) and meets DEC assessment criteria for freshwater ecosystem protection (Golder 2006).

Troglofauna

Rock types that were considered prospective for troglofauna habitat in the Project area were:

1. The VMS ore body (gossan) deposit which contains cavernous zones at depth.
2. Other rocks where secondary permeability is developed as air-filled fractures, weathered zones or other cavities above the watertable.

The Sulphur Springs VMS mineralisation is a massive sulphide lens extending for approximately 500m east-west along strike and for a similar distance down-dip (Sulphur Springs Feasibility Study 2002). The mineralisation outcrops at surface as a series of gossans, a term used to describe the weathered remnants of base metal sulphides. The gossan material is porous and honeycombed in texture. The exposed gossan is less extensive than the underlying massive sulphide lens, which can be > 50m thick; the upper contact of the lens is cavernous (Sulphur Springs Feasibility Study 2002).

Troglofauna might potentially occur in the gossan and weathered cavernous zone at the upper contact of the VMS lens. This assumes that the secondary permeability is sufficiently developed to provide a suitably inter-connected air-filled habitat that is dark, humidified and micro-climatically stable over evolutionary time frames. Initially, CBH searched drill logs and identified two drill holes (SSD001 and SSD002) in the deposit which encountered major cavities during drilling: (1) SSD001: minor voids 12, 16m, complete leaching 22m, minor pyritic void 34m, significant cavity 68m, major cavity (> 3m) 103m, major cavity (hole abandoned) 110m; (2) SSD002: major cavern 78.5 to 90m. These two holes could not be relocated for sampling and it is likely that they have been buried by subsequent drilling operations, although two other holes in the approximate same location (SSP027 and SSP28) were sampled for troglofauna.

Other rocks in the Project area include the sandstones, siltones, shales, cherts, volcanics, granites, and alluvium. Examination of available drill logs and diamond core photographs for a subset of the holes drilled for water supply and mineral exploration did not indicate the presence of well developed secondary permeability in the form of integrated cavity systems like those seen in karst or CID, that might provide a prospective habitat for troglofauna.

The desktop assessment of the likelihood of troglofauna occurrence in the Project area suggested there was a low likelihood that a significant troglobitic fauna community occurred in the mine pit area.

The desktop assessment was based on:
1. the currently known occurrences and habitat preferences of troglobitic fauna in Western Australia;
2. the suitability of prospective habitat in the mine pit and waste area based on a geology report, drills logs and diamond core photographs;

and given that:
3. the geologic / geomorphic environments in the Project area are not karst or vuggy CID, from which troglobitic fauna has been recorded elsewhere;
4. to date, there are no published records of troglobitic fauna from deep VMS and gossan deposits, or other non-karstic or pseudo-karstic deposits (except vuggy CID in the Robe Valley {Biota 2006}, and more recently Archaean BIF, Subterranean Ecology unpublished data).

Field confirmation surveys (pilot and phase 1) were instigated to validate the desktop assessment.

4. TROGLOFAUNA SURVEY

4.1. Sampling approach & methods

Prior to this survey, troglofauna had not previously been identified in weathered VMS and gossan deposits, or other non-karstic or pseudo-karstic deposits (except vuggy CID in the Robe Valley), so the initial sampling approach was a pilot survey aimed at establishing the likely presence or absence of troglofauna within the pit area.

Troglofauna was sampled using litter traps suspended in boreholes following the procedure adopted by Biota (2006) for Mesa A and the Robe Valley. The traps comprised 32 or 55 mm diameter PVC pipe cut to a length of 140 mm. Leaf litter was collected by hand from the ground locally, mostly comprising *Spinifex* and *Acacia* with some *Eucalyptus.* The litter was soaked in water and irradiated for 10 minutes in a microwave set on high power, to kill any invertebrates present. The sterilised litter was packed inside the traps and the ends of the tube covered with 10mm aviary mesh. The packed traps were sealed in zip lock bags to retain moisture and sterile conditions.

The litter traps were wetted again prior to installation in boreholes. The traps were suspended in boreholes using venetian blind cord. Where bore configuration allowed, three traps were suspended in each hole, with each trap spaced about 5 to 10 m apart. Where possible, the traps were aligned at depths corresponding to recorded cavities in drill logs. The opening of each borehole was sealed with plastic and stones to retain humidity as much as possible, and to minimise the ingress of surface fauna. Traps were left in place for at least six weeks or longer to allow colonisation by fauna. When traps were recovered the condition (moist or dry) of the bore environment and the litter in each trap was recorded, then the traps were sealed in zip lock bags for transport to the laboratory.

Pilot sampling was initiated in February 2007 when six litter traps were placed in two drill holes (SSP27 and SSP28) identified as prospective habitat for troglofauna on the criterion of recorded voids. The first set of traps traps were collected in May 2007 after three months in situ, and returned to Perth for extraction of fauna. A colonization period of > 6 weeks may be considered usefully indicative for establishing the existence of troglofauna (cf. Biota 2006), although confounding factors may include, inter alia, geologic heterogeneity, bore suitability, relative humidity and rainfall. At the time of trap collection in May, six new traps were installed in the same two drill holes and 45 additional traps were installed in 16 other drill holes located in the mine pit area (Table ##, Figure ##). The test bores selected for troglofauna sampling were sealed to maintain a high relative humidity as much as possible, and increase the chances of attracting troglofauna should they exist in the study area. The second set of traps was collected in late June after ca. 6 weeks in situ, returned to Perth and the fauna extracted and identified.

In the laboratory, fauna was extracted from the litter using Tullgren funnels and preserved in 100% ethanol. Invertebrates were picked from the preserved samples using a dissecting microscope, and preliminary sorted to order or morpho-species level. Each identified taxon was kept in a separate labelled vial and assigned a specimen tracking code (Appendix ##). Specimen and site collection data were recorded in an Excel spreadsheet. At the conclusion of the study, all specimens will be lodged at the Western Australian Museum.

Taxonomic groups known to contain troglobitic representatives were examined in more detail to determine if the specimens collected in this study were possible troglobitic forms. Troglobitic forms were distinguished by the possession of troglomorphic characters such as depigmentation, reduction or loss of eyes, elongation of appendages and sensory structures. Troglobitic status was assigned after comparison with the morphology of other close relatives in the group, and current knowledge on their distribution and ecology where known. Identifications were confirmed by comparison with type specimens held at the Western Australian Museum, or specialist taxonomists as necessary. Field work was conducted by Stefan Eberhard, Peter Bell, Tim Moulds and Katherine Muirhead.

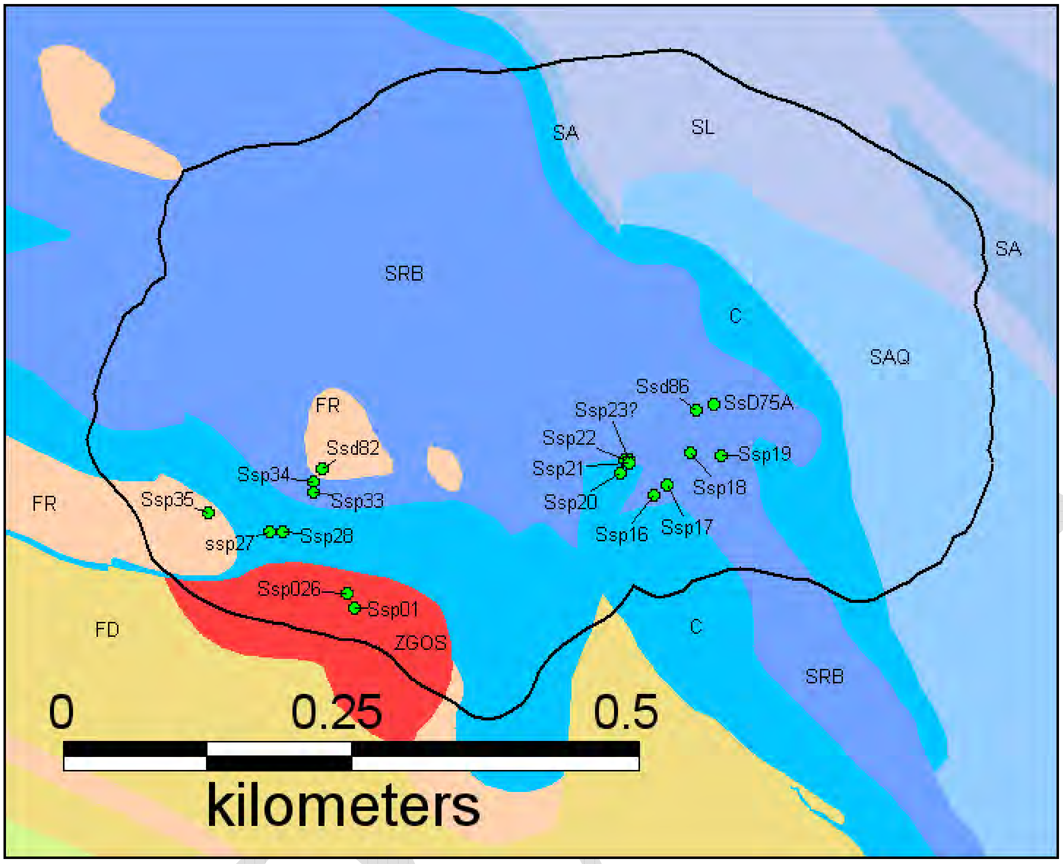
4.2. Sample sites & survey effort

The pilot survey involved 6 traps deployed in two drill holes in the pit area. The next survey (phase 1) involved 51 traps installed in 18 drill holes in the pit void area (Table ##, Figure ##).

Table 4-1. Sample sites pilot and phase 1 troglofauna survey.

			Pilot		Phase 1						Hole
Bore No.	DEC LAT	DEC LONG	Dep.	Ret.	Dep.	Ret.	Tra ps	Depth (m)	Surf. Geol.	Notes	Enviro.
Pit East											
SsD75 A	21.1490	119.2073			9-May-07	22-Jun-07	3	23, 28, 33	chert	Water	moist
Ssd86	21.1490	119.2072			9-May-07	22-Jun-07	3	26, 30, 33	chert		moist
Ssp18	21.1494	119.2071			9-May-07	22-Jun-07	3	8, 13, 17	shale	Water ca. 20m	moist
Ssp19	21.1494	119.2074			9-May-07	22-Jun-07	3	5, 5, 5	shale	Water ca. 20m	moist
Ssp22	21.1494	119.2066			9-May-07	22-Jun-07	3	5, 10, 15	chert		moist
Ssp23	21.1494	119.2066			9-May-07	22-Jun-07	3	8, 20, 25	chert-gossan		dry
Ssp21	21.1494	119.2066			9-May-07	22-Jun-07	3	5, 10, 13	chert-gossan	Water ca. 30-40m	moist
Ssp20	21.1495	119.2066			9-May-07	22-Jun-07	3	12, 20, 28	chert	Water ca. 30-40m	dry-moist
Ssp17	21.1496	119.2069			9-May-07	22-Jun-07	2	8, 10	Shale, chert		moist
Ssp16	21.1497	119.2068			9-May-07	22-Jun-07	2	5, 7	shale	Water ca. 20m	moist
Pit West											
Ssd82	21.1495	119.2041			9-May-07	22-Jun-07	2	10, 17	chert		moist
Ssp34	21.1496	119.2040			9-May-07	22-Jun-07	3	9, 16, 24	chert		dry
Ssp33	21.1497	119.2040			9-May-07	22-Jun-07	3	7, 14, 19	Siltstone ,chert, breccia		dry
Ssp35	21.1499	119.2031			9-May-07	22-Jun-07	3	62, 70, 79	volcanic	Cavity 68-76m	moist
ssp27	21.1500	119.2036	7-Feb-07	9-May-07	9-May-07	22-Jun-07	3	10, 17, 24	chert		moist
Ssp28	21.1500	119.2037	7-Feb-07	9-May-07	9-May-07	22-Jun-07	3	10, 17, 22	chert	20cm Cavity at 33m	moist
Ssp026	21.1505	119.2043			9-May-07	22-Jun-07	3	5, 11, 18	gossan	Cavity 26-33m	dry
Ssp01	21.1506	119.2043			9-May-07	22-Jun-07	3	7, 14, 21	gossan		dry
18	holes						51	Traps			

Figure 1. Troglofauna sample sites (pilot and phase 1) showing relationship to geology and approximate pit outline. Geology: gossan (ZGOS), ryolite (FR), dacite (FD), chert (C), polymict breccia (SRB), siltstone (SR), sandstone (SA), quartzite (SAQ).



4.3. Results & Discussion

Invertebrates were collected from each of the 18 holes sampled. The mean number of specimens per hole was 51 (range 1 – 156) and the mean number of taxa per hole was 5 (range 1 – 12). For both surveys, 1079 specimens comprising 23 morpho-species were collected. (Table ##). The pilot survey in two drill holes collected 275 invertebrate specimens comprising 12 taxa belonging to Acarina (6 morpho-species), Collembola (3), and Diptera (1). All of the taxa collected in the pilot study, except one, were recollected in the phase 1 survey. The phase 1 survey in 18 holes collected 804 specimens comprising 21 taxa belonging to Acarina (10 morpho-species), Collembola (4), Hemiptera (1), Diptera (2), Coleoptera (2), Psocoptera (1), and Blattodea (1).

Table 4-2. List of identified morpho-species and the number of recorded specimens and drill hole occurrences for pilot study (2 holes), phase 1 (18 holes), and combined. Troglomorphic taxa in bold.

Phylum:Class	Order	Identification	Pilot Spec.	Phase 1 Spec.	Phase 1 Holes	Combined Spec.	Combined Holes
Chelicerata							
Arachnida	Acarina	Oribatidae sp 1 (SS)	160	288	9	448	9
		Oribatidae sp. 2 (SS)	2	4	1	6	3
		Oribatidae sp. 3 (SS)	6	0	0	6	2
		Acarina sp.1 (SS)	5	138	9	143	10
		Acarina sp. 2 (PD)	37	35	5	72	7
		Acarina sp. 11 (PD)		23	3	23	3
		Mesostigmata sp. 1 (SS)	4	18	5	22	6
		Mesostigmata sp. 2(SS)		0	0	0	1
		Mesostigmata sp.3 (SS)		41	4	41	4
		Mesostigmata sp. 7 (PD)		1	1	1	1
		Acarina sp. 9(PD)		1	1	1	1
		Mesostigmata undetermined		3	2	3	2
Uniramia							
Collembola	Collembola	Entomobryidae(blind white)		165	11	165	11
		Collembola Type I	47	52	3	99	5
		Collembola Isotomidae	1	3	1	4	2
		Collembola Type II (Sminthuridae)	2	2	2	4	4
Insecta	Hemiptera	Hemipteran juvenile		3	1	3	2
	Diptera	Dipteran larvae (as seLN230)	2	1	1	3	2
		Muscidae larvae		3	1	3	1
	Coleoptera	Pselaphidae		1	1	1	1
		Carabidae sp 1		4	2	4	2
	Psocoptera	Psocoptera		8	2	8	2
	Blattodea	**Blattodea sp.**		10	3	10	3
		No. Specimens	275	804		1079	
		No. Taxa	12	21		23	

More than two-thirds (71 %) of specimens were Acarina (mites), which were also the most diverse group with 12 species represented. The next most abundant group was Collembola (springtails) which comprised one-quarter of specimens with four species identified. The remaining specimens were insects representing five orders comprising Hemiptera (bugs), Diptera (flies), Coleoptera (beetles), Psocoptera (psocids) and Blattodea (cockroaches). Most taxa belonged to members of invertebrate orders (viz. Acarina, Collembola, Hemiptera, Psocoptera, Coleoptera, Diptera), which are not generally known to include troglobitic forms in the Pilbara region, although this does not preclude their possible existence. Nonetheless, most collected members of these orders lacked obvious troglomorphic characters and appeared to be epigean (surface) or edaphic (soil dwelling) forms, that are unlikely to be at risk of short range distribution in the minesite. These taxa were not considered further herein.

One species of entomobryid collembolan lacked eyes and pigment, and may be an edaphic or hypogean (subsoil) form, or it may opportunistically dwell in both habitats. The determination of obligate subterranean existence based on morphology is difficult in some invertebrate groups including Collembola, which commonly and simultaneously inhabit both edaphic and hypogean habitats. The Sulphur Springs entomobryid was collected in eleven of the 18 sampled holes, and was the second-most abundant species collected (165 specimens), indicating that is common and widespread in the sampled area. True troglobitic species are not usually collected in such relative abundance in litter traps in drill holes, compared with other ecological categories of troglofauna.

One of the species collected, a cockroach (Blattodea) is a group known to include troglobitic representatives at Robe Valley and Cape Range. Ten specimens were collected from three holes (SSP19, SSP21, SSP23) situated close together on the western side of the valley and inside the proposed pit void. The specimens showed troglomorphologic characters suggesting they are fully adapted to subterranean life, including reduced pigment, reduced eyes, elongated antennae and appendages (Figure ##).

The Sulphur Springs specimens were compared with type specimens of subterranean cockroaches (Nocticolidae) held at the Western Australian Museum. All of the Sulphur Springs specimens (10) were immature nymphs, although for positive identification and description mature adults are needed for dissection of the genitalia. For some invertebrate groups, it is not unusual to collect mostly immature specimens, including for this genus of cockroaches. Most of the collections of nocticolid cockroaches held at the Western Australian Museum comprise immature specimens.

Based on gross morphology, the Sulphur Springs animals are clearly quite different to the highly troglomorphic *Nocticola flabella* Roth 1991 described from caves at Cape Range (Figure ##). The Sulphur Springs animals also appear to be different from the other described species, *Nocticola brooksi* Roth 1995 recorded from caves in the Kimberley and Northern Territory (Figure ##). There are two other described Australian species of *Nocticola*, *N. australiensis* (cavernicolous) and *N. babindaensis* (epigean) both from Queensland (Roth 1988). This genus of cockroaches is recorded from surface habitats in wet forest / tropics in Queensland but the troglomorphic species recorded from caves in Western Australia appear to be true troglobites restricted to subterranean habitats. Two species of troglomorphic cockroaches were collected in the Robe Valley study by Biota (2006), where it was noted that this is a poorly studied group with little taxonomic framework available to refine identifications. Given the geographic separation of these other localities from Sulphur Springs, it is possible that the Sulphur Springs cockroaches represent a distinct species.

Figure 2. Cockroach nymph collected from Sulphur Springs drill hole SSP23. Ventral view. Body length approximately 3-4mm. Photo Subterranean Ecology / Western Australian Museum.

Figure 3. Cockroach nymph collected from Sulphur Springs drill hole SSP23. Dorsal view. Photo Subterranean Ecology / Western Australian Museum.

Figure 4. ***Nocticola flabella*** **Roth nymph collected from cave CR169 Cape Range. Paratype Western Australian Museum. Photo Subterranean Ecology / Western Australian Museum.**

Figure 5.***Nocticola brooksi*** **Roth nymph collected from cave KNI19 Ningbing Range, Kimberley. Paratype Western Australian Museum. Photo Subterranean Ecology / Western Australian Museum.**

Figure 6. *Nocticola brooksi* Roth adult male collected from cave KNI19 Ningbing Range, Kimberley. Paratype Western Australian Museum. Photo Subterranean Ecology / Western Australian Museum.

4.4. Habitat Characterisation

To characterize the subsurface habitat for troglofauna in the proposed pit area, drill logs and diamond core photographs were examined for each of the holes sampled. Drill logs for 15 SSP holes and diamond core photographs for the three SSD holes were provided by CBH Resources. Diamond core photographs of an additional eight SSD holes located in close proximity to the SSP holes were also examined (hard copy photographs held at CBH Resources). The sampled holes were all located in the Kangaroo Caves Formation in the Sulphur Springs Group. The typical profiles consisted of slightly weathered chert and shale, polymict breccia or rhyolite, and intersection with sulphide enriched zones at depth. Most of the drill logs reported no major cavities, vugs, fracturing, or other voids, except for three holes (SSP26, SSP28, SSP35) situated on the western side of the valley. The cavernous zones in these holes occurred in gossan, volcanics and chert at depths of > 20 to ca. 100 m below the ground surface, consistent with the logs for SSD001 and SSD002 described earlier, and coinciding with the upper contact of the sulphide lens.

The three sampled holes with major cavities did not contain invertebrate assemblages that were markedly more abundant or diverse than those in other holes with no cavities reported (Appendix ##). The cavernous zone occurring at depth in the contact zone between overlying sediments (chert and polymict breccia) and underlying sulphide lens appears to be isolated and disconnected from shallow surface weathering zones, with no intervening development of secondary permeability that might provide habitat connectivity between the potential deep and shallow subsurface habitats.

With few exceptions, the diamond core photographs that were examined displayed highly coherent lithologies with no indication of cavities, vugs, fracturing, or other voids in the profiles, although it should be noted that most of the diamond core drilling commenced at some depth (ca. 80 m) below the surface. In a few cases, diamond cores commenced at the surface where the upper few metres showed some degree of weathering, and one hole (SSD069, not sampled) reported very broken ground in chert rich breccia probably associated with a fault zone.

The troglomorphic cockroaches were collected from three holes (SSP19, SSP21, SSP23) situated close together (< 100 m apart) on the western side of the valley. The surface geology in this location is the upper chert, shale, sandstone and polymict breccia of the Kangaroo Caves Formation in the Sulphur Springs Group. The drill logs for these holes reported slightly weathered lithologies in the upper few metres (< 20 m) of profile, and increasing sulphide enrichment with depth, but no major cavity development was reported. Similarly, diamond core photographs from holes (SSD055, SSD074, SSD075, SSD085, SSD087) located < 100 m away showed highly compact lithologies, albeit with some shearing and fault structures, but no major air-filled cavities. The lithology at depth in this area does not appear to offer prospective habitat for troglofauna.

At the times of trap deployment and trap collection, two of the holes which contained cockroaches (SSP19, SSP21) contained standing water estimated to lie at about 20 m (SSP 19) and 30-40m (SSP21) below ground level. The upper lithology in these two holes comprised chert and shale, and in these holes the mineralized sulphide zone is intersected at depths > ca. 50m, viz., below standing water level. The cockroaches were collected in traps placed at depths of between 5 m and 25 m below the ground surface, and therefore must have colonized the traps from above the level of standing water in these holes.

The depth of trap placement cannot be used to determine the specific depth or lithology from which the fauna colonized the traps, because the constructed drill hole functions as a conduit that facilitates movement of invertebrates up and down the vertical profile. As a result, traps are colonized by a mixture of fauna derived from the surface, soil, regolith, and potentially troglobites from deeper subsurface habitats. The sampling results in this and other studies (eg. Biota 2006) reflect this, with the majority of collected specimens being non-troglomorphic and classifiable as troglophiles, trogloxenes, edaphophiles, or ‘accidental’ epigeans. Drill holes and the traps placed within them constitute artificial habitats which provide a moist and sheltered environment, which are likely to attract hygrophilic invertebrates which are prone to desiccation in the hot and arid surface environment of the Pilbara. During sampling, the entrance of holes was sealed with plastic, firstly to maintain a humid environment suitable for troglobitic fauna, and secondly, to minimize ‘contamination’ from surface fauna, however this would not entirely prevent invertebrate fauna from colonizing drill holes through small holes in the seal and collars, or the space between the collar and the hole.

4.5. Comparison with other Studies

The first phase sampling results at Sulphur Springs were consistent with other studies such as that of Biota (2006) in the Robe Valley, where troglomorphic taxa were detected in very low numbers compared with non-troglomorphic taxa. In the comprehensive Robe Valley study, 3,892 invertebrate specimens were collected, of which only about 156 specimens (4 %) were troglomorphic taxa. The Robe Valley troglomorphic assemblage is relatively diverse, with at least 16 species belonging to six orders identified. However, most troglomorphic taxa were represented by only a few specimens: Araneae (1 taxon, 1 spec.), Diplopoda (2, 2), Blattodea (2, 6), Diplura (4, 11), Thysanura (1, 11), Pseudoscorpionida (2, 10), Schizomida (4, 115).

The sampling effort applied in the Robe Valley study, consisted of three sampling phases with 597 traps deployed in 186 holes spanning eight deposits. The strike rate (the percentage of sampled holes that contained invertebrates) across eight ore deposits (n = 186 holes, 597 traps) ranged from 8 to 64 % (mean 36 %) (Biota 2006). With this sampling effort, the overall strike rate was 6.5 invertebrates and 0.26 troglomorphic species per trap event, which equates to 26 troglomorphs per 100 trap events. If the Schizomida, the most abundant troglomorphic group in the Robe Valley (58 % of troglomorphs) which were not detected at Sulphur Springs, are excluded then the strike rate for all other troglomorphs equates to 42 individuals or about seven troglomorphic taxa per 100 trap events.

In another Pilbara study (Subterranean Ecology unpublished data), the strike rate for invertebrates was 92 % in 24 drill holes spanning six deposits. In this study, mean species richness per hole was 3.5 (range 0 - 15) and mean number of individuals was 12.6 (range 0 to 145). The strike rate for troglomorphic taxa was 0.04 individuals per trap event, which equates to about four individual troglomorphs per 100 trap events.

At Sulphur Springs, the strike rate for invertebrates was 100 % (n = 18 holes, 51 traps), and for troglomorphic individuals the strike rate was 0.18 or about 18 troglomorphs per 100 trap events. These statistics lie within the same order of magnitude of each other, however, the geomorphic setting and history of the Robe Valley is very different to that at Sulphur Springs. In the Robe Valley the mesa landforms span a much larger area, and are geomorphic ‘habitat islands’ isolated from each other by an ‘inhospitable sea’ of less permeable strata. This particular terrain setting has facilitated isolation and speciation of populations, contributing to species richness in troglobites (Biota 2006).

The survey effort applied in other studies is related to a number of factors, including:

1) size of the deposit(s);
2) geologic characteristics as potential habitat;
3) availability of sampling points (holes);
4) knowledge required on the distribution of troglobitic species where present;
5) area of species distribution range that may be impacted.

These examples illustrate the low recovery rates achievable in relation to sampling effort for troglobites, and the real practical sampling difficulties involved in attempting to collect all, or nearly all, potentially troglobitic species in an area. This presents problems for environmental impact assessment when it is expected that most species have been collected and their distribution has been determined. Confounding factors that may affect the ability to detect troglofauna may include, inter alia, geologic heterogeneity, drillhole characteristics, relative humidity, seasonality and rainfall. In the Robe Valley, Biota (2006) observed that low rainfall periods reduced the strike rate for capture of troglofauna.

4.6. Conservation Assessment

At Sulphur Springs, a plausible explanation for the observed occurrences of troglomorphic species, and troglofauna generally, is that the drill holes were colonised from the shallow subsurface (regolith and soil) and surface (epigean) zones. In an ecological context, the regolith may be referred to as the *underground shallow medium* (in French: *milieu souterrain superficial* or MSS) (Juberthie et al. 1980). The MSS is distinct from deeper cavernous environments, but is a recognised habitat where exchanges occur between surface and subsurface, and where surface animals discover and colonise the underground environment (Bakalowicz 2005). Invertebrate assemblages inhabiting the MSS include troglobites such as found in montane environments in Europe where diverse troglomorphic faunas have been recorded from the zone of fractured rocks between the soil and non-calcareous bedrock (Juberthie et al. 1980). In the Pilbara and Australia generally, this habitat has been barely studied, but such faunas are known to occur (see overview earlier). In the study area there is no a priori reason to exclude the possible existance of such a fauna. Indeed, the extensive availability of prospective geomorphic environments (shallow subsurface refugia) coupled with the climatic history (increasing aridity) of the region, support the probable existence of a rich terrestrial subsurface fauna (in both shallow and deep habitats) analagous to the situation with stygofauna.

The steeper terrain in the study area has poorly developed and skeletal soils, but the regolith is well developed, and represents a prospective *shallow subsurface habitat* for invertebrates, including possible troglomorphic species. The regolith is the loose, incoherent mantle of rock fragments, soil, sand, alluvium, etc which rests upon solid rock, i.e. bedrock. In the proposed pit area the bedrock is weathered, fractured and broken, with colluvium, talus and scree slopes (Figure ##). This terrain occurs widely throughout the ranges in the area (Figure ##, ##), with unconsolidated colluvium sands, silts and gravels on outwash fans and on scree and talus slopes in pockets beneath the ridges of the George Creek and Sulphur Springs Groups (Golders 2006). Prospective shallow subsurface habitats are not restricted to the VMS deposit or the proposed pit area, rather they are extensive and more or less continuous throughout the wider region. Given the continuity of this habitat, with no obvious barriers to dispersal or other geomorphic isolating mechanisms (cf. mesa landforms Robe valley), it is considered probable that the species sampled from the pit area occur in contiguous regolith habitats outside the pit impact zone.

Figure 7. View southeast from proposed pit area in vicinity of holes SSP19, 21 and 23 where the cockroaches were collected. Note the well developed colluvial slope deposits (arrowed) on left side of the valley representing prospective shallow subsurface habitat in the regolith. Photo Peter Bell / Subterranean Ecology.

Figure 8. View of ranges from proposed pit area showing extensive colluvial slope deposits (examples arrowed) representing prospective shallow subsurface habitat in the regolith. Photo Peter Bell / Subterranean Ecology.

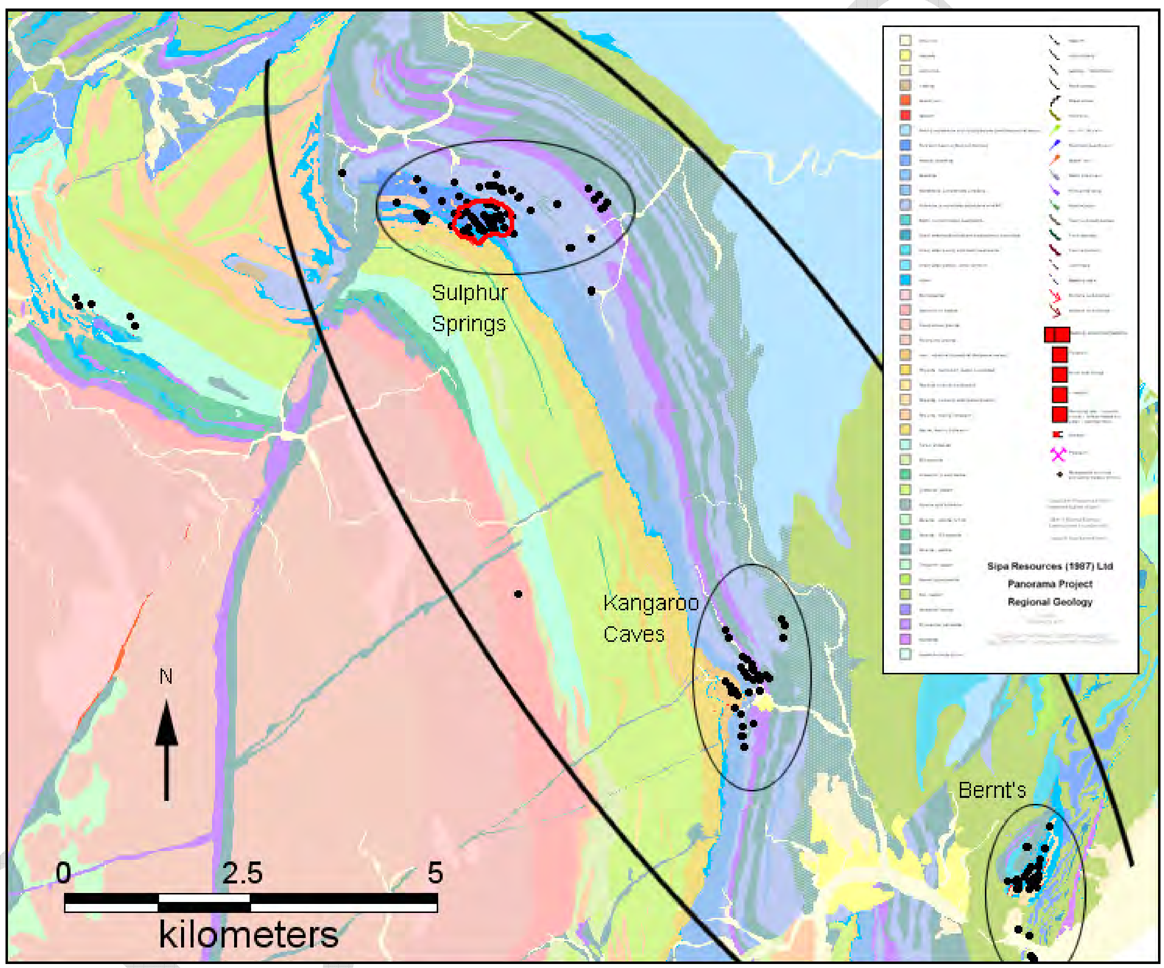
Figure 9. View of terrain in Sulphur Springs Creek showing talus and boulder fields (examples arrowed) representing prospective shallow subsurface habitat in the regolith. Photo Eberhard / Subterranean Ecology.

4.7. Further investigations in progress

Further investigations are in progress to collect and identify the invertebrate fauna in *underground shallow medium* outside the proposed pit area. A field survey (phase 2) commenced in July 2007 with the aim of sampling as many holes as possible that could be located in similar geology outside the zone of influence of the proposed mine site (Kangaroo Caves and Bernts prospects). Similar geologies compromising Kangaroo Caves Formation (with prospective VMS deposits and associated cherts, shales, siltstones and sandstones) occur in lineations extending northwest and southeast of the proposed mine site (Figure ##). Many exploration holes have been drilled in the area immediately surrounding the proposed mine site, and the nearest other VMS prospects at Kangaroo Caves and Bernts, situated seven and eleven kilometers to the southeast. The three day field survey (11-13th July) focused on these areas.

Unfortunately, virtually all of the earlier constructed drill holes in these areas had been destroyed by natural processes of collapse, erosion, sedimentation and burial, most likely during cyclonic rainfall events. Overall, the phase 2 survey managed to deploy traps in eleven holes found to be accessible which spanned two discrete but geologically contiguous areas in the Kangaroo Caves Formation (Figure ##). No accessible holes were found in several key areas targeted for sampling immediately surrounding the proposed pit area (including BLP series situated ca. 700 m west of pit, the SSD series ca. 500-700 m northeast of pit, and the SSP010 – SSP015 series located 1.6 km east of pit). At Bernts prospect only two of 38 holes were accessible and had traps placed, the remainder had been destroyed by erosion from the recent cyclones. At Kangaroo Caves, nine out of about 49 hole locations were accessible and traps placed. At this site most holes were drilled in creek drainages with only a short depth to the water table, so only one trap was installed in these holes. In some cases the hole collar extended below the water table, thus restricting access for terrestrial fauna.

Figure 10. Areas targeted in phase 2 sampling showing relationship to regional geology and recorded drill holes. Large ellipse encompasses the major structural lineation of the Kangaroo Caves Formation (predominantly aqua-blue and mauve shaded colours), with the three prospects at Sulphur Springs, Kangaroo Caves, and Bernts. Approximate outline of proposed pit (red). Geology map and drill hole locations provided by CBH Resources.



At the completion of phase 2 the results will be examined to see if the species assemblages found in the regional sampling are similar or different to the assemblages found inside the pit area. If the assemblages found at Kangaroo Caves and Bernts prospects are faunistically similar to those found inside the proposed pit area, then it is likely that no further assessment issues exist for troglofauna in relation to this project. If significant faunistic differences are evident, then further sampling may be warranted in prospective regolith habitats located closer to the proposed pit. This may necessitate drilling of shallow holes designed for sampling troglofauna in the regolith zone.

5. STYGOFAUNA SURVEY

5.1. Sampling approach & methods

Because this area had not previously been sampled for stygofauna, the sampling approach adopted for the first survey was a rapid reconnaissance to identify which catchments and aquifers within the zone of mine influence contained stygofauna. The second survey aimed to repeat the sampling of known stygofauna locations, and extend the sampling coverage outside the zone of influence to determine the distribution and conservation status of species. Sites for sampling were selected to cover both deep and shallow groundwater habitats spanning all aquifers and surface catchments within the zone of mine influence, and connected drainage systems immediately outside the zone of influence.

Collecting methods used were similar to those used by the DEC Pilbara Stygofauna Survey (PSS) (Eberhard *et al.* 2005) and consistent with the EPA Guidance Statement No. 54 (EPA 2003). Bores were sampled for stygofauna using a plankton net of suitable diameter (45mm to 300 mm) to match the bore/well. The net (125 µm mesh), with a weighted vial attached, was lowered into the bore and then hauled up through the water column. Initially, to obtain a sediment-free sample and identify stygofauna occurring near the top of the water column, the first haul of the net was dropped to about -5 m below standing water level then retrieved. To collect fauna near the base of the bore, on the second haul, the net was dropped to the base of the bore then agitated up and down (±1 m) several times to disturb the bottom sediment. Additional net hauls were conducted as required to obtain additional specimens. Each net haul sample was transferred to a labelled polycarbonate container and preserved in 100% alcohol. Samples with large quantities of sediment were elutriated. To minimise the possibility of faunal contamination between sites, the nets were thoroughly rinsed in water and air-dried.

Besides net hauling, trapping and pumping methods were employed at a selected subset of sites. The traps consisted of small nalgene bottles (approximate volume 50 and 100 ml) with the lids removed and the bottom cut off and covered with 125 µm mesh. The weighted traps were baited with cheese or meat, then lowered into wells and boreholes and left overnight. The next day the traps were retrieved and the contents washed through 125 µm mesh and preserved.

Sampling of stygofauna was also undertaken opportunistically during routine purge sampling of five bores (SSWB01, 06, 36, 40, 52) for water chemistry samples. Prior to pumping, a net haul sample of the entire water column was collected. During pumping, the pumped water was passed through a 125 µm net and preserved separately. After purging of the bore, another net haul sample of the entire water column was collected. The bores were purged using a Grundfoss SQ submersible pump lowered about 5 m below the standing water level. Pump rates were set at approximately 1 L/sec and pumped from one to two hours until water physico-chemistry parameters which were continuously monitored (temperature, pH, dissolved,oxygen, conductivity, redox, turbidity) became stable. Bore capacities ranged from about 300 L to 3,800 L, and the volume of water pumped from each bore ranged from 2 to 7x bore volume, except SSWB40 which was pumped for 19x bore volume.

Shallow groundwater habitats in porous unconsolidated sediments (hyporheos) in springs and spring-brooks was sampled by the Karaman-Chappuis method. The Karaman-Chappuis method involves excavating a shallow pit in unconsolidated sediments and then passing the collected water through a net (125 µm mesh). The volume of sediment in samples was reduced by elutriation, and samples were preserved as above.

Sorting occurred in the laboratory under a dissecting microscope. Each taxon was identified to the lowest taxonomic rank possible using published keys and descriptions, and the numbers of each taxon were recorded. Identification of microfauna and dissected macrofauna used a compound microscope. Examples of new and undescribed (morpho-) species were retained in a voucher collection and used for checking identifications and designating new species. Identifications were done by Harley Barron (Copepoda), Dr Mark Harvey (Acarifromes), Dr Ivana Karanovic (Ostracoda), Stefan Eberhard (Amphipoda, Copepoda and other groups). Field work was conducted by Stefan Eberhard and Peter Bell.

5.2. Sample sites & survey effort

Survey effort for stygofauna involved two rounds of sampling undertaken in December 2006 and February 2007. Fifty-four (54) prospective sample sites were visited (eight sites were inaccessible for sampling), including bores, wells and springs. Sites were sampled using a combination of net hauling, trapping, pumping, and Karaman-Chappuis methods. Overall, the survey effort involved 74 sample events spread across 46 sites, of which 36 were located within the potential impact zone and 10 reference sites located outside the impact zone. Potential sample sites in the near vicinity of the project area are listed in Table 1 and shown in Figures 1 and 2. All sampled sites were located within the catchments of the Shaw and East Strelley Rivers, and their tributaries (Sulphur Springs Creek, Minnieritchie Creek, Six Mile Creek, 'Lalla Rookh Creek', Carlindi Creek).

Figure 11. Subterranean fauna survey sites showing relation to surface drainage and conceptual groundwater drawdown contours as modelled by Golder Associates (Technical Memorandum 19th April 2007). Note that the drawdown contours are indicative only.

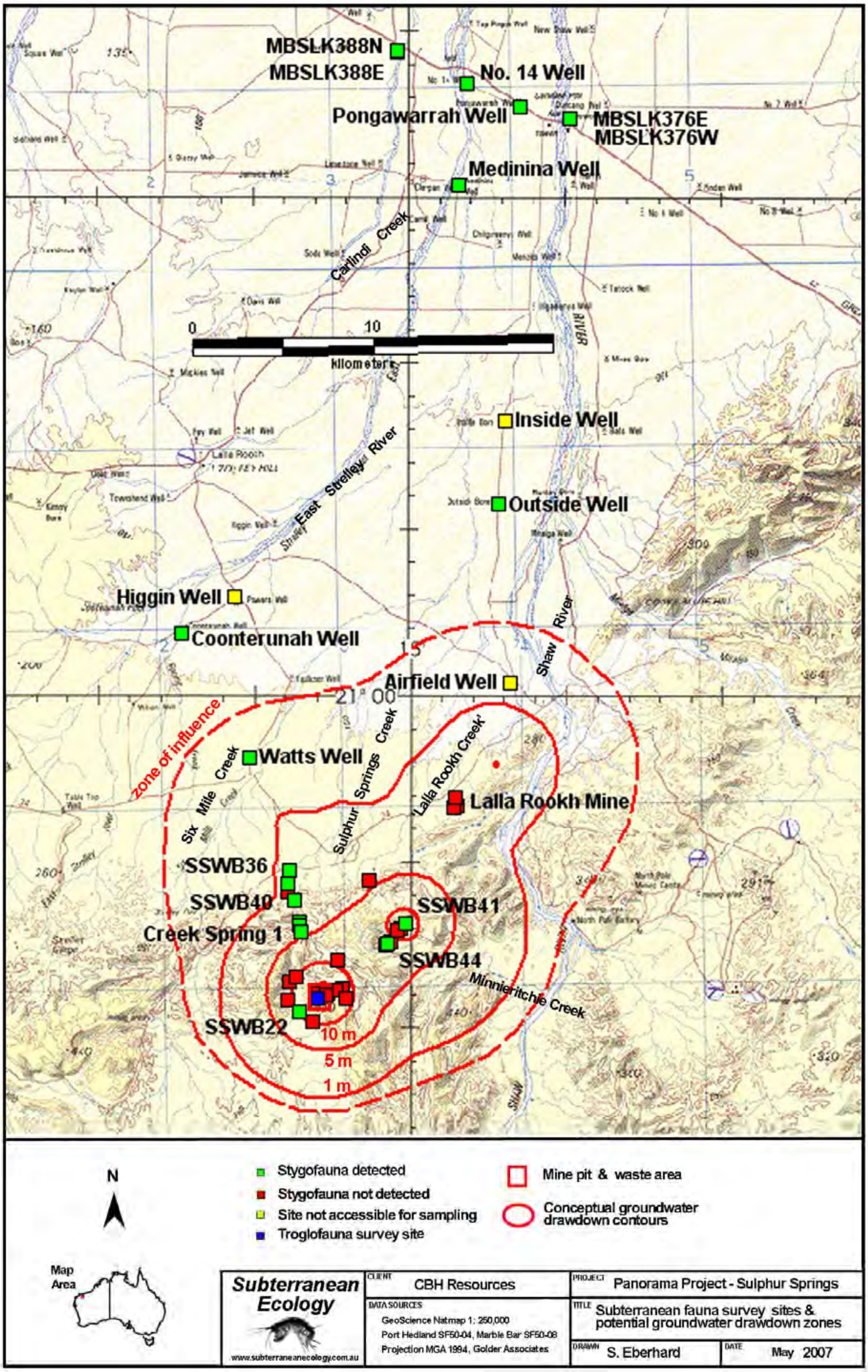


Table 5-1. Sites surveyed for subterranean fauna, listed by surface drainage catchment, location in the conceptual drawdown zone of influence (ZI) or local reference (R) zone, geology, sample methods and sampling effort (*n* events).

Catchment	Site Name	Fauna detected	ZI / R	Geology	Methods	*n*	Lat	Long
Carlindi Creek	MBSLK388E	Detected	R	CS	NH	1	-20.6761	119.2454
	MBSLK388E	Detected	R	CS	NH	1	-20.6761	119.2454
	MBSLK388N	Detected	R	CS	NH	1	-20.6755	119.2455
East Strelley River	Coonterunah Well	Detected	R	CS	NH	1	-20.9681	119.1295
	Medinina Well	Detected	R	CS	NH	1	-20.7429	119.2782
	No. 14 Well	Detected	R	CS	NH	1	-20.6917	119.2826
	Pongawarrah Well	Detected	R	CS	NH	1	-20.7036	119.3109
	Higgin Well	not accessible	R	CS	na	0	-20.9499	119.1578
Lalla Rookh Creek'	Airfield Well	not accessible	ZI	CS	na	0	-20.9927	119.3050
	Lalla Rookh Mine	Not detected	ZI	G	ST	1	-21.0510	119.2763
	SSWB37	Not detected	ZI	DGG	NH	2	-21.0920	119.2304
	SSWB52	Not detected	ZI	DGG, GCG	NH, P	4	-21.0544	119.2771
	SSWB53	Not detected	ZI	DGG	NH	2	-21.0552	119.2756
Minnieritchie Creek	SSWB41	Detected	ZI	DGG	NH	1	-21.1139	119.2497
	SSWB44	Detected	ZI	DGG	NH	1	-21.1243	119.2393
	SSWB003	Not detected	ZI	PMF	NH	1	-21.1466	119.2155
	SSWB005	Not detected	ZI	PMF	NH	2	-21.1474	119.2120
	SSWB006	Not detected	ZI	PMF	NH, P	4	-21.1519	119.2174
	SSWB009	Not detected	ZI	PMF	NH	1	-21.1519	119.2173
	SSWB42	Not detected	ZI	DGG	NH	1	-21.1165	119.2464
	SSWB42A	Not detected	ZI	DGG	NH	1	-21.1164	119.2464
	SSWB43	Not detected	ZI	DGG	NH	1	-21.1176	119.2453
	SSWB47	Not detected	ZI	DGG	NH	1	-21.1163	119.2470
	SSWB50	Not detected	ZI	DGG	NH	1	-21.1231	119.2416
	SSWB51	Not detected	ZI	DGG	NH	1	-21.1245	119.2391
Shaw River	MBSLK376E	Detected	R	CS	NH	1	-20.7094	119.3374
	MBSLK376W	Detected	R	CS	NH	1	-20.7094	119.3369
Shaw River - 6 Mile Ck	Outside Well	Detected	R	CS, cc	NH, ST	4	-20.9029	119.2995
	Inside Well	not accessible	R	CS	na	0	-20.8612	119.3024
Six Mile Creek	SSWB22	Detected	ZI	SSV	NH	1	-21.1581	119.1924
	Watts Well	Detected	ZI	CS	NH	1	-21.0305	119.1660
	SSWB21	Not detected	ZI	SSV	na	0	-21.1637	119.1998
Sulphur Springs Creek	Creek Spring 1	Detected	ZI	CS, cc	KC	1	-21.1129	119.1925
	Creek Spring 2	Detected	ZI	CS, cc	KC	1	-21.1150	119.1924
	Creek Spring 3	Detected	ZI	CS, cc	KC	1	-21.1180	119.1932
	SSWB36	Detected	ZI	G	NH, ST, P	5	-21.0871	119.1869
	SSWB38	Detected	ZI	G	NH, ST	4	-21.0940	119.1863
	SSWB40	Detected	ZI	CS, WF	NH, ST, P	5	-21.1022	119.1901
	SSWB14	not accessible	ZI	SSV	na	0	-21.1490	119.2052
	SSWB15	not accessible	ZI	SSV	na	0	-21.1494	119.2053
	SSWB18	not accessible	ZI	PMF	na	0	-21.1485	119.2063
	SSWB20	not accessible	ZI	SSV	na	0	-21.1492	119.2076
	SSTP03	Not detected	ZI	PMF	NH	1	-21.1432	119.1877
	SSWB01	Not detected	ZI	SSG	NH, P	4	-21.1494	119.2054
	SSWB19	Not detected	ZI	SSV	NH	1	-21.1489	119.2025
	SSWB19A	Not detected	ZI	SSV	NH	1	-21.1489	119.2025
	SSWB23	Not detected	ZI	SSV	NH	1	-21.1529	119.1867
	SSWB25	Not detected	ZI	PMF	NH	2	-21.1406	119.1905
	SSWB26	Not detected	ZI	PMF	NH	1	-21.1324	119.2131
	SSWB28	Not detected	ZI	PMF	NH	1	-21.1478	119.2068
	SSWB29	Not detected	ZI	PMF	NH	1	-21.1496	119.2071
	SSWB39	Not detected	ZI	WF	NH	2	-21.0979	119.1868
	SSP027	Trog. in progress	ZI	SSV	LT	1	-21.1514	119.2023
	SSP028	Trog. in progress	ZI	SSV	LT	1	-21.1513	119.2023

Total sample events 74

Geology Key

DGG - De Grey Group: Lallah Rookh Sandstone
GCG - Gorge Creek Group
WF - Warrangoona Formation
PMF - Paddy Market Formation
SSV - Sulphur Springs Volcanics
CS - Cainozoic sediments
G - Granites
cc - calcrete

Methods key

NH - Net Haul
ST Stygofauna trap
LT - Litter trap
P - Pump
na - not accessible

5.3. Results & Discussion

Stygofauna was detected at 20 (40 %) of the 46 sites sampled (Table 1, Figures 1, 2) and in seven of the eight topographic (sub) catchments sampled:

1. Carlindi Creek;
2. East Strelley River;
3. Minnieritchie Creek;
4. Shaw River;
5. Six Mile Creek;
6. Sulphur Springs Creek.

Stygofauna was not detected in the 'Lalla Rookh Creek' subcatchment.

Within the zone of mine influence, stygofauna was recorded from three of the six aquifers defined by Golder Associates (Technical Memorandum 19th April 2007):

1. Cainozoic sediments and underlying Carlindi Granites;
2. Lalla Rookh sandstones;
3. Warrangoona Formation.

Stygofauna was not detected in three aquifers:

1. Corboy Formation, Paddy Market Siltstone and Honeyeater Basalts;
2. Lalla Rookh Fault Zone;
3. Mine sequence.

Stygofauna was collected from both deep and shallow groundwater habitats. The deep groundwater habitats comprised fractured-rock aquifers. Shallow groundwater habitats included alluvium and calcrete, and the hyporheos (porous interstitial) of springs and spring-brooks (Creek Spring in Sulphur Springs Creek).

The detected stygofauna comprised representatives of the major common groundwater taxa known in the Pilbara, including Crustacea (Amphipoda, Copepoda, Ostracoda, Isopoda), Acariformes, Nematoda and Oligochaeta. More than 1,161 individual specimens were retrieved from samples (Table 2), with approximately 957 individuals identified to the level of species or the lowest taxonomic rank possible (Appendices 1, 2).

Table 5-2. Summary of major taxa collected, number of specimens and number of sites each taxon was recorded from. Full details are in Appendix 1 and 2.

Taxon	No. spec.	No. sites
Acariformes	60	12
Amphipoda	115	22
Cyclopoida	691	18
Harpacticoida	43	6
Ostracoda	186	19
Isopoda	10	3
Oligochaeta	46	6
Nematoda	2	1
Diptera	many	5
Copleoptera	8	1
Total	1161	

Twenty seven taxa were identified, of which 24 were found within the zone of influence of mine dewatering and water supply drawdown. Of these 24 taxa, 20 have distributions recorded outside the zone of influence, either at local scale of further downstream in the catchments of the Shaw and East Strelley Rivers, and/or at regional scale of the Pilbara or greater (Table 3).

Table 5-3. Subterranean fauna survey sites showing relation to surface drainage, and conceptual groundwater drawdown contours (enlarged from Figure 1) as modelled by Golder Associates (Technical Memorandum 19th April 2007). Note that the drawdown contours are indicative only.

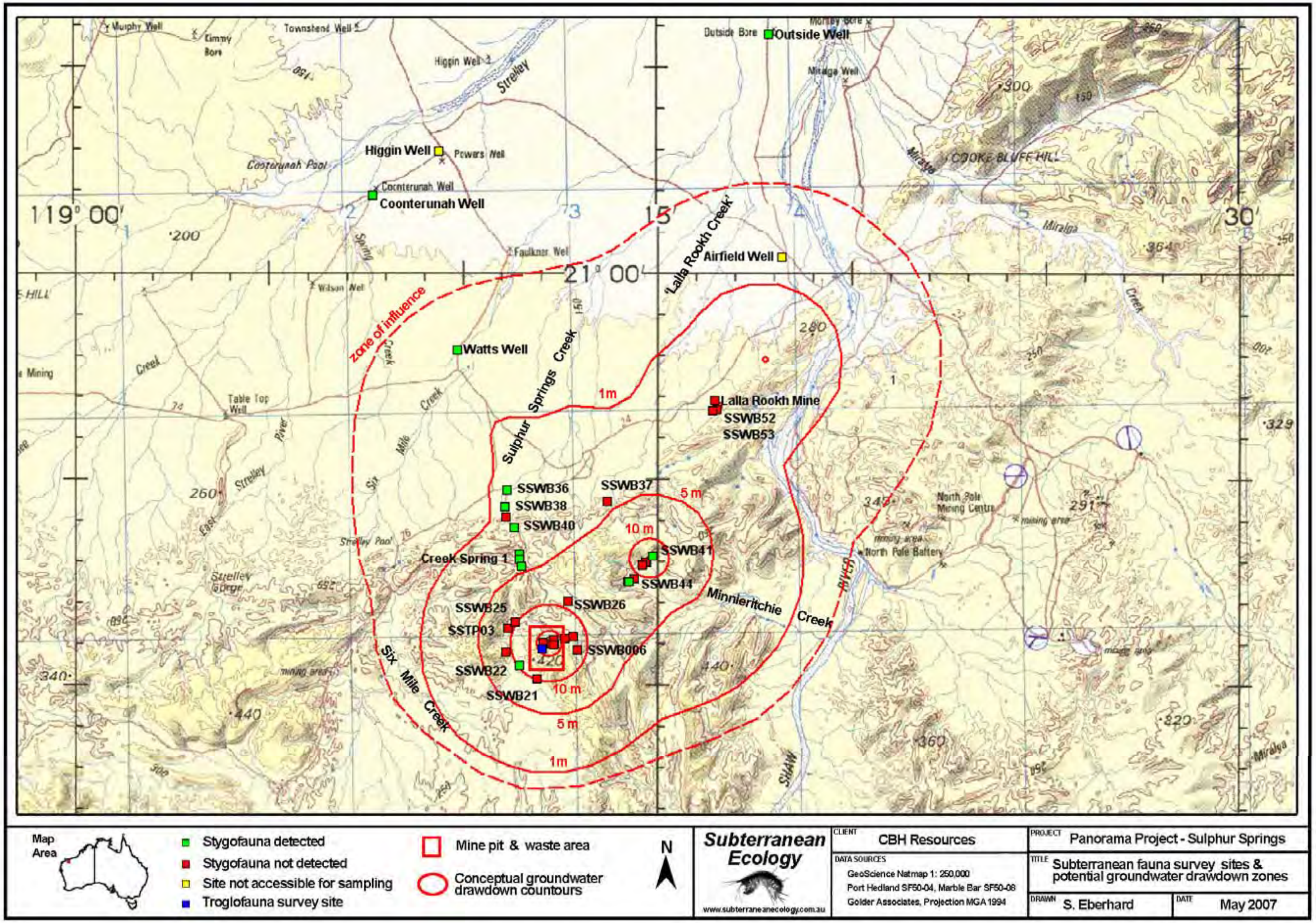


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Table 5-4. List of taxa recorded, their ecological status (E.S.), distribution and conservation status in relation to zone of mine influence (Z.I.), local reference (Ref.), and the Pilbara region.

Taxon 1	Taxon 2	Lowest taxonomic identification		Recorded distribution (no. sites)				Conservation assessment
			E.S.	Indiv.	Z.I.	Ref.	Region	
Acariformes	Oribatida	*Guineaxonopsis* sp.	Sp?	1	1		yes	Non stygobitic, widespread in the Pilbara (M. Harvey pers. comm.)
		Oribatida Gen et sp. or spp. Indet.	Sp?	50	5	2	?	Non stygobitic, spp. indet.*
	Prostigmata	Prostigmata Gen et sp. Indet.	T	1	1			Terrestrial, not troglobitic
		Prostigmata (Eupodididae?) Gen et sp. Indet.	Sp?	1	1		?	non stygobitic, sp. indet.*
	Fam. Indet.	Fam. Gen et spp. Indet.	Sp?	7	1	1	?	Non stygobitic, sp. indet.*
Amphipoda	Melitidae	Melitidae (cf. *Norcapensis*) n. sp. cf. sp. 1 (PSS)	Sb	32	2	3	yes	Taxon undescribed, morphospecies widespread in Pilbara
	Melitidae	*Nedsia* sp.	Sb	39	1	3	yes	Taxon undescribed, genus widespread in Pilbara
	Paramelitidae	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	Sb	44	3	3	yes	Taxon undescribed, morphospecies widespread in Pilbara
Copepoda	Cyclopoida	*Diacyclops cockingi* Karanovic	Sb	2	1		yes	Widespread in Pilbara, 16 published records (Karanovic 2006)
		Diacyclops humphreysi humphreysi Karanovic	Sb	225	3	1	yes	Abundant & widespread in Pilbara (Karanovic 2006)
		Diacyclops sobeprolatus Karanovic	Sb	129	3		yes	Central & East Pilbara, 11 published records (Karanovic 2006)
		Fierscyclops (Pilbaracyclops) cf *frustratio* Karanovic	Sb	4	2		yes	East Pilbara (SE unpub.data), Lake Disappointment (Karanovic 2006)
		Microcyclops varicans (Sars 1863)	Sp	135	5		yes	Cosmopolitan, widespread stygophile in Pilbara (Karanovic 2006)
	Harpacticoida	*Elaphoidella humphreysi* Karanovic	Sb	30	3	1	yes	East & west Pilbara, 5 published records (Karanovic 2006)
		Stygonitocrella trispinosa Karanovic	Sb	13	2		yes	East Pilbara, 4 published records (Karanovic 2006)
Isopoda	Microcerberidae	*Coxicerberus* sp.	Sb	10		3	yes	Taxon undescribed, genus et spp. n. recorded Pilbara region
Ostracoda	Candonidae	*Leicacandona 'mookae'* Karanovic 2007	Sb	7	1		yes	East Pilbara, one other regional locality (I. Karanovic, pers. comm.)
	Cyprididae	*Cypretta seurati* Gauthier, 1938	Sp	54	1	3	yes	Non stygobitic, widespread in Pilbara
		Stenocypris bolieki Ferguson 1962	Sp	2		1	yes	Non stygobitic
		Strandesia sp.	Sp	105		2	?	Non stygobitic, sp. indet.*
	Darwinulidae	Darwinulidae Gen et sp. Indet.	Sp	2	2		yes?	Non stygobitic, sp. indet.*
	Limnocytheridae	*Gomphodella hirsuta* Karanovic 2006	Sp	16	3	1	yes	Widespread in Pilbara
Oligochaeta	Phreodrilidae	Phreodrilidae Gen et sp. Indet.	?	1	1		?	sp. indet.* Probably occurs outside zone of influence
	Tubificidae	*Monophylephorus* n. sp.	Sp?	5	1	1	yes	Widespread in Pilbara, was *Pristina* n. sp. WA3
		Pristina longiseta Ehrenberg	Sp	20	1		yes	Cosmopolitan (Pinder 2001)
		Tubificidae SS sp. 1	?	21	2		?	Probably occurs outside zone of influence
Nematoda	Fam. Indet.	Nematoda SS sp. 1	?	1	1		?	Probably occurs outside zone of influence
	Fam. Indet.	Nematoda SS sp. 2	?	1	1		?	Probably occurs outside zone of influence
Abbreviations:			Total indiv.	957				

Ecological Status (ES): Stygobite (Sb), Stygophile (Sp), terrestrial (T)
Distribution sites / areas: no. sites Potential Impact (PI) area, no. sites local reference (R) area
* Species indeterminate (sp. indet.), definitive conservation assessment precluded

5.4. Assessment of conservation status

The local distribution patterns of identified (morpho) species were consistent with predictions based on patterns of surface drainage and catchments. Taxa not detected or identified to species level because of taxonomic limitations are likely to display similar distributions related to local patterns in surface drainage and catchments. The four taxa not collected or otherwise recorded from outside the zone of influence were two species of Oligochaeta and two species of Nematoda. Groundwater Oligochaeta generally display widespread distributions. The taxonomy and distribution of Nematoda is poorly defined, however the collected taxa are considered likely to display similar distribution patterns to the other taxa collected during this survey.

The most important area sampled for stygofauna lies in Sulphur Springs Creek in the vicinity of bores SSWB36 to SSWB40, which is a local hotspot with 14 species recorded. In this area, the natural seasonal variations in water levels recorded at these bores (+/- 4 m). About 1.5 km upstream of this area is a spring and spring-brook, where stygofauna was recorded from shallow interstitial habitats in unconsolidated alluvial sediments of the creek bed. If groundwater pumping affects the discharge regime at this spring then the local populations of stygofauna here may be affected. The spring populations may also be affected by road construction activities such as sedimentation or pollutants.

Stygofauna was not detected in the pit and waste areas. The apparent absence of stygofauna in this area may be related to the groundwater quality which is acidic (pH range 2.8 to 4.8) and with low oxygen (DO < 0.5 mg/L). Beyond the pit and waste areas, the evidence from drill logs and pump sampling (SSWB36, SSWB40) suggests that stygofauna habitat occurs in the fractured rocks below the superficial alluvium, where the saturated thicknesses range from an approximate minimum of 30 m (eg. SSWB40, SSWB41) to > 60 m (eg. SSWB36, SSWB22).

In the Six Mile Creek catchment in the vicinity of bore SSWB22, the inferred habitat is fractured basalt and dacite with a saturated thickness of > 60 m remaining after accounting for the conceptual dewatering drawdown of about 10 m. At this bore one species of copepod with a Pilbara-wide distribution was recorded. In the Minnieritchie Creek catchment, the inferred habitat is fractured sandstones with saturated thicknesses exceeding 30m. If this area is pumped for water supply then localised drawdown cones of 10 to 20 m + are modelled in the vicinity of bore SSWB41. The sampled bores in this catchment / aquifer detected only two species of stygofauna with wider distributions in the Pilbara.

The failure to detect stygofauna in the aquifer of the Lalla Rookh Fault Zone might be considered a sampling artefact related to the boreholes SSWB52 and SSWB53 that were only recently constructed (late 2006) and hence may not yet provide a suitable environment for colonisation by stygofauna. However, pump sampling of the surrounding aquifer at SSWB52 also failed to yield any stygofauna specimens and suggests the apparent absence of stygofauna in this aquifer may be real.

5.5. Potential impacts on stygofauna in the Project Area

The assessment of potential drawdown impacts on stygofauna in the Project area was based on:

1. Potential changes to groundwater quality and flow regime, seepage, sedimentation and contamination from waste rock dumps, TSF, road construction, infrastructure and plant equipment;
2. current knowledge on the taxonomy, distribution and habitats of stygofauna at local and regional scales in the Pilbara region;
3. the survey effort, sampling adequacy and taxonomic limitations;
4. known distribution of taxa collected and identified to the level of (morpho) species;
5. the probable distribution of taxa where taxonomic limitations precluded a definitive statement on their distribution and conservation status;
6. the probable distribution of taxa not detected in the survey.

In consideration of potential drawdown impacts to the conservation of stygofauna species, and given that:

1. All taxa identified to the level of (morpho) species were collected and/or previously recorded from areas further downstream in the catchments of the East Strelley and Shaw Rivers, or more widely in the Pilbara region;
2. the local distribution patterns of identified (morpho) species were consistent with predictions based on patterns of surface drainage and catchments;
3. taxa not detected or identified to species level because of taxonomic limitations are likely to display similar distributions related to local patterns in surface drainage and catchments;

it is concluded on the basis of current available knowledge, that there is a low likelihood that any stygofauna species will be threatened with extinction as a result of groundwater drawdown impacts from the mine development.

In consideration of potential drawdown impacts to the conservation of local populations, and given that:

1. Stygofauna was not detected in the pit and waste areas, and there is a low likelihood of their occurrence in the area of maximum pit dewatering drawdown;
2. beyond the pit and waste areas, the evidence from drill logs and pump sampling suggests that the major stygofauna habitat is deep groundwater in fractured rocks with saturated thicknesses ranging from an approximate minimum of 30 m (eg. SSWB40, SSWB41) to > 60 m (eg. SSWB36, SSWB22);
3. the local hotspot near SSWB36 to SSWB40, the natural seasonal variations in water levels recorded at these bores is +/- 4 m.

it is concluded on the basis of current available knowledge, that most of the deep groundwater habitat will be retained within the zone of fractured rocks that remain saturated below the limits of potential watertable drawdown.

In consideration of potential drawdown impacts to the conservation of local populations inhabiting shallow groundwater habitats in Creek Spring, it is concluded that populations at this site may be adversely affected if the drawdown from pit dewatering or water supply abstraction affect the flow regime of the spring.

In addition to groundwater drawdown, other potential impacts include alteration to groundwater flow regime and water quality, pit salinisation, sedimentation and contaminated seepage from roads and other cleared surfaces, the TSF, plant equipment and infrastructure. These potential impacts may be localised but they need to be carefully managed considering the Creek Spring populations and stygofauna hotspot (SSWB36 to SSWB40) are situated in Sulphur Springs Creek alongside the access road and immediately downstream of the TSF, plant and pit.

5.6. Further investigations warranted and potential management actions

Further investigations that may be warranted prior to mine development include:

5. Baseline sampling at proposed new water supply bores;
6. Baseline sampling of bores in the area of the TSF;

Further investigations that may be warranted during mine operation include:

7. Monitoring drawdown and possible impacts on stygofauna populations;
8. Monitoring groundwater quality and possible contaminants in Sulphur Springs Creek;

To improve understanding of the vertical distribution of stygofauna populations and drawdown impacts it would be useful if piezometers constructed for monitoring water levels were constructed as nested series screened at discrete depth intervals. Additional useful baseline information on stygofauna could be obtained by opportunistic sampling during pump testing operations for water supply and pit dewatering.

Potential management activities to minimise impacts on stygofauna populations include, where practicable, minimise drawdown in areas of known populations. Standard precautions for protecting groundwater quality should be followed, including minimising sediment runoff, salinisation, contamination from seepage, infrastructure, and plant equipment.

6. SUMMARY OF FINDINGS (Stygofauna and Troglofauna)

Table 6-1. Summary of subterranean fauna assessment for the Panorama CBH Sulphur Springs Project.

Area assessed: **Mine pit & waste dump area**	**Stygofauna**	**Troglofauna**
Habitat assessment	Prospective habitat fractured rocks in mine sequence and cavernous zones in gossan. Groundwater quality less prospective: acidic (pH range 2.8 to 4.8) with low oxygen (DO < 0.5 mg/L).	Prospective habitat: (1) regolith; (2) isolated cavernous zones at depth in weathered gossan-sulphide lens contact zone.
Likelihood of occurrence	Low likelihood, not detected in surveys.	Troglofauna detected in field survey of drill holes, probable source colonisation from widespread shallow regolith habitats and unlikely from deep specialised habitats.
Potential Impacts	In the event that stygofauna are present: direct habitat removal, dewatering of habitat, alteration to groundwater flow regime and reduction in water quality, pit salinisation, seepage and contamination from waste rock areas, TSF, plant and infrastructure.	In the event that short range endemic troglobitic species are present: direct habitat removal, changes to subterranean microclimate, surface & groundwater contamination, reduction in organic inputs, blast vibration disturbance, reduction in extent of retained habitat & viable population sizes.
Further investigation & potential management activities	None.	Field verification survey currently in progress.
Mine dewatering, plant & TSF zone		
Habitat assessment	Deep groundwater habitats are fractured rock aquifers; shallow groundwater habitats are alluvium and springs in Sulphur Springs Creek. Groundwater quality overall good & meets DEC assessment criteria for freshwater ecosystem protection (Golder 2006).	Shallow regolith habitats extensive and widespread. For deeper habitats, drill logs do not indicate major cavernous zones above the watertable, and only minor localised fracturing.
Likelihood of occurrence	Stygofauna detected. Species identified were found to occur outside the zone of influence, or are considered likely to occur outside the zone of influence.	High likelihood in shallow regolith habitats that are extensive and widespread in region. Low likelihood in deeper zones. Drill logs do not indicate cavernous rocks above the watertable, and only minor localised fracturing.
Potential Impacts	Drawdown and mounding of watertable, alteration to groundwater flow and spring flow regimes and water quality, seepage and contamination from waste rock areas, pit salinisation, TSF and infrastructure.	In the event that troglofauna are present then possible impacts related to watertable drawdown may include changes to subterranean microclimate (drying of habitat), potential contamination and alteration to groundwater & nutrient recharge regimes affecting microclimate and food sources. Impacts likely to be of localised extent.
Further investigation & potential management activities	Monitor drawdown and mounding, spring flow regime & possible impacts on stygofauna. Where practicable, minimise drawdown and alteration to natural flow regimes in areas of known populations. Monitor groundwater quality & contaminants.	Field survey (phase 2) outside pit zone of influence currently in progress. Manage threatening processes in areas of potential occurrences.

Water supply borefield zone of influence	**Stygofauna**	**Troglofauna**
Habitat assessment	Prospective habitat fractured rock aquifers, and alluvial sequences in creeks and Shaw River. Groundwater quality overall good & meets DEC assessment criteria for freshwater ecosystem protection (Golder 2006).	High likelihood in shallow regolith habitats that are extensive and widespread in region. Low likelihood in deeper zones. Drill logs do not indicate cavernous rocks above the watertable, and only minor localised fracturing.
Likelihood of occurrence	Stygofauna detected. All species identified were found to occur outside the zone of influence, or are considered likely to occur outside the zone of influence.	Potential occurrence.
Potential Impacts	Drawdown of watertable, alteration to groundwater flow regime and water quality.	In the event that troglofauna are present then possible impacts related to watertable drawdown may include changes to subterranean microclimate (drying of habitat), potential contamination and alteration to groundwater & nutrient recharge regimes affecting microclimate and food sources. Impacts likely to be of localised extent around pumping bores.
Further investigation & potential management activities	Prior to mine development, additional baseline sampling at new water supply bores and TSF. During mine operation, monitor drawdown & possible impacts of drawdown on stygofauna. Where practicable, minimise drawdown in areas of known populations.	None.

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9. APPENDICES

9.1. APPENDIX 1. List of troglofauna taxa, abundance and sites.

Phylum	Class	Order	Identification	Pilot Site	SSP27-T3	SSP28-T1	SSP28-T2	SSP28-T3	SSP27-T1	SSP27-T2	SSP27-T3
				Field No	seFN099	seFN100	seFN101	seFN102	seFN097	seFN098	seFN103
Chelicerata	Arachnida	Acarina	Oribatidae sp 1 (SS)		20		100	10	10	20	
			Oribatidae sp. 2 (SS)		1					1	
			Oribatidae sp. 3 (SS)		6						
			Acarina sp.1 (SS)				5				
			Acarina sp. 2 (PD)		1	2			20	14	
			Acarina sp. 11 (PD)								1
			Mesostigmata sp. 1 (SS)		2			1		1	
			Mesostigmata sp. 2(SS)						1	6	
			Mesostigmata sp.3 (SS)								2
			Mesostigmata sp. 7 (PD)								
			Acarina sp. 9(PD)								
			Mesostigmata undetermined								
Uniramia	Collembola	Collembola	Entomobryidae(blind white)								
			Collembola Type I		30		1		6	10	
			Collembola Isotomidae		1						
			Collembola Type II (Sminthuridae)		2						
	Insecta	Hemiptera	Hemipteran juvenile							2	
		Diptera	Dipteran larvae (as seLN230)		2						
			Muscidae larvae								3
		Coleoptera	Pselaphidae								
			Carabidae sp 1								
		Blattodea	**Nocticolidae**								
		Psocoptera	Psocoptera								
			No. Specimens		65	2	106	11	37	54	6
			No. Taxa		10	2	4	3	5	8	4

				Phase 1								
Phylum	Class	Order	Identification	SSP28	SSP27	SSP26	SSP20	SSP1	SSD82	SSP16	SSP36	SSP17
				seFN142	seFN141	seFN139	seFN143	seFN145	seFN156	seFN155	seFN140	seFN147
Chelicerata	Arachnida	Acarina	Oribatidae sp 1 (SS)	50	6				10	30		26
			Oribatidae sp. 2 (SS)									
			Oribatidae sp. 3 (SS)									
			Acarina sp.1 (SS)		1		1			3		1
			Acarina sp. 2 (PD)							6		
			Acarina sp. 11 (PD)							6		
			Mesostigmata sp. 1 (SS)	1						3		
			Mesostigmata sp. 2(SS)									
			Mesostigmata sp.3 (SS)							30		
			Mesostigmata sp. 7 (PD)									
			Acarina sp. 9(PD)									
			Mesostigmata undetermined		1							
Uniramia	Collembola	Collembola	Entomobryidae(blind white)				1	1		30	1	
			Collembola Type I						50			
			Collembola Isotomidae									
			Collembola Type II (Sminthuridae)					1				
	Insecta	Hemiptera	Hemipteran juvenile									
		Diptera	Dipteran larvae (as seLN230)							1		
			Muscidae larvae									
		Coleoptera	Pselaphidae									
			Carabidae sp 1									
		Blattodea	**Nocticolidae**									
		Psocoptera	Psocoptera			1						
			No. Specimens	51	8	1	2	2	60	109	1	27
			No. Taxa	3	4	2	3	3	3	9	2	3

Phylum	Class	Order	Identification	SSP21	SSD75A	SSP18	SSP33	SSP86	SSP22	SSP19	SSP34	SSP23?
				seFN146	seFN150	seFN149	seFN154	seFN151	seFN153	seFN148	seFN152	seFN144
Chelicerata	Arachnida	Acarina	Oribatidae sp 1 (SS)			6	50		100	10		
			Oribatidae sp. 2 (SS)					4??				
			Oribatidae sp. 3 (SS)									
			Acarina sp.1 (SS)		100			28		2	1	1
			Acarina sp. 2 (PD)		2			19			2	6
			Acarina sp. 11 (PD)	16								
			Mesostigmata sp. 1 (SS)			8		3		3		
			Mesostigmata sp. 2(SS)									
			Mesostigmata sp.3 (SS)				6					3
			Mesostigmata sp. 7 (PD)				1					
			Acarina sp. 9(PD)					1				
			Mesostigmata undetermined		2							
Uniramia	Collembola	Collembola	Entomobryidae(blind white)	2	5	50	7	16		50		2
			Collembola Type I		1							1
			Collembola Isotomidae		3							
			Collembola Type II (Sminthuridae)									1
	Insecta	Hemiptera	Hemipteran juvenile	3								
		Diptera	Dipteran larvae (as seLN230)									
			Muscidae larvae									
		Coleoptera	Pselaphidae							1		
			Carabidae sp 1	3						1		
		Blattodea	**Nocticolidae**	2						6		2
		Psocoptera	Psocoptera			7						
			No. Specimens	26	113	71	64	67	100	73	3	16
			No. Taxa	6	7	5	5	6	2	8	3	8

9.2. APPENDIX 2. Troglofauna specimen tracking details.

Phylum	Class	Order	Identification	Site	SSP27-T3	SSP28-T1	SSP28-T2	SSP28-T3	SSP27-T1	SSP27-T2	SSP27-T3
				Field No	seFN099	seFN100	seFN101	seFN102	seFN097	seFN098	seFN103
Chelicerata	Arachnida	Acarina	Oribatidae sp 1 (SS)		seLN285		seLN269	seLN176	seLN281	seLN272	
			Oribatidae sp. 2 (SS)		seLN289					seLN273	
			Oribatidae sp. 3 (SS)		seLN291						
			Acarina sp.1 (SS)				seLN271				
			Acarina sp. 2 (PD)		seLN287	seLN268			seLN280	seLN277	
			Acarina sp. 11 (PD)								seLN335
			Mesostigmata sp. 1 (SS)		seLN290			seLN334		seLN276	
			Mesostigmata sp. 2(SS)						seLN282	seLn275	
			Mesostigmata sp.3 (SS)								seLN336
			Mesostigmata sp. 7 (PD)								
			Acarina sp. 9(PD)								
			Mesostigmata undetermined								
Uniramia	Collembola	Collembola	Entomobryidae(blind white)								
			Collembola Type I		seLN283		seLN270		seLN279	seLN274	
			Collembola Isotomidae		se LN284						
			Collembola Type II (Sminthuridae)		seLN286						
	Insecta	Hemiptera	Hemipteran juvenile							seLn278	
		Diptera	Dipteran larvae (as seLN230)		seLN288						
			Muscidae larvae								seLN337
		Coleoptera	Pselaphidae								
			Carabidae sp 1								
		Blattodea	**Nocticolidae**								
		Psocoptera	Psocoptera								
			No. Specimens								
				Vials Tot	9	1	3	2	4	7	3

Phylum	Class	Order	Identification	SSP28	SSP27	SSP26	SSP20	SSP1	SSD82	SSP16	SSP36	SSP17
				seFN142	seFN141	seFN139	seFN143	seFN145	seFN156	seFN155	seFN140	seFN147
Chelicerata	Arachnida	Acarina	Oribatidae sp 1 (SS)	seLN433	seLN434				seLN441	seLN446		seLN450
			Oribatidae sp. 2 (SS)									
			Oribatidae sp. 3 (SS)									
			Acarina sp.1 (SS)		seLN434		seLN437			seLN445		seLN450
			Acarina sp. 2 (PD)							seLN448		
			Acarina sp. 11 (PD)							seLN447		
			Mesostigmata sp. 1 (SS)	seLN433						seLN444		
			Mesostigmata sp. 2(SS)									
			Mesostigmata sp.3 (SS)							seLN444		
			Mesostigmata sp. 7 (PD)									
			Acarina sp. 9(PD)									
			Mesostigmata undetermined		seLN435							
Uniramia	Collembola	Collembola	Entomobryidae(blind white)				seLN438	seLN439		seLN442	seLN449	
			Collembola Type I						seLN440			
			Collembola Isotomidae									
			Collembola Type II (Sminthuridae)					seLN439				
	Insecta	Hemiptera	Hemipteran juvenile									
		Diptera	Dipteran larvae (as seLN230)							seLN443		
			Muscidae larvae									
		Coleoptera	Pselaphidae									
			Carabidae sp 1									
		Blattodea	**Nocticolidae**									
		Psocoptera	Psocoptera			seLN436						
			No. Specimens									
				2	2	1	2	1	2	7	1	1

Phylum	Class	Order	Identification	SSP21	SSD75A	SSP18	SSP33	SSP86	SSP22	SSP19	SSP34	SSP23?
				seFN146	seFN150	seFN149	seFN154	seFN151	seFN153	seFN148	seFN152	seFN144
Chelicerata	Arachnida	Acarina	Oribatidae sp 1 (SS)			seLN464	seLN466		seLN470	seLN472		
			Oribatidae sp. 2 (SS)					seLN468				
			Oribatidae sp. 3 (SS)									
			Acarina sp.1 (SS)		serLN458			seLN467		seLN472	seLN476	seLN477
			Acarina sp. 2 (PD)		seLN460			seLN467			seLN476	seLN477
			Acarina sp. 11 (PD)	seLN451								
			Mesostigmata sp. 1 (SS)			seLN461		seLN467		seLN472		
			Mesostigmata sp. 2(SS)									
			Mesostigmata sp.3 (SS)				seLN466					seLN477
			Mesostigmata sp. 7 (PD)				seLN466					
			Acarina sp. 9(PD)					seLN468				
			Mesostigmata undetermined		seLN460							
Uniramia	Collembola	Collembola	Entomobryidae(blind white)	seLN453	seLN457	seLN462	seLN465	seLN469		seLN471		seLN478
			Collembola Type I		seLN459							seLN478
			Collembola Isotomidae		seLN456							
			Collembola Type II (Sminthuridae)									seLN478
	Insecta	Hemiptera	Hemipteran juvenile	seLN452								
		Diptera	Dipteran larvae (as seLN230)									
			Muscidae larvae									
		Coleoptera	Pselaphidae							seLN473		
			Carabidae sp 1	seLN454						seLN475		
		Blattodea	**Nocticolidae**	seLN455						seLN474, 482		seLN485
		Psocoptera	Psocoptera			seLN463						
			No. Specimens									
				5	5	4	2	3	1	5	1	2

9.3. APPENDIX 3. List of stygofauna taxa and sites.

Taxon 1	Taxon 2	Genus	Identification	Site name	Spec.	All	Sites
Acariformes	Fam. Indet.	Gen. indet.	Gen et sp. Indet.	Outside Well	1	7	2
Acariformes	Fam. Indet.	Gen. indet.	Gen et sp. Indet.	SSWB38	6		
Acariformes	Oribatida	Gen. indet.	Gen et sp. Indet.	Creek Spring 1	1	50	7
Acariformes	Oribatida	Gen. indet.	Gen et sp. Indet.	Creek Spring 2	6		
Acariformes	Oribatida	Gen. indet.	Gen et sp. Indet.	Creek Spring 3	15		
Acariformes	Oribatida	Gen. indet.	Gen et sp. Indet.	Medinina Well	1		
Acariformes	Oribatida	Gen. indet.	Gen et sp. Indet.	No. 14 Well	25		
Acariformes	Oribatida	Gen. indet.	Gen et sp. Indet.	SSWB36	1		
Acariformes	Oribatida	Gen. indet.	Gen et sp. Indet.	SSWB40	1		
Acariformes	Oribatida	*Guineaxonopsis*	*Guineaxonopsis sp.*	Creek Spring 3	1	1	1
Acariformes	Prostigmata	Gen. indet.	Gen et sp. Indet.	SSWB25	1	1	1
Acariformes	Prostigmata (Eupodididae?)	Gen. indet.	Gen et sp. Indet.	SSWB006	1	1	1
Amphipoda	Melitidae	cf. Norcapensis	Melitidae n. sp. cf. Melitidae sp. 1 (PSS)	MBSLK376W	10	32	5
Amphipoda	Melitidae	cf. Norcapensis	Melitidae n. sp. cf. Melitidae sp. 1 (PSS)	MBSLK388N	1		
Amphipoda	Melitidae	cf. Norcapensis	Melitidae n. sp. cf. Melitidae sp. 1 (PSS)	SSWB36	3		
Amphipoda	Melitidae	cf. Norcapensis	Melitidae n. sp. cf. Melitidae sp. 1 (PSS)	SSWB40	3		
Amphipoda	Melitidae	cf. Norcapensis	Melitidae n. sp. cf. Melitidae sp. 1 (PSS)	SSWB40	15		
Amphipoda	Melitidae	*Nedsia*	*Nedsia sp.*	MBSLK376E	25	39	4
Amphipoda	Melitidae	*Nedsia*	*Nedsia* sp.	MBSLK376W	10		
Amphipoda	Melitidae	*Nedsia*	*Nedsia* sp.	MBSLK388N	2		
Amphipoda	Melitidae	*Nedsia*	*Nedsia* sp.	Watts Well	2		
Amphipoda	Paramelitidae	Gen. indet.	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	MBSLK376E	1	44	13
Amphipoda	Paramelitidae	Gen. indet.	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	No. 14 Well	4		
Amphipoda	Paramelitidae	Gen. indet.	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	Outside Well	1		
Amphipoda	Paramelitidae	Gen. indet.	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	Outside Well	3		
Amphipoda	Paramelitidae	Gen. indet.	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	SSWB36	4		
Amphipoda	Paramelitidae	Gen. indet.	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	SSWB38	2		
Amphipoda	Paramelitidae	Gen. indet.	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	SSWB40	6		
Amphipoda	Paramelitidae	Gen. indet.	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	SSWB40	5		
Amphipoda	Paramelitidae	Gen. indet.	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	SSWB40	2		
Amphipoda	Paramelitidae	Gen. indet.	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	Watts Well	11		
Amphipoda	Paramelitidae	Gen. indet.	Paramelitidae n. sp. aff. CALM sp. 7 (PSS)	Outside Well	1		
Amphipoda	Paramelitidae	Gen. indet.	Paramelitidae n. sp. aff. CALM sp. 7 (PSS)	Outside Well	1		
Amphipoda	Paramelitidae	Gen. indet.	Paramelitidae n. sp. aff. CALM sp. 7 (PSS)	Watts Well	3		
Coleoptera	Fam. Inet.	Gen. indet.	Gen et sp. Indet.	Creek Spring 1	8	8	1
Copepoda	Cyclopoida	*Diacyclops*	*Diacyclops cockingi Karanovic*	SSWB40	2	2	1
Copepoda	Cyclopoida	*Diacyclops*	*Diacyclops cf. humphreysi humphreysi Karanovic*	Outside Well	20	225	6
Copepoda	Cyclopoida	*Diacyclops*	*Diacyclops cf. humphreysi humphreysi Karanovic*	SSWB36	100		
Copepoda	Cyclopoida	*Diacyclops*	*Diacyclops cf. humphreysi humphreysi Karanovic*	SSWB38	100		
Copepoda	Cyclopoida	*Diacyclops*	*Diacyclops humphreysi humphreysi Karanovic*	SSWB01	1		
Copepoda	Cyclopoida	*Diacyclops*	*Diacyclops humphreysi humphreysi Karanovic*	SSWB40	2		

Taxon 1	Taxon 2	Genus	Identification	Site name	Spec.	All	Sites
Copepoda	Cyclopoida	*Diacyclops*	*Diacyclops humphreysi humphreysi Karanovic*	SSWB40	3		
Copepoda	Cyclopoida	*Diacyclops*	*Diacyclops sobeprolatus Karanovic*	SSWB38	100	129	4
Copepoda	Cyclopoida	*Diacyclops*	*Diacyclops sobeprolatus Karanovic*	SSWB40	26		
Copepoda	Cyclopoida	*Diacyclops*	*Diacyclops sobeprolatus Karanovic*	SSWB40	2		
Copepoda	Cyclopoida	*Diacyclops*	*Diacyclops sp. cf. sobeprolatus Karanovic*	SSWB22	1		
Copepoda	Cyclopoida	*Diacyclops*	*Diacyclops sp.*	SSWB36	100	100	1
Copepoda	Cyclopoida	*Fierscyclops*	*Fierscyclops (Pilbaracyclops) cf frustratio Karanovic*	SSWB36	4		
Copepoda	Cyclopoida	*Fierscyclops*	*Fierscyclops (Pilbaracyclops) cf frustratio Karanovic*	SSWB40	2		
Copepoda	Cyclopoida	Gen. indet.	Gen et sp. Indet. (juveniles)	SSWB40	100	100	1
Copepoda	Cyclopoida	*Microcyclops*	*Microcyclops varicans (Sars 1863)*	Creek Spring 1	100	135	5
Copepoda	Cyclopoida	*Microcyclops*	*Microcyclops varicans (Sars 1863)*	Creek Spring 3	3		
Copepoda	Cyclopoida	*Microcyclops*	*Microcyclops varicans (Sars 1863)*	SSWB38	1		
Copepoda	Cyclopoida	*Microcyclops*	*Microcyclops varicans (Sars 1863)*	SSWB40	29		
Copepoda	Cyclopoida	*Microcyclops*	*Microcyclops varicans (Sars 1863)*	Watts Well	2		
Copepoda	Harpacticoida	*Elaphoidella*	*Elaphoidella humphreysi Karanovic*	Creek Spring 3	1	30	4
Copepoda	Harpacticoida	*Elaphoidella*	*Elaphoidella humphreysi Karanovic*	Outside Well	26		
Copepoda	Harpacticoida	*Elaphoidella*	*Elaphoidella humphreysi Karanovic*	SSWB44	1		
Copepoda	Harpacticoida	*Elaphoidella*	*Elaphoidella humphreysi Karanovic*	SSWB38	2		
Copepoda	Harpacticoida	*Stygonitocrella*	*Stygonitocrella trispinosa Karanovic*	SSWB36	1	13	2
Copepoda	Harpacticoida	*Stygonitocrella*	*Stygonitocrella trispinosa Karanovic*	SSWB40	12		
Diptera	Ceratopogonidae	Gen. indet.	Gen et sp. Indet.	Creek Spring 1			1
Diptera	Culicidae	Gen. indet.	Gen et sp. Indet.	Creek Spring 1			4
Diptera	Culicidae	Gen. indet.	Gen et sp. Indet.	SSWB006			
Diptera	Culicidae	Gen. indet.	Gen et sp. Indet.	SSWB006			
Diptera	Culicidae	Gen. indet.	Gen et sp. Indet.	SSWB26			
Diptera	Culicidae	Gen. indet.	Gen et sp. Indet.	SSWB38			
Isopoda	Microcerberidae	*Coxicerberus*	*Coxicerberus sp.*	MBSLK376W	1	10	3
Isopoda	Microcerberidae	*Coxicerberus*	*Coxicerberus sp.*	MBSLK388E	1		
Isopoda	Microcerberidae	*Coxicerberus*	*Coxicerberus sp.*	Pongawarrah Well	8		
Oligochaeta	Phreodrilidae	Gen. indet.	Gen et sp. Indet.	Creek Spring 1	1+	1	1
Oligochaeta	Tubificidae	*Monophylephorus*	*Monophylephorus n. sp.*	Outside Well	3	4	2
Oligochaeta	Tubificidae	*Monophylephorus*	*Monophylephorus n. sp.*	Watts Well	1		
Oligochaeta	Tubificidae	*Pristina*	*Pristina longiseta Ehrenberg*	Creek Spring 1	20	20	1
Oligochaeta	Tubificidae	Gen. indet.	Tubificidae SS sp. 1	Creek Spring 1	20	21	2
Oligochaeta	Tubificidae	Gen. indet.	Tubificidae SS sp. 1	SSWB36	1		
Ostracoda	Candonidae	*Leicacandona*	*Leicacandona mookae Karanovic 2007*	SSWB40	7	7	1
Ostracoda	Cyprididae	*Cypretta*	*Cypretta seurati Gauthier, 1938*	Coonterunah Well	8	54	4
Copepoda	Cyprididae	*Cypretta*	*Cypretta seurati Gauthier, 1938*	No. 14 Well	3		
Ostracoda	Cyprididae	*Cypretta*	*Cypretta seurati Gauthier, 1938*	Pongawarrah Well	23		
Ostracoda	Cyprididae	*Cypretta*	*Cypretta seurati Gauthier, 1938*	Watts Well	20		
Ostracoda	Cyprididae	*Stenocypris*	*Stenocypris bolieki Ferguson 1962*	Medinina Well	2	2	1
Ostracoda	Cyprididae	*Strandesia*	*Strandesia sp.*	No. 14 Well	22	105	4

Taxon 1	Taxon 2	Genus	Identification	Site name	Spec.	All	Sites
Ostracoda	Cyprididae	*Strandesia*	*Strandesia sp.*	Outside Well	12		
Ostracoda	Cyprididae	*Strandesia*	*Strandesia sp.*	Outside Well	10		
Ostracoda	Cyprididae	*Strandesia*	*Strandesia sp.*	Outside Well	61		
Ostracoda	Darwinulidae	Gen. indet.	Gen et sp. Indet.	Creek Spring 1	1	2	2
Ostracoda	Darwinulidae	Gen. indet.	Gen et sp. Indet.	Creek Spring 3	1		
Ostracoda	Limnocytheridae	*Gomphodella*	*Gomphodella hirsuta Karanovic 2006*	Coonterunah Well	5	16	7
Ostracoda	Limnocytheridae	*Gomphodella*	*Gomphodella hirsuta Karanovic 2006*	SSWB40	3		
Ostracoda	Limnocytheridae	*Gomphodella*	*Gomphodella hirsuta Karanovic 2006*	SSWB40	2		
Ostracoda	Limnocytheridae	*Gomphodella*	*Gomphodella hirsuta Karanovic 2006*	SSWB40	1		
Ostracoda	Limnocytheridae	*Gomphodella*	*Gomphodella hirsuta Karanovic 2006*	SSWB40	3		
Ostracoda	Limnocytheridae	*Gomphodella*	*Gomphodella hirsuta Karanovic 2006*	SSWB41	1		
Ostracoda	Limnocytheridae	*Gomphodella*	*Gomphodella hirsuta Karanovic 2006*	SSWB44	1		
Nematoda	Fam. Inet.	Gen. indet.	Nematoda SS sp. 1	SSWB38	1	1	1
Nematoda	Fam. Inet.	Gen. indet.	Nematoda SS sp. 2	SSWB36	1	1	1
				Total spec.	**1161**		

9.4. APPENDIX 4. List of stygofauna sites sampled, sample dates and methods, and recorded taxa with specimen tracking details.

Site name	Lat		Long		Date	Field No.	Meth.	Identification	Vial no.	Spec.	Slide	Comments
Coonterunah Well	-20	58.1	119	7.8	08-Feb-07	seFN035	NH	*Cypretta seurati* Gauthier, 1938	seLN090	8		6F, 1M, 1juv. In alcohol
Coonterunah Well	-20	58.1	119	7.8	08-Feb-07	seFN035	NH	*Gomphodella hirsuta* Karanovic 2006	seLN090	5		
Creek Spring 1	-21	6.8	119	11.6	02-Dec-06	na	KC	Oribatida sp. Indet.	seLN023	1		non stygal
Creek Spring 1	-21	6.8	119	11.6	02-Dec-06	na	KC	Coleoptera sp. Indet.	seLN020	8		non stygal
Creek Spring 1	-21	6.8	119	11.6	02-Dec-06	na	KC	*Microcyclops varicans* (Sars 1863)	seLN024	100	seS052	not stygofauna
Creek Spring 1	-21	6.8	119	11.6	02-Dec-06	na	KC	Ceratopogonidae sp. Indet.				not stygofauna, not collected
Creek Spring 1	-21	6.8	119	11.6	02-Dec-06	na	KC	Culicidae sp. Indet.				2 x F dissected on slide
Creek Spring 1	-21	6.8	119	11.6	02-Dec-06	na	KC	Phreodrilidae sp. Indet.	seLN022	1		Fragments, paired ventral chetae, bifid+simple pointed; dorsal chetae w. support chetae
Creek Spring 1	-21	6.8	119	11.6	02-Dec-06	na	KC	Tubificidae SS sp. 1	seLN022	20		Imm. Tubificidae with bifid hair crochets ventral and dorsal dissimilar, cf. seLN008,
Creek Spring 1	-21	6.8	119	11.6	02-Dec-06	na	KC	*Pristina longiseta* Ehrenberg	seLN022	20		Needle chetae end in fine point
Creek Spring 1	-21	6.8	119	11.6	02-Dec-06	na	KC	Darwinulidae sp. Indet.	seLN021	1		5F In alcohol
Creek Spring 2	-21	6.9	119	11.5	02-Dec-06	na	KC	Oribatida sp. Indet.	seLN051	6		
Creek Spring 3	-21	7.1	119	11.6	02-Dec-06	na	KC	*Guineaxonopsis* sp.	seLN056	1		1 M to MH
Creek Spring 3	-21	7.1	119	11.6	02-Dec-06	na	KC	Oribatida sp. Indet.	seLN056	15		
Creek Spring 3	-21	7.1	119	11.6	02-Dec-06	na	KC	*Microcyclops varicans* (Sars 1863)	seLN055	3	seS061	1 spec on slide
Creek Spring 3	-21	7.1	119	11.6	02-Dec-06	na	KC	*Elaphoidella humphreysi* Karanovic	seLN054	1	seS060	2 x F, 1 x juv dissected on slide, 1 F in vial
Creek Spring 3	-21	7.1	119	11.6	02-Dec-06	na	KC	Darwinulidae sp. Indet.	seLN053	1		1 juv.
Lalla Rookh Mine	-21	3.1	119	16.6	01-Feb-07	seFN036	T	Mesoveliidae sp. Indet.	na	1		seLN93 spec discarded
MBSLK376E	-20	42.6	119	20.2	08-Feb-07	seFN019	NH	Nedsia sp.	seLN047	25		
MBSLK376E	-20	42.6	119	20.2	08-Feb-07	seFN019	NH	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	seLN046	1		
MBSLK376E	-20	42.6	119	20.2	08-Feb-07	seFN018, 20	NH	Amphipoda	seLN116	9		
MBSLK376W	-20	42.6	119	20.2	01-Feb-07	seFN021, 22	NH	Nedsia sp.	seLN117	10		
MBSLK376W	-20	42.6	119	20.2	01-Feb-07	seFN021, 22	NH	Melitidae n. sp. cf. Melitidae sp. 1 (PSS)	seLN117	10		
MBSLK376W	-20	42.6	119	20.2	01-Feb-07	seFN021, 22	NH	*Coxicerberus* sp.	seLN118	1		
MBSLK388E	-20	40.6	119	14.7	08-Feb-07	seFN30	NH	*Coxicerberus* sp.	seLN126	1		
MBSLK388E	-20	40.6	119	14.7	08-Feb-07	seFN30	NH	Amphipoda	seLN124	2		
MBSLK388E	-20	40.6	119	14.7	08-Feb-07	seFN30	NH	Cyclopoida	seLN125	7		
MBSLK388N	-20	40.6	119	14.7	08-Feb-07	seFN031,32,33,34	NH	Nedsia sp.	seLN049	2		
MBSLK388N	-20	40.6	119	14.7	08-Feb-07	seFN031,32,33,34	NH	Melitidae n. sp. cf. Melitidae sp. 1 (PSS)	seLN050	1		see p. 86 lab book
MBSLK388N	-20	40.5	119	14.7	08-Feb-07	seFN32,33,34	NH	Amphipoda	seLN111	12		
MBSLK388N	-20	40.5	119	14.7	08-Feb-07	seFN32,33,34	NH	Cyclopoida	seLN112	1		
MBSLK388W	-20	40.6	119	14.7	08-Feb-07	seFN29	NH	*Coxicerberus* sp.	seLN121	7		
MBSLK388W	-20	40.6	119	14.7	08-Feb-07	seFN29	NH	Amphipoda	seLN122	1		
MBSLK388W	-20	40.6	119	14.7	08-Feb-07	seFN29	NH	Cyclopoida	seLN123	8		
Medinina Well	-20	44.6	119	16.7	08-Feb-07		NH	Oribatida sp. Indet.	seLN099	1		
Medinina Well	-20	44.6	119	16.7	08-Feb-07	seFN028	NH	*Stenocypris bolieki* Ferguson 1962	seLN100	2		1 x valve
No. 14 Well	-20	41.5	119	17.0	08-Feb-07	seFN028	NH	Oribatida sp. Indet.	seLN113	25		5F, 17 juv. in alcohol
No. 14 Well	-20	41.5	119	17.0	08-Feb-07	seFN024, 25, 26	NH	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	seLN048	4		see p. 87 lab book

Site name	Lat		Long		Date	Field No.	Meth.	Identification	Vial no.	Spec.	Slide	Comments
No. 14 Well	-20	41.5	119	17.0	08-Feb-07	seFN024, 25, 26	NH	*Cypretta seurati* Gauthier, 1938	seLN114	3		2 juv. In alcohol
No. 14 Well	-20	41.5	119	17.0	08-Feb-07	seFN024, 25, 26	NH	*Strandesia* sp.	seLN114	22		3F in alcohol
No. 14 Well	-20	41.5	119	17.0	08-Feb-07	seFN024, 25, 26	NH	Amphipoda	seLN115	22		3F in alcohol
Outside Well	-20	54.2	119	18.0	06-Feb-07	seFN001, 002	NH	Gen et sp. Indet.	seLN030	1		1 larva
Outside Well	-20	54.2	119	18.0	06-Feb-07	seFN001, 002	NH	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	seLN033	1	seS046	5F, 17 juv. in alcohol
Outside Well	-20	54.2	119	18.0	06-Feb-07	seFN001, 002	NH	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	seLN034	3		1 spec. dissected on slide, p. 73-74 lab book
Outside Well	-20	54.2	119	18.0	06-Feb-07	seFN001, 002	NH	Paramelitidae n. sp. aff. CALM sp. 7 (PSS)	seLN031	1	44, 45	
Outside Well	-20	54.2	119	18.0	06-Feb-07	seFN001, 002	NH	Paramelitidae n. sp. aff. CALM sp. 7 (PSS)	seLN032	1		1 spec. dissected on slide, p. 71 lab book
Outside Well	-20	54.2	119	18.0	06-Feb-07	seFN001, 002	NH	*Diacyclops* cf. *humphreysi humphreysi* Karanovic	seLN026	20	seS053	3 spec dissected on slide, > 100 spec in vial seFN002
Outside Well	-20	54.2	119	18.0	06-Feb-07	seFN001, 002	NH	*Elaphoidella humphreysi* Karanovic	seLN025	26	seS047	3 spec on slide, 1 x M. varicans, 2 x juv.
Outside Well	-20	54.2	119	18.0	06-Feb-07	seFN001, 002	NH	*Monophylephorus* n. sp.	seLN029	3		was Pristina n. sp. WA3,
Outside Well	-20	54.2	119	18.0	06-Feb-07	seFN001, 002	NH	*Strandesia* sp.	seLN027	12		5F, 17 juv. in alcohol
Outside Well	-20	54.2	119	18.0	06-Feb-07	seFN001, 002	NH	*Strandesia* sp.	seLN028	10		7F, 5 juv., more spec in seFN002
Outside Well	-20	54.2	119	18.0	07-Feb-07	seFN011	T	Melitidae n. sp. cf. Melitidae sp. 1 (PSS)	seLN092	1		1 spec. damaged
Outside Well	-20	54.2	119	18.0	07-Feb-07	seFN011	T	*Strandesia* sp.	seLN091	61		10 juv, 38 valves more spec in seFN002
Pongawarrah Well	-20	42.2	119	18.7	08-Feb-07	seFN001, 002	NH	*Cypretta seurati* Gauthier, 1938	seLN119	23		50F, 11Juv., more spec in seFN002
Pongawarrah Well	-20	42.2	119	18.7	08-Feb-07	seFN023	NH	*Coxicerberus* sp.	seLN121	8		50F, 11Juv., more spec in seFN002
SSTP03	-21	8.6	119	11.3	30-Nov-06	seFN023	NH	NIL STYGOFAUNA				
SSWB003	-21	8.8	119	12.9	10-Feb-07	seFN056	NH	NIL STYGOFAUNA				
SSWB005	-21	8.8	119	12.7	01-Dec-06		NH	Oniscidea				terrestrial epigean, not stygofauna
SSWB006	-21	9.1	119	13.0	01-Dec-06		NH	Prostigmata (Eupodididae?) sp. Indet.	seLN107	1		
SSWB006	-21	9.1	119	13.0	01-Dec-06		NH	Culicidae sp. Indet.				not stygofauna, not collected
SSWB006	-21	9.1	119	13.0	10-Feb-07	seFN054	P	Culicidae sp. Indet.				not stygofauna, seLN108 discarded
SSWB006	-21	9.1	119	13.0	10-Feb-07	seFN055	postNH	NIL STYGOFAUNA				
SSWB006	-21	9.1	119	13.0	10-Feb-07	seFN052	preNH	NIL STYGOFAUNA				
SSWB009	-21	9.1	119	13.0	01-Feb-07	seFN053	NH	NIL STYGOFAUNA				
SSWB01	-21	9.0	119	12.3	01-Dec-06		NH	NIL STYGOFAUNA				
SSWB01	-21	9.0	119	12.3	10-Feb-07	seFN050	P	*Diacyclops humphreysi humphreysi* Karanovic	seLN089	1	sesS051	1 on slide - probable CONTAMINANT from SSWB40
SSWB01	-21	9.0	119	12.3	10-Feb-07	seFN048	preNH	NIL STYGOFAUNA				
SSWB01	-21	9.0	119	12.3	10-Feb-07	seFN051	postNH	NIL STYGOFAUNA				
SSWB19	-21	8.9	119	12.2	01-Dec-06		NH	NIL STYGOFAUNA				
SSWB19A	-21	8.9	119	12.2	01-Dec-06		NH	NIL STYGOFAUNA				
SSWB21	-21	9.8	119	12.0	01-Dec-06		NH	NIL STYGOFAUNA				
SSWB22	-21	9.5	119	11.5	01-Dec-06		NH	*Diacyclops* sp. cf. *sobeprolatus* Karanovic		1	seS043	
SSWB23	-21	9.2	119	11.2	30-Nov-06		NH	NIL STYGOFAUNA				
SSWB25	-21	8.4	119	11.4	30-Nov-06		NH	Prostigmata sp. Indet.	seLN016	1	seS057	part dissected on slide, terrestrial
SSWB25	-21	8.4	119	11.4	10-Feb-07	seFN057	NH	NIL STYGOFAUNA				
SSWB26	-21	7.9	119	12.8	02-Dec-06		NH	Culicidae sp. Indet.	na			not stygofauna, not collected
SSWB28	-21	8.9	119	12.4	01-Dec-06		NH	NIL STYGOFAUNA				
SSWB29	-21	9.0	119	12.4	10-Feb-07	seFN049	NH	NIL STYGOFAUNA				
SSWB36	-21	5.2	119	11.2	30-Nov-06		NH	Oribatida sp. Indet.	seLN004	1		

Site name	Lat		Long		Date	Field No.	Meth.	Identification	Vial no.	Spec.	Slide	Comments
SSWB36	-21	5.2	119	11.2	30-Nov-06		NH	Melitidae n. sp. cf. Melitidae sp. 1 (PSS)	seLN009	3		
SSWB36	-21	5.2	119	11.2	30-Nov-06		NH	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	seLN005	4		see notes in lab book
SSWB36	-21	5.2	119	11.2	30-Nov-06		NH	*Diacyclops* sp.	seLN007	100	seS039	1 x F dissected on slide, p65 lab book
SSWB36	-21	5.2	119	11.2	30-Nov-06		NH	*Diacyclops* cf. *humphreysi humphreysi* Karanovic	seLN007	100	seS055	2 x juv. dissected on slide, further ID pending
SSWB36	-21	5.2	119	11.2	30-Nov-06		NH	*Fierscyclops (Pilbaracyclops)* cf *frustratio* Karanovic	seLN003	4	37, 38, 56	3 spec. dissected on slide
SSWB36	-21	5.2	119	11.2	30-Nov-06		NH	*Stygonitocrella trispinosa* Karanovic	seLN006	1		2 x F, 1 x M dissected on slides, 1 F in vial
SSWB36	-21	5.2	119	11.2	30-Nov-06		NH	Tubificidae SS sp. 1	seLN008	1		same as seLN022
SSWB36	-21	5.2	119	11.2	08-Feb-07	seFN040	P	Amphipoda	seLN127	1		head only
SSWB36	-21	5.2	119	11.2	08-Feb-07	seFN040	P	Cyclopoida	seLN128	5		
SSWB36	-21	5.2	119	11.2	08-Feb-07	seFN028	T	NIL STYGOFAUNA	na			
SSWB36	-21	5.2	119	11.2	08-Feb-07	seFN041, 042	postNH	Melitidae n. sp. cf. Melitidae sp. 1 (PSS)	seLN130	1		
SSWB36	-21	5.2	119	11.2	08-Feb-07	seFN041, 042	postNH	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	seLN130	1		
SSWB36	-21	5.2	119	11.2	08-Feb-07	seFN041, 042	postNH	Nematoda SS sp. 2	seLN129	1		see p. 81 lab book
SSWB36	-21	5.2	119	11.2	08-Feb-07	seFN041, 042	postNH	*Monophylephorus* n. sp.	seLN327	1		p. 81 & 69 lab book
SSWB37	-21	5.5	119	13.8	02-Dec-06		NH	NIL STYGOFAUNA				
SSWB37	-21	5.5	119	13.8	08-Feb-07	seFN37	NH	NIL STYGOFAUNA				
SSWB38	-21	5.6	119	11.2	30-Nov-06		NH	Acariformes sp. Indet.	seLN012	6		
SSWB38	-21	5.6	119	11.2	30-Nov-06		NH	Paramelitidae ? sp. Indet.	seLN014	1		see notes in lab book, p. 61-62
SSWB38	-21	5.6	119	11.2	30-Nov-06		NH	*Diacyclops* cf. *humphreysi humphreysi* Karanovic	seLN011	100	seS036	spec lost
SSWB38	-21	5.6	119	11.2	30-Nov-06		NH	*Diacyclops cockingi* Karanovic	seLN011	100	seS035	1 x F dissected on slide + 1 x *Diacyclops* sp. juv.
SSWB38	-21	5.6	119	11.2	30-Nov-06	seFN005	NH	*Elaphoidella humphreysi* Karanovic	seLN015	2	seS058	1 x M, 1 x F dissected on slide, 1 husk discarded
SSWB38	-21	5.6	119	11.2	30-Nov-06	seFN005	NH	Culicidae sp. Indet.	na			not stygofauna, not collected
SSWB38	-21	5.6	119	11.2	06-Feb-07	seFN005	NH	*Microcyclops varicans* (Sars 1863)	seLN104	1	seS048	Further ID pending
SSWB38	-21	5.6	119	11.2	06-Feb-07	seFN005	NH	Nematoda SS sp. 1	seLN106	1		"Fat tailed nematode" p. 78 lab book
SSWB38	-21	5.6	119	11.2	07-Feb-07	seFN013	NH	Diptera sp. Indet.	na	1		not stygofauna, not collected
SSWB38	-21	5.6	119	11.2	07-Feb-07	seFN013	NH	Tanypodinae sp. Indet.	na	1		not stygofauna, not collected
SSWB38	-21	5.6	119	11.2	07-Feb-07	seFN014	NH	NIL STYGOFAUNA	na			not stygofauna, not collected
SSWB39	-21	5.9	119	11.2	30-Nov-06		NH	NIL STYGOFAUNA				
SSWB39	-21	5.9	119	11.2	07-Feb-07	seFN015	NH	NIL STYGOFAUNA				
SSWB40	-21	6.1	119	11.4	30-Nov-06	na	NH	Melitidae n. sp. cf. Melitidae sp. 1 (PSS)	seLN004	3		
SSWB40	-21	6.1	119	11.4	30-Nov-06	na	NH	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	seLN002	6		see notes in lab book
SSWB40	-21	6.1	119	11.4	30-Nov-06	na	NH	*Diacyclops sobeprolatus* Karanovic	seLN003	26	seS041	
SSWB40	-21	6.1	119	11.4	30-Nov-06	na	NH	*Diacyclops sobeprolatus* Karanovic	seLN003	2	seS042	1 dissected on slide
SSWB40	-21	6.1	119	11.4	30-Nov-06	na	NH	*Fierscyclops (Pilbaracyclops)* cf *frustratio* Karanovic	seLN003	2	seS040	1 x M dissected on slide + 1 x *Diacyclops* sp. juv.
SSWB40	-21	6.1	119	11.4	30-Nov-06	na	NH	*Microcyclops varicans* (Sars 1863)	seLN003	29	seS041	2 x F dissected on slide
SSWB40	-21	6.1	119	11.4	30-Nov-06	na	NH	*Gomphodella hirsuta* Karanovic 2006	seLN010	3	seS065	8F, 15juv.
SSWB40	-21	6.1	119	11.4	06-Feb-07	seFN008	NH	*Diacyclops humphreysi humphreysi* Karanovic	seLN102	2	seS062	2 x F dissected on slide
SSWB40	-21	6.1	119	11.4	06-Feb-07	seFN008	NH	*Gomphodella hirsuta* Karanovic 2006	seLN101	2		1F on slide, 2F, 4 valves, 1 shell in alcohol
SSWB40	-21	6.1	119	11.4	06-Feb-07	seFN007	NH	NIL STYGOFAUNA	na	0		
SSWB40	-21	6.1	119	11.4	07-Feb-07	seFN017	NH	Oribatida sp. Indet.	seLN097	1		
SSWB40	-21	6.1	119	11.4	07-Feb-07	seFN016	NH	Melitidae n. sp. cf. Melitidae sp. 1 (PSS)	seLN098	3		

Site name	Lat		Long		Date	Field No.	Meth.	Identification	Vial no.	Spec.	Slide	Comments
SSWB40	-21	6.1	119	11.4	07-Feb-07	seFN017	NH	*Diacyclops humphreysi humphreysi* Karanovic	seLN096	3	seS063	2 adults & 3 juv on slide
SSWB40	-21	6.1	119	11.4	07-Feb-07	seFN017	NH	*Diacyclops cockingi* Karanovic	seLN096	2	seS063	3 spec on slide, incl. Diacyclops juv.
SSWB40	-21	6.1	119	11.4	07-Feb-07	seFN017	NH	*Gomphodella hirsuta* Karanovic 2006	seLN095	1		2F, 1 shell in alcohol
SSWB40	-21	6.1	119	11.4	10-Feb-07	seFN045	P	Melitidae n. sp. cf. Melitidae sp. 1 (PSS)	seLN041	15		see notes in lab book
SSWB40	-21	6.1	119	11.4	10-Feb-07	seFN044, 45, 46	P	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	na	5		see p. 79 lab book, many more in seLN045
SSWB40	-21	6.1	119	11.4	10-Feb-07	seFN045	NH	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	seLN045	2		not collected, fragments in seFN045
SSWB40	-21	6.1	119	11.4	10-Feb-07	seFN045	P	Cyclopoida et sp. Indet. (juveniles)	seLN043	100	seS049	3 spec dissected
SSWB40	-21	6.1	119	11.4	10-Feb-07	seFN045	P	*Stygonitocrella trispinosa* Karanovic	seLN044	12	seS050	1M, 1F spec on slide
SSWB40	-21	6.1	119	11.4	10-Feb-07	seFN045	P	*Leicacandona mookae* Karanovic 2007	seLN042	7	ses066	1F in alcohol
SSWB40	-21	6.1	119	11.4	10-Feb-07	seFN044, 45, 46	P	*Gomphodella hirsuta* Karanovic 2006	seLN042	3		1F, 1M on slide, 2F, 2M, 1juv in alcohol
SSWB40	-21	6.1	119	11.4	10-Feb-07	seFN047	postNH	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	seLN045	2		
SSWB40	-21	6.1	119	11.4	10-Feb-07	seFN047	postNH	Copepoda sp. indet.	na	0		not collected
SSWB41	-21	6.8	119	15.0	02-Dec-06		NH	*Gomphodella hirsuta* Karanovic 2006	seLN019	1		2juv, 1F, 13 valves
SSWB42	-21	7.0	119	14.8	02-Dec-06		NH	NIL STYGOFAUNA				
SSWB42A	-21	7.0	119	14.8	02-Dec-06		NH	NIL STYGOFAUNA				
SSWB43	-21	7.1	119	14.7	02-Dec-06		NH	NIL STYGOFAUNA				
SSWB44	-21	7.5	119	14.4	02-Dec-06		NH	*Elaphoidella humphreysi* Karanovic	seLN018	1	seS059	3 juv. Dissected, > 1000 spec. in seFN045
SSWB44	-21	7.5	119	14.4	02-Dec-06		NH	*Gomphodella hirsuta* Karanovic 2006	seLN017	1		1 x valve
SSWB47	-21	7.0	119	14.8	02-Dec-06	na	NH	NIL STYGOFAUNA				
SSWB50	-21	7.4	119	14.5	02-Dec-06		NH	NIL STYGOFAUNA				
SSWB51	-21	7.5	119	14.3	02-Dec-06			NIL STYGOFAUNA				
SSWB52	-21	3.3	119	16.6	02-Dec-06		NH	NIL STYGOFAUNA				
SSWB52	-21	3.3	119	16.6	05-Feb-07	seFN003	preNH	NIL STYGOFAUNA				
SSWB52	-21	3.3	119	16.6	08-Feb-07	seFN038	P	NIL STYGOFAUNA				
SSWB52	-21	3.3	119	16.6	08-Feb-07	seFN039	postNH	NIL STYGOFAUNA				
SSWB53	-21	3.3	119	16.5	02-Dec-06		NH	NIL STYGOFAUNA				
SSWB53	-21	3.3	119	16.5	05-Feb-07	seFN004	NH	NIL STYGOFAUNA				
Watts Well	-21	1.8	119	10.0	06-Feb-07	seFN009, 010	NH	Nedsia sp.	seLN039	2		
Watts Well	-21	1.8	119	10.0	06-Feb-07	seFN009, 010	NH	Paramelitidae n. sp. aff. CALM sp. 7 (PSS)	seLN038	3		
Watts Well	-21	1.8	119	10.0	06-Feb-07	seFN009, 010	NH	Paramelitidae n. sp. aff. CALM sp. 2 (PSS)	seLN040	11		
Watts Well	-21	1.8	119	10.0	06-Feb-07	seFN009, 010	NH	*Microcyclops varicans* (Sars 1863)	seLN036	2	seS054	1F dissected on slide
Watts Well	-21	1.8	119	10.0	06-Feb-07	seFN009, 010	NH	*Monophylephorus* n. sp.	seLN037	1		Fragments, imm. Tubificidae w. bifid hair crochets vent. + dors. dissimilar, cf. seLN022
Watts Well	-21	1.8	119	10.0	06-Feb-07	seFN009, 010	NH	*Cypretta seurati* Gauthier, 1938	seLN035	20		1 x disintegrated in alcohol

Panorama Project
Subterranean Fauna Report 3: Troglofauna Phase 2 Results Phase 3 Sites

Prepared for

CBH Sulphur Springs Pty Ltd

Prepared by

Subterranean Ecology

Scientific Environmental Services

October 2007

Panorama Project
Subterranean Fauna Survey Report 3
Troglofauna Phase 2 Results & Phase 3 sites

Subterranean Ecology
Scientific Environmental Services
ABN 61 973 518 568
11 Dillenia Way, Greenwood WA 6024, Australia
Phone: Int - 61 (0)8 9343 4141
Mobile: Int: 61 (0)401 436 968
Email: info@subterraneanecology.com.au
www.subterraneanecology.com.au

Project No. 52

Prepared for CBH Resources P/L

Prepared by: Subterranean Ecology

Date: October 2007

COVER: Cockroach collected from the project area. Photo Subterranean Ecology / Western Australian Museum.

CONTENTS

1. INTRODUCTION

1.1 Purpose and Scope of this Report

This interim report presents the results of the second phase of troglofauna sampling at the Panorama Project, and provides an assessment of the results in relation to the pilot and first phase surveys. This report should be appended to the previous report (Subterranean Ecology 2007) which presents the earlier results and includes important background information, details of methods and assessment of potential impacts. Additionally, this report lists the sites and trap details for the third phase of trap deployment initiated in August 2007. The phase 3 results will be reported separately after extraction, sorting and identification of specimens has occurred.

1.2 Background

The pilot and first phase surveys were conducted in 18 holes situated within the proposed pit void. These surveys involved 20 sample events and collected 1079 invertebrate specimens comprising 23 morpho-species including one species of cockroach which displayed troglomorphic characters including eye regression, depigmentation, and elongated appendages. The troglomorphic characters suggested that the cockroach may be an obligate subterranean form (troglobite) restricted to subsurface habitats. The previous report (Subterranean Ecology 2007) assessed the potential habitat for troglofauna in the pit and surrounding areas. Examination of drill logs and diamond core photographs of holes in which the troglomorphic fauna had been collected showed an absence of any air-filled cavities in the bedrock that may have served as a prospective deep habitat for troglofauna. It was suggested that the fauna may have colonized the holes from shallow subsurface habitats in the surrounding regolith. Potential shallow subsurface habitats are well developed in colluvium on slopes in the pit area, and similar deposits occur extensively and continuously throughout the ranges in the wider region. In the absence of any obvious barriers to fauna dispersal via the regolith medium, it was considered likely that the distribution of the collected fauna, including the troglomorphic cockroach, was unlikely to be restricted to the proposed pit disturbance area and probably occurred more widely in similar habitats in the region. To test this hypothesis the phase 2 survey aimed to sample areas of similar geological habitat located nearby but outside the zone of influence of the proposed mine site.

1.3 Sample Sites Phase 2

A field survey (phase 2) commenced in June 2007 with the aim of sampling as many holes as possible that could be located in similar geology outside the zone of influence of the proposed mine site. Similar geologies comprising Kangaroo Caves Formation (with prospective Volcanogenic Massive Sulphide (VMS) deposits and associated cherts, shales, siltstones and sandstones) occur in a structural lineation extending northwest and southeast of the proposed mine site (Figure 1). The nearest VMS prospects occur from seven to 25 km southeast of the proposed mine site, namely at Kangaroo Caves, Bernts, Breakers, Man O'War, Anomaly 45, and Jamersons. Closer to the proposed mine site, potential sample sites in the Kangaroo Caves Formation occur in The BLP series located immediately west of the proposed pit and the area near the Outokumpu Camp about 1.5 km east of the proposed pit and outside the zone of influence of pit dewatering and TSF mounding. Potential sample sites also occur in bores drilled in the Lalla Rookh sandstone formation in the Dead Mans Hill area.

A three day field survey in June 2007 visited 80 hole locations in six areas (Kangaroo Caves 22 holes, Bernts 17 holes, BLP series 12 holes, East Pit 10 holes, Dead Mans Hill 16 holes, Outokumpu Camp 3 holes) but most of these holes (70 holes) could not be sampled. Unfortunately, virtually all of the drill holes in these areas had been destroyed by natural processes of collapse, erosion, sedimentation and burial. Alternatively, the holes were cased to the depth of the water table and therefore not suitable for troglofauna sampling. Overall, the phase 2 survey managed to deploy traps in 10 holes found to be accessible at the Kangaroo Caves (8 holes) and Bernts (2 holes) prospects (Table1).

Figure 1. Areas targeted in phase 2 sampling showing relationship to regional geology and recorded drill holes. Large ellipse encompasses the major structural lineation of the Kangaroo Caves Formation (predominantly aqua-blue and mauve shaded colours), with the three prospects at Sulphur Springs, Kangaroo Caves, and Bernts. Approximate outline of proposed pit (red). Geology map and drill hole locations provided by CBH Resources.

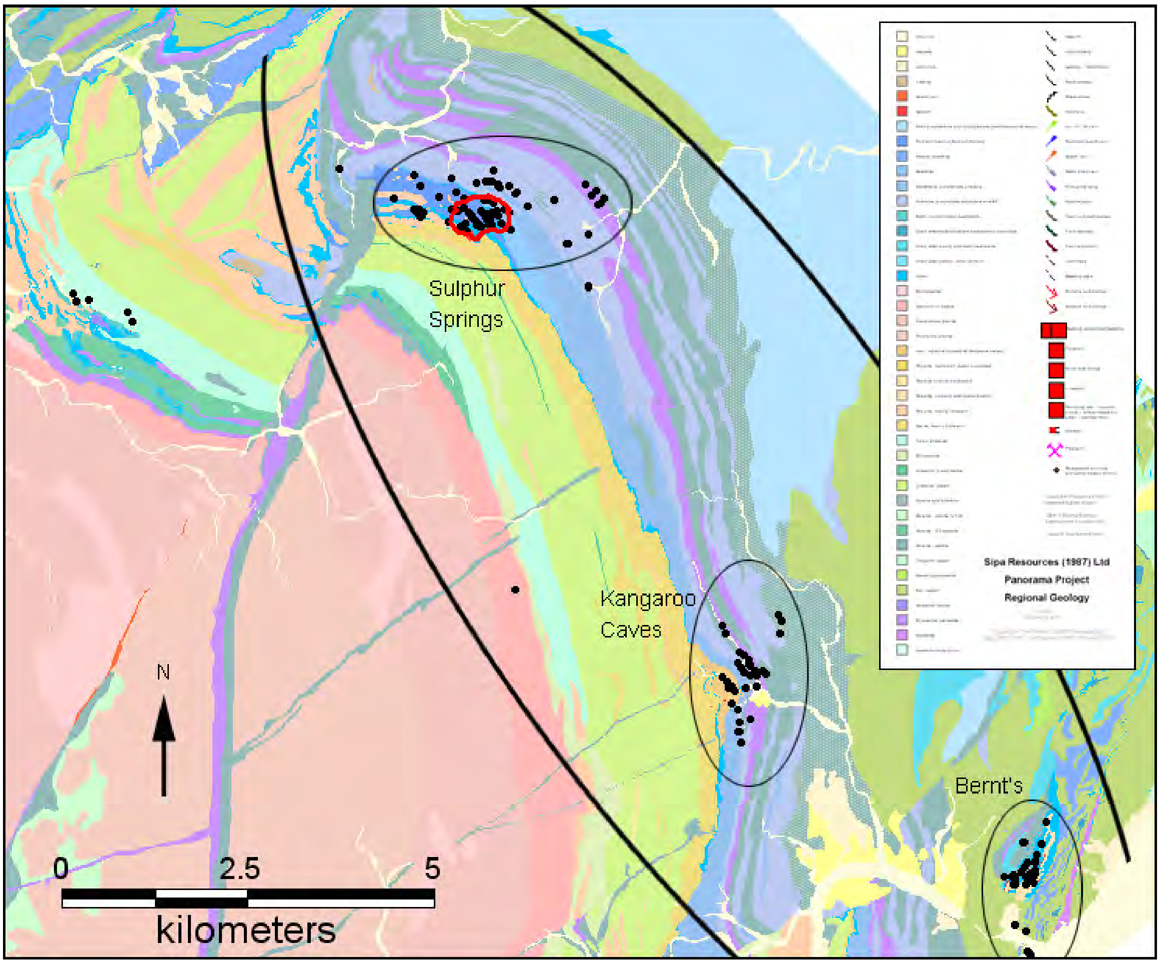


Table 1-1.Holes sampled Phase 2.

Bore #	Prospect	Dec Lat	Dec Long	Installed	No. traps	Recovered
Bernts?1	Bernts	21.2275	119.2785	22-Jun-07	1	16-Aug-07
Bernts?2		21.2268	119.2777	22-Jun-07	1	16-Aug-07
KCC001	Kangaroo Caves	21.2020	119.2415	22-Jun-07	2	16-Aug-07
KCC002		21.2026	119.2416	22-Jun-07	2	16-Aug-07
KCC005		21.1973	119.2456	22-Jun-07	1	16-Aug-07
KCC008		21.2025	119.2402	22-Jun-07	1	16-Aug-07
KCC009		21.2033	119.2433	22-Jun-07	1	16-Aug-07
KCC031		21.2028	119.2418	22-Jun-07	1	16-Aug-07
KCC032		21.2026	119.2414	22-Jun-07	1	16-Aug-07
KCC006?		21.2092	119.2419	22-Jun-07	2	16-Aug-07
10 Holes					**13 traps**	

2. Results Phase 2

Phase 2 sampling collected 1,204 invertebrates from the 10 holes sampled. The mean number of specimens per hole was 93 (range 1 – 740) and the mean number of taxa per hole was 3.6 (range 1 to 8). The invertebrate specimens comprised eight orders belonging to Acarina (6 taxa), Coleoptera (4), Collembola (3), Psocoptera (1), Isopoda (1), Blattodea (1), Diptera (1) and Pseudoscorpionida (1). Overall the collection comprised 18 taxa of which 13 were identified to the level of morpho-species. The other five taxa were larval or immature forms that were not identified further (Appendix 1). Besides larval and immature forms, the phase 2 survey collected five taxa (three beetles, one pseudoscorpion, one oniscid isopod) not detected in previous surveys, however none of these specimens displayed obvious troglomorphic characters. Ten specimens of a troglomorphic cockroach were collected from three holes (KC006, KC031, Bernts 1?) located outside the zone of influence of the proposed mine site. All of the cockroach specimens were juveniles but clearly belong to the same form (also juveniles) previously collected inside the proposed mine site.

The Kangaroo Caves and Bernts prospects present similar geomorphic terrain as found at Sulphur Springs, with potential shallow subsurface habitats developed in colluvial slope regolith (Figures 2 and 3). This terrain occurs extensively throughout the ranges in this region.

Figure 2. Kangaroo Caves hole KC006. The depth of colluvial regolith is indicated in the exposed cutting. Cockroaches were collected at this site and other holes in this area. Photo Katherine Muirhead.

Figure 3. Kangaroo Caves near hole KC006 showing characteristic terrain in the project area with extensive regolith of colluvium on slopes. Photo Katherine Muirhead.

3. Discussion Phase 2

Thus far the combined troglofauna survey effort consisted of 70 traps deployed in 30 holes during three sample phases spanning six months from February to August 2007. With this survey effort the total number of individual specimens collected was 2,283 consisting of 28 taxa (Table 2).

Table 2. Summary of survey efforts and faunal diversity for pilot, phase 1 and phase 2.

	pilot	phase 1	phase 2	All
holes	2	18	10	30
traps	6	51	13	70
Individuals	275	804	1204	2283
No. taxa	12	21	18	
Cumulative taxa	12	23	28	28

Of the 23 taxa collected at the Sulphur Springs prospect during pilot and phase 1 surveys, 13 (64 %) of these were also found at Kangaroo Caves and Bernts prospects during phase 2. The taxa shared between Sulphur Springs and the other localities included the troglomorphic cockroach. This species was considered most likely to be of possible conservation concern because of its possession of troglomorphic characters and potential restriction to subterranean habitats. The broad overlap in species composition across all localities sampled, including troglomorphic species, supports the conclusion that the troglofauna community found inside the proposed mine site is widely distributed in similar geological habitats that occur extensively in the surrounding areas outside the proposed mine site.

Because of the limited number of holes which were found to be accessible for sampling outside the zone of influence of the proposed mine site, a third phase of sampling was initiated in August 2007.

4. Sample Sites Phase 3

The spatially more extensive phase 3 sampling aims to better understand the composition and distribution of troglofauna communities in the wider project area, and will assist the environmental impact assessment for the proposed mine site. The phase 3 sampling deployed 58 traps in 24 holes located in six areas, all situated outside the zone of influence of the proposed mine site. Traps baited with cheese were placed in 14 holes, each paired with an un-baited trap to enable a comparison of invertebrate abundances, and baited versus un-baited trap sampling methods. This technique is aimed to improve capture rates of subterranean invertebrates.

Five of the sampled areas are located in the Kangaroo Caves Formation, and one hole was located in the Lalla Rookh sandstone at Dead Man's Hill (Table3, Appendix 3). The Breakers and Jamersons deposits are located in the same geologic lineation as Kangaroo Caves and Bernts, and about 15 and 25 km south of the Sulphur Springs deposit and proposed mine site. The area near the Outokumpu Camp is situated about 1.5 km east of the proposed pit and outside the zone of influence of modeled pit dewatering and TSF water table mounding.

The phase 3 traps were deployed 16-17th august and collected 5-6th October after about seven weeks in situ. The phase 3 sampling results will be reported separately after extraction, sorting and identification of specimens has occurred.

Table 3. Phase 3 sites with 58 traps deployed 16-17th August and collected 5-6th October.

Location	No. holes trapped
Kangaroo Caves	9
Bernts	2
Jamersons	6
Breakers	3
Dead Man's Hill	1
Near Outokumpu camp	3
Total	24

2 REFERENCE

Subterranean Ecology 2007. Panorama Project Subterranean Fauna Survey Report 2. Report prepared for CBH Resources Pty Ltd, July 2007. 57 pp.

3 Appendix 1. Phase 2 Taxa abundance x sites.

Taxa	Hole ID	KCC009	KCC005	KCC008	KCC032	KCC031	KCC006? -T1	KCC006? -T2	KCC002-T1	KCC002-T2	KCC001-T1	KCC001-T2	Bernts 1?1	Bernts ?2
	Field No.	seFN261	seFN262	seFN263	seFN264	seFN265	seFN266	seFN267	seFN269	seFN270	seFN272	seFN271	seFN273	seFN274
Entomobryidae(blind white)							8	4			1		40	
Collembola Type I		1		2			1	1	1			1		
Collembola Isotomidae											30			
Collembola Type II(Sminthimidae)														
Oribatidae sp 1 (SS)														
Oribatidae sp. 2 (SS)														
Oribatidae sp. 3 (SS)														
Acarina sp.1(SS)					20			200		1	90	50		
Acarina sp. 2 (PD)							10	500	1		70	30	10	
Acarina sp. 11 (PD)														
Mesostigmata sp. 1 (SS)				11	3							1		2
Mesostigmata sp. 2(SS)							7							
Mesostigmata sp.3 (SS)														
Mesostigmata sp. 7(PD)							3							
Acarina sp. 9(PD)														
Mesostigmata undetermined										1				
Hemipteran juvenile														
Dipteran larvae(as seLN230 PD)							1	32			16		30	
Muscidae larvae														
Pselaphidae														
Carabidae sp 1										1				
Nocticolidae						1	1	1					1	
Psocoptera			1									1		2
Pseudoscorpion								2						
Coleoptera larvae													1	1
Carabidae larvae					7									
Isopoda							2							
Coleoptera indet.													3	
Taxa Tot		1	1	2	3	1	8	7	2	3	5	5	6	3
Individuals		1	1	13	30	1	33	740	2	3	207	83	85	5

4 Appendix 2. Phase 2 Specimen vial tracking numbers.

Taxa	Hole ID	KCC009	KCC005	KCC008	KCC032	KCC031	KCC006?-T1	KCC006?-T2	KCC002-T1	KCC002-T2	KCC001-T1	KCC001-T2	Bernts 1?1	Bernts ?2
	Field No.	seFN261	seFN262	seFN263	seFN264	seFN265	seFN266	seFN267	seFN269	seFN270	seFN272	seFN271	seFN273	seFN274
Entomobryidae(blind white)							seLN535	seLN522			seLN543		seLN547	
Collembola Type I		seLN559		seLN525			seLN535	seLN522	seLN528			seLN558		
Collembola Isotomidae											seLN541			
Collembola Type II(Sminthimidae)														
Oribatidae sp 1 (SS)														
Oribatidae sp. 2 (SS)														
Oribatidae sp. 3 (SS)														
Acarina sp.1(SS)					seLN534			seLN521		seLN555	seLN542	seLN556		
Acarina sp. 2 (PD)							seLN536	seLn521	seLN527		seLN542	seLN556	seLN551	
Acarina sp. 11 (PD)														
Mesostigmata sp. 1 (SS)				seLN526	seLN534							seLN556		seLN530
Mesostigmata sp. 2(SS)							seLN536							
Mesostigmata sp.3 (SS)														
Mesostigmata sp. 7(PD)							seLN536							
Acarina sp. 9(PD)														
Mesostigmata undetermined										seLN553				
Hemipteran juvenile														
Dipteran larvae(as seLN230 PD)							seLN540	seLN523			seLN544		seLN548	
Muscidae larvae														
Pselaphidae														
Carabidae sp 1										seLN554				
Nocticolidae						seLN545	seLN537	seLN529					seLN550	
Psocoptera			seLN546									seLN557		seLN531
Pseudoscorpion								seLN524						
Coleoptera larvae													seLN552	seLN532
Carabidae larvae					seLN533									
Isopoda							seLN538							
Coleoptera indet.													seLN549	

5 Appendix 3. Phase 3 sample sites.

Hole #	Area	Dec Lat	Dec Long	Installed	No. traps	Depths (m)	Comments	Recovered
SSP3	Behind Outokumpu Camp	21.1471	119.2211	16-Aug-07	2	7,8		05-Oct-07
SSP4		21.1499	119.2031	16-Aug-07	3	4,6,7	T3 baited with cheese	05-Oct-07
SSP5		21.1468	119.2215	16-Aug-07	3	4,4,5	T3 baited with cheese	05-Oct-07
Bernts?1	Bernts	21.2275	119.2785	17-Aug-07	2	4,4		05-Oct-07
Bernts?2		21.2268	119.2777	17-Aug-07	1	3		05-Oct-07
BKC001	Breakers	21.2713	119.2354	17-Aug-07	3	4,5,5	T3 baited with cheese	05-Oct-07
BKC002?		21.2728	119.2321	17-Aug-07	3	11,15,16	T3 baited with cheese	05-Oct-07
BkC003?		21.2737	119.2322	17-Aug-07	3	14,15,20	T1 baited with cheese	05-Oct-07
JMC002	Jamersons	21.3428	119.1979	17-Aug-07	3	4,5,11		05-Oct-07
JMC003		21.3427	119.1979	17-Aug-07	3	7,12,17		05-Oct-07
JMC005		21.3409	119.1976	17-Aug-07	3	7,8,15	T1 baited with cheese	05-Oct-07
JMC?1		21.3409	119.1976	17-Aug-07	1	3		05-Oct-07
JMC?2		21.3426	119.1980	17-Aug-07	3	11,15,17	T2 baited with cheese	05-Oct-07
JMC?3		21.3427	119.1979	17-Aug-07	2	4,6		05-Oct-07
KCC001	Kangaroo Caves	21.2020	119.2415	16-Aug-07	2	4,5	T2 baited with cheese	05-Oct-07
KCC002		21.2026	119.2416	16-Aug-07	2	4,5	T2 baited with cheese	05-Oct-07
KCC005		21.1973	119.2456	16-Aug-07	2	4,6		05-Oct-07
KCC008		21.2025	119.2402	16-Aug-07	3	4,4,5	T1 baited with cheese	05-Oct-07
KCC009		21.2033	119.2433	16-Aug-07	3	3,3,4	T1 baited with cheese	05-Oct-07
KCC028		21.2025	119.2402	16-Aug-07	2	6,6		05-Oct-07
KCC031		21.2028	119.2418	16-Aug-07	2	4,4	T1 baited with cheese	05-Oct-07
KCC032		21.2026	119.2414	16-Aug-07	2	4,4	T2 baited with cheese	05-Oct-07
KCC006?		21.2092	119.2419	16-Aug-07	3	7,7,8	T1 baited with cheese	05-Oct-07
SStoilet1	Dead Man's Hill	21.1122	119.2516	16-Aug-07	2	8,11	Old drillers toilet	05-Oct-07
24 Holes					58			

Panorama Project Subterranean Fauna Report 4: Troglofauna Phase 3 Survey

Prepared for

CBH Sulphur Springs Pty Ltd

Prepared by

Subterranean Ecology

Scientific Environmental Services

November 2007

Sulphur Springs Panorama Project

Subterranean Fauna Report 4

Troglofauna Phase 3 Survey

Subterranean Ecology
Scientific Environmental Services
ABN 61 973 518 568
11 Dillenia Way, Greenwood WA 6024, Australia
Phone: Int - 61 (0)8 9343 4141
Mobile: Int: 61 (0)401 436 968
Email: info@subterraneanecology.com.au
www.subterraneanecology.com.au

Project No. 55

Prepared for CBH Resources Pty Ltd

Prepared by: Subterranean Ecology

Date: November 2007

COVER: Traps used for collecting troglofauna may be colonized by epigean (surface) fauna, including frogs ("froglofauna"), which seek the moist and sheltered conditions in bore holes. (photo copyright *Subterranean Ecology*).

INTRODUCTION

1.1 Purpose and Scope of this Report

This final report presents the results of the third phase of troglofauna sampling at the Sulphur Springs Panorama Project, and provides an assessment of the results in relation to the pilot survey, first and second phase surveys. This report should be appended to the previous reports (Subterranean Ecology 2007a, b) which present the earlier results and provide important background information including details of methods and assessment of potential impacts. The spatially more extensive phase 3 sampling, which deployed 58 traps in 24 reference holes, aimed to detect troglomorphic species in a regional context. Traps baited with cheese were placed in 13 holes from reference sites in Jamersons, Breakers, Kangaroo Caves and behind the Outokumpu Camp, each paired with an unbaited trap to enable a comparison of invertebrate abundances and baited versus un-baited trap sampling methods. This sampling method was trialed to investigate capture rates of subterranean invertebrates. This report provides the identifications and specimen tracking codes for all troglofauna specimens collected during these surveys (Appendices 1 and 2).

1.2 Background and Sampling effort

The pilot and first phase surveys were conducted in 18 holes situated within the proposed pit void (Table 1) and collected 23 morpho-species of invertebrate specimens including one species of cockroach (Blattodea sp. 1) which displayed troglomorphic characters including eye regression, depigmentation, and elongated appendages. The troglomorphic cockroach was suspected to inhabit shallow subsurface habitats in the regolith surrounding the drill holes where it was collected (Subterranean Ecology 2007b). Potential shallow subsurface habitats are well developed in colluvium on slopes in the pit area, and similar deposits occur extensively and continuously throughout the ranges in the wider region. In the absence of any obvious barriers to fauna dispersal via the regolith medium, it was considered likely that the distribution of the collected fauna, including the troglomorphic cockroach, was unlikely to be restricted to the proposed pit disturbance area and probably occurred more widely in similar habitats in the region. Results from the regionally extensive phase 2 (Table 1) supported this hypothesis with additional cockroach specimens being found in regolith habitats outside the expected zone of influence of the proposed mine site in the Kangaroo Caves and Bernts deposits (Subterranean Ecology 2007b). Phase 3 sampling was aimed at increasing the survey adequacy and regional survey effort, with the principal aim of better defining the distribution of the troglomorphic cockroach, the species most likely to be of potential conservation concern. The phase 3 survey involved sampling additional deposits outside the zone of influence, with 24 bores sampled from Bernts, Breakers, Dead Man's Hill, Jamersons, Kangaroo Caves, and behind Outokumpu Camp.

Table 1. Fifty-three bores from seven deposits were sampled over three phases in the project area.

Bore location	Deposit	Phase Sampled		
Bernts ?1	Bernts		Phase 2	Phase 3
Bernts ?2	Bernts		Phase 2	Phase 3
BKC01	Breakers			Phase 3
BKC02	Breakers			Phase 3
BKC03?	Breakers			Phase 3
JMC?1	Jamersons			Phase 3
JMC?2	Jamersons			Phase 3
JMC?3	Jamersons			Phase 3
JMC02	Jamersons			Phase 3
JMC03	Jamersons			Phase 3
JMC05	Jamersons			Phase 3
KCC001	Kangaroo Caves		Phase 2	Phase 3
KCC002	Kangaroo Caves		Phase 2	Phase 3
KCC005	Kangaroo Caves		Phase 2	Phase 3
KCC006	Kangaroo Caves		Phase 2	Phase 3
KCC008	Kangaroo Caves		Phase 2	Phase 3
KCC009	Kangaroo Caves		Phase 2	Phase 3
KCC028	Kangaroo Caves		Phase 2	Phase 3
KCC031	Kangaroo Caves		Phase 2	Phase 3
KCC032	Kangaroo Caves		Phase 2	Phase 3
SSP003	Outokumpu Camp			Phase 3
SSP005	Outokumpu Camp			Phase 3
SSP004	Outokumpu Camp			Phase 3
SSD75A	Sulphur Springs	Phase 1		
SSD82	Sulphur Springs	Phase 1		
SSP001	Sulphur Springs	Phase 1		
SSP016	Sulphur Springs	Phase 1		
SSP017	Sulphur Springs	Phase 1		
SSP018	Sulphur Springs	Phase 1		
SSP019	Sulphur Springs	Phase 1		
SSP20	Sulphur Springs	Phase 1		
SSP21	Sulphur Springs	Phase 1		
SSP22	Sulphur Springs	Phase 1		
SSP23?	Sulphur Springs	Phase 1		
SSP26	Sulphur Springs	Phase 1		
SSP27	Sulphur Springs	Phase 1		
SSP28	Sulphur Springs	Phase 1		
SSP33	Sulphur Springs	Phase 1		
SSP34	Sulphur Springs	Phase 1		
SSP36	Sulphur Springs	Phase 1		
SSP86	Sulphur Springs	Phase 1		
SS-Toilet	Dead Man's Hill			Phase 3
	Total	**18**	**11**	**24**

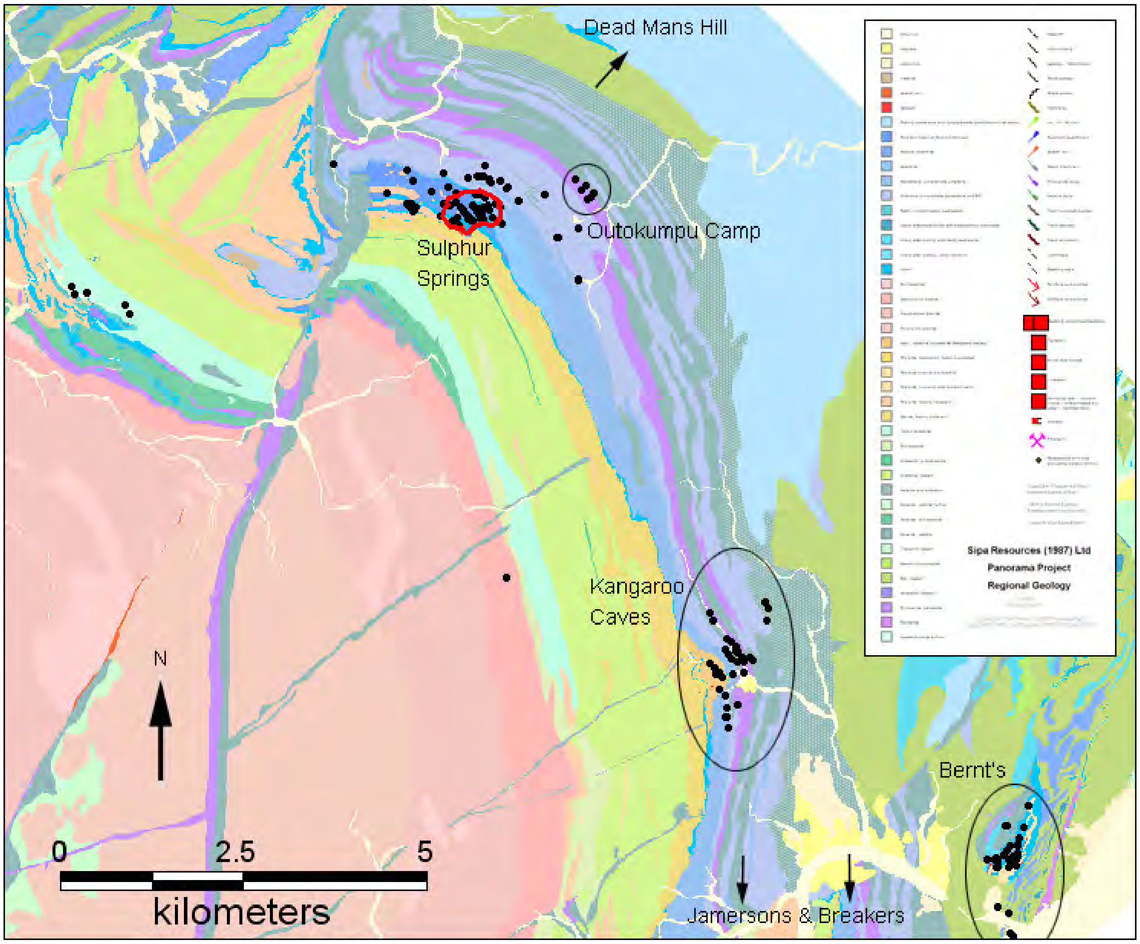
Sample Sites Phase 3

The spatially more extensive phase 3 sampling aimed to better understand the composition and distribution of troglofauna communities in the wider project area, and demonstrate sampling adequacy consistent with environmental approval requirements (EPA Guidance Statement 54 and 54a) for the proposed mine site. The phase 3 sampling deployed 58 traps in 24 holes located in six areas (Table 2), all a significant distance from the proposed mine site (Figure 1). Traps baited with cheese were placed in 14 holes, each paired with an unbaited trap to enable a comparison of invertebrate abundances, and baited versus un-baited trap sampling methods. This technique is aimed to improve capture rates of subterranean invertebrates. Five of the sampled areas are located in the Kangaroo Caves Formation, and one hole was located in the Lalla Rookh sandstone at Dead Man's Hill located about 7 km northeast of the proposed mine site. The Breakers and Jamersons deposits are located in the same geologic lineation as Kangaroo Caves and Bernts, and about 15 and 25 km south of the Sulphur Springs deposit and proposed mine site. The area near the Outokumpu Camp is situated about 1.5 km east of the proposed pit. The phase 3 traps were deployed 16-17th August and collected 5-6th October after about seven weeks in situ.

Table 2. Phase 3 sampling locations from six prospects. 58 traps were deployed in 24 holes.

Bore #	Prospect	Easting	Northing	No. Traps	Trap Depths (m)	Comments
SSP3	Outokumpu camp	730651	7659961	2	7,8	
SSP4	Outokumpu camp	728778	7659679	3	4,6,7	T3 baited with cheese
SSP5	Outokumpu camp	730697	7659995	3	4,4,5	T3 baited with cheese
Bernts?1	Bernts	736486	7650968	2	4,4	
Bernts?2	Bernts	736402	7651047	1	3	
BKC001	Breakers	731941	7646182	3	4,5,5	T3 baited with cheese
BKC002?	Breakers	731603	7646023	3	11,15,16	T3 baited with cheese
BKC003?	Breakers	731610	7645921	3	14,15,20	T1 baited with cheese
JMC002	Jamersons	727941	7638326	3	4,5,11	
JMC003	Jamersons	727941	7638330	3	7,12,17	
JMC005	Jamersons	727909	7638535	3	7,8,15	T1 baited with cheese
JMC?1	Jamersons	727913	7638536	1	3	
JMC?2	Jamersons	727949	7638346	3	11,15,17	T2 baited with cheese
JMC?3	Jamersons	727941	7638329	2	4,6	
KCC001	Kangaroo Caves	732683	7653850	2	4,5	T2 baited with cheese
KCC002	Kangaroo Caves	732697	7653778	2	4,5	T2 baited with cheese
KCC005	Kangaroo Caves	733117	7654363	2	4,6	
KCC008	Kangaroo Caves	732552	7653796	3	4,4,5	T1 baited with cheese
KCC009	Kangaroo Caves	732873	7653698	3	3,3,4	T1 baited with cheese
KCC028	Kangaroo Caves	732551	7653794	2	6,6	
KCC031	Kangaroo Caves	732714	7653766	2	4,4	T1 baited with cheese
KCC032	Kangaroo Caves	732678	7653786	2	4,4	T2 baited with cheese
KCC006?	Kangaroo Caves	732718	7653052	3	7,7,8	T1 baited with cheese
SStoilet1	Dead Man's Hill	733878	7663777	2	8,11	Old drillers toilet
Total	24 Holes			58	Traps	

Figure 1. Areas targeted in phase 3 sampling showing relationship to regional geology and recorded drill holes. Approximate outline of proposed pit (red). Breakers and Jamersons deposits are located about 15 and 25 km south of the proposed mine site, and Dead Mans Hill is located about 7 km northeast of the proposed mine site. Geology map and drill hole locations provided by CBH Resources.



Results

Phase 3 sampling consisted of 24 bore sites and 58 traps from the Bernts, Breakers, Jamersons, and Kangaroo caves deposits, and behind the Outokumpu Camp, and collected approximately 164,000 individuals, of which, only 3 individuals (0.001%) were the troglomorphic cockroach species (Blattodea sp. 1), and the remainder were epigean species (Appendix 1). Individual samples may be traced using Appendix 2. Phase 3 sampling collected invertebrates from 22 of the 24 holes sampled. The mean number of specimens per hole was 6,836 (range 0 – 151,094) and the mean number of taxa per hole was 5.9 (range 0 – 13). The majority of specimens were composed of Acarina (79%) and Collembola (24.5%) species.

The number of specimens collected during Phase 3 was significantly greater per trap, possibly reflecting the use of 13 traps baited with parmesan cheese and/or warmer surface temperatures. The 13 baited traps were placed in holes within the Kangaroo Caves, Breakers, and Jamersons site and collected 160,975 individuals (98.1% of all specimens collected in

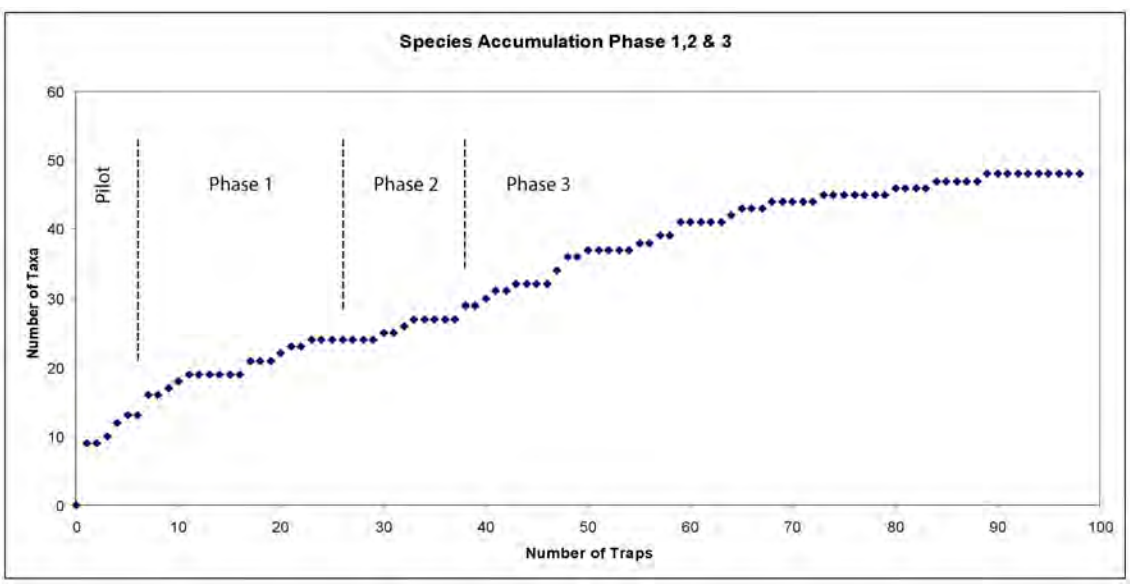
Phase 3). The baited traps contained two of the three troglomorphic cockroaches collected during phase 3, but were dominated by Acarina (160,186) and terrestrial Diptera (726).

The capture rate of invertebrates per trap for combined Phase 1, 2 and 3 data was 96 % (n = 43 holes, 95 traps, 53 samples), with 11 individuals of the troglomorphic cockroach detected. The expected capture rate for collecting troglobites usually falls in the range of <5 – 25 troglomorphs per 100 trap events (Subterranean Ecology unpublished data, Biota 2006). The capture rate for troglomorphic taxa in the Project Area is within this range with approximately 12 individuals per 100 trap events. The trapping intensity in the Project Area is comparable to sampling intensity in similar sized deposits (Subterranean Ecology 2007c).

Species accumulation curve

The adequacy of sampling was evaluated by a species accumulation curve (Figure 1). The initial steep slope of the curve lessens midway through the first sampling phase and shows a slight flattening near the end of phase 1. Phase 2 shows a consistent increase in taxa again with a distinct flattening toward the end of the sampling period. The beginning of phase 3 shows an initial rapid rise in newly detected species, although the rate of increase lessens after around 20 samples, and the remainder of phase 3 shows few new species. The initial rise in new taxa from phase 3 samples may be attributed to seasonal changes, and sampling over a wider area. The flattening of the curve suggests that most species which were present in the sampled holes during sampling have been collected. It would be expected, however, that a few previously undetected species would be collected with additional sampling in the same areas.

Figure 1. Species accumulation curve phase 1, 2, and 3 combined. Only a single troglomorphic species has been detected from all three sampling phases.



Concluding remarks

The only troglomorphic taxa collected from 53 samples (95 traps) during all three phases of troglofauna sampling was the cockroach (Blattodea sp. 1), which was detected within the proposed pit during the first phase of sampling. Subsequent sampling showed that this species is locally widespread, and occurs within the Kangaroo Caves, Bernts and behind the Outokumpu Camp areas (Table 3). The presence of this species in several deposits and outside the zone of influence, combined with the extensive and continuous regolith habitat it probably inhabits, means this species of no further conservation concern in relation to the Project.

Table 3. Distribution of troglomorphic cockroach Blattodea sp. 1 from the Project Area.

Bore ID	Deposit	No. specimens collected	Phase collected	Reference area
Bernts ?1	Bernts	1	2	Yes
KCC031	Kangaroo Caves	1	2	Yes
KCC006?-T1	Kangaroo Caves	1	2	Yes
KCC006-T2	Kangaroo Caves	1	2	Yes
KC006?-T2	Kangaroo Caves	2	3	Yes
SSP003-T2	Outokumpu Camp	1	3	Yes
SSP21	Sulphur Springs	2	1	Pit
SSP19	Sulphur Springs	2	1	Pit

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Appendix 1

All data (Pilot, Phase 1, 2, and 3 surveys).

		Phase	pilot	pilot	pilot	pilot	pilot	pilot
Phylum:Class	Order	Taxa	SSP27-T3	SSP28-T1	SSP28-T2	SSP27-T2	SSP27-T1	SSP28-T3
Chelicerata			seFN099	seFN100	seFN101	seFN098	seFN097	seFN102
Arachnida	Pseudoscorpionida	Pseudoscorpion						
	Arachnida	Araneae sp1						
	Acarina	Oribatidae sp 1 (SS)	20		100	20	10	10
		Oribatidae sp. 2 (SS)	1			1		
		Oribatidae sp. 3 (SS)	6					
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)			5			
		Acarina sp. 2 (PD)	1	2		14	20	
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)	2			1		1
		Mesostigmata sp. 2(SS)				6	1	
		Mesostigmata sp.3 (SS)						
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)						
		Collembola sp1	30		1	10	6	
		Collembola Isotomidae	1					
		Collembola (Sminthuridae)	2					
Insecta	Hemiptera	Hemipteran juvenile				2		
		Hemipteran undetermined						
	Diptera	Dipteran larvae(as seLN230)	2					
		Muscidae larvae						
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)						
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.) Sciaridae?						
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae						
		Coleoptera larvae sp. 2						
		Carabidae larvae						
		Coleoptera LN597						
		undetermined coleoptera						
		Undetermined coleoptera sp2						
	Blattodea	Blattodea sp. 1						
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera						
	Orthoptera	Orthoptera sp. 1						
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1						
		Sp1						
Crustacea	Isopoda	Isopoda						
		Total individuals	65	2	106	54	37	11

		Phase	pilot	1	1	1	1	1	1
Phylum:Class	Order	Taxa	SSP21	SSP28	SSP27	SSP26	SSP20	SSP1	SSD82
Chelicerata			seFN103	seFN142	seFN141	seFN139	seFN143	seFN145	seFN156
Arachnida	Pseudoscorpionida	Pseudoscorpion							
	Arachnida	Araneae sp1							
	Acarina	Oribatidae sp 1 (SS)		50	6				10
		Oribatidae sp. 2 (SS)							
		Oribatidae sp. 3 (SS)							
		Oribatidae sp. 4 (SS)							
		Acarina sp.1(SS)			1		1		
		Acarina sp. 2 (PD)							
		Acarina sp. 4 (PD)							
		Acarina sp. 11 (PD)	1						
		Mesostigmata sp. 1 (SS)		1					
		Mesostigmata sp. 2(SS)							
		Mesostigmata sp.3 (SS)	2						
		Mesostigmata sp. 7(PD)							
		Acarina sp. 9(PD)							
		Mesostigmata undetermined			1				
Collembola	Collembola	Entomobryidae(blind white)					1	1	
		Collembola sp1							50
		Collembola Isotomidae							
		Collembola (Sminthuridae)						1	
Insecta	Hemiptera	Hemipteran juvenile							
		Hemipteran undetermined							
	Diptera	Dipteran larvae(as seLN230)							
		Muscidae larvae	3						
		Diptera sp1 (Terr. Culicidae?)							
		Diptera sp2 (Terr.)							
		Diptera sp3 (Terr.)							
		Diptera sp4 (Terr.) Sciaridae?							
		Diptera sp5 (Terr.)							
		Diptera sp6 (Terr.)							
		Diptera muscidae sp1							
	Coleoptera	Pselaphidae							
		Carabidae sp 1							
		Coleoptera larvae							
		Coleoptera larvae sp. 2							
		Carabidae larvae							
		Coleoptera LN597							
		undetermined coleoptera							
		Undetermined coleoptera sp2							
	Blattodea	Blattodea sp. 1							
	Lepidoptera	Tineidae sp1							
		Undetermined Lepidoptera							
	Orthoptera	Orthoptera sp. 1							
	Psocoptera	Psocoptera				1			
	Hymenoptera	Formicidae sp1							
		Sp1							
Crustacea	Isopoda	Isopoda							
		Total individuals	6	51	8	1	2	2	60

		Phase	1	1	1	1	1	1	1
Phylum:Class	Order	Taxa	SSP16	SSP36	SSP17	SSP21	SSD75A	SSP18	SSP33
Chelicerata			seFN155	seFN140	seFN147	seFN146	seFN150	seFN149	seFN154
Arachnida	Pseudoscorpionida	Pseudoscorpion							
	Arachnida	Araneae sp1							
	Acarina	Oribatidae sp 1 (SS)	30		26			6	50
		Oribatidae sp. 2 (SS)							
		Oribatidae sp. 3 (SS)							
		Oribatidae sp. 4 (SS)							
		Acarina sp.1(SS)	3		1		100		
		Acarina sp. 2 (PD)	6				2		
		Acarina sp. 4 (PD)							
		Acarina sp. 11 (PD)	6			16			
		Mesostigmata sp. 1 (SS)	3					8	
		Mesostigmata sp. 2(SS)							
		Mesostigmata sp.3 (SS)	30						6
		Mesostigmata sp. 7(PD)							1
		Acarina sp. 9(PD)							
		Mesostigmata undetermined					2		
Collembola	Collembola	Entomobryidae(blind white)	30	1		2	5	50	7
		Collembola sp1					1		
		Collembola Isotomidae					3		
		Collembola (Sminthuridae)							
Insecta	Hemiptera	Hemipteran juvenile				3			
		Hemipteran undetermined							
	Diptera	Dipteran larvae(as seLN230)	1						
		Muscidae larvae							
		Diptera sp1 (Terr. Culicidae?)							
		Diptera sp2 (Terr.)							
		Diptera sp3 (Terr.)							
		Diptera sp4 (Terr.) Sciaridae?							
		Diptera sp5 (Terr.)							
		Diptera sp6 (Terr.)							
		Diptera muscidae sp1							
	Coleoptera	Pselaphidae							
		Carabidae sp 1				3			
		Coleoptera larvae							
		Coleoptera larvae sp. 2							
		Carabidae larvae							
		Coleoptera LN597							
		undetermined coleoptera							
		Undetermined coleoptera sp2							
	Blattodea	Blattodea sp. 1				2			
	Lepidoptera	Tineidae sp1							
		Undetermined Lepidoptera							
	Orthoptera	Orthoptera sp. 1							
	Psocoptera	Psocoptera						7	
	Hymenoptera	Formicidae sp1							
		Sp1							
Crustacea	Isopoda	Isopoda							
		Total individuals	109	1	27	26	113	71	64

		Phase	1	1	1	1	1	2	2
Phylum:Class	Order	Taxa	SSP86	SSP22	SSP19	SSP34	SSP23?	KCC009	KCC005
Chelicerata			seFN151	seFN153	seFN148	seFN152	seFN144	seFN261	seFN262
Arachnida	Pseudoscorpionida	Pseudoscorpion							
	Arachnida	Araneae sp1							
	Acarina	Oribatidae sp 1 (SS)		100	10				
		Oribatidae sp. 2 (SS)	4??						
		Oribatidae sp. 3 (SS)							
		Oribatidae sp. 4 (SS)							
		Acarina sp.1(SS)	28		2	1	1		
		Acarina sp. 2 (PD)	19			2	6		
		Acarina sp. 4 (PD)							
		Acarina sp. 11 (PD)							
		Mesostigmata sp. 1 (SS)	3		3				
		Mesostigmata sp. 2(SS)							
		Mesostigmata sp.3 (SS)					3		
		Mesostigmata sp. 7(PD)							
		Acarina sp. 9(PD)	1						
		Mesostigmata undetermined							
Collembola	Collembola	Entomobryidae(blind white)	16		50		2		
		Collembola sp1					1	1	
		Collembola Isotomidae							
		Collembola (Sminthuridae)					1		
Insecta	Hemiptera	Hemipteran juvenile							
		Hemipteran undetermined							
	Diptera	Dipteran larvae(as seLN230)							
		Muscidae larvae							
		Diptera sp1 (Terr. Culicidae?)							
		Diptera sp2 (Terr.)							
		Diptera sp3 (Terr.)							
		Diptera sp4 (Terr.) Sciaridae?							
		Diptera sp5 (Terr.)							
		Diptera sp6 (Terr.)							
		Diptera muscidae sp1							
	Coleoptera	Pselaphidae			1				
		Carabidae sp 1			1				
		Coleoptera larvae							
		Coleoptera larvae sp. 2							
		Carabidae larvae							
		Coleoptera LN597							
		undetermined coleoptera							
		Undetermined coleoptera sp2							
	Blattodea	Blattodea sp. 1			2				
	Lepidoptera	Tineidae sp1							
		Undetermined Lepidoptera							
	Orthoptera	Orthoptera sp. 1							
	Psocoptera	Psocoptera							1
	Hymenoptera	Formicidae sp1							
		Sp1							
Crustacea	Isopoda	Isopoda							
		Total individuals	67	100	69	3	14	1	1

		Phase	2	2	2	2	2	2
Phylum:Class	Order	Taxa	KCC008	KCC032	KCC031	KCC006?-T1	KCC006-T2	KCC002-T1
Chelicerata			seFN263	seFN264	seFN265	seFN266	seFN267	seFN269
Arachnida	Pseudoscorpionida	Pseudoscorpion					2	
	Arachnida	Araneae sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)		20			200	
		Acarina sp. 2 (PD)				10	500	1
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)	11	3				
		Mesostigmata sp. 2(SS)				7		
		Mesostigmata sp.3 (SS)						
		Mesostigmata sp. 7(PD)				3		
		Acarina sp. 9(PD)						
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)				8	4	
		Collembola sp1	2			1	1	1
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
		Hemipteran undetermined						
	Diptera	Dipteran larvae(as seLN230)				1	32	
		Muscidae larvae						
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)						
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.) Sciaridae?						
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae						
		Coleoptera larvae sp. 2						
		Carabidae larvae		7				
		Coleoptera LN597						
		undetermined coleoptera						
		Undetermined coleoptera sp2						
	Blattodea	Blattodea sp. 1			1	1	1	
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera						
	Orthoptera	Orthoptera sp. 1						
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1						
		Sp1						
Crustacea	Isopoda	Isopoda				2		
		Total individuals	13	30	1	31	738	2

		Phase	2	2	2	2	2	3
Phylum:Class	Order	Taxa	KCC002-T2	KCC001-T2	KCC001-T1	Bernts ?1	Bernts?2	SSP005-T1
Chelicerata			seFN270	seFN271	seFN272	seFN273	seFN274	SEFN259
Arachnida	Pseudoscorpionida	Pseudoscorpion						
	Arachnida	Araneae sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						50
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)	1	50	90			
		Acarina sp. 2 (PD)		30	70	10		
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)		1			2	
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)						
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined	1					
Collembola	Collembola	Entomobryidae(blind white)			1	40		11
		Collembola sp1		1				
		Collembola Isotomidae			30			
		Collembola (Sminthuridae)						2
Insecta	Hemiptera	Hemipteran juvenile						
		Hemipteran undetermined						
	Diptera	Dipteran larvae(as seLN230)			16	30		
		Muscidae larvae						
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)						
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.) Sciaridae?						
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1	1					
		Coleoptera larvae				1	1	
		Coleoptera larvae sp. 2						
		Carabidae larvae						
		Coleoptera LN597						
		undetermined coleoptera				3		
		Undetermined coleoptera sp2						
	Blattodea	Blattodea sp. 1				1		
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera						
	Orthoptera	Orthoptera sp. 1						
	Psocoptera	Psocoptera		1			2	
	Hymenoptera	Formicidae sp1						
		Sp1						
Crustacea	Isopoda	Isopoda						
		Total individuals	3	83	207	85	5	63

		Phase	3	3	3	3	3	3
Phylum:Class	Order	Taxa	SSP005-T2	SSP005-CH	SSP003-T1	SSP003-T2	SSP04-CH	SSP04-T1
Chelicerata			SEFN260	SEFN275	SEFN279	SEFN280	SEFN278	SEFN276
Arachnida	Pseudoscorpionida	Pseudoscorpion						
	Arachnida	Araneae sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)	20	100000				
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)			4	1	10000	
		Acarina sp. 2 (PD)		50000				
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)			1	3		30
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)						
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)	1000					1
		Collembola sp1		1	1			
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
		Hemipteran undetermined						
	Diptera	Dipteran larvae(as seLN230)					1	
		Muscidae larvae						
		Diptera sp1 (Terr. Culicidae?)	1					
		Diptera sp2 (Terr.)	1	7	3	5	1	11
		Diptera sp3 (Terr.)				1		
		Diptera sp4 (Terr.) Sciaridae?						1
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae				1		
		Coleoptera larvae sp. 2						
		Carabidae larvae						
		Coleoptera LN597						
		undetermined coleoptera				1	1	
		Undetermined coleoptera sp2						
	Blattodea	Blattodea sp. 1				1		
	Lepidoptera	Tineidae sp1						2
		Undetermined Lepidoptera						
	Orthoptera	Orthoptera sp. 1						
	Psocoptera	Psocoptera		1				
	Hymenoptera	Formicidae sp1						
		Sp1						
Crustacea	Isopoda	Isopoda						
		Total individuals	1022	150009	9	13	10003	45

Phylum:Class	Order	Phase Taxa	3 SSP04-T2	3 BKC01-T1	3 BKC01-T2	3 BKC01-CH	3 BKC02-T1	3 BKC02-T2
Chelicerata			SEFN277	SEFN289	SEFN290	SEFN291	SEFN292	SEFN293
Arachnida	Pseudoscorpionida	Pseudoscorpion						
	Arachnida	Araneae sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						1
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)						
		Acarina sp. 2 (PD)						
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)	30					
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)		100	30	30		1
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)	2	20				
		Collembola sp1		50	50	50		
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile	1					
		Hemipteran undetermined						
	Diptera	Dipteran larvae(as seLN230)						
		Muscidae larvae				500		1
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)	7	1	5		8	1
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.) Sciaridae?						4
		Diptera sp5 (Terr.)	1					
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1	1					
	Coleoptera	Pselaphidae						
		Carabidae sp 1	2					
		Coleoptera larvae						
		Coleoptera larvae sp. 2						
		Carabidae larvae						
		Coleoptera LN597						
		undetermined coleoptera						
		Undetermined coleoptera sp2						
	Blattodea	Blattodea sp. 1						
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera						
	Orthoptera	Orthoptera sp. 1						
	Psocoptera	Psocoptera			1			
	Hymenoptera	Formicidae sp1						
		Sp1						
Crustacea	Isopoda	Isopoda						
		Total individuals	44	171	86	580	8	8

		Phase	3	3	3	3	3
Phylum:Class	Order	Taxa	BKC02-CH	BKC03?-T3	BKC03?-T2	BKC03?-CH	JMC?1-T1
Chelicerata			SEFN297	SEFN295	SEFN294	SEFN296	seFN304
Arachnida	Pseudoscorpionida	Pseudoscorpion					
	Arachnida	Araneae sp1					
	Acarina	Oribatidae sp 1 (SS)					
		Oribatidae sp. 2 (SS)					
		Oribatidae sp. 3 (SS)					
		Oribatidae sp. 4 (SS)					
		Acarina sp.1(SS)					
		Acarina sp. 2 (PD)					
		Acarina sp. 4 (PD)					
		Acarina sp. 11 (PD)					
		Mesostigmata sp. 1 (SS)					
		Mesostigmata sp. 2(SS)					
		Mesostigmata sp.3 (SS)					
		Mesostigmata sp. 7(PD)					
		Acarina sp. 9(PD)					
		Mesostigmata undetermined					
Collembola	Collembola	Entomobryidae(blind white)					
		Collembola sp1					
		Collembola Isotomidae					
		Collembola (Sminthuridae)					
Insecta	Hemiptera	Hemipteran juvenile					
		Hemipteran undetermined					
	Diptera	Dipteran larvae(as seLN230)				1	
		Muscidae larvae	14				
		Diptera sp1 (Terr. Culicidae?)					
		Diptera sp2 (Terr.)	22	1	6	6	
		Diptera sp3 (Terr.)					
		Diptera sp4 (Terr.) Sciaridae?	4		2		
		Diptera sp5 (Terr.)					
		Diptera sp6 (Terr.)					
		Diptera muscidae sp1	6				
	Coleoptera	Pselaphidae					
		Carabidae sp 1					
		Coleoptera larvae					
		Coleoptera larvae sp. 2					
		Carabidae larvae					
		Coleoptera LN597					
		undetermined coleoptera					2
		Undetermined coleoptera sp2					
	Blattodea	Blattodea sp. 1					
	Lepidoptera	Tineidae sp1	2				
		Undetermined Lepidoptera					
	Orthoptera	Orthoptera sp. 1					
	Psocoptera	Psocoptera					
	Hymenoptera	Formicidae sp1					1
		Sp1					
Crustacea	Isopoda	Isopoda					
		Total individuals	48	1	8	7	3

		Phase	3	3	3	3	3	3
Phylum:Class	Order	Taxa	JMC?3-T1	JMC?3-T2	JMC05-CH	JMC05-T2	JMC05-T3	JMC03-T2
Chelicerata			seFN283	seFN284	seFN298	seFN299	seFN300	seFN287
Arachnida	Pseudoscorpionida	Pseudoscorpion						
	Arachnida	Araneae sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)				1		
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)						
		Acarina sp. 2 (PD)				1		
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)					11	
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)				1	2	
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)	5			1		1
		Collembola sp1						
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
		Hemipteran undetermined						
	Diptera	Dipteran larvae(as seLN230)						
		Muscidae larvae			150			
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)		8	1	3	1	1
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.) Sciaridae?		2			1	1
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)			1			
		Diptera muscidae sp1			1			
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae	4					
		Coleoptera larvae sp. 2						
		Carabidae larvae						
		Coleoptera LN597						
		undetermined coleoptera						
		Undetermined coleoptera sp2						
	Blattodea	Blattodea sp. 1						
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera		1				
	Orthoptera	Orthoptera sp. 1						
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1	1					
		Sp1						
Crustacea	Isopoda	Isopoda						
		Total individuals	10	11	153	7	15	3

Phylum:Class	Order	Taxa	JMC03-T1	JMC03-T3	JMC02-T1	JMC02-T2	JMC02-T3	JMC?2-T1
		Phase	3	3	3	3	3	3
Chelicerata			seFN286	seFN288	seFN305	seFN306	seFN307	seFN281
Arachnida	Pseudoscorpionida	Pseudoscorpion						
	Arachnida	Araneae sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)						
		Acarina sp. 2 (PD)			2			11
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)						
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)						17
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined			1			
Collembola	Collembola	Entomobryidae(blind white)						
		Collembola sp1			3	2		
		Collembola Isotomidae			1			
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
		Hemipteran undetermined						
	Diptera	Dipteran larvae(as seLN230)						
		Muscidae larvae						
		Diptera sp1 (Terr. Culicidae?)			1			
		Diptera sp2 (Terr.)	5	2		1	8	
		Diptera sp3 (Terr.)	1				3	
		Diptera sp4 (Terr.) Sciaridae?	1				1	
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1	2				1	
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae			25			
		Coleoptera larvae sp. 2						
		Carabidae larvae						
		Coleoptera LN597						
		undetermined coleoptera						
		Undetermined coleoptera sp2					1	
	Blattodea	Blattodea sp. 1						
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera			1	1	8	
	Orthoptera	Orthoptera sp. 1						
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1						
		Sp1					2	
Crustacea	Isopoda	Isopoda						
		Total individuals	9	2	34	4	24	28

		Phase	3	3	3	3	3	3
Phylum:Class	Order	Taxa	JMC?2-CH	JMC?2-T3	Bernts 32	Bernts?1-T1	Bernts?1-T2	KC009-CH
Chelicerata			seFN285	seFN282	seFN301	seFN302	seFN303	seFN308
Arachnida	Pseudoscorpionida	Pseudoscorpion						
	Arachnida	Araneae sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)					100	12
		Acarina sp. 2 (PD)					40	
		Acarina sp. 4 (PD)				1		
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)			40			
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)						
		Mesostigmata sp. 7(PD)			1	4		
		Acarina sp. 9(PD)				3		
		Mesostigmata undetermined				2		
Collembola	Collembola	Entomobryidae(blind white)		1		60		
		Collembola sp1						
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
		Hemipteran undetermined						
	Diptera	Dipteran larvae(as seLN230)						
		Muscidae larvae						
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)	7	3				
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.) Sciaridae?	1					
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae				1		
		Coleoptera larvae sp. 2						
		Carabidae larvae						
		Coleoptera LN597						1
		undetermined coleoptera			1			
		Undetermined coleoptera sp2						
	Blattodea	Blattodea sp. 1						
	Lepidoptera	Tineidae sp1					1	3
		Undetermined Lepidoptera		1				
	Orthoptera	Orthoptera sp. 1						
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1						
		Sp1						
Crustacea	Isopoda	Isopoda		1				
		Total individuals	8	5	42	71	141	16

		Phase	3	3	3	3	3	3
Phylum:Class	Order	Taxa	KC009-T2	KC009-T3	KC032-T1	KC032-CH	KC008-CH	KC008-T2
Chelicerata			seFN309	seFN310	seFN311	seFN312	seFN313	seFN314
Arachnida	Pseudoscorpionida	Pseudoscorpion						
	Arachnida	Araneae sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)		1				
		Acarina sp. 2 (PD)	4	1	100	1		
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)				20	10	6
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)						
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)			2			
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)						
		Collembola sp1						
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
		Hemipteran undetermined			1			
	Diptera	Dipteran larvae(as seLN230)	3				1	6
		Muscidae larvae			44			
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)						
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.) Sciaridae?						
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae						
		Coleoptera larvae sp. 2						
		Carabidae larvae						
		Coleoptera LN597						
		undetermined coleoptera						
		Undetermined coleoptera sp2						
	Blattodea	Blattodea sp. 1						
	Lepidoptera	Tineidae sp1	1			1	1	
		Undetermined Lepidoptera						
	Orthoptera	Orthoptera sp. 1						1
	Psocoptera	Psocoptera		6				
	Hymenoptera	Formicidae sp1						
		Sp1						
Crustacea	Isopoda	Isopoda						
		Total individuals	8	8	147	22	12	13

		Phase	3	3	3	3	3	3
Phylum:Class	Order	Taxa	KC008-T3	KC001-T1	KC001-CH	KC006?-CH	KC006?-T2	KC006?-T3
Chelicerata			seFN315	seFN316	seFN317	seFN318	seFN319	seFN320
Arachnida	Pseudoscorpionida	Pseudoscorpion						
	Arachnida	Araneae sp1	1					
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)					2	
		Acarina sp.1(SS)	100	200	100	1	15	40
		Acarina sp. 2 (PD)	6	100	10	1		
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)						
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)	2					
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)			1		2	
		Collembola sp1			1			
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
		Hemipteran undetermined						
	Diptera	Dipteran larvae(as seLN230)			2		16	
		Muscidae larvae		50				400
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)						
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.) Sciaridae?						
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae						
		Coleoptera larvae sp. 2						1
		Carabidae larvae						
		Coleoptera LN597						
		undetermined coleoptera						
		Undetermined coleoptera sp2						
	Blattodea	Blattodea sp. 1					2	
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera						
	Orthoptera	Orthoptera sp. 1						
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1						
		Sp1						
Crustacea	Isopoda	Isopoda						
		Total individuals	108	350	114	2	37	441

		Phase	3	3	3	3	3	3
Phylum:Class	Order	Taxa	KC031-CH	KC031-T2	KC028-T1	KC028-T2	KC005-T1	KC005-T2
Chelicerata			seFN321	seFN322	seFN323	seFN324	seFN325	seFN326
Arachnida	Pseudoscorpionida	Pseudoscorpion						
	Arachnida	Araneae sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)						N
		Acarina sp.1(SS)		1		1		I
		Acarina sp. 2 (PD)						L
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)	1	1		1	2	F
		Mesostigmata sp. 2(SS)						O
		Mesostigmata sp.3 (SS)						U
		Mesostigmata sp. 7(PD)						N
		Acarina sp. 9(PD)						D
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)		3	25			
		Collembola sp1						
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
		Hemipteran undetermined						
	Diptera	Dipteran larvae(as seLN230)			1			
		Muscidae larvae				1		
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)						
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.) Sciaridae?						
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae						
		Coleoptera larvae sp. 2						
		Carabidae larvae						
		Coleoptera LN597						
		undetermined coleoptera						
		Undetermined coleoptera sp2						
	Blattodea	Blattodea sp. 1						
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera						
	Orthoptera	Orthoptera sp. 1						
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1						
		Sp1						
Crustacea	Isopoda	Isopoda		1				
		Total individuals	1	5	26	3	2	0

		Phase	3	3	3
Phylum:Class	Order	Taxa	KC002-T1	SS-Toilet-T1	SS-Toilet-T2
Chelicerata			seFN327	seFN328	seFN329
Arachnida	Pseudoscorpionida	Pseudoscorpion			
	Arachnida	Araneae sp1			
	Acarina	Oribatidae sp 1 (SS)			
		Oribatidae sp. 2 (SS)			
		Oribatidae sp. 3 (SS)			
		Oribatidae sp. 4 (SS)			N
		Acarina sp.1(SS)	11	10	I
		Acarina sp. 2 (PD)	1	6	L
		Acarina sp. 4 (PD)			
		Acarina sp. 11 (PD)			
		Mesostigmata sp. 1 (SS)	1	10	F
		Mesostigmata sp. 2(SS)			O
		Mesostigmata sp.3 (SS)			U
		Mesostigmata sp. 7(PD)			N
		Acarina sp. 9(PD)			D
		Mesostigmata undetermined			
Collembola	Collembola	Entomobryidae(blind white)	1		
		Collembola sp1			
		Collembola Isotomidae			
		Collembola (Sminthuridae)			
Insecta	Hemiptera	Hemipteran juvenile			
		Hemipteran undetermined			
	Diptera	Dipteran larvae(as seLN230)			
		Muscidae larvae			
		Diptera sp1 (Terr. Culicidae?)			
		Diptera sp2 (Terr.)			
		Diptera sp3 (Terr.)			
		Diptera sp4 (Terr.) Sciaridae?			
		Diptera sp5 (Terr.)			
		Diptera sp6 (Terr.)			
		Diptera muscidae sp1			
	Coleoptera	Pselaphidae			
		Carabidae sp 1			
		Coleoptera larvae			
		Coleoptera larvae sp. 2			
		Carabidae larvae			
		Coleoptera LN597			
		undetermined coleoptera			
		Undetermined coleoptera sp2			
	Blattodea	Blattodea sp. 1			
	Lepidoptera	Tineidae sp1			
		Undetermined Lepidoptera			
	Orthoptera	Orthoptera sp. 1			
	Psocoptera	Psocoptera			
	Hymenoptera	Formicidae sp1	1	4	
		Sp1			
Crustacea	Isopoda	Isopoda		1	
		Total individuals	15	30	0

Appendix 2

Specimen Tracking Codes all survey phases (pilot, 1, 2, and 3). Coloured vials are vouchers.

Phylum:Class	Order	Phase Taxa	Pilot SSP27-T3	Pilot SSP28-T1	Pilot SSP28-T2	Pilot SSP27-T2	Pilot SSP27-T1	Pilot SSP28-T3
Chelicerata	Arachnida	Araneae sp1	seFN099	seFN100	seFN101	seFN098	seFN097	seFN102
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1						
	Acarina	Oribatidae sp 1 (SS)	seLN285		seLN269	seLN272	seLN281	seLN176
		Oribatidae sp. 2 (SS)	seLN289			seLN273		
		Oribatidae sp. 3 (SS)	seLN291					
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)			seLN271			
		Acarina sp. 2 (PD)	seLN287	seLN268		seLN277	seLN280	
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)	seLN290			seLN276		seLN334
		Mesostigmata sp. 2(SS)				seLn275	seLN282	
		Mesostigmata sp.3 (SS)						
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)						
		Collembola Type I	seLN283		seLN270	seLN274	seLN279	
		Collembola Isotomidae	se LN284					
		Collembola (Sminthuridae)	seLN286					
Insecta	Hemiptera	Hemipteran juvenile				seLn278		
	Diptera	Dipteran larvae(as seLN230)	seLN288					
		Muscidae larvae						
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)						
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.)						
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae						
		Carabidae larvae						
		undetermined coleoptera						
		Undetermined coleoptera sp2						
	Blattodea	Nocticolidae						
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera						
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1						
	Hymenoptera	Sp1						
Crustacea	Isopoda	Isopoda						

Phylum:Class	Order	Phase	Pilot	1	1	1	1	1	1
		Taxa	SSP21	SSP28	SSP27	SSP26	SSP20	SSP1	SSD82
Chelicerata	Arachnida	Araneae sp1	seFN103	seFN142	seFN141	seFN139	seFN143	seFN145	seFN156
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1							
	Acarina	Oribatidae sp 1 (SS)		seLN433	seLN434				seLN441
		Oribatidae sp. 2 (SS)							
		Oribatidae sp. 3 (SS)							
		Oribatidae sp. 4 (SS)							
		Acarina sp.1(SS)			seLN434		seLN437		
		Acarina sp. 2 (PD)							
		Acarina sp. 4 (PD)							
		Acarina sp. 11 (PD)	seLN335						
		Mesostigmata sp. 1 (SS)		seLN433					
		Mesostigmata sp. 2(SS)							
		Mesostigmata sp.3 (SS)	seLN336						
		Mesostigmata sp. 7(PD)							
		Acarina sp. 9(PD)							
		Mesostigmata undetermined			seLN435				
Collembola	Collembola	Entomobryidae(blind white)					seLN438	seLN439	
		Collembola Type I							seLN440
		Collembola Isotomidae							
		Collembola (Sminthuridae)						seLN439	
Insecta	Hemiptera	Hemipteran juvenile							
	Diptera	Dipteran larvae(as seLN230)							
		Muscidae larvae	seLN337						
		Diptera sp1 (Terr. Culicidae?)							
		Diptera sp2 (Terr.)							
		Diptera sp3 (Terr.)							
		Diptera sp4 (Terr.)							
		Diptera sp5 (Terr.)							
		Diptera sp6 (Terr.)							
		Diptera muscidae sp1							
	Coleoptera	Pselaphidae							
		Carabidae sp 1							
		Coleoptera larvae							
		Carabidae larvae							
		undetermined coleoptera							
		Undetermined coleoptera sp2							
	Blattodea	Nocticolidae							
	Lepidoptera	Tineidae sp1							
		Undetermined Lepidoptera							
	Psocoptera	Psocoptera				seLN436			
	Hymenoptera	Formicidae sp1							
	Hymenoptera	Sp1							
Crustacea	Isopoda	Isopoda							

Phylum:Class	Order	Phase	1	1	1	1	1	1	1
		Taxa	SSP16	SSP36	SSP17	SSP21	SSD75A	SSP18	SSP33
Chelicerata	Arachnida	Araneae sp1	seFN155	seFN140	seFN147	seFN146	seFN150	seFN149	seFN154
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1							
	Acarina	Oribatidae sp 1 (SS)	seLN446		seLN450			seLN464	seLN466
		Oribatidae sp. 2 (SS)							
		Oribatidae sp. 3 (SS)							
		Oribatidae sp. 4 (SS)							
		Acarina sp.1(SS)	seLN445		seLN450		serLN458		
		Acarina sp. 2 (PD)	seLN448				seLN460		
		Acarina sp. 4 (PD)							
		Acarina sp. 11 (PD)	seLN447			seLN451			
		Mesostigmata sp. 1 (SS)	seLN444					seLN461	
		Mesostigmata sp. 2(SS)							
		Mesostigmata sp.3 (SS)	seLN444						seLN466
		Mesostigmata sp. 7(PD)							seLN466
		Acarina sp. 9(PD)							
		Mesostigmata undetermined					seLN460		
Collembola	Collembola	Entomobryidae(blind white)	seLN442	seLN449		seLN453	seLN457	seLN462	seLN465
		Collembola Type I					seLN459		
		Collembola Isotomidae					seLN456		
		Collembola (Sminthuridae)							
Insecta	Hemiptera	Hemipteran juvenile				seLN452			
	Diptera	Dipteran larvae(as seLN230)	seLN443						
		Muscidae larvae							
		Diptera sp1 (Terr. Culicidae?)							
		Diptera sp2 (Terr.)							
		Diptera sp3 (Terr.)							
		Diptera sp4 (Terr.)							
		Diptera sp5 (Terr.)							
		Diptera sp6 (Terr.)							
		Diptera muscidae sp1							
	Coleoptera	Pselaphidae							
		Carabidae sp 1				seLN454			
		Coleoptera larvae							
		Carabidae larvae							
		undetermined coleoptera							
		Undetermined coleoptera sp2							
	Blattodea	Nocticolidae				seLN455			
	Lepidoptera	Tineidae sp1							
		Undetermined Lepidoptera							
	Psocoptera	Psocoptera						seLN463	
	Hymenoptera	Formicidae sp1							
	Hymenoptera	Sp1							
Crustacea	Isopoda	Isopoda							

Phylum:Class	Order	Phase	1	1	1	1	1	2	2
		Taxa	SSP86	SSP22	SSP19	SSP34	SSP23?	KCC009	KCC005
Chelicerata	Arachnida	Araneae sp1	seFN151	seFN153	seFN148	seFN152	seFN144	seFN261	seFN262
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1							
	Acarina	Oribatidae sp 1 (SS)		seLN470	seLN472				
		Oribatidae sp. 2 (SS)	seLN468						
		Oribatidae sp. 3 (SS)							
		Oribatidae sp. 4 (SS)							
		Acarina sp.1(SS)	seLN467		seLN472	seLN476	seLN477		
		Acarina sp. 2 (PD)	seLN467			seLN476	seLN477		
		Acarina sp. 4 (PD)							
		Acarina sp. 11 (PD)							
		Mesostigmata sp. 1 (SS)	seLN467		seLN472				
		Mesostigmata sp. 2(SS)							
		Mesostigmata sp.3 (SS)					seLN477		
		Mesostigmata sp. 7(PD)							
		Acarina sp. 9(PD)	seLN468						
		Mesostigmata undetermined							
Collembola	Collembola	Entomobryidae(blind white)	seLN469		seLN471		seLN478		
		Collembola Type I					seLN478	seLN559	
		Collembola Isotomidae							
		Collembola (Sminthuridae)					seLN478		
Insecta	Hemiptera	Hemipteran juvenile							
	Diptera	Dipteran larvae(as seLN230)							
		Muscidae larvae							
		Diptera sp1 (Terr. Culicidae?)							
		Diptera sp2 (Terr.)							
		Diptera sp3 (Terr.)							
		Diptera sp4 (Terr.)							
		Diptera sp5 (Terr.)							
		Diptera sp6 (Terr.)							
		Diptera muscidae sp1							
	Coleoptera	Pselaphidae			seLN473				
		Carabidae sp 1			seLN475				
		Coleoptera larvae							
		Carabidae larvae							
		undetermined coleoptera							
		Undetermined coleoptera sp2							
	Blattodea	Nocticolidae			seLN474				
	Lepidoptera	Tineidae sp1							
		Undetermined Lepidoptera							
	Psocoptera	Psocoptera							seLN546
	Hymenoptera	Formicidae sp1							
	Hymenoptera	Sp1							
Crustacea	Isopoda	Isopoda							

Phylum:Class	Order	Phase	2	2	2	2	2	2
		Taxa	KCC008	KCC032	KCC031	KCC006?-T1	KCC006-T2	KCC002-T1
Chelicerata	Arachnida	Araneae sp1	seFN263	seFN264	seFN265	seFN266	seFN267	seFN269

Arachnida	Pseudoscorpionida	Pseudoscorpion sp1					seLN524	
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)		seLN534			seLN521	
		Acarina sp. 2 (PD)				seLN536	seLn521	seLN527
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)	seLN526	seLN534				
		Mesostigmata sp. 2(SS)				seLN536		
		Mesostigmata sp.3 (SS)						
		Mesostigmata sp. 7(PD)				seLN536		
		Acarina sp. 9(PD)						
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)				seLN535	seLN522	
		Collembola Type I	seLN525			seLN535	seLN522	seLN528
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
	Diptera	Dipteran larvae(as seLN230)				seLN540	seLN523	
		Muscidae larvae						
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)						
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.)						
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae						
		Carabidae larvae		seLN533				
		undetermined coleoptera						
		Undetermined coleoptera sp2						
	Blattodea	Nocticolidae			seLN545	seLN537	seLN529	
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera						
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1						
	Hymenoptera	Sp1						
Crustacea	Isopoda	Isopoda				seLN538		

Phylum:Class	Order	Phase Taxa	2 KCC002-T2	2 KCC001-T2	2 KCC001-T1	2 Bernts ?1	2 Bernts?2	3 SSP005-T1
Chelicerata	Arachnida	Araneae sp1	seFN270	seFN271	seFN272	seFN273	seFN274	SEFN259
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						seLN788
		Oribatidae sp. 4 (SS)						

		Acarina sp.1(SS)	seLN555	seLN556	seLN542			
		Acarina sp. 2 (PD)		seLN556	seLN542	seLN551		
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)		seLN556			seLN530	
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)						
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined	seLN553					
Collembola	Collembola	Entomobryidae(blind white)			seLN543	seLN547		seLN787
		Collembola Type I		seLN558				
		Collembola Isotomidae			seLN541			
		Collembola (Sminthuridae)						seLN786
Insecta	Hemiptera	Hemipteran juvenile						
	Diptera	Dipteran larvae(as seLN230)			seLN544	seLN548		
		Muscidae larvae						
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)						
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.)						
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1	seLN554					
		Coleoptera larvae				seLN552	seLN532	
		Carabidae larvae						
		undetermined coleoptera	1	1	1	seLN549		
		Undetermined coleoptera sp2						
	Blattodea	Nocticolidae				seLN550		
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera						
	Psocoptera	Psocoptera		seLN557			seLN531	
	Hymenoptera	Formicidae sp1						
	Hymenoptera	Sp1						
Crustacea	Isopoda	Isopoda						

Phylum:Class	Order	Phase Taxa	3 SSP005-T2	3 SSP005-CH	3 SSP003-T1	3 SSP003-T2	3 SSP04-CH	3 SSP04-T1
Chelicerata	Arachnida	Araneae sp1	SEFN260	SEFN275	SEFN279	SEFN280	SEFN278	SEFN276
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)	seLN789	seLN793				
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)			seLN800	seLN803	seLN811	
		Acarina sp. 2 (PD)		seLN793				
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)			seLN799	seLN805		seLN815

		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)						
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)	seLN790					seLN816
		Collembola Type I		seLN795	seLN797			
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
	Diptera	Dipteran larvae(as seLN230)					seLN810	
		Muscidae larvae						
		Diptera sp1 (Terr. Culicidae?)	seLN791					
		Diptera sp2 (Terr.)	seLN792	seLN796	seLN798	seLN804	seLN809	seLN812
		Diptera sp3 (Terr.)				seLN801		
		Diptera sp4 (Terr.)						seLN813
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae				seLN802		
		Carabidae larvae						
		undetermined coleoptera				seLN806	seLN808	
		Undetermined coleoptera sp2						
	Blattodea	Nocticolidae				seLN807		
	Lepidoptera	Tineidae sp1						seLN814
		Undetermined Lepidoptera						
	Psocoptera	Psocoptera		seLN794				
	Hymenoptera	Formicidae sp1						
	Hymenoptera	Sp1						
Crustacea	Isopoda	Isopoda						

Phylum:Class	Order	Phase Taxa	3 SSP04-T2	3 BKC01-T1	3 BKC01-T2	3 BKC01-CH	3 BKC02-T1	3 BKC02-T2
Chelicerata	Arachnida	Araneae sp1	SEFN277	SEFN289	SEFN290	SEFN291	SEFN292	SEFN293
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						seLN833
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)						
		Acarina sp. 2 (PD)						
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)	seLN822					
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)		seLN824	seLN825	seLN828		seLN833
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined						

Collembola	Collembola	Entomobryidae(blind white)	seLN820	seLN824				
		Collembola Type I		seLN824	seLN825	seLN828		
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile	seLN821					
	Diptera	Dipteran larvae(as seLN230)						
		Muscidae larvae				seLN828		seLN832
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)	seLN817	seLN824	seLN826		seLN829	seLN831
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.)						seLN830
		Diptera sp5 (Terr.)	seLN818					
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1	seLN819					
	Coleoptera	Pselaphidae						
		Carabidae sp 1	seLN823					
		Coleoptera larvae						
		Carabidae larvae						
		undetermined coleoptera						
		Undetermined coleoptera sp2						
	Blattodea	Nocticolidae						
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera						
	Psocoptera	Psocoptera			seLN827			
	Hymenoptera	Formicidae sp1						
	Hymenoptera	Sp1						
Crustacea	Isopoda	Isopoda						

Phylum:Class	Order	Phase Taxa	3 BKC02-CH	3 BKC03?-T3	3 BKC03?-T2	3 BKC03?-CH	3 JMC?1-T1	3 JMC?3-T1
Chelicerata	Arachnida	Araneae sp1	SEFN297	SEFN295	SEFN294	SEFN296	seFN304	seFN283
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)						
		Acarina sp. 2 (PD)						
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)						
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)						
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)						seLN847
		Collembola Type I						
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						

	Diptera	Dipteran larvae(as seLN230)				seLN843		
		Muscidae larvae	seLN838					
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)	seLN835	seLN839	seLN840	seLN842		
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.)	seLN837		seLN841			
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1	seLN836					
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae						seLN846
		Carabidae larvae						
		undetermined coleoptera					seLN844	
		Undetermined coleoptera sp2						
	Blattodea	Nocticolidae						
	Lepidoptera	Tineidae sp1	seLN834					
		Undetermined Lepidoptera						
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1					seLN845	seLN848
	Hymenoptera	Sp1						
Crustacea	Isopoda	Isopoda						

Phylum:Class	Order	Phase Taxa	3 JMC?3-T2	3 JMC05-CH	3 JMC05-T2	3 JMC05-T3	3 JMC03-T2	3 JMC03-T1
Chelicerata	Arachnida	Araneae sp1	seFN284	seFN298	seFN299	seFN300	seFN287	seFN286
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)			seLN856			
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)						
		Acarina sp. 2 (PD)			seLN858			
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)				seLN862		
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)			seLN859	seLN861		
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)			seLN860		seLN867	
		Collembola Type I						
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
	Diptera	Dipteran larvae(as seLN230)						
		Muscidae larvae		seLN855				
		Diptera sp1 (Terr. Culicidae?)						
		Diptera sp2 (Terr.)	seLN850	seLN854	seLN857	seLN863	seLN866	seLN870
		Diptera sp3 (Terr.)						seLN871

		Diptera sp4 (Terr.)	seLN849			seLN864	seLN865	seLN868
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)		seLN853				
		Diptera muscidae sp1		seLN852				seLN869
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae						
		Carabidae larvae						
		undetermined coleoptera						
		Undetermined coleoptera sp2						
	Blattodea	Nocticolidae						
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera	seLN851					
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1						
	Hymenoptera	Sp1						
Crustacea	Isopoda	Isopoda						

Phylum:Class	Order	Phase Taxa	3 JMC03- T3	3 JMC02- T1	3 JMC02- T2	3 JMC02- T3	3 JMC?2- T1	3 JMC?2- CH
Chelicerata	Arachnida	Araneae sp1	seFN288	seFN305	seFN306	seFN307	seFN281	seFN285
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)						
		Acarina sp. 2 (PD)		seLN878			seLN891	
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)						
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)					seLN890	
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined		seLN876				
Collembola	Collembola	Entomobryidae(blind white)						
		Collembola Type I		seLN873	seLN881			
		Collembola Isotomidae		seLN879				
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
	Diptera	Dipteran larvae(as seLN230)						
		Muscidae larvae						
		Diptera sp1 (Terr. Culicidae?)		seLN875				
		Diptera sp2 (Terr.)	seLN872		seLN882	seLN884		seLN892
		Diptera sp3 (Terr.)				seLN885		
		Diptera sp4 (Terr.)				seLN888		seLN893
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1				seLN886		
	Coleoptera	Pselaphidae						

		Carabidae sp 1						
		Coleoptera larvae		seLN874				
		Carabidae larvae						
		undetermined coleoptera						
		Undetermined coleoptera sp2				seLN889		
	Blattodea	Nocticolidae						
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera		seLN877	seLN880	seLN883		
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1						
	Hymenoptera	Sp1				seLN887		
Crustacea	Isopoda	Isopoda						

Phylum:Class	Order	Phase Taxa	3 JMC?2-T3	3 Bernts 32	3 Bernts?1-T1	3 Bernts?1-T2	3 KC009-CH	3 KC009-T2
Chelicerata	Arachnida	Araneae sp1	seFN282	seFN301	seFN302	seFN303	seFN308	seFN309
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)				seLN593	seLN595	
		Acarina sp. 2 (PD)				seLN593		seLN598
		Acarina sp. 4 (PD)			seLN 606			
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)		seLN608				
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)						
		Mesostigmata sp. 7(PD)		seLN608	seLN606			
		Acarina sp. 9(PD)			seLN606			
		Mesostigmata undetermined			seLN606			
Collembola	Collembola	Entomobryidae(blind white)	seLN896					
		Collembola Type I			seLN605			
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
	Diptera	Dipteran larvae(as seLN230)						
		Muscidae larvae						
		Diptera sp1 (Terr. Culicidae?)						se LN599
		Diptera sp2 (Terr.)	seLN895					
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.)						
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae						
		Carabidae larvae						
		undetermined coleoptera			seLN607			
		Undetermined coleoptera sp2						

	Blattodea	Nocticolidae						
	Lepidoptera	Tineidae sp1					seLN597	
		Undetermined Lepidoptera	seLN894	seLN609				
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1						
	Hymenoptera	Sp1						
Crustacea	Isopoda	Isopoda	seLN897			seLN594	seLN596	seLN600

Phylum:Class	Order	Phase Taxa	3 KC009- T3	3 KC032- T1	3 KC032- CH	3 KC008- CH	3 KC008- T2	3 KC008- T3
Chelicerata	Arachnida	Araneae sp1	seFN310	seFN311	seFN312	seFN313	seFN314	seFN315
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1						
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)						
		Acarina sp.1(SS)	seLN561					seLN565
		Acarina sp. 2 (PD)	seLN561	seLN563	seLN940			seLN565
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)			seLN940	seLN943	seLN610	
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)						seLN565
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)		seLN563				
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)						
		Collembola Type I						
		Collembola Isotomidae						
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
	Diptera	Dipteran larvae(as seLN230)						
		Muscidae larvae		seLN564				
		Diptera sp1 (Terr. Culicidae?)				seLN942	seLN612	
		Diptera sp2 (Terr.)		seLN562				
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.)						
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae						
		Carabidae larvae						
		undetermined coleoptera						
		Undetermined coleoptera sp2						
	Blattodea	Nocticolidae						
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera						
	Psocoptera	Psocoptera	seLN560					
	Hymenoptera	Formicidae sp1						

	Hymenoptera	Sp1					seLN611	
Crustacea	Isopoda	Isopoda			seLN941	seLN944		

Phylum:Class	Order	Phase Taxa	3 KC001- T1	3 KC001- CH	3 KC006?- CH	3 KC006?- T2	3 KC006?- T3	3 KC031- CH
Chelicerata	Arachnida	Araneae sp1	seFN316	seFN317	seFN318	seFN319	seFN320	seFN321
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1				seLN583		
	Acarina	Oribatidae sp 1 (SS)						
		Oribatidae sp. 2 (SS)						
		Oribatidae sp. 3 (SS)						
		Oribatidae sp. 4 (SS)				seLN585		
		Acarina sp.1(SS)	seLN567	seLN577	seLN586	seLN582	seLN602	
		Acarina sp. 2 (PD)	seLN567	seLN577	seLN586			
		Acarina sp. 4 (PD)						
		Acarina sp. 11 (PD)						
		Mesostigmata sp. 1 (SS)						seLN604
		Mesostigmata sp. 2(SS)						
		Mesostigmata sp.3 (SS)						
		Mesostigmata sp. 7(PD)						
		Acarina sp. 9(PD)						
		Mesostigmata undetermined						
Collembola	Collembola	Entomobryidae(blind white)						
		Collembola Type I		seLN578		seLN584		
		Collembola Isotomidae		seLN579				
		Collembola (Sminthuridae)						
Insecta	Hemiptera	Hemipteran juvenile						
	Diptera	Dipteran larvae(as seLN230)						
		Muscidae larvae						
		Diptera sp1 (Terr. Culicidae?)		seLN580		seLN581		
		Diptera sp2 (Terr.)	seLN568				seLN601	
		Diptera sp3 (Terr.)						
		Diptera sp4 (Terr.)						
		Diptera sp5 (Terr.)						
		Diptera sp6 (Terr.)						
		Diptera muscidae sp1						
	Coleoptera	Pselaphidae						
		Carabidae sp 1						
		Coleoptera larvae						
		Carabidae larvae						
		undetermined coleoptera						
		Undetermined coleoptera sp2					seLN603	
	Blattodea	Nocticolidae						
	Lepidoptera	Tineidae sp1						
		Undetermined Lepidoptera						
	Psocoptera	Psocoptera						
	Hymenoptera	Formicidae sp1						
	Hymenoptera	Sp1						
Crustacea	Isopoda	Isopoda						

Phylum:Class	Order	Phase Taxa	3 KC031-	3 KC028-	3 KC028-	3 KC005-	3 KC005-

			T2	T1	T2	T1	T2
Chelicerata	Arachnida	Araneae sp1	seFN322	seFN323	seFN324	seFN325	seFN326
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1					
	Acarina	Oribatidae sp 1 (SS)					
		Oribatidae sp. 2 (SS)					
		Oribatidae sp. 3 (SS)					
		Oribatidae sp. 4 (SS)					
		Acarina sp.1(SS)	seLN575		seLN569		
		Acarina sp. 2 (PD)					
		Acarina sp. 4 (PD)					
		Acarina sp. 11 (PD)					
		Mesostigmata sp. 1 (SS)	seLN575		seLN569	seLN571	
		Mesostigmata sp. 2(SS)					
		Mesostigmata sp.3 (SS)					
		Mesostigmata sp. 7(PD)					
		Acarina sp. 9(PD)					
		Mesostigmata undetermined					
Collembola	Collembola	Entomobryidae(blind white)					
		Collembola Type I	seLN576	seLN572			
		Collembola Isotomidae					
		Collembola (Sminthuridae)					
Insecta	Hemiptera	Hemipteran juvenile					
	Diptera	Dipteran larvae(as seLN230)					
		Muscidae larvae					
		Diptera sp1 (Terr. Culicidae?)		seLN573			
		Diptera sp2 (Terr.)			seLN570		
		Diptera sp3 (Terr.)					
		Diptera sp4 (Terr.)					
		Diptera sp5 (Terr.)					
		Diptera sp6 (Terr.)					
		Diptera muscidae sp1					
	Coleoptera	Pselaphidae					
		Carabidae sp 1					
		Coleoptera larvae					
		Carabidae larvae					
		undetermined coleoptera					
		Undetermined coleoptera sp2					
	Blattodea	Nocticolidae					
	Lepidoptera	Tineidae sp1					
		Undetermined Lepidoptera					
	Psocoptera	Psocoptera					
	Hymenoptera	Formicidae sp1					
	Hymenoptera	Sp1					
Crustacea	Isopoda	Isopoda					

Phylum:Class	Order	Phase Taxa	3 KC002-T1	3 SS-Toilet-T1	3 SS-Toilet-T2
Chelicerata	Arachnida	Araneae sp1	seFN327	seFN328	seFN329
Arachnida	Pseudoscorpionida	Pseudoscorpion sp1			
	Acarina	Oribatidae sp 1 (SS)			
		Oribatidae sp. 2 (SS)			

		Oribatidae sp. 3 (SS)		
		Oribatidae sp. 4 (SS)		
		Acarina sp.1(SS)	seLN587	seLN590
		Acarina sp. 2 (PD)	seLN587	seLN590
		Acarina sp. 4 (PD)		
		Acarina sp. 11 (PD)		
		Mesostigmata sp. 1 (SS)	seLN587	seLN590
		Mesostigmata sp. 2(SS)		
		Mesostigmata sp.3 (SS)		
		Mesostigmata sp. 7(PD)		
		Acarina sp. 9(PD)		
		Mesostigmata undetermined		
Collembola	Collembola	Entomobryidae(blind white)		
		Collembola Type I	seLN588	
		Collembola Isotomidae		
		Collembola (Sminthuridae)		
Insecta	Hemiptera	Hemipteran juvenile		
	Diptera	Dipteran larvae(as seLN230)		
		Muscidae larvae		
		Diptera sp1 (Terr. Culicidae?)		
		Diptera sp2 (Terr.)		
		Diptera sp3 (Terr.)		
		Diptera sp4 (Terr.)		
		Diptera sp5 (Terr.)		
		Diptera sp6 (Terr.)		
		Diptera muscidae sp1		
	Coleoptera	Pselaphidae		
		Carabidae sp 1		
		Coleoptera larvae		
		Carabidae larvae		
		undetermined coleoptera		
		Undetermined coleoptera sp2		
	Blattodea	Nocticolidae		
	Lepidoptera	Tineidae sp1		
		Undetermined Lepidoptera		
	Psocoptera	Psocoptera		
	Hymenoptera	Formicidae sp1		
	Hymenoptera	Sp1		
Crustacea	Isopoda	Isopoda		

APPENDIX 8: STAKEHOLDER CONSULTATION REGISTER

STAKEHOLDER ENGAGEMENT REGISTER

Date	Description of Consultation	Stakeholders	Stakeholder Comments/Issues	Response/Resolution	Stakeholder Response
11/01/2012	Discuss the potential presence of extremophiles in low pH water emanating from the SS ore body and any need for environmental protection	Tim Gentle (OEPA) Phil Boglio (DMP)	East Pilbara rocks are very old and the pH/dissolved metal conditions in Sulphur Spring appear relatively unique. Identification of extremophile species and protection of unique species may be required. It is acknowledged that the flow is small during the dry season and substantial due to overland water during the wet season Tim Gentle acknowledged that it was sensible that the project be assessed by Mining Proposal route if acceptable solutions were found for any issues that arose. He believed that there were no formal notes from the Venturex/EPA meeting on 31 May, 2011. TG was aware that the meeting had occurred and would normally have attended if available The PER submitted by CBH was still officially in abeyance. TG asked that it be formally withdrawn if there were no plans to proceed with it.	There are no EPA guidelines or standardised investigative procedures in relation to extremophiles. Sampling and species identification could be regarded as in the realms of research rather than project feasibility or assessment. The area around the spring itself will not be disturbed by the project but the ore body will be de-watered and spring flow will cease as a result. Noted and accepted Venturex, as owners of CBH Sulphur Springs Pty Ltd, to write to the EPA formally cancelling the PER.	Given that the ore body water will be treated before use or release, is it possible to divert a small flow of untreated water to the existing watercourse? The aim should be to artificially retain the existing environment and then allow it to return naturally after mine closure. Such an outcome is likely to be acceptable
27/04/2012	Brockman tenement issue	Ian Suckling and Brockman	Clarification was sought in respect of a tenement		
15/05/2012	Presentation to Njamal in Port Hedland describing the Sulphur Springs Project. The presentation was presented by Michael Mulroney and Ian Suckling and took several hours, including lunch.	Njamal People and lawyers	Presentation generally well received and a number of issues were raised in general discussion and question time	A letter was sent to Njamal after the meeting to thank them for the opportunity of presenting	Ongoing. Letters have been received via lawyers for further study and clarification of points made
18/05/2012	Atlas Iron Meeting beginning date. A number of regular meetings are held between Atlas and Venturex and are minuted. Each meeting generally is held fortnightly. Atlas record minutes	Atlas Iron and VXR	A forum for exchange of information, ideas and current issues ongoing	Minuted	As required
24/05/2012	Email letter of introduction from John Cooper (Sustainability Coordinator). Informed Ray of a field trip to Sulphur Springs by the feasibility team and invited Ray to attend	Ray Butler of Warran/Strelly Station	No issues raised	Response wasn't received before the trip	Refer phone call below; Ray rang back in June
18/06/2012	Phone call received from Ray Butler to John Cooper (Sustainability Coordinator) to follow up initial email	Ray Butler of Warrarn/Strelly Station	Phone call was quite long and cordial. Ray was interested in the project and was brought up to date with the current status of the feasibility study. Ray felt that access, visitors, wildlife and fencing would be issues of the haul road in relation to the pastoral leases	Ray provided a lot of background to the school and the station's history	Ray suggested that a presentation to the school may be useful in the future

Date	Description of Consultation	Stakeholders	Stakeholder Comments/Issues	Response/Resolution	Stakeholder Response
22/06/2012	Letter sent to EPA withdrawing original PER for the Sulphur Springs Project	EPA VXR Company Secretary	EPA made contact with Venturex initially to determine the status of the previous CBH submission in relation to Sulphur Springs project. A response was sent to EPA on 22 June requesting withdrawal (PER application number 1664)	The withdrawal was granted after a letter was sent by Venturex requesting it be withdrawn on the basis the proponent entity was no longer relevant and on the grounds the likely proposal is significantly different	No objection to the withdrawal application. No current applications are pending with EPA
9/07/2012	Letter sent to Njamal via Lawyer (Bavani Beloo) to follow up meeting of 15 May	Njamal People and lawyers	Follow up letter. Murray Meaton's economic assessment of the proposed Sulphur Springs project assessment was a key consideration	Murray Meaton to undertake an economic analysis of the project paying particular attention to revenues	Murray Meaton's response received in August for report dated July 2012
20/07/2012	State Deed for L45/173 Lodged after agreement reached	DMP Njamal People VXR	L45/173 has been signed by the Njamal people – DMP has advised the Deed will be lodged with the Tribunal the week of the 25th July and a Minute sent to Marble Bar to enable grant		
09/08/2012	Meeting with Shire of East Pilbara offices to provide an overview of the Sulphur Springs Project on behalf of Venturex Sulphur Springs.	Mr Rick Miller, Director Technical and Development Services and Mr Adam Majid, Manager (Shire of East Pilbara John Cooper (VXR)	Shire stated that its main interaction with VXR in respect of the feasibility and proposal is the development applications of the village and the airstrip	In respect of the airstrip the shire stated it would be interested in it in the context of other airstrips and air traffic in the area that may affect the operation of the Newman airport which it administers	Shire was ok with the information presented and stated that many companies do not present prior to works getting underway but felt this was positive
30/08/2012	Meeting with DMP to ascertain level of assessment for the Sulphur Springs Project and to provide an update of the feasibility study	Ian Suckling, Andrew Robertson, Mark Goldstone (Outback) Danielle Risbey, Adrian Wiley (DMP)	Discussions were held between attendees at the East Perth offices of the DMP. Venturex and partner consultants put forth new and significantly revised proposal which detailed tailings and other design features.	DMP officers concluded that the Pilbara Cu-Zn Project could be assessed without referral to the EPA.	The level of assessment to be via Mining Proposal in 2013 with associated documentation
12/10/2012	Letter to Simon Temby from Managing Director, Michael Mulroney	Department of Sustainability, Environment, Water, Populations and Communities.	Venturex sent a letter requesting EPBC Application 2007/3310 for the Panorama project be withdrawn and also notified of name changes in respect of ownership.	Withdrawn without contest	Email received from Mr Temby on the same day stating the application had been received and subsequently withdrawn.
8/11/2012	Second Presentation and Meeting with Njamal and the lawyers representing them at Lotteries House South Hedland. The meeting was attended by Michael Mulroney, Liza Carpene and John Cooper of Venturex	Njamal People and lawyers	Further discussions and negotiations with Njamal and their lawyers in respect of the claimant agreement for Sulphur Springs project. A further update was provided by MM regarding the Sulphur Springs project	Issues ongoing and not resolved at this meeting. A number of new items of business were put forth by the Njamal which requires further discussion and agreement between VXR and the lawyers representing them. Fee structures, royalties and provision of employment and contracting opportunities were covered	Negotiations are ongoing. Liza and Abbey from the claimant lawyers to meet again during December to further develop the agreement
5/12/2012	Phone call and emails with initial information in relation to Sulphur Springs DFS and mine closure plan	Panorama Station Cynthia Stoney	Cynthia was not aware of recent developments in respect of Venturex activities and welcomed the information.	Await further contact from Outback Ecology Consultants re Mine closure plan and mining proposal	Agreed to further meetings with OE in early 2013
5/12/2012	Phone calls and emails to update Sulphur Springs project and introduce Outback Ecology as consultants for mine closure and mining proposals	Ray Butler Strelley Station	Ray appreciated the update and Outback Ecology will be organising a formal meeting with Ray in the New Year.	Await contact from Outback Ecology	Standing by for further contact
10/12/2012	Emails	Rick Miller, Director Technical and Development Services (Shire of East Pilbara)	Rick was contacted through a series of emails and phone calls between 4 and 10 December to provide an update on the SS project, specifically with closure plan and mining proposal in mind as per stakeholder consultation process.	Outback Ecology to contact Rick at the shire for any other information in respect of the Sulphur springs Project	Rick was open to any other communication required
17/12/2015	Met to discuss proposed Sulphur Springs project and regional environmental issues including	Ian Zlatnick and Simon Carter (Fortescue Metals Group) John Nitschke (VXR)			

Date	Description of Consultation	Stakeholders	Stakeholder Comments/Issues	Response/Resolution	Stakeholder Response
	targeted surveys for *Pityrodia* sp Marble Bar.	Karen Ganza (MBS Environmental)			
21/12/2015	Met to discuss proposed Sulphur Springs project and regional environmental issues including targeted surveys for *Pityrodia* sp Marble Bar.	Eric Kely, Brendan Bow (Atlas Iron) John Nitschke and Trevor Hart (VXR) Karen Ganza (MBS Environmental)	Met to discuss proposed Sulphur Springs project and regional environmental issues including targeted surveys for *Pityrodia* sp Marble Bar.		
13/1/16	Venturex contacted Hillside Station by phone to request a meeting to provide an update on the Project	Brent Smooth (Hillside Station) James Guy (VXR)		No response received.	
10/03/2016	Meeting with OEPA.	Chris Stanley and Marie Heath (OEPA) John Nitschke and James Guy (VXR) Kristy Sell and Karen Ganza (MBS Environmental)	VXR/MBS made presentation on status of Sulphur Springs Project to the EPA. Discussions around how permit process would work; EPA officers pretty noncommittal on how process would proceed		
16/03/16	Email sent to Marcus Ford, lawyer for the Njamal, requesting a meeting to give him an update and sort out a way forward on any issues. He did not respond.	Njamal People Marcus Ford (Lawyer) John Nitschke (VXR)			
21/03/2016	Meeting with Department of Parks and Wildlife.	Sandra Thomas. Murray Baker Stephen Dillion - senior technical officer and two others (DPaW) John Nitschke and James Guy (VXR) Kristy Sell and Karen Ganza (MBS)	Run through presentation prepared by Karen. Useful session, Looks like two specie of Pityrodia not one. Condition of FMG approval for North Star that they conduct a definitive survey should be no need for VXR to do additional survey, but if two species confirmed will need to discriminate. Leaf Nose Bat and Northern Quoll. Stephan Dillion very knowledgeable and helpful		Keep them informed as permit proceeds
22/03/16	Meeting with Njamal People	Njamal People Marcus Ford (Lawyer) John Nitschke (VXR)	The agenda is to discuss the agreement and how it applies to tenements beyond Sulphur Springs		
14/09/2016	Meeting with Njamal representative	Gavin Mitchell – Njamal People Emma Bamforth/John Nitschke (Venturex)	Introductory meeting with Gavin to discuss the Njamal people's current group representation since YMAC was dismissed earlier this year. Also to identify the right Njamal people for Venturex to be liaising with regarding activities at Sulphur Springs. Gavin suggested a meeting with the Njamal Trust would be a good starting point and offered assistance to arrange a meeting.	Emma to send an e-mail to Gavin to request a meeting with Trust representatives.	
13/10/2016	Meeting with Indigenous Services – Managers of Njamal Trust	Wesley Aird, Jack Cullity – Indigenous Services Emma Bamforth/John Nitschke - Venturex	Introductory meeting with Indigenous services who has replaced YMAC as the body representing the Njamal People. Informative meeting providing great background to the Njamal claimant groups and issues the group had with YMAC.		
16/11/2016	Meeting with EPA	Chris Stanley – EPA Emma Bamforth/John Nitschke – Venturex Freea Itzstein- Davey - MBS	Provided the EPA with an update on the referral document development and changes in scope to the project since last meeting in April.	Provide Chris with a draft referral for review before formally submitting the document to speed up the assessment process.	

Date	Description of Consultation	Stakeholders	Stakeholder Comments/Issues	Response/Resolution	Stakeholder Response
24/11/2016	Phone call with DPaW	Sandra Thomas – DpaW Emma Bamforth - Venturex	Spoke with DPaW regarding Sulphur Springs referral and Norther Quoll matters. Sandr indicated that the Quoll is not a new matter to the Pilbara and can be managed through implementation of appropriate management plans. Doesn't feel a meeting is required. I offered to send her a copy of the presentation provided to EPA for her records.	Emma to send copy of the EPA presentation to Sandra	
24/11/2016	Phone call with Indigenous Services	Wesley Aird – Indigenous services Emma Bamforth – Venturex	Contacted Wesley to discuss arranging a meeting (as representatives of the Njamal claimants) with Casteldine Gregory (Njamals future acts representatives) RE: mining tenements and NTT mediation.	Agreed to send Wesley a copy of the Mining agreement which addresses future acts	
24/11/2016	Meeting with DMP	Rob Irwin, Phil Boglio, Matt Boardman – DMP Emma Bamforth/John Nitschke Venturex	Met with DMP to provide an update on the Sulphur Springs referral document development and changes in scope to the project since last meeting in April.	Sent draft referral in for comment before formally submitting the project.	
1/12/2016	E-mail to EPA	Chris Stanley - EPA	A copy of the amended draft referral was provided to EPA for preliminary comments		
6/12/2016	E-mail from EPA	Chris Stanley - EPA	Comments on the draft referral document received from EPA.	EPA comments addressed and final referral document developed.	