Subterranean Ecology Pty Ltd

Scientific Environmental Services

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NORTH STAR PROJECT

Subterranean Fauna Survey and Assessment

Prepared for:

Fortescue Metals Group Limited

24 May 2012

660NS-00000-RP-EN-0002 rev 0

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SUBTERRANEAN FAUNA SURVEY AND ASSESSMENT
MAY 2012

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Report No. 2011/10

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COVER: View from the North Star Prospect. Photo by Subterranean Ecology.

LIMITATIONS: This survey 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. Information not made available to this study, or which subsequently becomes available may alter the conclusions made herein.

VERSION	PREPARED BY	REVISED BY	RECIPIENT	DATE
Rev D	R. Keogh /S. Callan/ K. Eriksson	R. Keogh	Fortescue Metals Group Ltd	15/03/2012
DRAFT	K. Eriksson	S. Eberhard	Fortescue Metals Group Ltd	08/05/2012
FINAL	Subterranean Ecology		Fortescue Metals Group Ltd	18/05/2012

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Executive Summary

The North Star Magnetite Project Mining Area, hereafter referred to as the NSP Study Area, is located approximately 110 km south of Port Hedland, in the central Pilbara region of Western Australia. Subterranean Ecology was commissioned by Fortescue Metals Group to undertake a desktop habitat assessment and baseline field survey of subterranean fauna to support documentation for environmental assessment of the mining proposal.

The desktop habitat assessment concluded that the NSP Study Area contained prospective habitat for: (1) troglofauna, likely to be found in mineralised BIF; and (2) stygofauna, likely to be found in alluvium, colluvium, and fractured rock aquifers.

A two-phase baseline field survey consistent with EPA Guidance Statement No. 54A (2007), and spanning the wet and dry seasons, was undertaken between March and July 2011. The survey effort met or exceeded the EPA Guidance survey effort for troglofauna (83 sites, 153 samples) and stygofauna (31 sites, 52 samples).

Eleven (11) species of troglofauna were identified, comprising pseudoscorpions, schizomids, millipedes, symphylids, pauropods, diplurans, cockroaches, beetles, planthoppers and isopods. The troglofauna assemblage was predominantly recorded in the Gorge Creek BIF at North Star (proposed mine pit) and Glacier Valley (reference area). Six troglofauna species have to date only been recorded from within the proposed mine pit (Polyxenida sp. NS, Curculionidae sp. NS, Meenoplidae sp. NS) and tailings dam / waste dump area (Symphyla sp. NS, Anajapygidae sp. NS, Chthoniidae sp. NS). Some of these troglofauna are potential range-restricted species and may be of potential conservation interest in relation to this project.

Of these six species, all except Curculionidae sp. NS belong to families that are generally not known to be range restricted, and the wider distribution of geo-habitat make it likely that these four species have distributions beyond the proposed mine footprint. The subterranean Curculionidae species generally have lower capabilities of dispersal and include multiple potential range-restricted species in the Pilbara. Therefore Curculionidae sp. NS may be a species of potential conservation interest in relation to this project.

Seventeen (17) species of stygofauna were identified, comprising amphipods, copepods, syncarids, ostracods, isopods and annelids. Stygofauna were not detected in the Gorge Creek BIF at North Star (proposed mine pit) or Glacier Valley (reference area). Stygofauna were detected adjacent to the proposed tailings dam and waste dump (Packers Bore and Gusboy Bore). Two species, Paramelitidae sp. NS and Melitidae sp. NS1 (genetically distinct from other Pilbara species / haplotypes) are presently only recorded from Packers Bore and Gusboy Bore, hence these two species may be of potential conservation in relation to this project.

The main potential impacts for subterranean fauna identified in relation to this project are:

- Habitat removal (mine pit);
- Habitat alteration (tailings dam, waste dump area); and
- Changes in groundwater quality and regime (tailings dam, waste dump, localised pumping, contamination).

The proposed habitat removal (mine pit) represents approximately 16 % of the area of contiguous Gorge Creek BIF outcrop, while the area of habitat alteration (tailings dam, waste dump) represents approximately 28% of the area of contiguous Gorge Creek iron mudstone/siltstone outcrop as depicted on the 1:500 000 geology sheet (2011).

As minimal pit dewatering is likely to be required, and process water supply will be sourced from outside the study area, no major groundwater drawdown impacts are likely. Should abstraction occur localised pumping from Gusboy and Packers Bores could potentially impact groundwater habitat for Paramelitidae sp. NS and Melitidae sp. NS1. Potential changes to groundwater quality and groundwater regime, including contamination and/or potential impacts to groundwater from the tailings / waste dump areas, can be managed through standard groundwater quality protection procedures and monitoring of groundwater levels, groundwater quality, and stygofauna.

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1 INTRODUCTION

Subterranean Ecology was commissioned by Fortescue Metals Group (Fortescue) to conduct a habitat assessment and subterranean fauna survey of the North Star Magnetite Project (hereafter referred to as the NSP Study Area). The NSP Study Area is situated approximately 110 km south of Port Hedland (Figure 1).

The objectives of the habitat assessment were to:

- Identify prospective subterranean fauna habitats based on geology and hydrogeology;
- Review existing local and regional subterranean fauna records to establish context, and;
- Assess the potential for subterranean fauna to occur in the lower impact zones.

The objectives of the subterranean fauna survey were to:

- Sample subterranean fauna (stygofauna and troglofauna) in exploration drill holes and water monitoring bores within the Project area in accordance with the Environmental Protection Authority's (EPA's) Guidance Statements 54 and 54a (EPA 2003, 2007);
- Identify stygomorphic and troglomorphic species (fauna that exhibit morphological modifications suited to subterranean life); and
- Assess the distribution and conservation status of identified subterranean species, at local and sub-regional scales.

1.1 Subterranean Fauna

Subterranean fauna include troglofauna (animals that inhabit air-filled caves or smaller cavities underground) and stygofauna (aquatic animals that inhabit groundwater). Certain subterranean species are amphibious, *i.e.* able to utilise both aquatic and terrestrial subterranean habitats. Most subterranean fauna are invertebrates, such as spiders, pseudoscorpions, millipedes, centipedes, beetles, bugs, crustaceans, and worms (Gibert et al. 1994). Obligate subterranean fauna, which spend their entire life underground, are known as troglobites or stygobites, for terrestrial or aquatic forms respectively.

Troglobites and stygobites generally exhibit troglomorphic or stygomorphic characteristics such as reduced or absent eyes, a lack of pigment, elongated appendages, and enhanced non-optic sensory structures (Christiansen 2005). These morphological features can indicate evolutionary adaptation to underground life. There are some species that utilise underground habitats but are not necessarily restricted to them, such are known as trogloxenes (or stygoxenes), and troglophiles (or stygophiles) (Christiansen 2005, Stanford and Ward 1993, Bichuette and Trajano 2004).

Soil dwelling fauna (edaphofauna) are also sometimes collected in the course of surveys of troglofauna, and may show some degree of troglomorphy (e.g. reduced eyes, or lack of pigment). In most studies morphological evidence is combined with ecological information in order to assess the status of each species and its potential occurrence throughout the various underground habitats (*e.g.* Humphreys 2008, Platnick 2008). Information about the biology, ranges and habitat preferences of stygofauna and troglofauna, however, is limited.

Stygofauna are known to inhabit alluvium, calcrete and fractured rocks aquifers, whilst troglofauna are known as predominantly from mineralised habitats, especially pisolite and banded iron formations, as well as calcrete and alluvium (Edward and Harvey 2008, Subterranean Ecology 2010a, 2011a).

Subterranean fauna usually have more restricted distribution than their surface counterparts, with up to 70% of stygofauna recorded from the Pilbara being short-range endemics (SRE's) (Eberhard *et al.*, 2009). The majority of troglofauna are also SRE's, even more so than stygofauna (Lamoreux 2004).

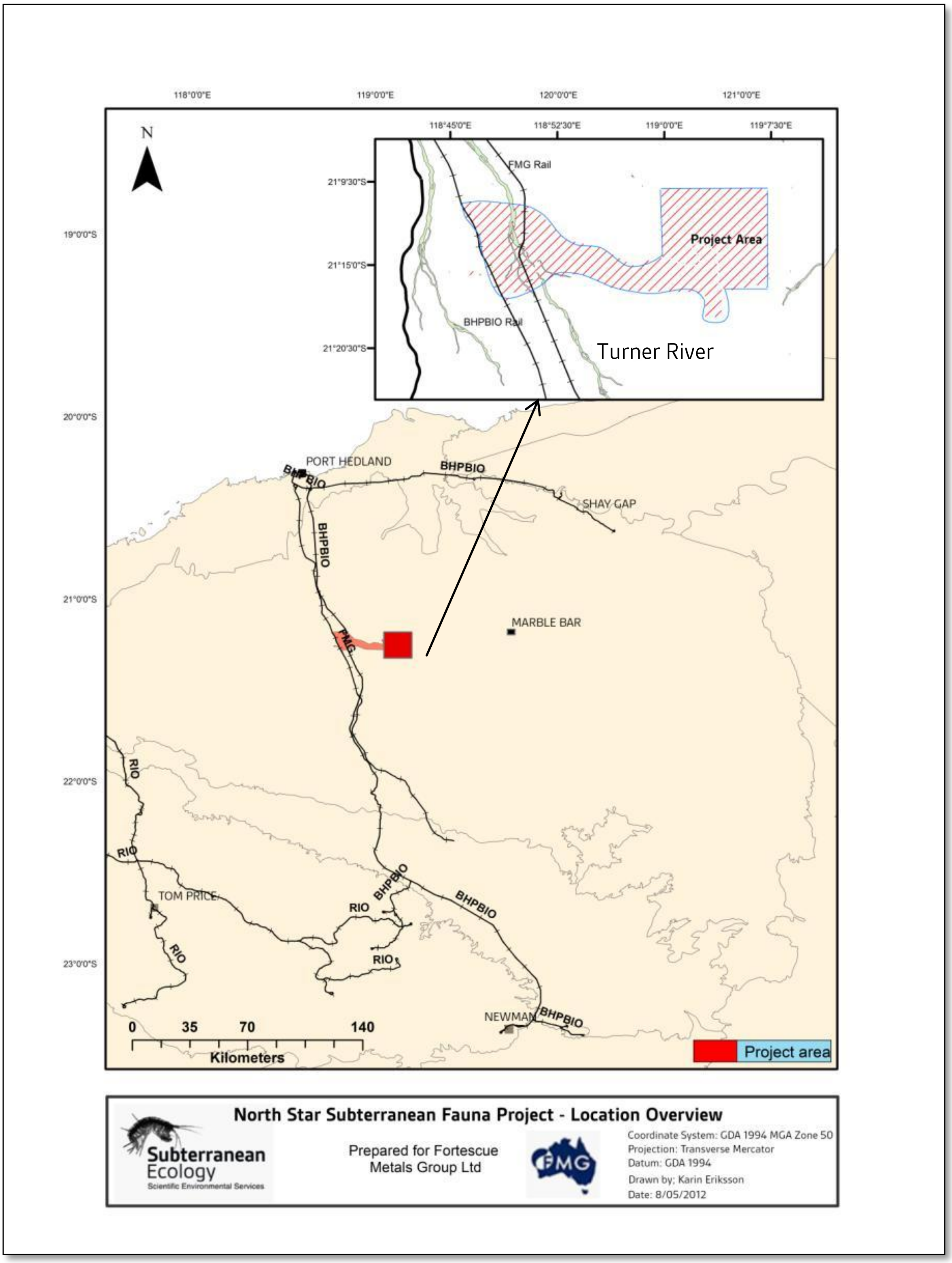

FIGURE 1: Location overview. Insert highlights North Star Project Study Area

1.2 Other Surveys in this Area

Several subterranean fauna surveys have been conducted in the region of the North Star Project Study Area. For example, troglofauna were collected approximately 50 kilometres to the southeast in the Mount Webber Mining area (Subterranean Ecology unpubl.). These surveys found troglofauna in relatively low abundance when compared to other areas within the Pilbara region. Further, troglofauna studies conducted approximately 20 km northeast of the NSP Study Area at Abydos, recorded eleven (11) species of troglofauna (Subterranean Ecology unpubl.) from Gorge Creek BIF; the same geological formation as the North Star orebody.

2 HABITAT CHARACTERISTICS

2.1 Geology and Hydrology

2.1.1 Geology

There are five main stratigraphic groups in the North Star Project Area; the Warrawoona Group, the Sulphur Springs Group, the George Creek Group, the De Grey Group, the Yule Granitic Complex and the Fortescue Group (Figure 2). The following detailed geological information for the impact zone is extracted from the WorleyParsons (2011) hydrological feasibility study:

"The North Star ore body is located in the Pincunah Formation BIF, an Archaean meta-sedimentary basal formation of the Gorge Creek Group. The mineralised area is 3 to 5 km long and 350 to 450 m wide. The main BIF member of the Pincunah Formation varies in stratigraphic thickness from 350 to 450 m and forms a north-south flat-topped striking ridge approximately 500 to 800 m wide and 80 to 120 m high. Fortescue exploration to date has shown the Pincunah BIF has a minimum depth extent of 300 m and remains open at depth (FMG 2010). Strata is sub-vertically (varying from 80° west to 70° east) dipping and strikes north-south. Common small scale folding has been recognised in the formation. The ore body is cut by a number of faults that strike parallel to sub-parallel to the stratigraphy (FMG 2010).

The footwall (western) sequence of the BIF comprises highly recessive, poorly exposed shales up to 500 m thick. The contact between the shales and the BIF which forms a prominent cliff is likely to be sheared or faulted (FMG 2010). The hanging wall (eastern) sequence of the BIF is over 400 m thick and is made up of Interbedded shales, mudstones, cherts, BIF and quartzite beds typically 1 to 20 m thick. These rocks form the eastern half of the ridge and are likely to be more competent than the footwall.

Two distinct domains of mineralisation have been recognised (grey and red). Grey is the dominant mineralisation of North Star, and is dominated by magnetite and chert with subordinate interbeds of stilpnomelane and clinochlore (chlorite) and may also contain finely disseminated haematite in the chert. The red domain is dominated by magnetite, chert and haematite (FMG 2010)."

2.1.2 Hydrogeology

The Project is located high in the catchment along a drainage basin divide at the head of three catchments, the Strelley River which flows to the north, the Shaw River to the northeast and the Turner River to the northwest. The Strelley and Shaw Rivers join together downstream and combine with the lower De Grey River (Worley Parsons 2011).

The most prominent aquifers identified in the proximity of the Project are located on the coastal plains, associated with the major water courses including Yule, Turner and De Grey Rivers. Groundwater generally occurs in unconfined Quaternary sediments hydraulically connected to underlying weathered-fractured rock aquifer (Haig 2009). Recharge to the alluvial aquifers occurs mostly from river flow, mainly in areas where major surface water courses cross the coastal plain. Palaeochannels are generally the thickest parts of the alluvial aquifer. The Project area is dominated by outcropping granites and greenstones. A substantial thickness of Quaternary sediments has not been located in the vicinity of the ore body, indicating a significant Quaternary alluvial aquifer may not be present (Worley Parsons 2011).

To the west groundwater can be up to 20 mbgl. The Turner River aquifer is comprised of Basement Archean granites and greenstones overlain by more recent alluvial sediments, which are clay and silt dominated with minor sand and gravel. The weathered horizon in basement rock is five to 30 m thick with secondary calcrete development common near the water table. The maximum thickness of Quaternary alluvium is 43 m. The alluvial aquifer fills a short northerly trending valley that coincides with the present location of the east and west Turner Rivers. Calcrete development has also been associated with a water bearing zone at the base of the alluvium. An underlying weathered bedrock aquifer with secondary calcrete development is also present and is thought to be hydraulically connected to the alluvium (Haig 2009). Hydraulic conductivity for the aquifer has been estimated from test pumping at 4 m^3 / day.

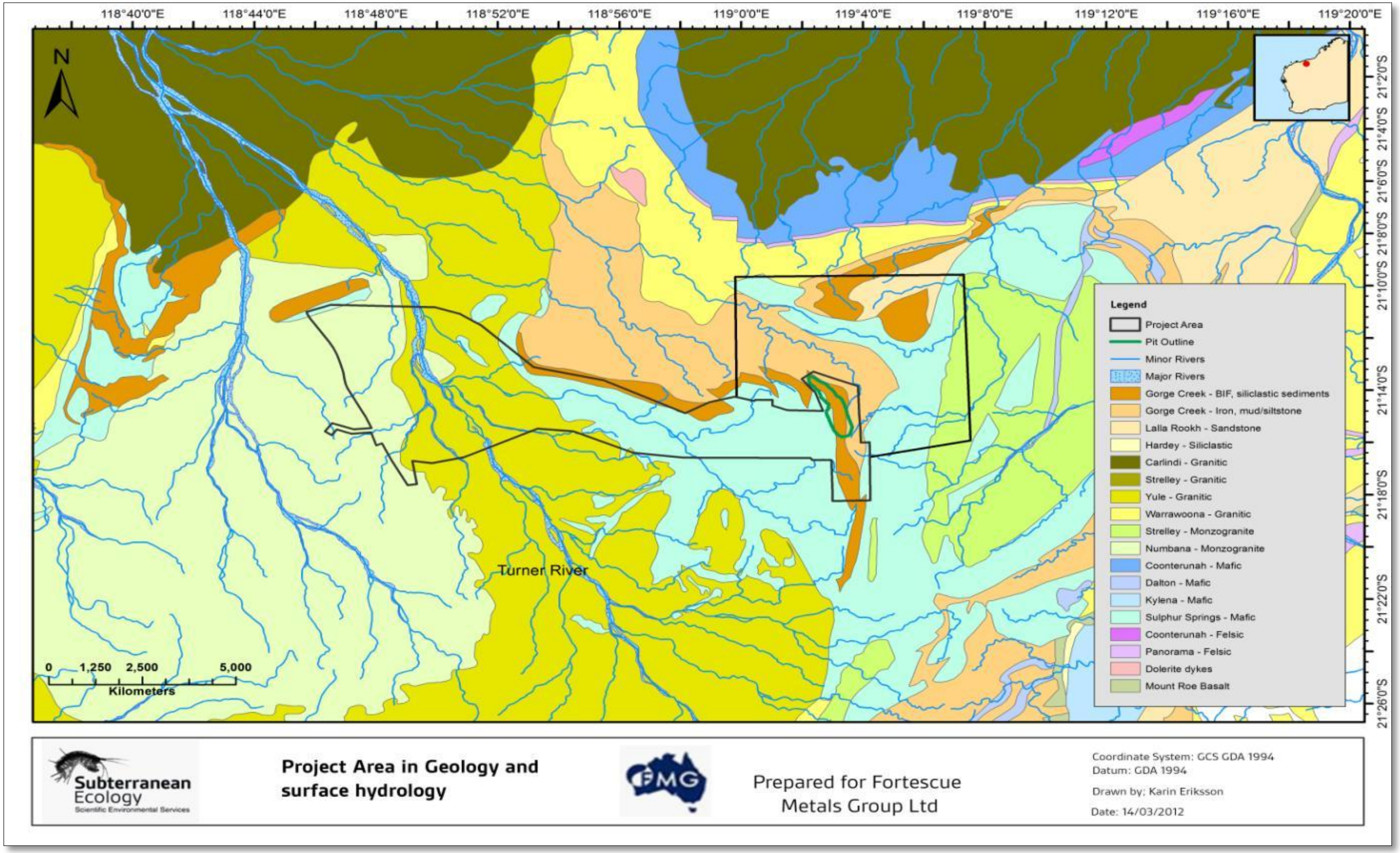

FIGURE 2: **Surficial geology (1: 500 000) and hydrology of the NSP Study Area.**

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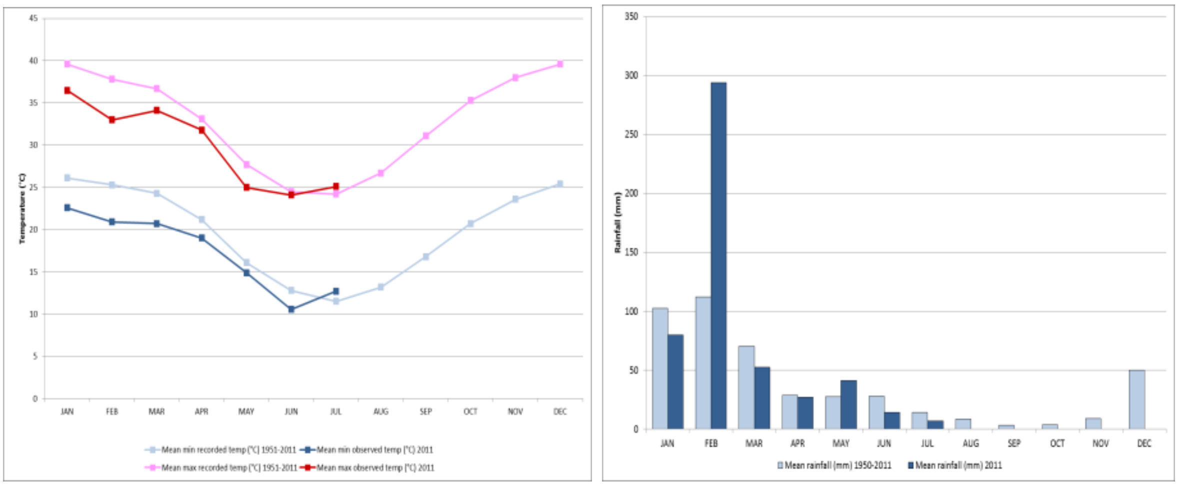
2.2 Climate

The Pilbara, where the Project area lies, is in general arid and hot with daily summer maximum temperatures usually above 35°C. Rainfall is variable and mainly cyclonic. Most rain falls during the summer months, from December to April, averaging about 400 mm/year (Figure 3).



(A) **(B)**

FIGURE 3: **Long term climate statistics for Wittenoom (BOM site number 005026; from 1950-2011), plotted against conditions observed in the period January to July 2011; A) monthly maximum and minimum temperatures (°C), and B) mean monthly rainfall (mm) (data from Bureau of Meteorology {BOM}2011).**

3 CONSTRAINTS AND LIMITATIONS

The sampling reported here was conducted within drill holes, bore holes and wells established for the purposes of either conducting geological surveys or for the purposes of accessing subterranean water resources. These holes represent artificial cavities within the porous or fractured subterranean habitat. Conditions within them may differ from the wider subterranean habitat. Troglofauna can be difficult to collect, and many samples are generally required to be confident of collecting a high proportion of the species present in any area (Eberhard *et al.* 2009; Subterranean Ecology 2007). Capture rates may be influenced by site characteristics and seasonal conditions. Dry seasonal conditions may suppress troglofauna activity, as suggested by Humphreys *et al.* (1991).

Normal selection criteria for drill holes to be suitable for sampling, including being vertical (90°) for stygofauna sampling, and uncased for troglofauna, were applied for this survey. This allowed stygofauna sampling within the non-impact zone (Glacier Valley), but limited sampling for troglofauna outside of the North Star orebody.

4 METHODS

4.1 Survey Methods

The sampling methods conform with the:

- EPA (2003) Guidance Statement 54 – Consideration of subterranean fauna in groundwater and caves during environmental impact assessment in Western Australia;
- EPA (2007) Guidance Statement 54a – Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia;
- Western Australian Wildlife Conservation Act (1950) (WC Act) and amendments;
- Western Australian Environmental Protection Act (1986) (EP Act); and
- Commonwealth Environment Protection and Biodiversity Conservation Act (1999) (EPBC Act).

4.2 Stygofauna and Troglofauna sampling

Stygofauna were sampled by net hauling as follows:

- Six hauls of the entire water column with a 150 µm and 50 µm mesh plankton net;
- Aperture of diameter to suit each bore (80 mm);
- Lead weight and sample vial (35 mL) to suit each net;
- Sediments agitated by raising and lowering the net at the bottom of the bore;
- Each haul emptied into a jug of water
- After the sixth haul samples were:
- elutriated, and filtered back through the net to remove water;
- preserved in chilled 100% ethanol, and stored in ice; and
- kept at 2°C during subsequent sorting and identification.

Troglofauna sampling involved the deployment of troglofauna traps as described below:

- Each trap comprised a PVC cylinder approximately 15 cm long and 50 mm diameter;
- The bottom of the cylinder was capped with a PVC end-cap through which a 5 mm hole was drilled to permit drainage of water;
- The top of each cap was covered with a coarse grid to allow access to invertebrates while excluding larger organisms and material;
- Each trap contained decaying Spinifex debris (decontaminated by heating in Microwave oven, 10 min's);
- A single trap was deployed in each drill hole;
- Where possible traps were, deployed to a target depth of 30 m and left for a period of approximately 5-6 weeks;
- Upon retrieval, traps were placed into paper bags, then within snap lock plastic bags and stored in an ice box;
- Fauna were extracted, in the laboratory, using Tullgren funnels for a period of 48 hours; and
- Specimens were preserved in 100 % ethanol and subsequently stored at 2°C.

Scrape sampling was performed as follows:

- Scraping the walls of drill holes with a plankton net fitted with a lead sinker and a 35 ml sample vial;
- A scraping attachment, comprising numerous strands of thick nylon lines was attached above the net;
- Each sample comprised the product of three hauls;
- On each scrape the net was lowered to the bottom of the drill hole and then retrieved;
- All materials collected from the three scrapes were combined in a large jug of water, elutriated and transferred into a vial;
- Samples were preserved in 100 % ethanol and subsequently stored at 2°C.

4.3 Groundwater Data

To characterise groundwater physico-chemistry, bailer samples were taken from bores prior to stygofauna sampling. One litre of groundwater was sampled, from a depth of approximately one metre below the water surface. The parameters recorded were temperature (° Celsius), acidity/alkalinity (pH), dissolved oxygen (DO, mg/L), and electrical conductivity (EC, μS/cm) and were measured using a "TPT" brand multi-functional water meter.

4.4 Sorting, Identification and DNA sequencing

Sorting of preserved samples was conducted in the laboratory using dissecting microscopes. Each specimen was identified to the lowest taxonomic rank possible and counted. Further identification of specimens was undertaken using published keys and descriptions using high resolution dissection or compound microscopes. Personnel and specialist taxonomists involved in sorting and identification are listed below in Table 1. New taxa were identified to morpho-species level using a para-taxonomic approach.

TABLE 1: Fauna handling tasks and personnel involved

Role	Names	Affiliation
Sorting	S. Blane, S. Catomore, K. Eriksson, G. Perina	Subterranean Ecology
Identifications	G. Perina, K. Eriksson	Subterranean Ecology
DNA	Dr T. Finston	Helix Molecular Solutions

Voucher specimens were photographed and retained in Subterranean Ecology's voucher collection. All remaining specimens will be lodged at the Western Australian Museum. Identifications were confirmed by specialist taxonomists as required. Where required, the verification of morpho-species identifications was undertaken using DNA sequences of the mitochondrial gene Cytochrome Oxidase subunit I (COI). The gene COI is routinely used to detect and explore species boundaries (genetic species) in groups of organisms and to add veracity to morphology-based species delineation, while the 12s mitochondrial gene is widely used in arthropod systematics.

Gene sequencing and analysis were conducted by Helix Molecular Solutions. Samples from 25 specimens, representing 10 morpho-species were selected for DNA sequencing based on the availability of sequences from the same taxa sampled in geographically proximal locations.

4.5 Sample Sites and Survey Effort

Sampling was conducted over two "back-to-back" phases spanning two consecutive seasons encompassing 83 sites (see Appendix 1 for drill hole details). A total of three visits were undertaken, with the first phase conducted during the wet season (March 2011) and the second phase during the drier months (May to July 2011). The drill holes that were surveyed geographically covered the Study Area (Figure 4). Sampling in the Study Area employed, over all phases, 130 litter traps, 23 troglofauna net scrapes, and 52 stygofauna net hauls (Table 2).

TABLE 2: North Star Project subterranean fauna survey effort.

Season	Troglofauna traps	Troglofauna scrapes	Stygofauna net hauls
Wet (March-11)	n/a	9	14
Dry (May/June-11)	58	8	20
Dry (July-11)	72	6	18
Total # Samples	130	23	52

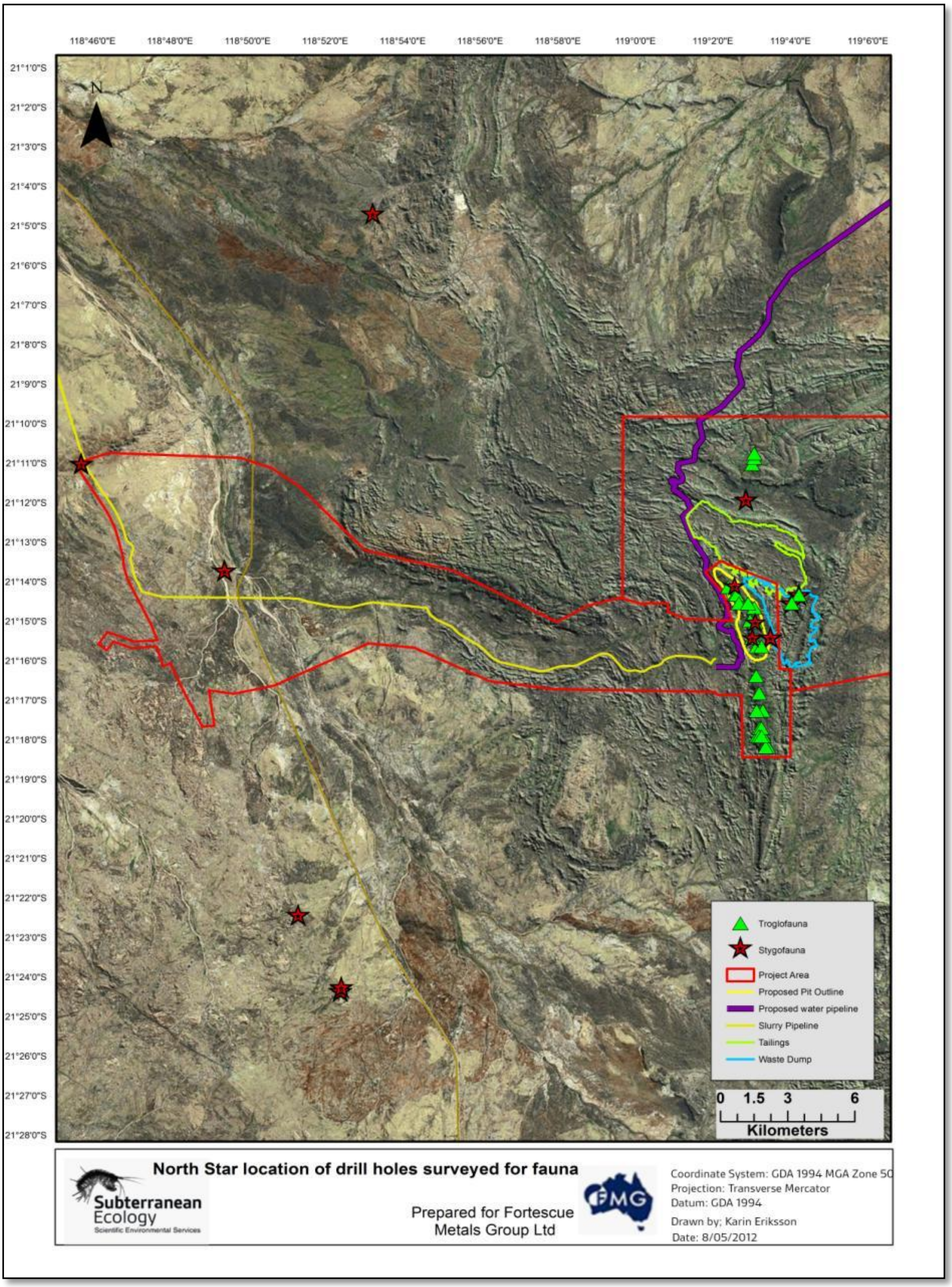


FIGURE 4: North Star Project Study Area showing sampled holes

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4.6 Data Analysis / Handling

Species accumulation curves and diversity estimations were made with EstimateS® (v 8.2.2) (Colwell 2006) using the default settings, with the following exceptions:

- Accumulation curves smoothed using 1,000 repetitions;
- Diversity estimators: Classic Formula for Chao 2 was chosen; and
- Rare species threshold set to 2, so as to more reliably treat 'rare' (singleton) taxa.

Scrape, trap and net haul samples collected from the same bore during the same field visit were treated as separate samples. Species diversity analyses were performed on the combined total of all net, trap and scrape samples in order to take into account the complementarity of sampling methods for troglofauna (Colwell and Coddington 1994, Moir *et al.* 2005). Net samples and scrape samples that extended below the water table were included for stygofauna. Troglofauna scrape samples that extended below the water table were also inspected for stygofauna.

5 RESULTS

5.1 Sampling Efficacy – "STRIKE RATE"

A total of 205 samples from 83 sites were collected throughout the survey, of which 73% yielded subterranean fauna. The strike rate is the proportion of sites yielding fauna. Table 3 shows the strike rates for stygofauna and troglofauna individually, for each visit and combined.

The higher strike rate for stygofauna than for troglofauna is typical for surveys such as this reflecting the difference in the media from which samples are collected. (The water being sampled is continuous with the normal habitat of stygofauna; troglofauna have to be "lured" out of their normal habitat into the bore being sampled.)

TABLE 3: Subterranean fauna strike rates.

Visit	Sites surveyed	Sites yielding specimens	Strike Rate (%)
Stygofauna			
1 (March 2011)	14	5	35.7
2 (May – June 2011)	20	10	50 0
3 (July 2011)	18	11	61.1
All sites combined	52	26	50
Troglofauna			
1 (March 2011)	N/A		
2 (May – June 2011)	58	12	20.7
3 (July 2011)	72	23	31.9
All sites combined	130	35	26.9

5.2 Stygofauna

A total of 1044 stygofauna specimens were recorded at the Study Area during 2011, summarised in Table 4 (full data in Appendix 2). One-thousand and one (1001) specimens representing 17 (morpho-) species were recorded in the survey. The higher taxonomic groups represented were: Copepoda; Amphipoda; Bathynellacea; Ostracoda; and Annelida. Approximately one-third (37%) of the (morpho-) species were abundant being represented by 20 specimens or more. The remaining two-thirds (63%) were recorded in lower abundance, represented by 12 specimens or less (Figure 5).

TABLE 4: Stygofauna (morpho-) species collected during the survey, including number of individuals and the number of bores each taxon was recorded from.

Sub-Phylum	Class	Order	Family	Morpho-species	Number of individuals	Number of bore records
Crustacea	Malacostraca	Amphipoda	Paramelitidae	Paramelitidae sp. NS	55	7
			Bogidiellidae	Bogidiellidae sp. NS	8	3
			Melitidae	Melitidae sp. NS2	3	4
				Nedsia sp. NS	14	4
		Bathynellacea	Bathynellidae	Bathynellidae sp. NS	60	1
			Parabathynellidae	Parabathynellidae sp. NS	14	4
	Maxillopoda	Cyclopoida	Cyclopoidae	*Diacyclops humphreysi*	231	9
				Microcyclops varicans	26	2
				Diacyclops sobeprolatus	18	3
		Harpacticoida	Canthocamptidae	Elaphoidella humphreysi	547	9
	Ostracoda	Podocopida		Ostracoda sp. NS1	2	1
				Ostracoda sp. NS2	1	1
				Ostracoda sp. NS3	1	1
Annelida	Oligochaeta	Haplotaxida	Phreodrilidae	Phreodrilidae sp. NS	5	2
				Dero furcata	1	1
			Naididae	Naididae sp. NS	1	1
			Enchytraeidae	Enchytraeidae sp. NS	14	4
				TOTAL	1001	
Incompletely identified taxa						
Crustacea	Malacostraca	Amphipoda	Paramelitidae	Paramelitidae indet	54	6
	Copepoda	Podocopida		Podocopida indet	2	2
Annelida	Oligochaeta	Haplotaxida	Naididae	Naididae indet	19	1
				TOTAL	75	26

547 231

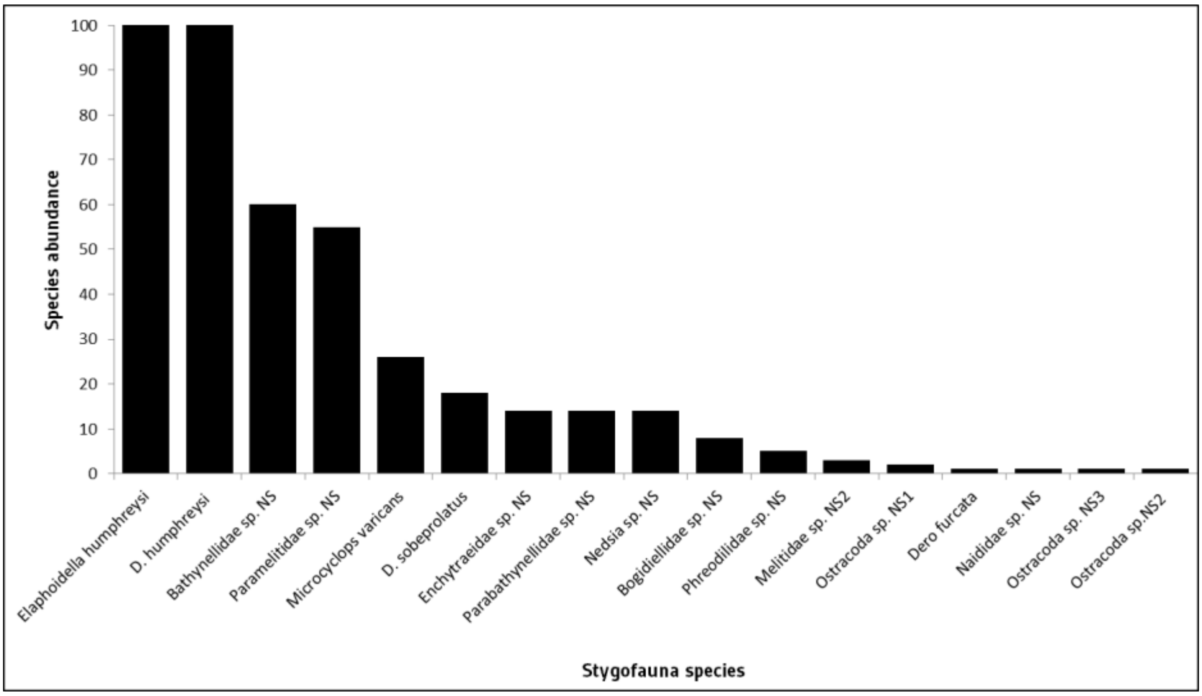

FIGURE 5: Abundance of stygofauna taxa in samples from the NSP Study Area.

The remaining 75 specimens could not be identified to species level due to either damage to the specimens resulting in failed DNA analysis and/ or being juveniles, where taxonomically they couldn't be identified further. These specimens were excluded from further analyses.

Elaphoidella humphreysi, *Dero furcata* and Parabathynellidae sp. NS were found both inside and outside the proposed footprint area (Table 5). Both *Elaphoidella humphreysi* and Parabathynellidae sp. NS were found in reference areas and/or other areas outside the proposed footprint.

Enchytraeidae sp. NS and Naididae sp. NS were found within proposed footprint of the direct and the indirect impact areas, respectively. These taxa were not able to be resolved to species level using standard morphological taxonomy, although both of these oligochaete families are well known from subterranean habitats elsewhere throughout the Pilbara. Stygofaunal naidids are generally considered limited to the extent of their aquifer habitats, although some naidid species such as *Dero furcata,* which was also recorded at North Star, are widespread cosmopolitan species (Pinder pers. comm.).

Enchytraeid oligochaetes are not obligate stygofauna (stygobites), as they can inhabit water films in unsaturated subterranean habitats and soils (Pinder pers. comm.). During the current survey, Enchytraeidae sp. NS was collected from troglofauna traps as well as stygofauna net haul samples, therefore its potential habitat range appears to extend beyond groundwater habitats.

The Paramelitidae sp. NS collected from a single site (Gusboy bore, Figure 6) is likely to be a distinct species, and shows a relatively recent common ancestor with one species previously detected in the Lower Shaw River (Finston and Berry 2011i). The paramelitid lineage differed from other Pilbara paramelitid lineages by 23.9 to 30.6% sequence divergence. There are currently no other known records of this species in the Pilbara.

The Melitidae sp. NS1 collected from a single site (Packers bore; Figure 6) is likely to be a distinct species that has so far not been recorded in the region but shares a common ancestor with other species from the Shaw River area and the Ord Ranges (Plate 1) (Finston and Terry 2011j). The Melitidae sp. NS1 showed a sequence divergence of 9.5% from the Shaw River specimen, indicating a recent evolutionary relationship.

PLATE 1: **Lateral view of Melitidae sp. NS1.**

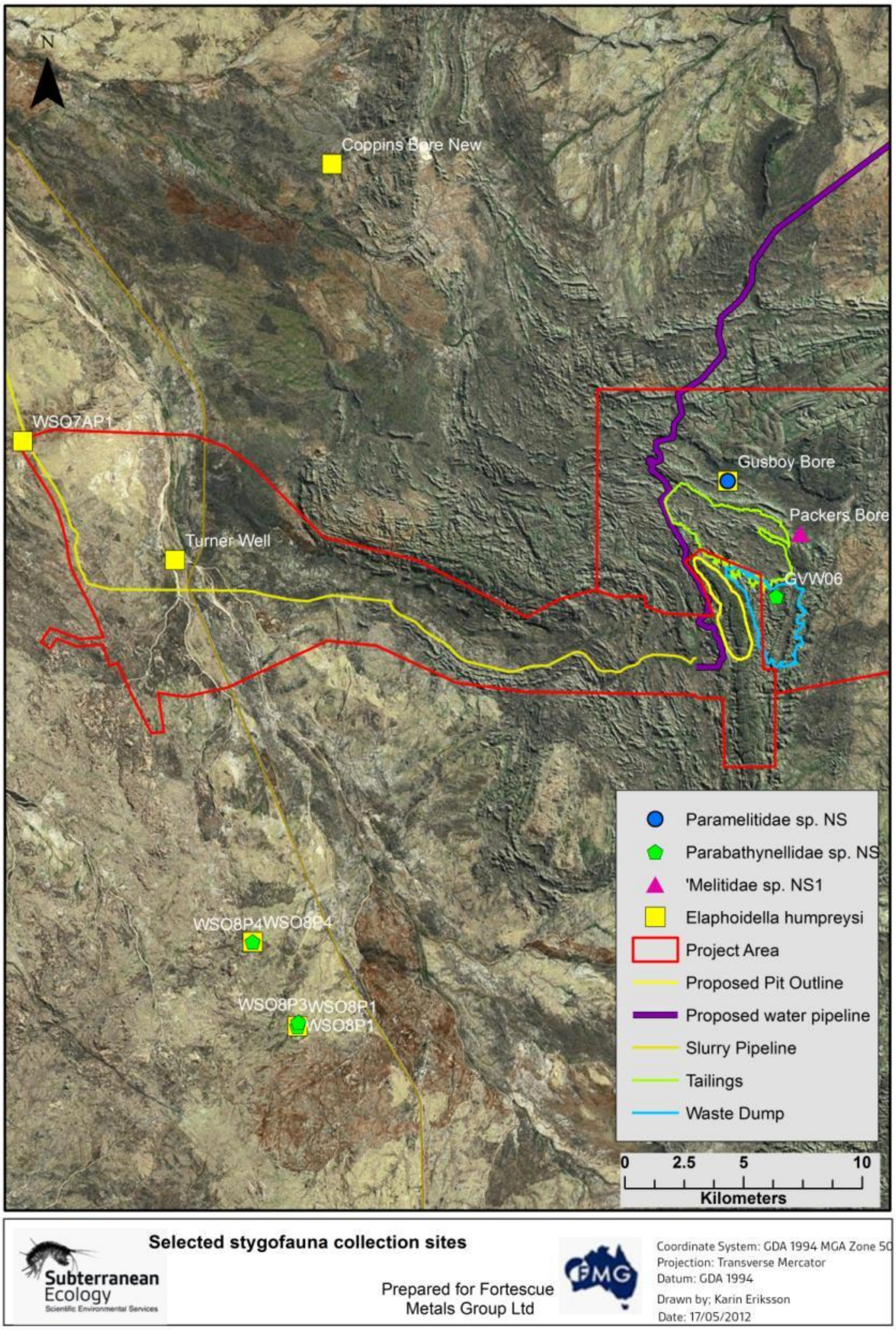

FIGURE 6: Collection sites for *E. humphreysi*, Parabathynellidae sp. NS, Paramelitidae sp. NS, and Melitidae sp. NS1.

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TABLE 5: Collection records of stygofauna in relation to project impact / footprint and other areas.

Taxon		North Star (proposed pit)	North Star (waste dump, tailings, footprint)	Glacier Valley (Reference)	NSP Study Area (Reference)	Other Records (Pilbara)	Reference
Copepoda	*Diacyclops humphreysi*				✓	✓	DEC Unpubl.; Karanovic 2006
	Microcyclops varicans				✓	✓	Karanovic 2006
	Diacyclops sobeprolatus				✓	✓	Karanovic 2006
	Elaphoidella humphreysi		✓		✓	✓	DEC unpubl.; Karanovic 2006
Amphipoda	Paramelitidae sp. NS				✓		Current survey
	Melitidae sp. NS1*				✓		Subterranean Ecology unpubl. (Abydos)
	Melitidae sp. NS2				✓		Current survey
	Nedsia sp. NS				✓		Current survey
	Bogidiellidae sp. NS				✓		Current survey
Syncarida	Bathynellidae sp. NS				✓		Current survey
	Parabathynellidae sp. NS		✓		✓		Current survey
Ostracoda	Ostracoda sp. NS1				✓		Current survey
	Ostracoda sp. NS2				✓		Current survey
	Ostracoda sp. NS3				✓		Current survey
Oligochaeta	Enchytraeidae sp. NS	✓			? ✓	?✓	Pinder pers. comm., DEC unpubl.
	Dero furcata	✓				✓	Pinder pers. comm.
	Naididae sp. NS		✓			? ✓	Pinder pers. comm., DEC unpubl.
	Phreodrilidae sp. NS				✓		Pinder pers. comm., DEC unpubl.

(*); specimen collected during an earlier survey (Subterranean Ecology unpubl.)

? Unconfirmed

5.3 Stygofauna Survey Completeness

A total of 17 taxa from 52 net haul samples were used to construct a species accumulation curve (Figure 7). The curve is approaching a plateau and the species richness estimators in EstimateS predicted approximately 87% of stygofauna species have been collected to date from the NSP Study Area.

Few of the collections were made from the NSP Study Area proposed impact area, whereas none were made from bores within the Glacier Valley outside the proposed impact area. A very high proportion of predicted total has been detected in the survey with a high degree of confidence of sampling effort in the North Star Project Area to date.

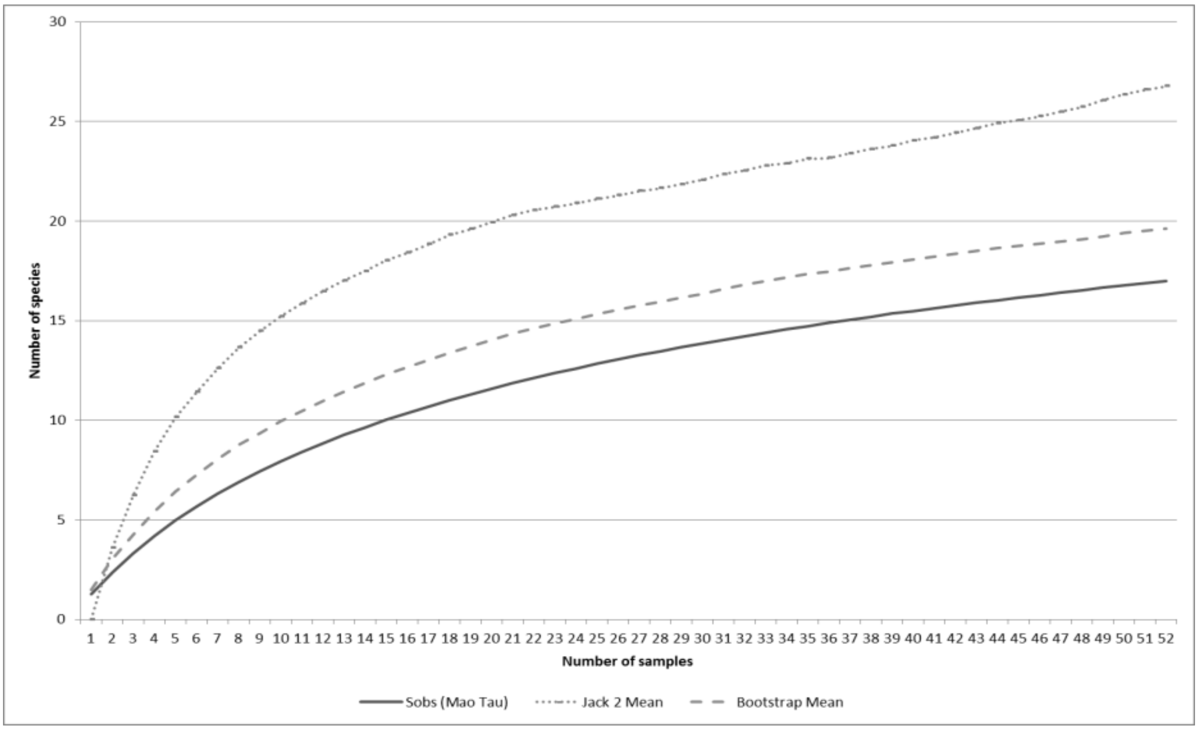

FIGURE 7: Species accumulation curve (Sobs Mao Tau, Jack 2 mean and Bootstrap Mean - EstimateS Colwell 2006) for stygofauna.

5.4 Groundwater Data

Groundwater physico-chemistry (electrical conductivity {EC}, dissolved oxygen {DO}, temperature {°C}, pH) measured during three visits are shown in Table 6.

Mean temperature was lower during the third visit in the dry season (26.7^{o}C ± 1.6) (Table 8). The EC ranged from freshwater to brackish (from 512 – 6953 µS/cm) with the third visit in the dry season recording the highest mean EC (Table 6). The pH showed a higher range during the first visit in the wet season compared to the third trip during dry season. Mean dissolved oxygen (DO) concentrations and redox values were comparable across all monitored sites (Table 6).

TABLE 6: Groundwater physico-chemical parameters measured at the Project Area from three sampling visits

Groundwater Parameters	Wet season March-11	Dry season May/June-11	Dry Season July-11
Temp. (°C)			
Mean	30.9	30.4	26.7
StDev	1.5	1.7	1.6
Electrical conductivity (EC)			
Mean	1790.1	2065.9	2208
StDev	1453.0	1735.7	1597.6
pH			
Range	6.44 - 8.31	6.43 - 8.06	6.33-7.56
DO (mg/L)			
Mean	1.4	1.5	2.3
StDev	1.1	1.2	1.8
Redox (Eh)			
Mean	46.3	47.49	32.58
StDev	27.1	69.9	38.5
Total # specimens collected	437	1087	442

Overall, measured groundwater physico-chemistry parameters were within the habitable ranges for stygofauna (Humphreys 1999, Malard and Hervant 1999, Humphreys 2008). Moreover, there were no consistent trends in the present data that would provide an obvious explanation for the observed differences in the numbers of specimens collected from one sampling to the next. For example, elevated dissolved oxygen has been associated with greater abundance of stygofauna in other surveys in the Pilbara (Subterranean Ecology 2010b). At the NSP Study Area, the DO ranged between a mean of 1.4 and 2.3 mg/L over the three sampling occasions; with the minimum DO level well within the tolerance range of stygofauna. Indeed, one species of harpacticoid and one species of ostracoda were recorded from sites that were within the lower ranges of dissolved oxygen.

5.5 Troglofauna

A total of 935 terrestrial invertebrate specimens were collected. The vast majority (95%) of these were clearly of epigean (surface) or endogean (soil) origin. Seventy troglomorphic specimens representing 11 morpho-species were collected and identified (Table 7). The troglofauna comprised of pseudoscorpions, symphylids, diplurans, cockroaches, beetles, planthoppers and isopods (full data in appendix 3).

Invertebrate communities generally consist of a few, very abundant species and many more species being represented by relatively few individuals. The troglomorphic community as represented by the results of this survey adhered to this general pattern.

The most abundant species (from family Nocticolidae) accounted for over 71% of individuals collected, while the remaining nine species contributed only 29% of total number of individuals collected (Figure 8). The most abundant troglomorphic species was *Nocticola* sp. S5_NS1 representing 53% of all specimens, and *Nocticola* sp. NS_2 was the next most abundant. Seven specimens of *Nocticola* sp. indet., were unable to be identified to species level because they were juvenile.

TABLE 7: Troglofauna morpho-species collected at the NSP Study Area, including number of individuals and the number of bores each species was recorded from.

Sub-Phylum	Class	Order	Family	Morpho-species	Number of individuals	Number of bore records
Chelicerata	Arachnida	Pseudoscorpiones	Chtoniidae	Chthoniidae sp. NS	1	1
Myriapoda	Diplopoda	Polyxenida		Polyxenida sp. NS	1	1
	Symphyla			Symphyla sp. NS	1	1
Hexapoda	Entognatha	Diplura	Japygidae	Anajapygidae sp. NS	6	2
	Insecta	Blattodea	Blattidae	Blattidae sp. NS	1	1
			Nocticolidae	*Nocticola* sp. NS_2	7	3
				Nocticola sp. S5_NS1	46	16
		Coleoptera	Curculionidae	Curculionidae sp. NS	2	1
			Carabidae	Anillini sp. NS	3	2
		Hemiptera	Meenoplidae	Meenoplidae sp. NS	2	2
Crustacea	Malacostraca	Isopoda		*Troglarmadillo* sp. NS	1	1
				TOTAL	71	35
Incompletely identified taxa						
Hexapoda	Insecta	Blattodea	Blattidae	*Nocticola* indet.	7	5

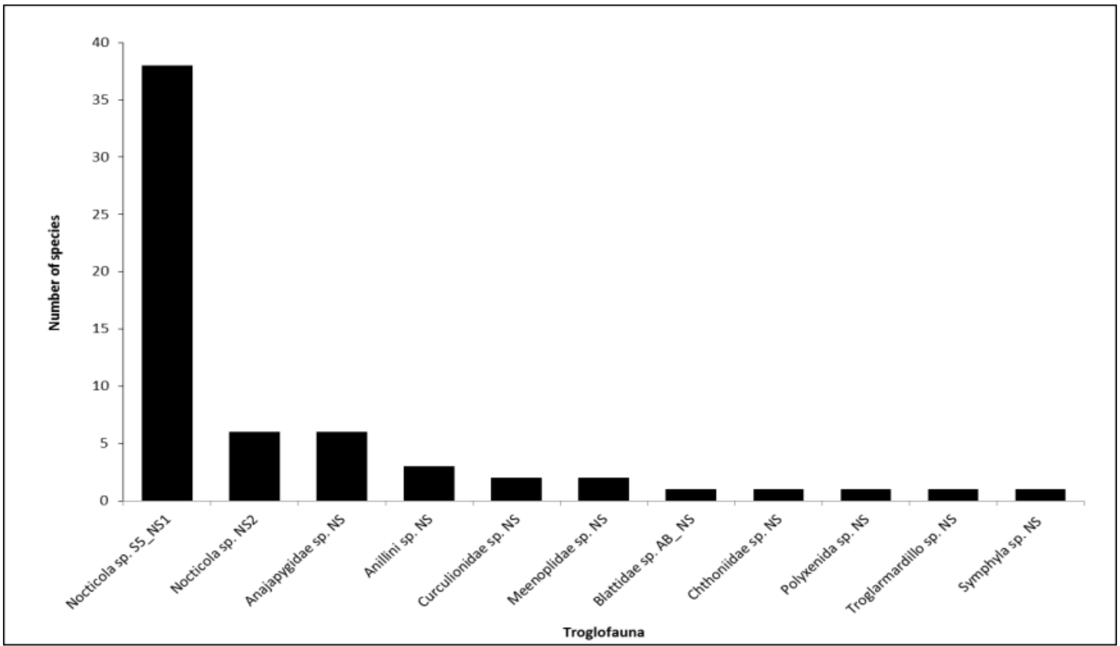

FIGURE 8: Abundance of troglomorphic taxa in samples from the Study Area.

Of the 11 troglomorphic species recorded from the NSP Study Area, two are known from elsewhere within the Pilbara (Table 8). The cockroach *Nocticola* sp.S5_ NS1 is a widespread species; recorded from numerous areas within the Pilbara and the Blattidae sp. AB_NS was shown to be of similar genetic lineage as Blattidae sp., recorded from a previous survey of a nearby area (Subterranean Ecology unpubl.).

The nocticolids, *Nocticola* sp. S5_NS1, *Nocticola* sp. NS2, the Blattidae sp. AB_NS and the Anillini sp. NS have been recorded from both within the proposed NSP Study Area impact zone and Glacier Valley, proposed non-impact zone (Table 8). Further, the *Troglarmadillo* sp. NS has only been recorded from within the proposed non-impact zone at Glacier Valley (Table 8).

Five species have to date only been collected from within the proposed impact area (Table 8). While two of these species (Polyxenida sp. NS, and Meenoplidae sp. NS) have morphologically similar species recorded from outside proposed footprint areas, these records have not been confirmed as the same species. The other four species (Curculionidae sp. NS, Symphyla sp. NS, Anajapygidae sp. NS and Chthoniidae sp. NS) have only been recorded from within proposed footprint areas.

TABLE 8: Collection records of troglofauna in relation to project impact / footprint and other areas. Morpho-species in bold may be of potential conservation concern in relation to the project.

Taxon		North Star (proposed pit)	North Star (proposed waste dump, tailings, footprint)	Glacier Valley (Reference)	Adjacent NSP Study Area (Reference)	Other Records	Reference
Arachnida	Chthoniidae sp. NS		□			x	(Helix 2011g)
Diplopoda	Polyxenida sp. NS	□				?*	(Helix 2011c)
	Symphyla sp. NS		□			x	(Helix 2011f)
Entognatha	Anajapygidae sp. NS		□			x	(Helix 2011b)
Insecta	Blattidae sp. AB_NS	□		□	□	□	(Helix 2011a)
	Nocticola sp. S5_NS1	□		□	□	?*	(Helix 2011a,Ecologia 2011)
	Nocticola sp. NS2	□		□		?*	(Helix 2011a, Ecologia 2011)
	Curculionidae sp. NS	□				x	(Helix 2011d)
	Anillini sp. NS		□	□		x	(Helix 2011d)
	Meenoplidae sp. NS	□	□			?*	(Helix 2011e)
Malacostraca	*Troglarmadillo* sp. NS			□		x	(Helix 2011h)

***** **?** **Unconfirmed**

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5.6 Troglofauna Genetic Diversity

DNA sequencing confirmed morpho-species designations and characterised the genetic variation between populations and species at local and sub-regional scales. Nine troglomorphic orders were sequenced for DNA, resulting in eleven morpho-species being recorded during the survey.

Pseudoscorpiones

Four specimens of Chthoniidae were analysed using the mitochondrial gene CO1. A total of two morpho-species were confirmed by this analysis, Chthoniidae sp. NS (one specimen from North Star survey, Plate 2) and *Tyrannochthonius* sp. S3 (three specimens from Abydos survey undertaken by Subterranean Ecology. The sequence divergence (6.6 to 24.3 %) between the two groups indicates that these are separate species, and may have been isolated from one another by between 2.8 and 3.3 million years (Finston and Terry 2011g). *Chthoniidae sp. NS* is a distinct species as yet known only from the NSP Study Area (Finston and Terry 2011g). The distribution of the endemic morpho-species within the Study Area is shown in Figure 9.

PLATE 2: Dorsal view of Chthoniidae sp. NS.

Symphyla

One specimen of Symphyla was analysed genetically to determine if the sequence divergence of this specimen differed to those found elsewhere in the Pilbara. The morpho-species Symphyla sp. NS differed from other species in the area by 23.6% to 34.3 % sequence divergence, indicating it is a distinct species as yet known only from the Study Area (Finston and Berry 2011f). The collection record of this morpho-species is shown in Figure 10.

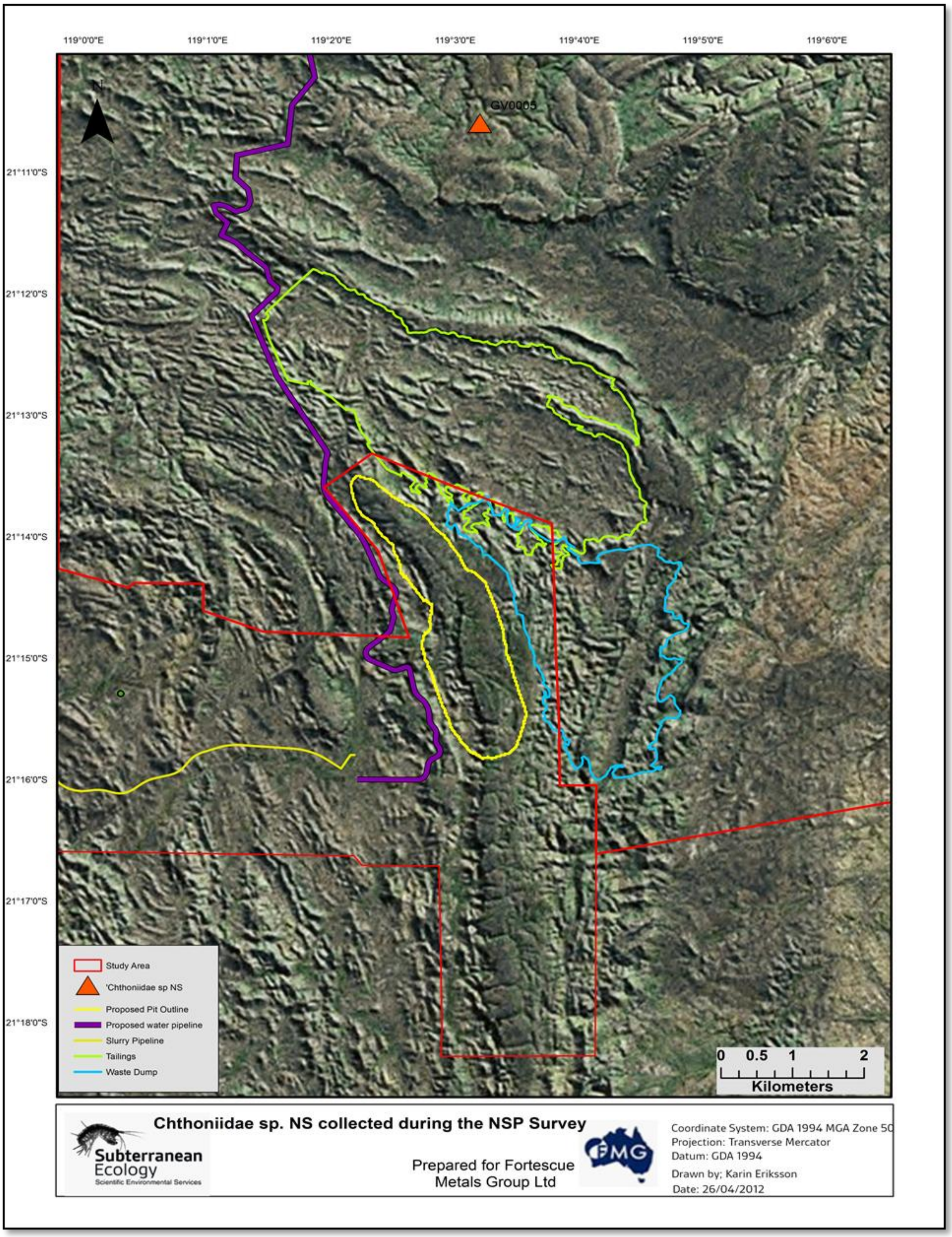

FIGURE 9: Pseudoscorpion collection sites in the North Star Project.

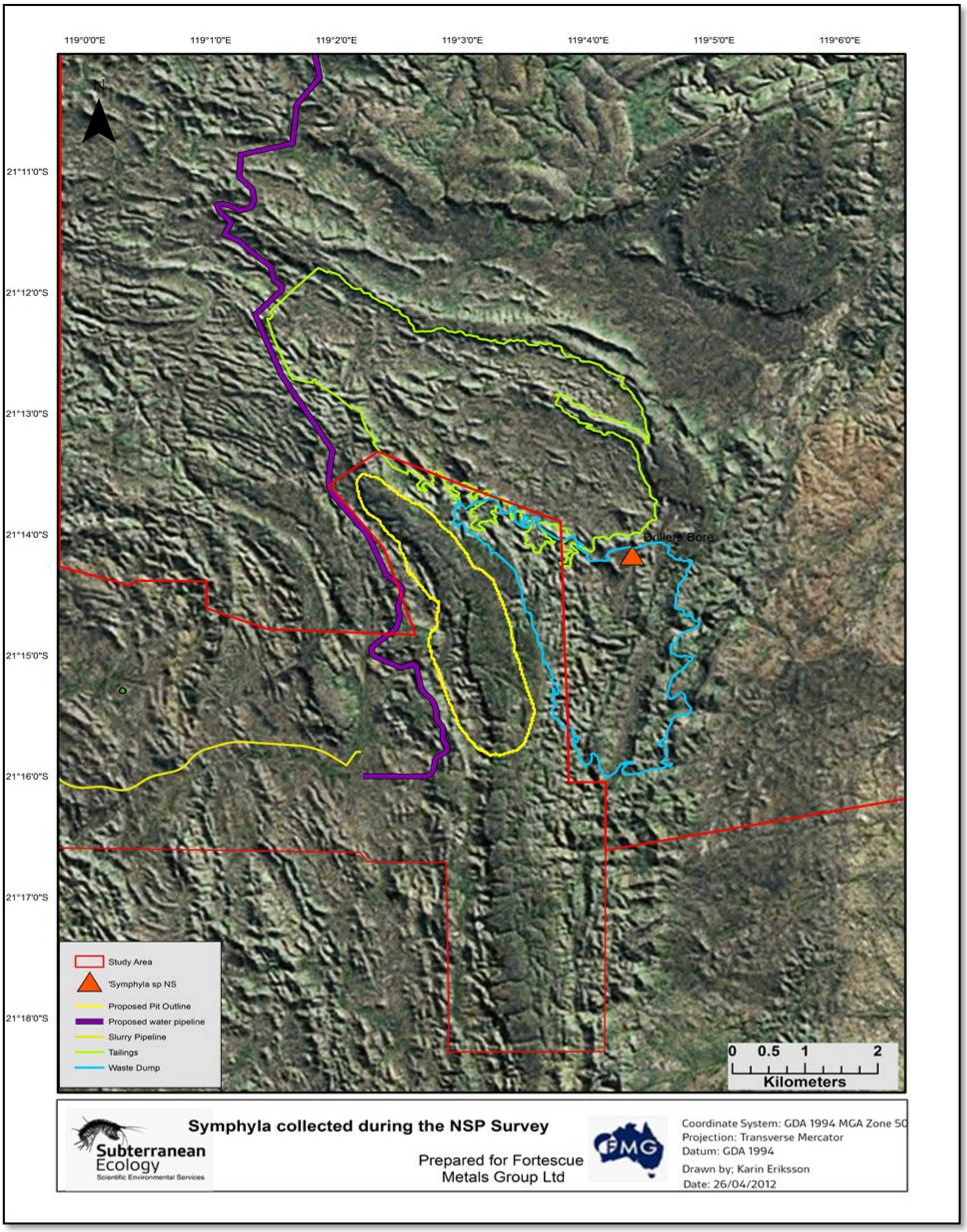

FIGURE 10: Symphylid collection sites in the North Star Project.

Diplura

Two specimens of diplurans were analysed using the COI mitochondrial gene, which resulted in the confirmation of one morpho-species, Anajapygidae sp. NS. The sequence divergence from other known species in the Pilbara ranged between 19.5% and 27.9 %. This indicates that this morpho-species is distinct, and have yet to be recorded from elsewhere in the Pilbara (Finston and Terry 2011b) (Figure 11).

Coleoptera

Four specimens of Coleoptera were sequenced for variation at the CO1 mitochondrial gene. Two specimens failed to amplify, while the two remaining specimens, the Anillini sp. NS (Plate 3) and Curculionidae sp. NS, have, to date, only been recorded from within the Study Area. Anillini sp. NS differed from Curculionidae sp. NS by 24% sequence divergence (Finston and Terry 2011d). The location of these morpho-species is shown in Figure 12).

PLATE 3: Dorsal view of Anillini sp. NS.

Hemiptera

Genetic analysis was undertaken on one specimen of planthopper. The mitochondrial gene CO1 was analysed for variation and the morpho-species Meenoplidae sp. NS, was confirmed. The sequence divergence from all other meenoplids known in the Pilbara region ranged from 11.6% to 22.1%, thus the Meenoplidae sp. NS have, to date, only been recorded from within the Study Area (Finston and Terry 2011e) (Figure 13).

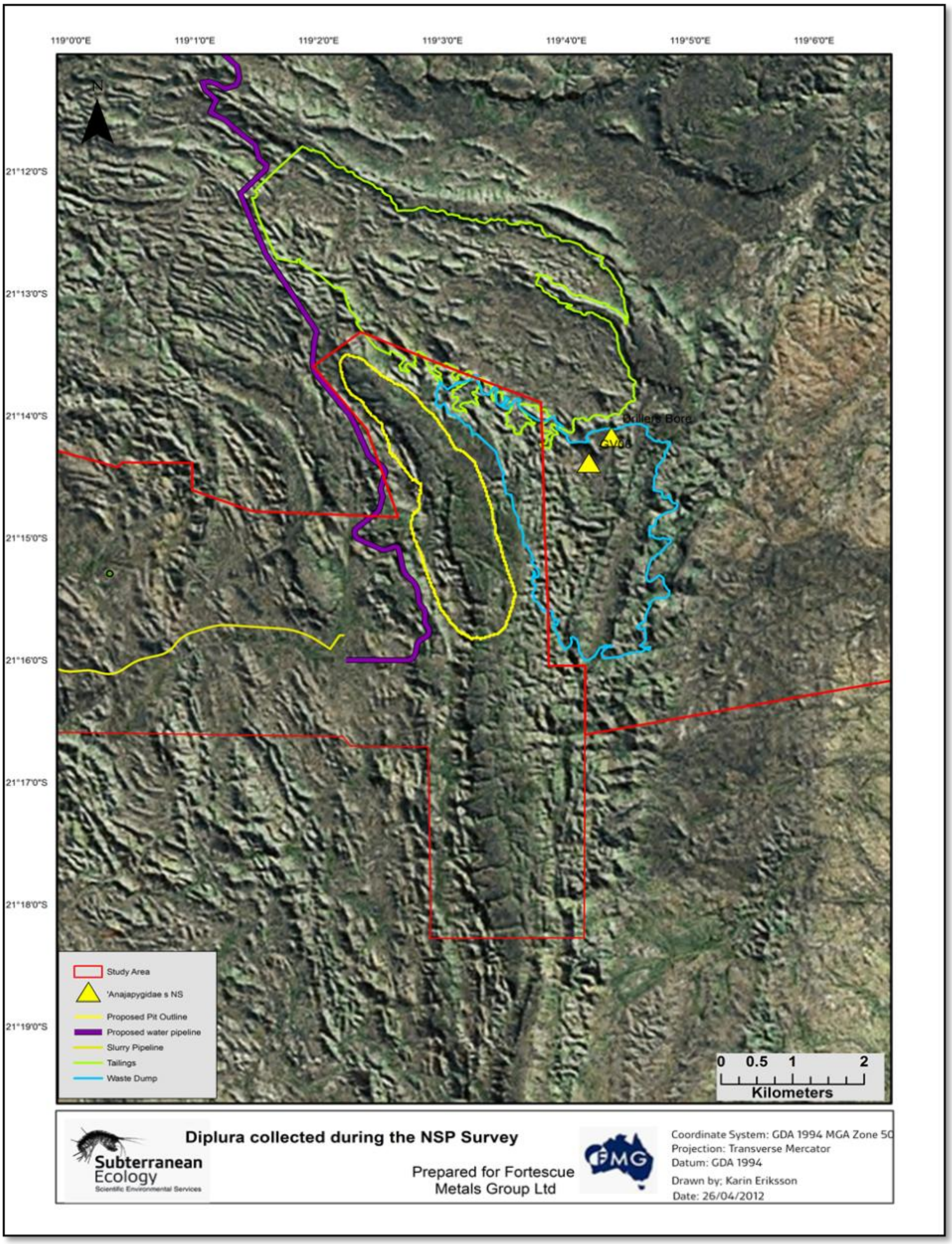

FIGURE 11: **Dipluran collection sites in the North Star Project**.

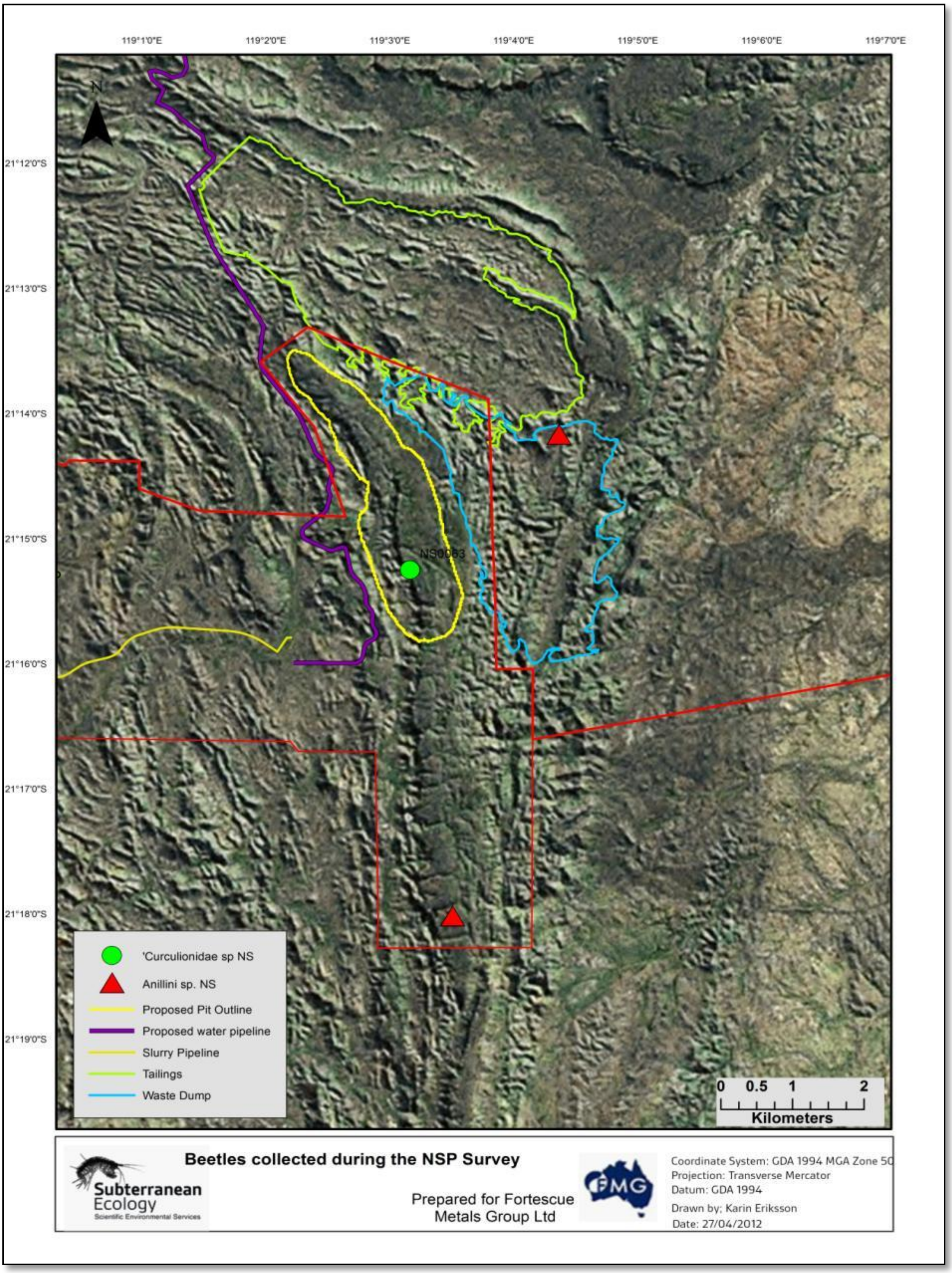

FIGURE 12: **Beetle collection sites in the North Star Project.**

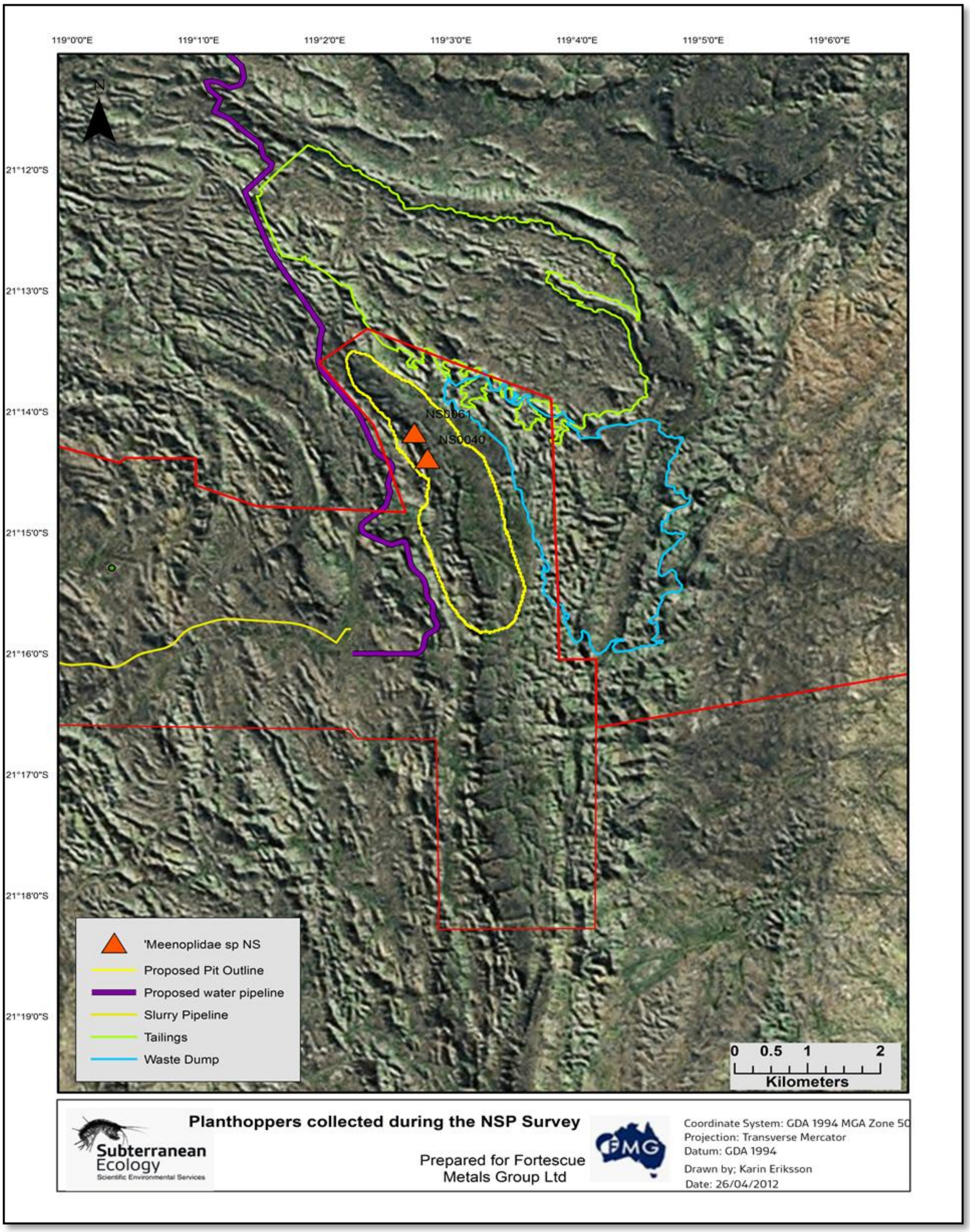

FIGURE 13: **Planthopper collection sites in the North Star Project.**

Polyxenida

Two specimens of Polyxenida (one from the North Star survey and one from a previous survey at Abydos were sequenced for variation at the CO1 and 12s mitochondrial genes. While the polyxenid recoded from Abydos is a widespread species, that from North Star, *Polyxenida* sp. NS (Plate 4), was found to be distinct from within the Study Area and differed from other species by around 30% sequence divergence (Finston and Terry 2011c) (Figure 14).

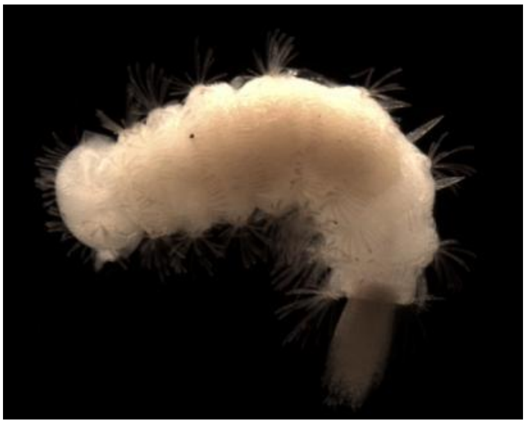

PLATE 4: Dorsal view of Polyxenida sp. NS.

Blattodea

Eight specimens of Blattodea were sequenced for variation at the CO1 mitochondrial gene. Two specimens were assigned to the morpho-species, Blattodea sp. BA_NS which is widespread across the Pilbara (Finston and Terry 2011a). Three specimens from within the Study Area and one from an earlier survey at Abydos were found to belong to the same lineage, *Nocticola* sp. S5_NS1 (Finston and Terry 2011a). One specimen *Nocticola* sp. NS2 (Plate 5), have, to date, only been recorded from within the Study Area (Finston and Terry 2011a). The location of these morpho-species is shown in Figure 15.

PLATE 5: Dorsal view of Nocticolid sp. S5_NS1.

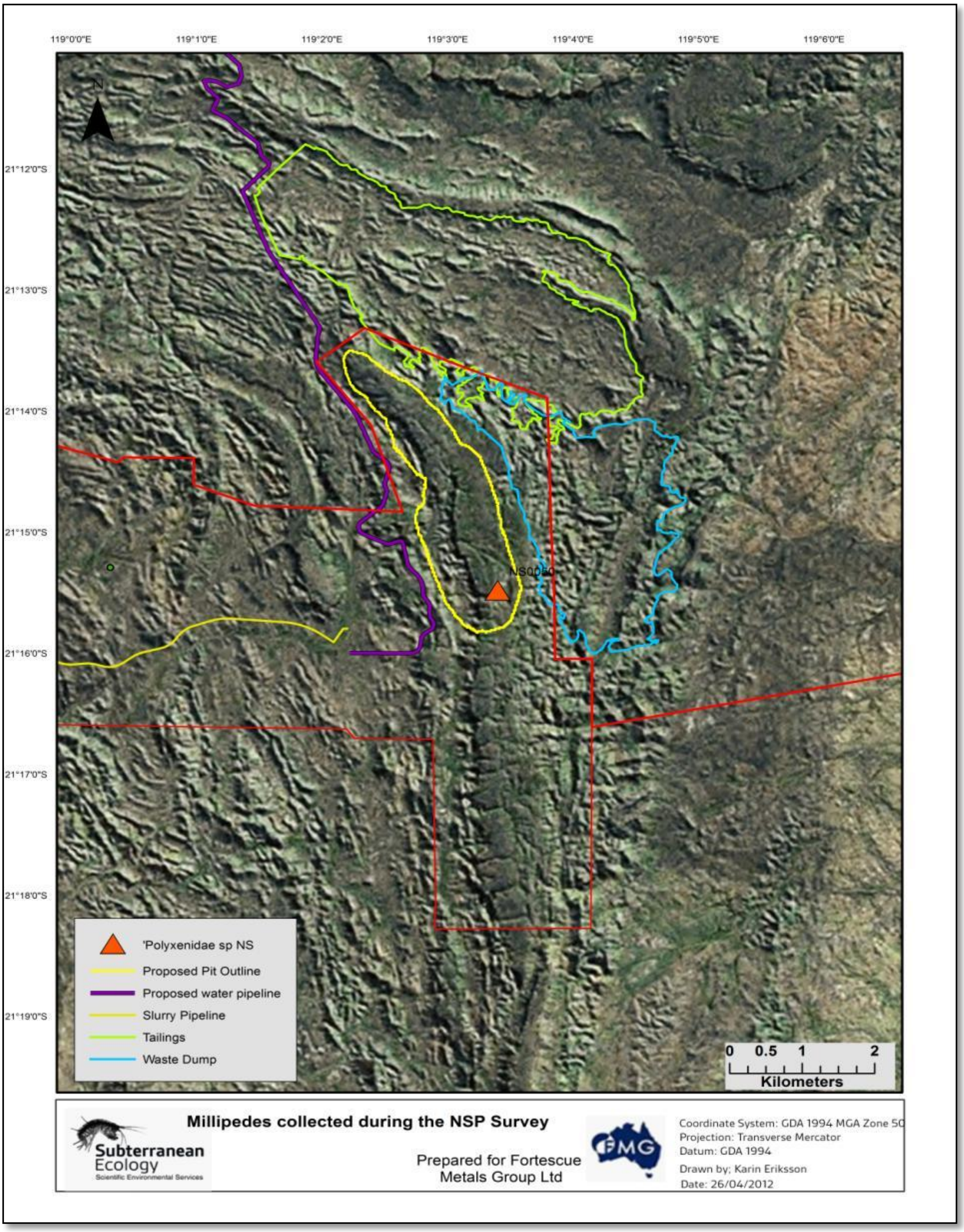

FIGURE 14: Millipedes collection sites in the North Star Project.

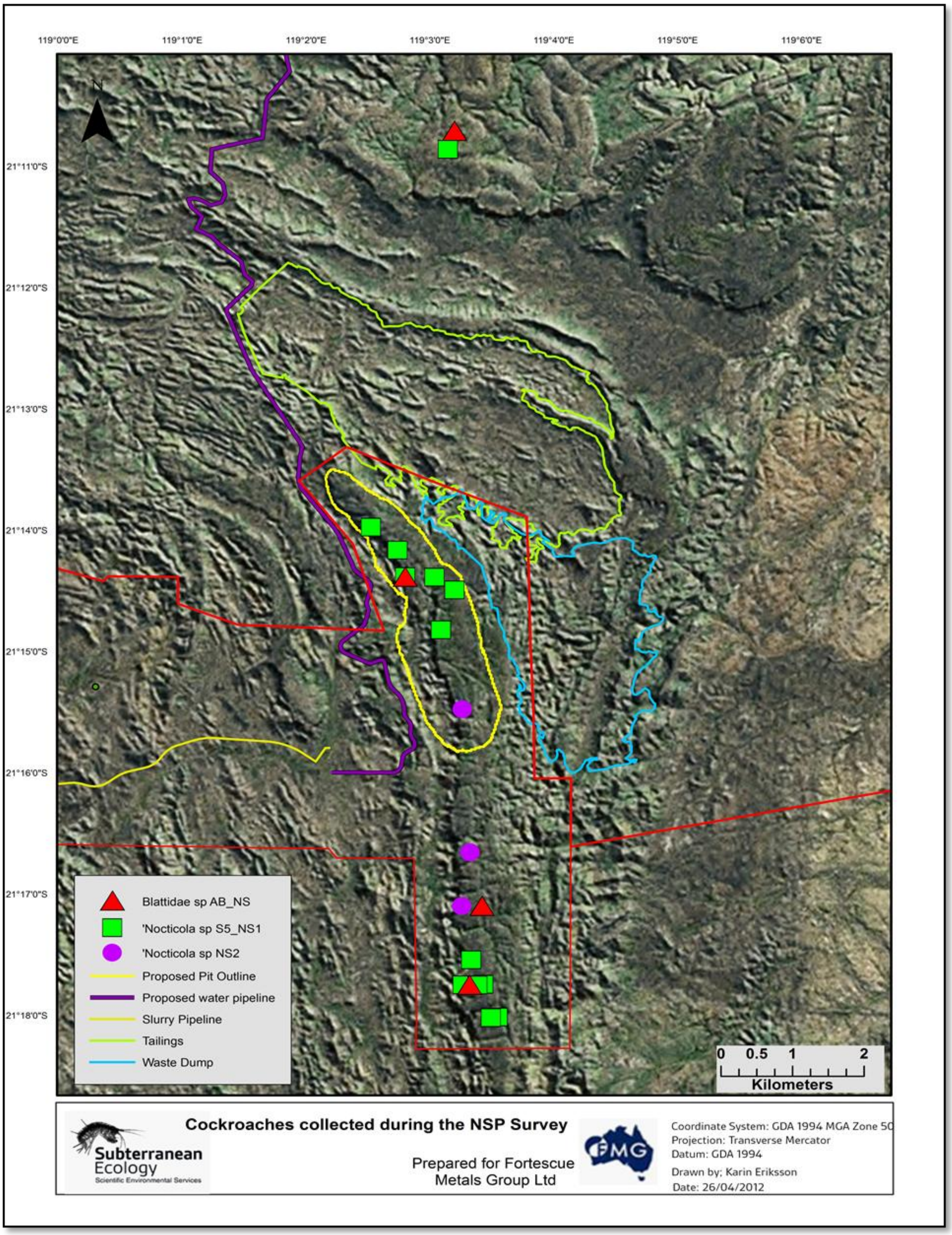

FIGURE 15: **Cockroaches collection sites within North Star Project.**

Isopoda

Genetic analysis was undertaken on one specimen of isopoda. The mitochondrial gene CO1 was analysed for variation and the morpho-species *Troglarmadillo* sp. NS was confirmed (Plate 6). This species is distinct to the Study Area, as the sequence divergence from all other known lineages of Troglarmadillo in the Pilbara region ranged from 22.2 to 27.6% (Finston and Terry 2011h). *Troglarmadillo* sp. NS has to date, only been recorded within the Study Area (Figure 16).

PLATE 6: Lateral view of *Troglarmadillo* sp. NS.

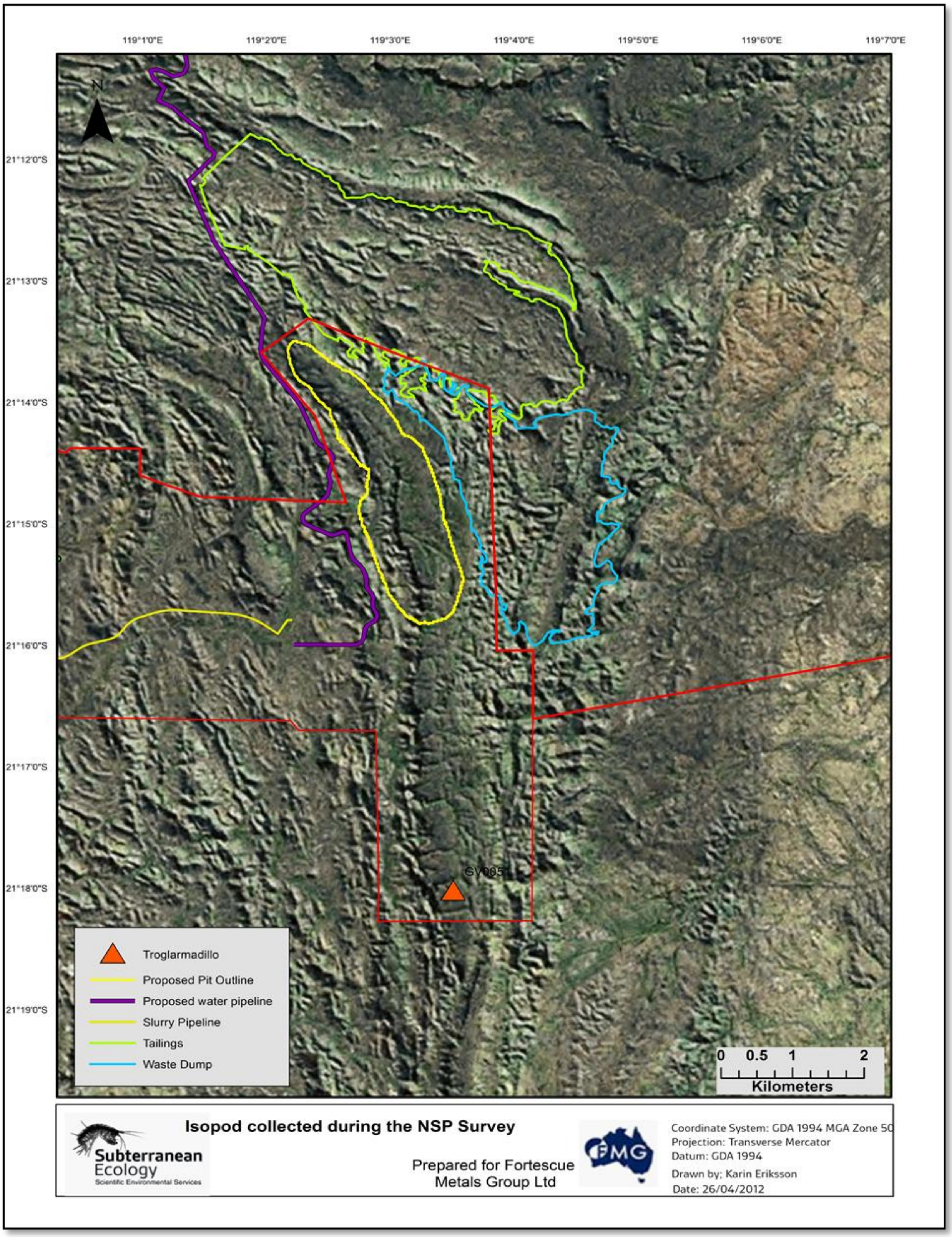

FIGURE 16: **Isopod collection sites within the North Star Project.**

5.7 Troglofauna Survey Completeness

At the NSP sites 42% of sampled drill holes yielded troglofauna. The species accumulation curve, which was based on the troglomorphic species collected from traps, scrapes and net hauls, indicated that, from a total of 154 samples, the curve is near reaching a plateau (Figure 17). The species richness estimators in EstimateS (Colwell 2006) predicted that approximately 83% of troglofauna species present have been collected to date.

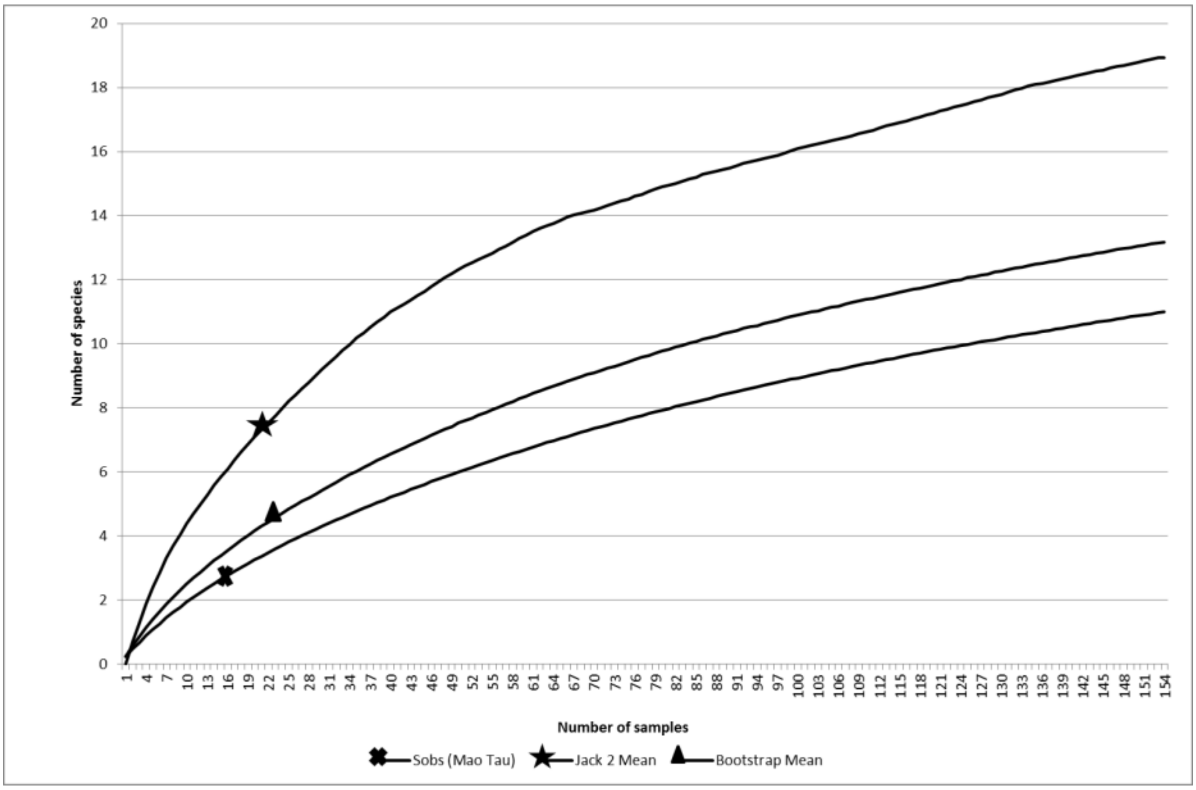

FIGURE 17: Species accumulation curve (Sobs Mao Tau, Jack 2 Mean and Bootstrap Mean - EstimateS Colwell 2006) for troglofauna species in the surveyed area.

A high proportion of predicted total species have been detected in the survey which suggests adequate sampling effort within the BIF orebody. The rate at which troglofauna species collected is however slower than stygofauna species due to a higher proportion of singletons, which is often due to the fact that troglofauna species require more effort to collect than stygofauna species.

6 DISCUSSION

The survey confirmed the occurrence of at least 17 stygofauna taxa and 11 morpho-species of troglofauna at the NSP Study Area. A study conducted by Subterranean Ecology (unpubl.) at nearby Abydos, recorded 11 troglofauna morpho-species in Gorge Creek BIF, similar geology constituting the NSP Study Area.

The groundwater analyses conducted at the NSP Study Area suggest water quality was within the acceptable range for stygofauna, and there were no extreme physico-chemical measurements that would preclude the presence of stygofauna.

The sampling effort at the NSP Study area exceeded EPA (2007) minimum recommended guidelines for troglofauna and met the guidelines for stygofauna, with 153 troglofauna samples and 52 stygofauna samples collected over three field trips. Most of the stygofauna were recorded from low lying alluvial plains, whereas the majority of troglofauna were recorded from the BIF orebody within the NSP Study Area. Consistent with other surveys in the region, the species accumulation curves for both stygofauna and troglofauna derived from the survey results indicated that the majority of subterranean fauna species present had been collected (~87% for stygofauna; ~83% for troglofauna). While in both cases the curves indicate a high sampling efficiency, not much additional effort would be required to reach a plateau.

For the stygofauna, while no species were collected only from within the proposed impact footprint, two species of amphipod, Paramelitidae sp. NS and Melitidae sp. NS1, were collected just outside the impact area. These two species / haplotypes are distinct from other known Pilbara species / haplotypes (Finston and Berry 2011 i, j) and are currently only known from Gusboy Bore and Packers Bore located within 500 – 1000 meters of the proposed tailings dam and waste dump.

The survey results revealed a small proportion of troglofauna species occurring at multiple sampling sites within the BIF orebody. This is particularly the case for the order Blattodea and may be attributed to the relatively small distances between some BIF habitats and the potential for some species to exhibit wider ranges. Two species within the order Blattodea, *Nocticola* sp. S5_NS1 and Blattodea sp. AB_NS were also recorded at Abydos (Subterranean Ecology unpubl.).

The geology of the North Star orebody shows well developed secondary porosity in the shallow subsurface BIF suggesting highly prospective troglofauna habitat (Plate 7). The deeper sections within this rock type however display no cavities, i.e. no habitat or habitat connections. This could explain the very low record of stygofauna collected from within the North Star orebody compared to the much higher record from the alluvium aquifer, suggesting better connectivity and habitat opportunities in the latter formation.

PLATE 7: Prospective troglofauna habitat at North Star showing well developed secondary porosity in shallow subsurface BIF (top right and left) and total absence of porosity / cavities in deeper sections (lower) (Photos Subterranean Ecology taken at the North Star prospect July 2011).

Six troglofauna morpho-species have been recorded, to date, only from proposed footprint areas in the NSP Study Area. These are

- Polyxenida sp. NS – proposed pit areas (unlikely to be SRE)
- Curculionidae sp. NS – proposed pit areas (potential SRE)
- Meenoplidae sp. NS – proposed pit areas (unlikely to be SRE)
- Symphyla sp. NS – infrastructure areas with no impact expected (potential SRE)
- Anajapygidae sp. NS – infrastructure areas with no impact expected (potential SRE)
- Chthoniidae sp. NS – infrastructure areas with no impact expected (potential SRE)

As far as the troglofauna listed above are concerned, while there are no records from other areas, two of the six morpho-species are members of taxonomic groups (Meenoplidae and Polyxenida) which are not usually range-restricted or dispersal limited. The Symphyla and Anajapygidae are taxonomically poorly described and the species / haplotypes Symphyla sp. NS and Anajapygidae sp. NS are genetically distinct from other sequenced members of these groups in the region. The Curculionidae and Chthoniidae families are characterised by numerous subterranean species in the Pilbara that are potential SRE's.

While the wide distribution of the geologies from which these species were found might suggest wider range distributions for these species, it cannot be assumed that the distribution range of subterranean species will necessarily be concordant with the geology. There are numerous examples of Pilbara troglofauna whose distribution ranges are restricted to relatively small areas within larger contiguous geological units, with no apparent barriers to habitat connectivity and fauna dispersal. Therefore it cannot be concluded that the wider occurrence of contiguous geological habitat at North Star necessarily infers a distribution range for Curculionidae sp. NS, or other potential SRE species, outside the project impact area.

7 IMPACT ASSESSMENT

7.1 General Potential Impacts

Because they occur underground, subterranean fauna usually have limited dispersal capacity and may therefore have localised distributions (Gibert and Deharveng 2002; Harvey 2002). The following general potential impacts of mining development are noted in the EPA (2003) Guidance Statement No. 54 (see also Table 9):

> *Lowering the water table sufficiently to dry out the zone in which some species live, or otherwise artificially changing water tables; or*
>
> *Causing a change in water quality (e.g. increasing salinity levels or altering haloclines, or an increase in nutrient levels or the availability of organic matter, or introducing pollutants); or*
>
> *Destroying or damaging caves (and other potential troglofauna habitat) including changing their temperature and humidity.* (EPA 2003)

TABLE 9: Potential impact risks to Subterranean Fauna

Hazard	Potential Impacts	
	Stygofauna	Troglofauna
Groundwater Abstraction	Localised loss of stygofauna Loss of stygofauna habitat	Localised loss of troglofauna habitat
Groundwater Pollution	Localised loss / reduction of stygofauna	
Soil excavation	Localised erosion, sedimentation, turbidity impacts to groundwater habitats	Localised loss / reduction of troglofauna Loss of troglofauna habitat
Soil pollution	Groundwater quality compromised	Localised loss / reduction of troglofauna
Overburden stockpiles, waste dumps & tailings – partial / complete sealing of surface-subsurface interface.	Habitat quality compromised. Loss of rhizosphere. Localised reduction / loss of rainfall recharge, nutrient inputs, roots, atmospheric and groundwater circulation. Localised loss/decrease of stygofauna	Habitat quality compromised. Loss of rhizosphere. Localised reduction / loss of rainfall recharge, nutrient inputs, roots, atmospheric and groundwater circulation. loss/decrease of troglofauna

7.2 Project Specific Potential Impacts & Risks to Subterranean Species

The main potential impacts for subterranean fauna identified in relation to this project are:

- Habitat removal (mine pit)
- Habitat alteration (tailings dam, waste dump area)
- Changes in groundwater quality and regime (tailings dam, waste dump, localised pumping, contamination).

The proposed habitat removal (mine pit) represents approximately 16% of the area of contiguous Gorge Creek BIF outcrop, while the area of habitat alteration (tailings dam, waste dump) represents approximately 28% of the area of contiguous Gorge Creek iron mudstone/siltstone outcrop as depicted on the 1:500 000 geology sheet (2011 – Figure 2).

Aside from naidid and enchytraeid oligochaetes, whose ecological status has been previously discussed, no stygobitic species were detected from the Gorge Creek BIF at North Star (proposed mine pit) or Glacier Valley (reference area). As minimal pit dewatering is anticipated, and process water supply will be sourced from outside the study area, no major groundwater drawdown impacts are likely, although localised pumping from Gusboy and Packers Bores should be considered to manage the risk of impacts to groundwater habitat for Paramelitidae sp. NS and Melitidae sp. NS1. These two amphipod species (genetically distinct from other Pilbara species / haplotypes) are presently only recorded from Packers Bore and Gusboy Bore, hence these two species may be of potential conservation concern in relation to this project should extraction from these bores be required and/or changes to groundwater quality / contamination are propagated from the tailings dam / waste dump areas nearby.

Potential changes to groundwater quality and groundwater regime, including contamination and/or potential impacts to groundwater from the tailings / waste dump areas can be managed through standard groundwater quality protection procedures and monitoring of groundwater levels, groundwater quality, and stygofauna. Further targeted surveys for Paramelitidae sp. NS and Melitidae sp. NS1 may reveal a wider distribution.

Six troglofauna species have to date only been recorded from within the proposed mine pit (Polyxenida sp. NS, Curculionidae sp. NS, Meenoplidae sp. NS) and tailings dam / waste dump area (Symphyla sp. NS, Anajapygidae sp. NS Chthoniidae sp. NS). Of these six species, all except Curculionidae sp. NS and Chthoniidae sp. NS belong to families that are generally not known to be range restricted, and the wider distribution of geo-habitat make it likely that these four species have distributions beyond the proposed mine footprint. The subterranean Curculionidae and Chthoniidae have generally lower dispersal capabilities and include multiple potential range-restricted species in the Pilbara. Chthoniidae sp. NS was found only within infrastructure areas and not within pit impact areas and so is not expected to be impacted by project activities. Curculionidae sp. NS, however was found only from pit impact areas and consequently may be a species of potential conservation concern in relation to this project.

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9 APPENDICES

Appendix 1: Drill hole / bore hole names and locations (in decimal degrees) at the North Star Project Study Area and the Type of sampling undertaken during each visit.

Bore Code	Lat.	Long.	T1	T2	T3	Subterranean Fauna Collected
GV0052	-21.29952	119.06093		L	L	□
GV0051	-21.29962	119.06001		L	L	□
GV0050	-21.2997	119.05894		L	L	
GV0014	-21.28426	119.05859		L	L	□
GV0016	-21.28433	119.05586		L	L	□
GV0035	-21.29515	119.05616		L	L	□
GV0036	-21.29511	119.05705		L	L	□
GV0037	-21.29514	119.05813		L	L	□
GV0038	-21.29504	119.05891		L	L	□
GV0028	-21.29171	119.05725		L	L	□
GV0029	-21.29156	119.05806		L	L	
GV0030	-21.29149	119.05886		L	L	
GV0034	-21.29144	119.05999		L	L	
GV0011	-21.27716	119.05597		L	L	
GV0012	-21.27695	119.05688		L	L	□
GV0054	-21.27349	119.0559		L	L	
GV0039	-21.26986	119.05471		L	L	□
GV0040	-21.26971	119.05552		L	L	□
GV0022	-21.26051	119.05656		L	L	
GV0023	-21.26076	119.05835		L	L	
GV0009	-21.24641	119.05156		L	L	
GV0006	-21.2464	119.05253		L	L	□
GV0008	-21.24637	119.0545		L	L	
GV0021	-21.23202	119.04368		L	L	
GV0020	-21.23178	119.04566		L	L	□
NS0025	-21.22844	119.04071		L	L	□
NS0026	-21.22844	119.0416		L	L	□
NS0027	-21.23199	119.04461		L	L	□
NS0075	-21.23239	119.04292		L	L	□
NS0028	-21.23239	119.04292		L	L	□
NS0061	-21.23565	119.04585	N / S	N / S / L	N / S / L	□
NS0062	-21.23552	119.04655		L	L	□
NS0004	-21.23595	119.04749		L	L	

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Bore Code	Lat.	Long.	T1	T2	T3	Subterranean Fauna Collected
NS0029	-21.2357	119.04849			L	□
NS0005	-21.23555	119.04937		L	L	
NS0040	-21.23916	119.04762	N / S	N / S / L	N / S / L	□
NS0031	-21.23914	119.04964		L	L	□
NS0041	-21.24104	119.05245		L	L	□
NS0039	-21.24089	119.0543		L	L	□
NS0101	-21.2446	119.05443		L	L	□
NS0059	-21.24816	119.05252		L	L	□
NS0069	-21.2482	119.05454		L	L	□
NS0076	-21.25171	119.05277		L	L	□
NS0052	-21.25171	119.0548		L	L	□
NS0053	-21.25156	119.05551		L	L	□
NS0064	-21.25365	119.0545		L	L	□
NS0049	-21.25357	119.05649		L	L	□
NS0009	-21.25359	119.06055		L	L	
NS0067	-21.25728	119.05556		L	L	□
NS0050	-21.25727	119.05762		L	L	□
NS0010	-21.2666	119.05578		L	L	□
NS0011	-21.26612	119.05639		L	L	
NS0045	-21.24701	119.05476	N / S	N / S / L	N / S / L	□
NS0063	-21.2536	119.05362	N / S	N / S / L	N / S / L	□
NS0066	-21.25343	119.06146	N / S	N / S / L		□
NS0038	-21.24112	119.05342		L	L	□
NS0042	-21.143395	119.031421			L	□
Drillers Bore	-21.2353	119.07341	N / S	N / S / L	N / S / L	□
GV06	-21.23889	119.07041	N / S	N / S / L	N / S / L	□
GVW06	-21.23889	119.0704	N	N	N	□
Packers Bore	-21.21498	119.07966	N	N	N	□
Gusboy Bore	-21.19538	119.05006	N	N	N	□
GV07	-21.21498	119.03602	N	N	N	
Coppings Bore	-21.07669	118.88791	N	N		□
Turner Well	-21.22795	118.82605	N	N	N	□
NS0074	-21.144025	119.030924			L	□
NS0029	-21.144035	119.031409		L	L	□
NS0060	-21.145331	119.031264			L	□
NS0007	-21.145632	119.031636			L	□

Bore Code	Lat.	Long.	T1	T2	T3	Subterranean Fauna Collected
NS0030	-21.142098	119.025482			L	□
NS0079	-21.142078	119.030564		N / S / L		□
NS0068	-21.152578	119.032385			L	□
GV0001	-21.104902	119.030923			L	□
GV0003	-21.103982	119.031233			L	□
GV0004	-21.103631	119.031235			L	□
GV0005	-21.103309	119.031223			L	□
WSO5P3	-21.031143	118.423497		N	N	□
WSO6P2	-21.052968	118.431446		N	N	□
WSO8P1	-21.24164	118.524125		N		□
WSO8P3	-21.24106	118.524277		N		□
WSO8P4	-21.222153	118.513435		N		□
WSO7AP1	-21.110028	118.454944		N		□
WSO7AP1B	-21.110028	118.454944			N	□

Appendix 2: Abundance and distribution of stygofauna taxa among the drill holes sampled at the NSP Study Area during 2011.

Higher Taxa – Species	WS08P4	WS08P3	WS08P1	WS07AP1B	WS07AP1	WS06P2	WS05P3	TURNER WELL	GUSBOY BORE	NS0066	NS0063	NS0045	GVW06	GV0020	DRILLERS BORE	COPPINGS BORE	TOTAL
AMPHIPODA																	
Paramelitidae sp. NS		2	13	17			13	1	2							7	55
Bogidiellidae sp. NS		1				1										6	8
Nedsia sp. indet				2		2	6									4	14
Melitidae sp. NS				1		1	1										3
BATHYNELLACEA																	
Bathynellidae sp. NS																60	60
Parabathynellidae sp. NS	10	1	1										2				14
CYCLOPOIDA																	
Diacyclops humphreysi	5	15	70	1	7	7	39		6						81		231
Microcyclops varicans								22							4		26
Diacyclops sobeprolatus		13				4	1										18
HARPACTICOIDA																	
Elaphoidella humphreysi	50	24	102	3		38	42	6	28							254	547

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Higher Taxa – Species	WSO8P4	WSO8P3	WSO8P1	WSO7AP1B	WSO7AP1	WSO6P2	WSO5P3	TURNER WELL	GUSBOY BORE	NS0066	NS0063	NS0045	GVW06	GV0020	DRILLERS BORE	COPPINGS BORE	TOTAL
PODOCOPIDA																	
Cypridiae sp. indet						1		23									24
Ostracoda sp. NS1						2											2
Ostracoda sp. NS2								1									1
Ostracoda sp. NS3								1									1
OLIGOCHAETA																	
Phreodrilidae sp. indet		1					4										5
Dero furcata											1						1
Naididae sp. indet								19									19
Naididae sp. NS											1						1
Enchytraeidae sp. indet				6								2	4		1	1	14
TOTAL	65	57	186	30	7	56	106	73	36	2	2	4	2	1	1	416	1044

Appendix 3: Abundance and distribution of troglofauna taxa among the drill holes sampled at the NSP Study Area during 2011.

Higher Taxa – Species	NS0079	GV0052	GV0005	GV0003	GV0001	NS0075	NS0067	NS0063	NS0062	NS0061	NS0050	NS0040	NS0039	GV06	GV0051	GV0040	GV0038	GV0037	GV0036	GV0035	GV0028	GV0016	GV0014	GV0012	GV0006	DRILLERS BORE	TOTAL
PSEUDOSCORPINES																											
Chthoniidae sp. NS				1																							1
POLYXENIDA																											
Polyxenida sp. indet											1																1
Symphyla sp. indet																										1	1
ENTOGNATHA																											
Anajapygidae sp. NS														2												4	6
MALACOSTRACA																											
Troglarmadillo sp. NS															1												1

Higher Taxa – Species	NS0079	GV0052	GV0005	GV0003	GV0001	NS0075	NS0067	NS0063	NS0062	NS0061	NS0050	NS0040	NS0039	GV06	GV0051	GV0040	GV0038	GV0037	GV0036	GV0035	GV0028	GV0016	GV0014	GV0012	GV0006	DRILLERS BORE	TOTAL
INSECTA																											
Blattidae sp. indet												1															1
Nocticola sp.NS_2		4																				2		1			7
Nocticola sp. S5_NS1	1			1	1	1			4			3	6		3	1	2	3	1	4	5		5		5		46
Curculionidae sp. NS								2																			2
Anillini sp. NS															2											1	3
Meenoplidae sp. NS										1		1															2
TOTAL	1	4	1	1	1	1	1	2	4	1	1	5	6	2	5	1	2	3	1	4	5	2	5	1	5	6	70

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