PHOENIX
ENVIRONMENTAL SCIENCES

**Australian Premium Iron Management Pty Ltd**

# Subterranean Fauna Desktop Review

Anketell Point Port Project

February 2010

# Subterranean Fauna Desktop Review

# Anketell Point Port Project

# Desktop Review, Version 2

## Prepared for Australian Premium Iron Management Pty Ltd

## Prepared by Phoenix Environmental Sciences Pty Ltd

Authors: Jarrad Clark and Conor O'Neill

Reviewer: Karen Crews

Date: 3rd February 2010

Submitted to: Michelle Carey



**Phoenix Environmental Sciences Pty Ltd**

**1/511 Wanneroo Road**

**BALCATTA WA 6021**

**P: 08 9345 1608**

**F: 08 6313 0680**

**E: admin@phoenixenv.com.au**

Project code: 940-AP-API-SUB

# TABLE OF CONTENTS



# LIST OF TABLES

# LIST OF FIGURES

# EXECUTIVE SUMMARY

Phoenix Environmental Sciences Pty Ltd was commissioned by Australian Premium Iron Management Pty Ltd, to undertake a desktop review in regards to the likelihood of occurrence and, subsequent risk to, subterranean fauna (stygofauna and troglofauna) at the proposed Anketell Point Port Project (the study area). This report documents the results of the review, undertaken in November 2009.

The proposed Anketell Point Port project encompasses the construction of a port and associated infrastructure 17km kilometres north of Roebourne on the Pilbara coast. The proposal involves the clearing and sealing of approximately 230.2 hectares of land for the port, stockyards, and associated infrastructure (2.3 $km^2$) and 12.2 ha in relation to the rail component.

The Pilbara region of Western Australia contains one of the world's richest assemblages of subterranean fauna. Over 850 species have now been recorded. There are two major diversions of obligate subterranean fauna currently recognised: stygofauna, and troglofauna. The harsh subterranean conditions have driven the morphological evolution of both divisions in similar directions, namely:

- loss of pigmentation due to the absence of ultraviolet light;
- loss of eyes due to the absence of ultraviolet light;
- filiform (worm like) body shape; and
- the development of elongated and highly sensitive appendages.

Stygofauna are aquatic animals, predominantly invertebrates, and all draw oxygen through gills from the water column in which they live. Troglofauna are typically invertebrate species that breathe atmospheric oxygen through modified lungs, such as 'book lungs', which are common in many arthropod groups. Troglofauna are further divided into three categories: troglobites, troglophiles, and trogloxenes. Two of which are considered less likely to adversely affected by mining and other development projects.

There are a number of potential threatening processes relating to mining operations and their associated infrastructure operations that may impact subterranean species and their habitats, namely:

- direct removal of habitat via excavation or quarrying
- clearing of native vegetation and sealing of land at the surface leading to changes in the hydrological regime, nutrient input levels and water quality;
- pollution (e.g. hydrocarbon or chemical spills which may soak into the underlying hydrology of the area); and
- vibration from construction or blasting.

It is considered very likely that the land overlies freshwater aquifers that harbour stygofauna. It is considered possible to likely that troglofauna are also present under the proposed terrestrial component of the port facilities and rail loop.

In regards to stygofauna, the unconsolidated quaternary sedimentary geology which encompass much of the study area is considered most likely to contain stygofauna, but it is expected that any assemblages and species associated with this aquifer type, are not restricted geographically and therefore not facing substantive risks from the proposal. The basic volcanic geology of the study area is typically highly erosion resistant and thus unlikely to harbour stygofauna. Erosion leading to fracturing (and thus the formation of stygofauna habitat) can occur where such geology extends

above the ground surface, but this limited in the study area and thus again the risk to stygofauna from the proposal would appear to be minimal.

With respect to troglofauna the case is less clear. The basic volcanic geology of the study area can lend itself to troglofauna habitation where weathering has been sufficient to create fractures, cavities, and voids. However, in the absence of site specific geological logging data, which provides more substantive information and access to the subterranean environment, no definitive judgement may be made.

There are currently no plans to extract materials or develop a bore field (desalination of seawater will be used). Therefore, no direct impact on subterranean fauna via habitat loss is expected. There is some risk of indirect impacts to subterranean fauna from altered hydrology due to clearing and subsequent sealing of land, and potential pollution events that would adversely impact the underlying aquifers and subterranean habitats.

Sealing of the land surface could lead to compaction, sedimentation, a reduction in oxygen concentration and water infiltration and, an increase in nutrient inputs to each system. However, the area of proposed disturbance is small (230 ha) relative to the area of catchment upstream of the study area. Further, only a portion of the 230 ha is to be sealed. Consequently, the risk to any subterranean fauna present from this process is considered very low.

Pollution events, such as hydrocarbon spills, can be minimised and mitigated by standard operating procedures (SOPs) such as:

- Reporting of Environmental Hazards;
- Use of spill control stations;
- Control (Stop the source);
- Contain (Stop the immediate flow by preventing drainage using polypropylene and other absorbent materials); and
- Cleanup (thorough remediation of the contaminated area using appropriate methods and materials).

Therefore again, the risk to subterranean fauna and their habitats in relation to pollution is considered low where strict adherence to SOP’s in maintained.

Noting the low level of risk to both troglofauna and stygofauna assemblages no field survey effort is considered necessary at this stage.

# 1 INTRODUCTION

In October 2009, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Australian Premium Iron Management Pty Ltd (API), to undertake a subterranean fauna desktop review in relation to the proposed Anketell Point Port Project (the study area).

## 1.1 BACKGROUND

API is developing the West Pilbara Iron Ore Project (WPIOP) on behalf of equal joint venture partners Aquila Resources Ltd and America Metals and Coal Industries. API proposes to develop the Anketell Point Port (APP), to process and export iron ore from the WPIOP Stage One mining operations, and later from additional, and possibly third party, mine sites. The study area encompasses the proposed project area for the APP. It is located within the Shire of Roebourne (Figure 1-1).

The proposed APP will be established at a previously unnamed rocky point, identified as Anketell Point. Anketell Point is situated at the eastern end of Nickol Bay, immediately adjacent to the eastern end of Dixon Island.

Roebourne lies approximately 1,500km north of Perth and 30km northeast of Karratha in the Pilbara Region of Western Australia. The total area included in this review approximated 200,000 $km^2$, encompassing the coastal and inland area abounding the Cape Range Peninsular in the west and the mouth of the De Grey River in the east (Figure 1-2).

The current proposed infrastructure associated with the WPIOP includes port facilities at Anketell Point, a rail alignment corridor heading west from the port facilities and a camp to house construction and later port workers.


**Figure 1-1 The Location of the Anketell Point Port Project.**

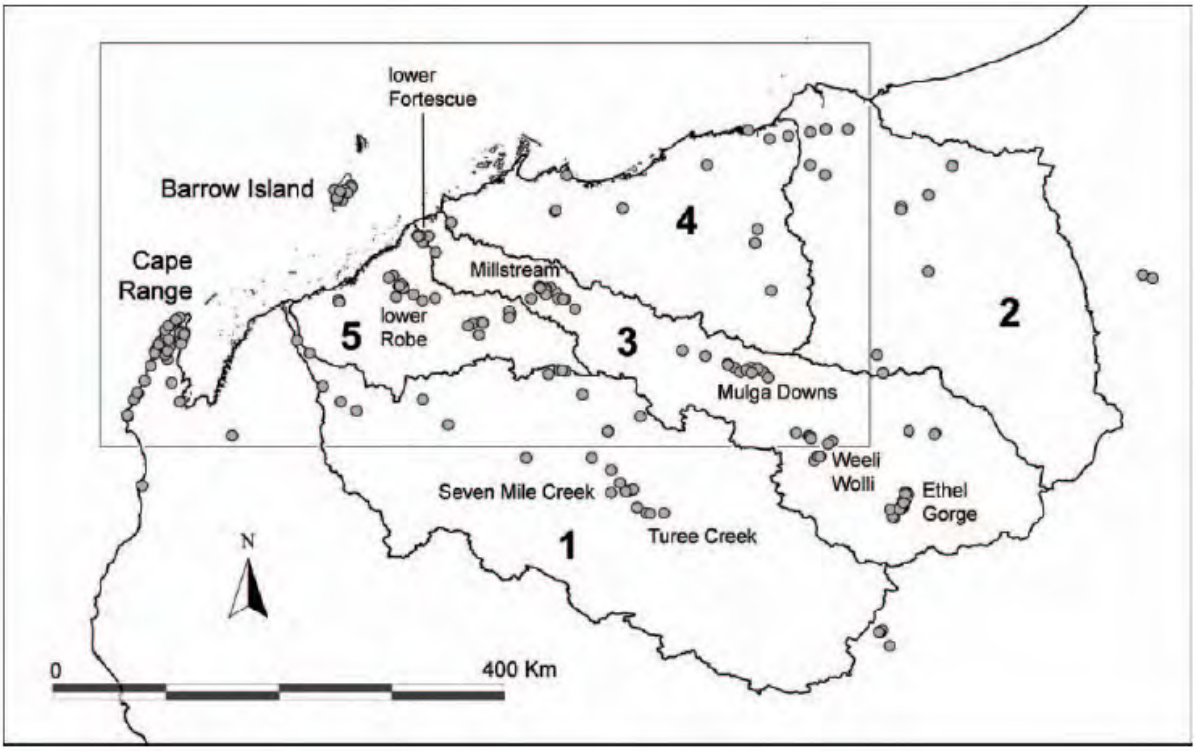


**Figure 1-2 The total area considered as part of the review.**

## 1.2 BIOLOGICAL CONTEXT

Troglofauna are invertebrate species that breathe atmospheric oxygen through modified lungs such as 'book lungs' which are common in many arthropod groups. Troglobitic taxa encompass insects, such as cockroaches (Blattodea) and thysanurans; arachnids, such as scorpions and modern spiders (araneaomorphae); and the 'many legged animals', such as slaters (Isopoda), millipedes (Diplopoda) and centipedes (Chilopoda). Troglofauna generally reflect the terrestrial, epigean invertebrate taxa.

Troglomorphs are typically divided into three categories of subterranean life:

a) Troglobitic fauna which display morphological adaptations to subterranean life and are unable to exist outside of this environment. True troglobites are eyeless or have significantly reduced eyes, have varying degrees of pigmentation loss as to appear colourless, and have no wings. They may also display adaptations such as elongated appendages or use chemical attractants to obtain food. True troglobites are presumed incapable of dispersal on the surface and as such are subject to the barriers of their living environment.
b) Troglophiles are facultative cave-dwelling animals that may complete their life cycles in the subterranean environment, but can also survive in above ground habitats
c) Trogloxenes are species which may use the caves and karstic environments for refuge but are unable to complete their life cycle within the subterranean environment. They will return to the surface for food and other needs.

A number of troglomorphic taxa encountered in the Pilbara region have also been found within the near-surface soil and plant roots and, the surface leaf litter, in addition to their presumably, preferred hypogean (Sub-surface or subterranean) habitats. Most Epigean (surface) forms are regarded to be at a lower risk of species-level spatial restriction (Biota 2005).

The Environmental Protection Authority (EPA 2003; 2007) has estimated the probability that subterranean fauna will be present in different regions of Western Australia (Table 1-1). The probability that a site contains a rich subterranean fauna is largely determined by the region in which the site occurs and the local geology. The presence of stygofauna in most geologies of the Pilbara is considered to be highly likely.

**Table 1-1 Likelihood of subterranean fauna occurrence in Western Australia's regions**

| Region | Geology | Stygofauna | Troglofauna |
|---|---|---|---|
| Kimberley | *Karst, limestone, sandstone, alluvium, islands* | | |
| Pilbara[1] | *Most geologies* | | |
| | *Barrow Island* | | |
| Inland deserts | *Calcrete, alluvium* | | |
| Gascoyne/Murchison | *Calcrete, alluvium, banded ironstone* | | |
| | *Cape Range* | | |
| Yilgarn/Goldfields | *Calcrete, alluvium, banded ironstone* | | |
| South-West | *Most geologies* | | |
| | *Karst* | | |
| Nullabor | *Karst* | | |

[1] Probability of a rich troglofauna assemblage is very high in parts of the Pilbara, e.g. Robe Valley.

Dark grey= very high, light grey = high, no colour = low.

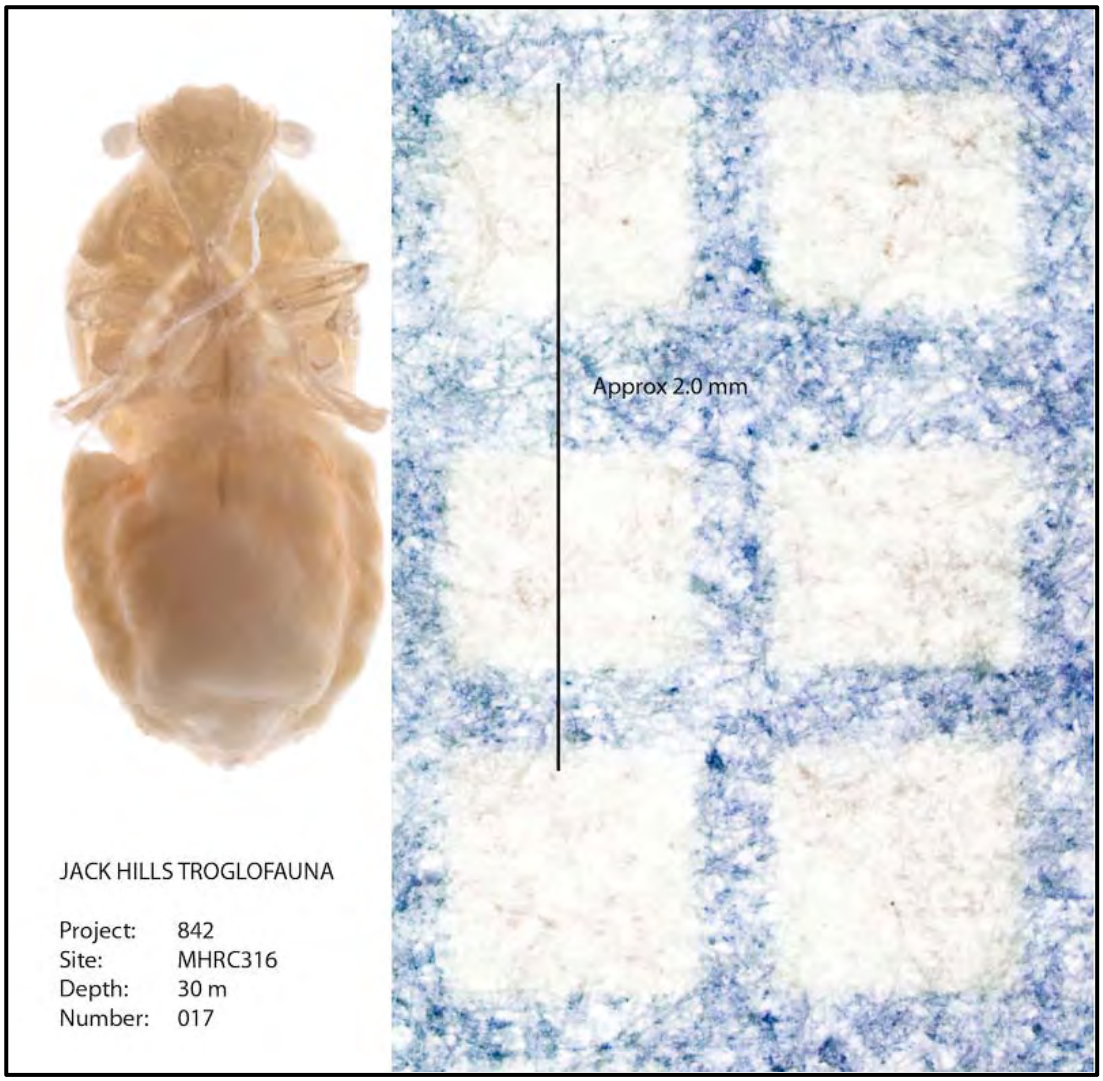


**Figure 1-3 Example of a troglofauna species from the Midwest of W.A. (Photo: Simon Pynt Photography).**

## 1.3 SCOPE OF WORK AND SURVEY OBJECTIVES

The aim of the review was to provide information on the presence and/or likelihood of presence of subterranean fauna species occurring in the study area to accurately assess the likely environmental impact that the proposed development would have on any subterranean species and habitats.

The scope of the works was as follows:

- Undertake a desktop habitat assessment, including the results of database searches for subterranean species and a review of geological maps of the study area;
- Provide a technical report that includes:
  - Incorporation of available, relevant data and information from previous subterranean fauna surveys in the area;
  - Identification and discussion of any subterranean species recorded in previous surveys, if any;
  - Assessment of potential habitats;
  - Assessment of potential impacts on subterranean fauna and habitats from the proposed development;
  - Recommendations for management of potential impacts; and
  - Recommendation of any further investigations if required.

## 1.4 THREATENING PROCESSES

Subterranean fauna, particularly species that occupy deeper subterranean habitats, tend to have localized distributions and to be short range endemics. Short range endemic species are defined by their restricted distributions (nominally defined as < 10km$^2$ in Harvey 2002) that are also often disjunct and highly localised. The most appropriate analogy is that of an island, where the movement of fauna is restricted by the surrounding marine waters, thus isolating the fauna from other terrestrial island populations.

There are a number of potential threatening processes relating to mining operations and their associated infrastructure that may impact subterranean species and their habitats:

- clearing of native vegetation and sealing of land at the surface leading to altered hydrological regimes, nutrient inputs and water quality;
- pollution (e.g. hydrocarbon or chemical spills which may soak into the underlying hydrology of the area);
- direct removal of habitat via excavation or quarrying; and
- vibration from construction or blasting.

## 1.5 EXISTING ENVIRONMENT

### *1.5.1 Interim Biogeographic Regionalisation of Australia (IBRA)*

The study area falls within the Pilbara biogeographic region as defined by the IBRA (Thackway and Cresswell 1995). The Pilbara bioregion has four main geological components (subregions):

- **Hamersley Range** - a mountainous area of Proterozoic sedimentary ranges and plateaus;
- **Fortescue Plains** - consisting of alluvial plains and river frontages;
- **Chichester range** - comprising Archaean granite and basalt plains; and
- **Roebourne** - consisting of Quaternary alluvial plains

The study area falls within the Roebourne subregion. The Roebourne subregion is characterised by Quaternary alluvial and older colluvial coastal and sub-coastal plains with a grass savanna of mixed bunch and hummock grasses, and dwarf shrub steppe of *Acacia translucens* or *A. pyrifolia* and *A. inequilatera*. Uplands of the Roebourne subregion are dominated by *Triodia* hummock grasslands; ephemeral drainage lines support *Eucalyptus* woodlands; alluvial flats and river deltas contain samphire, *Sporobulus* and mangal; linear basalt ranges occur on the coastal plains; and islands comprise Quaternary sand accumulations, basalt and/or limestone (DEWHA 2009).

### *1.5.2 Land Systems*

The Department of Agriculture and Food WA has mapped the Land Systems of the region from aerial photography, providing the largest scale interpretation of vegetation units for the study area. (Van Vreeswyk et al 2004)3 Land Systems occur within the study area:

- **Cheerawarra** - sandy coastal plains and saline clay plains supporting soft and hard spinifex grasslands and minor tussock grasslands. Depositional surfaces of gently undulating sandy surfaced coastal plains.
- **Littoral** - coastal fringe consisting of areas of mangal on the seaward fringe, samphire shrublands on mudflats, *Acacia coriacea* shrublands over spinifex or tussock grasses on coastal dunes and *Triodia angusta* hummock grasslands on broad sandy plains.

- **Rocklea** - rugged Basalt hills and plateau remnants with hard Spinifex grasslands; very small area in the southern portion of the survey area.
- **Horseflats** - extensive, gilgaied clay plains supporting tussock grasslands and minor grassy snakewood shrublands. Depositional surfaces consisting of gilgaied and non – gilgaied clay plains, stony plains, narrow linear drainage depressions and dissected slopes marginal to the River Land Systems.

### *1.5.3 Climate*

The Pilbara region has a semi-desert to tropical climate with highly variable, mostly summer rainfall. The average rainfall over the broader Pilbara area ranges from about 200mm to 350mm, although rainfall may vary widely from the average from year to year (DEWHA 2009). The Roebourne and coastal part of the Chichester subregion experience significant cyclonic activity, with several systems affecting the coast and hinterland annually (CALM 2003).

Average annual rainfall at Cossack (the nearest Bureau of Meteorology weather station) is 259mm. The bulk of rainfall in the region occurs from January to March and is significantly influenced by cyclonic activity. Average summer (December to March) maximum temperatures are 36.4°C and average winter maxima are 25.5°C.

### *1.5.4 Biological context*

In the Pilbara, subterranean fauna have been recorded in caves and groundwater communities established within non-carbonate rocks such as basalt, sandstone, quartzite, acid igneous rocks and unconsolidated sediments. Other environments where subterranean fauna are extant within Australia, if not more locally recorded include sea caves, boulder and talus caves, Aeolian caves, piping caves beneath silcrete crusts, and interstitial environments (Eberhard and Hamilton-Smith 1997).

### *1.5.5 Geology and landforms*

The Anketell Point Port (APP) Development Draft Environmental Scoping Document (2009) provides the following description of the geology and landforms of the study area:

> *'Anketell Point is mostly low-lying, with a mix of tidal mud flats and low sand dunes overlying basalt. A survey of the region (Van Vreeswyk et al. 2004) identified twenty-one broad soil groups. The most extensive soil types were shallow stony soil, occurring on the hills and ranges, and sands within the sand plains. The southern Pilbara consists predominantly of red earths overlying hardpan on level to gently inclined plains.*
>
> *The oldest rocks exposed at the surface in the region are Archaean age sedimentary sequences of banded chert, shale, jaspilite, hematite and metamorphosed sandstone (basement). Proterozoic age basic volcanic rocks overlie the sedimentary basement. These include metamorphosed rhyolite and basalt (greenschist facies). The rocks exposed at the surface of Anketell Point and on the eastern end of Dixon Island have been identified as Proterozoic age Mount Roe Basalt.'*

### *1.5.6 Land tenure and land use*

The proposed port site is uninhabited and zoned Strategic Industrial in the Shire of Roebourne Town Planning Scheme. Excluding Dixon Island, much of the terrestrial component of the proposal falls on Mt Welcome Pastoral Station, with the balance (a section of the railway) traversing unallocated Crown Land.

Historical land use in the study area comprises pastoral grazing, limited tourism and recreation and mining activities just outside the study area. Further mining is likely to take place in the future within the centre of the study area, where exploration activities have recently ceased. Pastoral activities are likely to continue well into the future. With significant economic growth predicted for the region, recreational use is also likely to grow.

## 1.6 ENVIRONMENTAL PROTECTION AUTHORITY GUIDANCE

In December 2003, the Environmental Protection Authority (EPA) released Guidance Statement No. 54: *Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia (EPA 2003).* The guidance statement outlined the information which the EPA will need when assessing development proposals where the protection of stygofauna and troglofauna is a relevant environmental factor.

This Guidance Statement was further refined and re-released in August 2007 (EPA 2007).

The EPA recognises that the Pilbara region contains rich diversity and abundance of stygofauna by world standards (EPA 2007). Coastal karst, limestone and sandstone systems, paleodrainages and calcrete systems within the Pilbara region contain rich subterranean fauna communities. Over 850 species of stygofauna and troglofauna have now been recorded.

# 2 METHODS

## 2.1 HABITAT CHARACTERISATION

Identification of suitable habitat (characterization) can be achieved for stygofauna using a groundwater chemistry probe to measure depth, ph, redox potential, total dissolved salts, temperature and dissolved oxygen (Biota 2005). That is, the presence of stygofauna can largely be discounted where the salinity is greater than 60,000 µs/cm (approximately twice the concentration of seawater). Where the salinity is less than this stygofauna are likely to be present, particularly in the Pilbara. Further, they are less likely to be present where the pH is particularly acidic (<5.0) or alkaline (>9.0). Water Quality Data is currently unavailable for the project area, however Haig (2009) reported that the salinity of the area is > 3000mg/L TDS (5 357 µs/cm).

In the absence of geotechnical logging of drilled bore holes, troglofauna habitat can be inferred from geophysical investigations using Electrical Resistivity Imaging for assessment of general depth to the halocline, and provide a limited assessment of the locations of caverns and fractured zones. This technique has not been used within or adjacent to the project area, however it has been used successfully on Barrow Island to determine presence or absence of caverns near adjacent bore holes (Biota 2005). Down-hole cameras can also be used to identify troglofauna presence relatively quickly and easily. No holes are currently available.

## 2.2 HABITAT ASSESSMENT OF STUDY AREA

There are three types of aquifers classified by Johnson and Wright (2001) occurring in the Pilbara Region: (1) unconsolidated sedimentary aquifers; (2) chemically deposited aquifers; and (3) fractured-rock aquifers.

Within the study area, unconsolidated sedimentary aquifers are contained within the coastal plain alluvium and colluvium, and fractured rock aquifers occur in the Proterozoic and Archaean sedimentary and volcanic rocks including the Mount Roe basalt, dolomite, sandstone, shale and chert (Eberhard et al 2005) (Figure 7). Primarily, groundwater recharge occurs from exposure of the fractured, jointed and weathered zones of the sedimentary and volcanic rocks to cyclonic rainfall events, creating areas of secondary porosity. Recharge is also absorbed from overlying sediments and contact with areas of surface flow (Haig 2009).

The study area is contained centrally within the coastal portion of the Port Hedland Coastal Basin (see Figure 2-1). The Harding River drains toward this locale, however the water flow of riverine systems of the Pilbara are ephemeral and largely dependent on cyclonic rainfall. There is limited direct recharge to the underlying aquifers of the subject area from this water source except in areas where the surface flow comes into contact with the secondary porosity of the rock structures and areas of weathering (Haig 2009).

These aquifers and subsequent unfilled air pockets provide ideal habitat for stygobitic and troglobitic fauna and are recognised by the EPA to be prevalent within much of the Pilbara (EPA 2003; 2007).

Habitats for stygofauna within the study area will be restricted to the most suitable hydrogeological zones. The unconsolidated sedimentary aquifers provide only interstitial habitats within the porous zones of the sedimentary rocks. Within the basalt and volcanic rock layers, fractured and weathered zones, throughout bedding planes and within joints are also favourable for stygofauna (Eberhard et al 2005) and troglofauna, where they are not inundated.

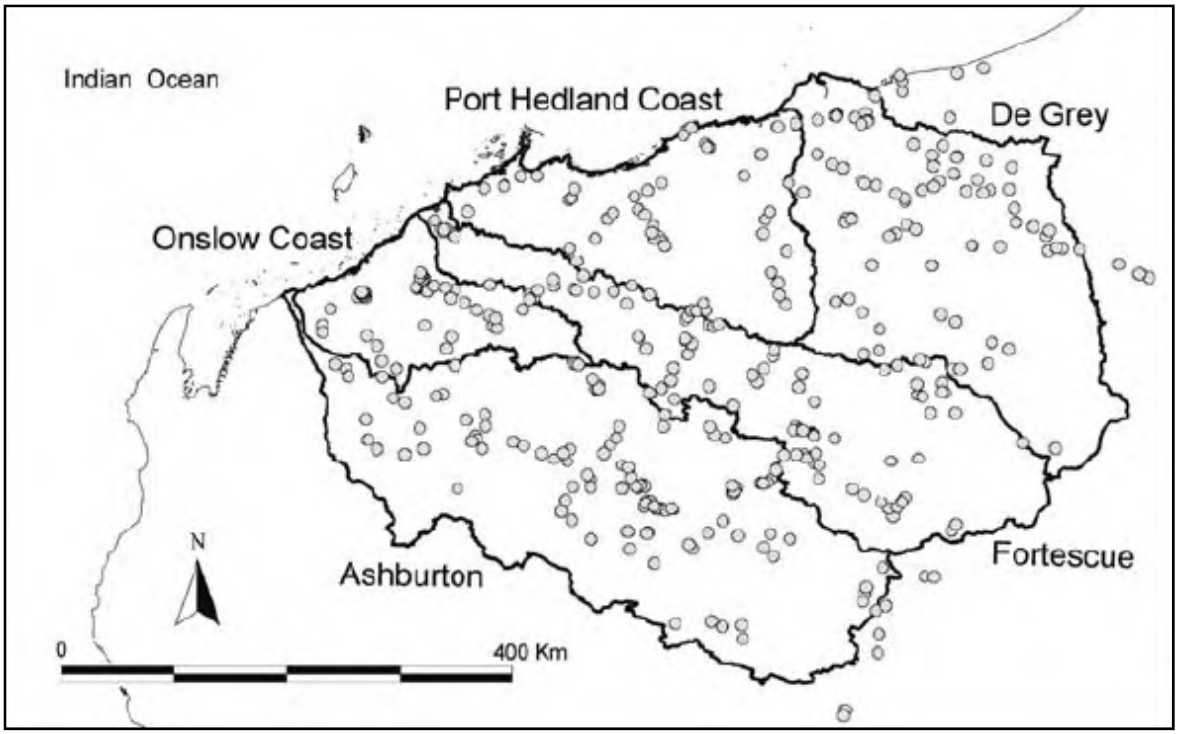


**Figure 2-1** **The five major hydrographic basins and 450 proposed bores and well selected for stygofauna sampling for the DEC Pilbara Biological Survey. Source: Eberhard et al (2004).**

## 2.3 TAXA DISTRIBUTION REPRESENTED IN STUDY AREA

The database searches and literature reviews produced the following maps of stygofauna species records within a 100km radius of the study area (Figure 2-2) and more broadly in the Pilbara region (Figure 2-3). The records are discussed in Section 3.

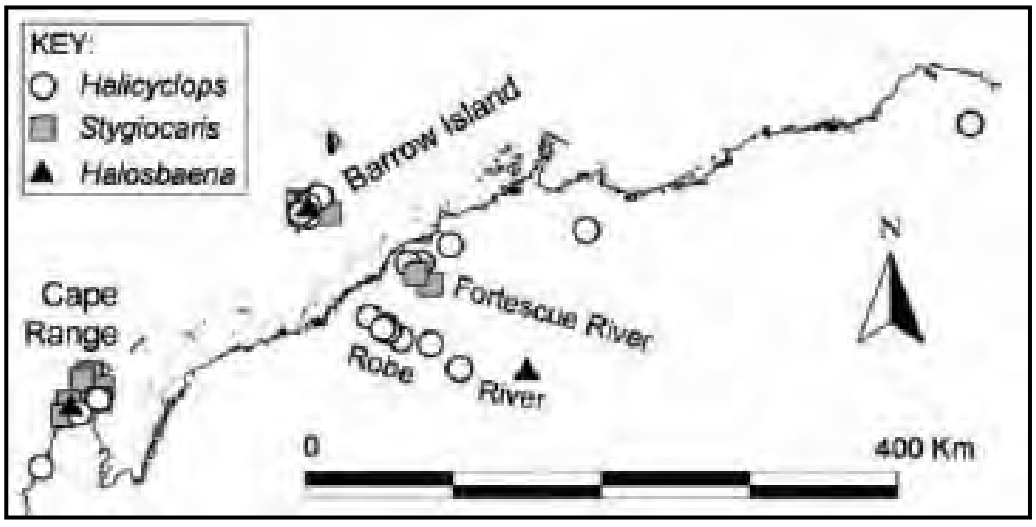


**Figure 2-2** **Source: Eberhard et al (2005) Distribution of published marine Stygofauna records.**

In most areas of the Pilbara, sampling for stygofauna has been constrained to bores and areas with suitable access points to groundwater. There are in excess of 3700 bores in the Pilbara (Allen 1997) and multiple springs and brooks, from which interstitial samples can be recovered. Eberhard et al (2005) sampled 223 sites which included water supply and mine dewatering bores, geotechnical

drill holes, pastoral wells, springs and shallow hyporheic habitats as part of the early stages of the Pilbara Biological Survey. Additionally, sampling efforts by the Department of Environment and Conservation (DEC) encompass approximately 550 bores (as yet unpublished).

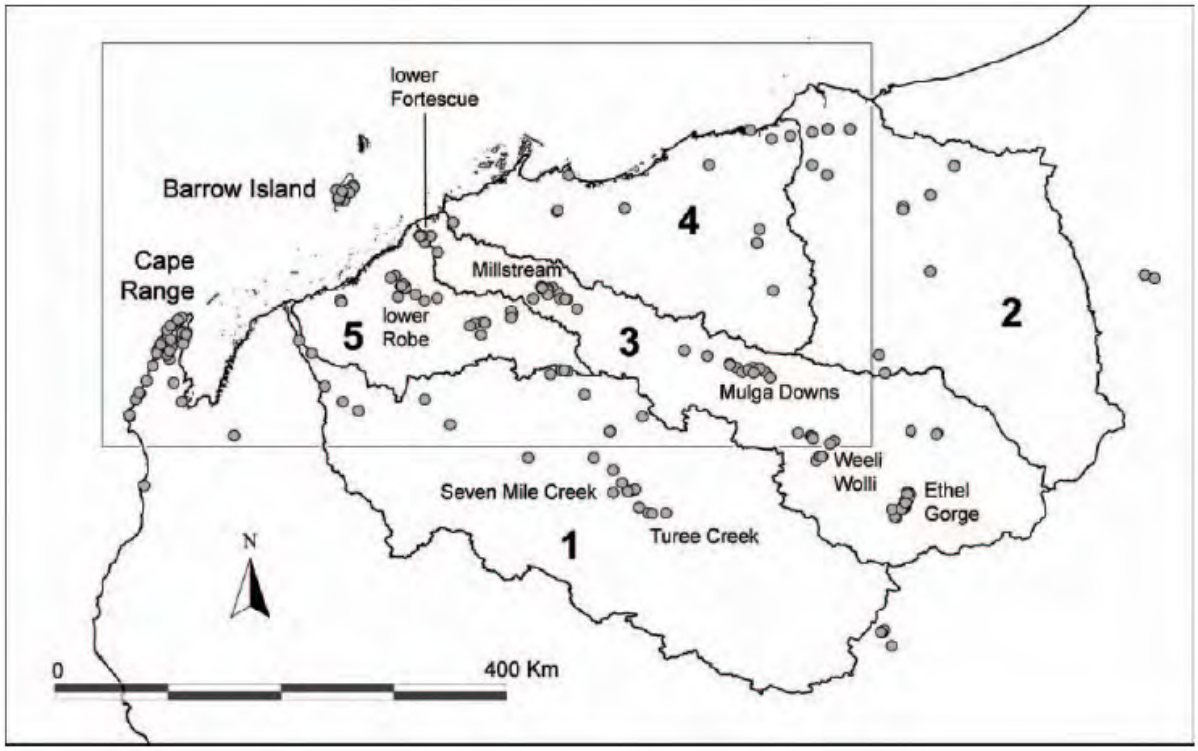


**Figure 2-3 Source: Eberhard et al (2005) Distribution of published Stygofauna records in the Pilbara region including the five major hydrographic basins.**

# 3 RESULTS

## 3.1 RESULTS OF THE DATABASE SEARCHES

An interrogation of the DEC NatureMap Database which contains records of the DEC Threatened Fauna Database and the FaunaBase database of the Western Australian Museum was conducted on 25 November 2009 for records of vouchered subterranean fauna from the area bounded by the following coordinates:

| | |
|---|---|
| NW | - 20°48’54’’S, 116°07’38’’E |
| N ‘Centre’ | - 20°34’03’’S, 117°12’07’’E |
| NE | - 20°29’56’’S, 117°54’29’’E |
| SE | - 20°38’09’’S, 117°55’26’’E |
| S ‘Centre’ | - 20°47’57’’S, 117°08’58’’E |
| SW | - 20°59’20’’S, 116°09’51’’E |

This area is bounded by James Point in the west and Forestier Bay in the east (Figure 3-1). The search returned no subterranean taxa.

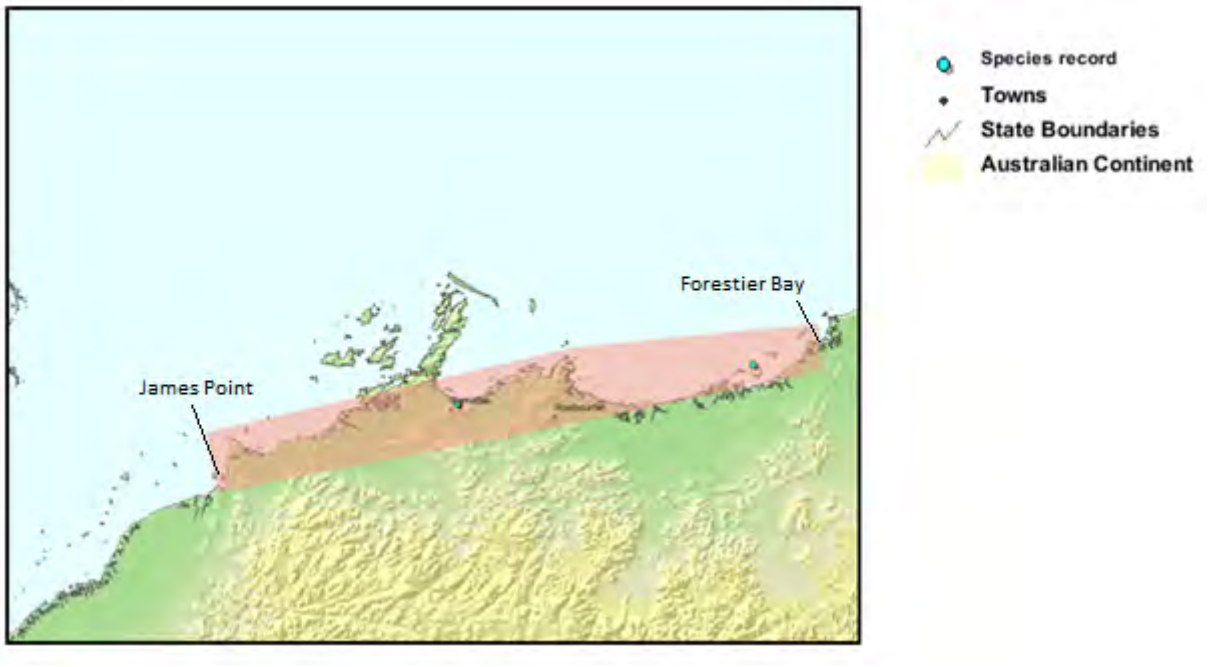


**Figure 3-1 Map courtesy of DEC NatureMap (2009).**

In addition, the Federal *Environment Protection and Biodiversity Conservation Act 1999* Protected Matters database was searched for fauna of environmental significance within the study area (Appendix 3). The bounding coordinates delineating the search area for this database were:

20.743°S, 116.02°E

21.108°S, 116.12°N

These coordinates encompassed a search area approximately 90 km east-west, and 40 km north-south of the study area. The search returned no records of conservation significant subterranean fauna.

## 3.2 TROGLOFAUNA

### *3.2.1 Additional records of troglofauna*

Eberhard et al (2009) presented findings of troglofauna surveys in the Pilbara at a recent conference held in Darwin in 2009. The results and paper are as yet unpublished; however they report that the taxa collected in the region includes arachnids (Araneae, Pseudoscorpionida, Schizomida, Palpigrada), insects (Diplura, Thysanura, Coleoptera, Hemiptera, Blattodea), myriapods (Diplopoda, Chilopoda, Symphyla, Pauropoda) and crustaceans (Isopoda). Species distribution patterns ranged from regionally widespread to highly localised short-range endemics. The distribution patterns were not always concordant with changes in geology or habitat.

The records of troglomorphic taxa presented by Eberhard et al (2009) suggest that the degree of specialisation to subterranean environments varies within troglomorphic fauna in the Pilbara region. A number of troglomorphic taxa encountered in the region have been found within the near-surface soil and plant roots and, the surface leaf litter, in addition to their presumably, preferred hypogean (Sub-surface or subterranean) habitats. Most Epigean (surface) forms are regarded to be at a lower risk of species-level spatial restriction (Biota 2005).

### *3.2.2 Troglofauna habitat*

To date no geotechnical drilling, Electrical Resistivity Imaging or down-hole camera surveys have been undertaken within the study area. Consequently, it was not possible to identify the presence of prospective troglofauna habitat within the geological structures which underlie the proposed APP development.

The majority of the proposal overlies predominantly marine derived, quaternary silty sands and mangrove flats (Figure 3-2) and Precambrian, Proterozoic basic volcanic rock. This type of rock tends to be highly erosion resistant and therefore does not typically provide habitat for troglofauna. Sufficient erosion can occur to allow for troglofauna habitat creation (air filled cavities and voids) where such rock extends above the ground surface. The marine derived quaternary sands that make up the rest of the geological stratigraphy are considered unlikely to harbour troglofauna.

Accessible records of troglofauna from the coastal western Pilbara are limited at present. The unpublished records from the Cape Preston Expansion Project are the only such records. A relatively widespread troglomorphic community was shown to exist, with a number of species being recorded from leaf litter at the surface, suggesting a more mobile assemblage. The geology (and nature of the project) differs in that the Cape Preston project targets iron ore (specifically magnetite) and thus the direct removal of material from the weathered Newman Land System. The Newman Land System is not present within the APP study area.

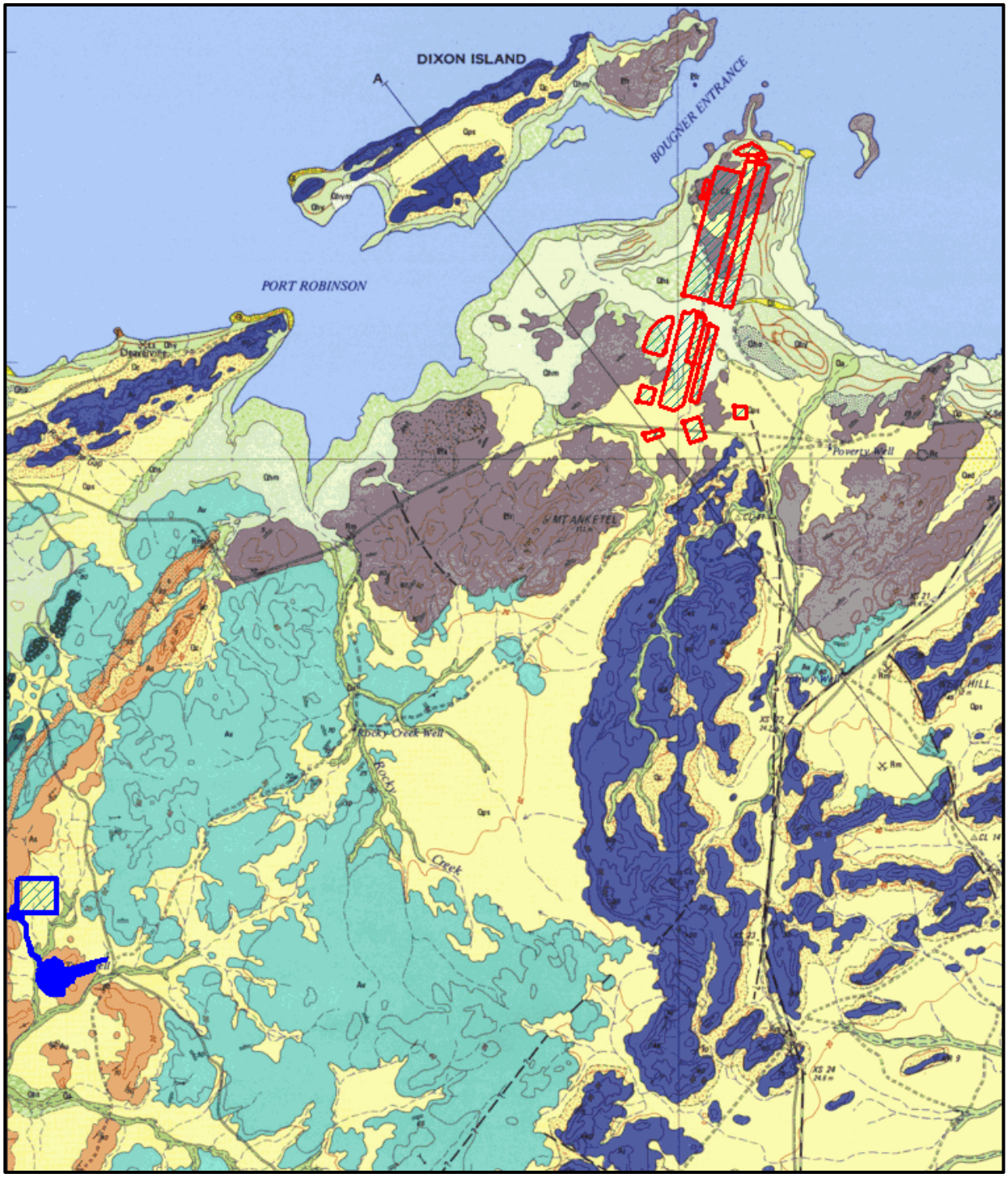


**Figure 3-2 The local broad-scale geology of the proposed Anketell Port Project (API 2009).**

## 3.3 RECORDS OF STYGOFAUNA

Eberhard et al (2005) reported that published stygofauna records from within the Port Hedland Basin are rare. There are however, numerous unpublished records. The clustered distribution of these records reflects the concentration of sampling specific, local aquifers mainly associated with industrial and mining projects. Only one study for a mining proposal at Mulga Downs exclusively focused on pastoral or artesian water sources for sampling effort (cited in Eberhard et al 2005).

Published records to 2005 within the Pilbara record 78 species from 41 genera and 21 families (Eberhard et al 2005). It was hypothesised at that time that the true diversity would be much greater. This theory was proven correct by the initial records from the DEC Pilbara Biological Survey, which recognised greater than 150 species belonging to 77 genera and 39 families (Eberhard et al 2004). More recently, unpublished records from the DEC Pilbara Biological Survey have recorded over 850 species of subterranean fauna including a high proportion of stygobitic faunal assemblages. The DEC Pilbara Biological Survey database includes species of Amphipods, Copepods, Isopods, Ostracods, Gastropods, marine Arachnids, and Oligochaetes (Table 3-1); A. Pinder, pers. comm., DEC November 2009).

Most species of stygofauna are freshwater, however Humphreys (1993; 2000) has reported a high proportion of species (atyid decapods, cirolanid isopods, thermosbaenaceans, melitid amphipods and the cyclopid copepods Halicyclops and Apocyclops) with marine Tethyan, Pangean and/or Gondwanan affinities within the area bounded by the Cape Range peninsular and the mouth of the De Grey River. It has been noted that the distribution of these species coincides with the coastal margins of the Northern Carnarvon Basin and the Pilbara craton (Humphreys 2001), hence there is an increased likelihood of encountering these marine affiliated species of stygofauna within the APP study area. The greatest penetration is 300 m above sea level, 100 km inland at Robe River valley (Eberhard et al 2005).

**Table 3-1 Stygofauna recorded in the DEC Pilbara Biological Survey within and adjacent to the study area[a]**

| Class | Order | Family | Genus | Lowest ID | No. of Individuals |
|---|---|---|---|---|---|
| Arachnida | Acariformes | Halacaridae | - | *Halacaridae* | 1 |
| Crustacea | Amphipoda | Bogidiellidae | - | *Bogidiellidae sp. 1* | 1 |
| | | Melitidae | Nedsia | *Nedsia sp.* | 2 |
| | Copepoda | - | - | *Calanoida* | 2 |
| | | - | - | *Calanoida sp. 1* | 2 |
| | | Ameiridae | Stygonitocrella | *Stygonitocrella sp.* | 1 |
| | | Cyclopidae | Diacyclops | *Diacyclops humphreysi humphreysi* | 1 |
| | | | Halicyclops | *Halicyclops (Rochacyclops) roachi* | 2 |
| | | | Mesocyclops | *Mesocyclops brooksi* | 1 |
| | | | Microcyclops | *Microcyclops varicans* | 1 |
| | | | Paracyclops | *Paracyclops chiltoni* | 1 |
| | | Parasteno-caridiidae | Parastenocaris | *Parastenocaris sp.* | 2 |

| Class | Order | Family | Genus | Lowest ID | No. of Individuals |
|---|---|---|---|---|---|
| | Isopoda | Amphisopodidae | Pilbaro-phreatoicus | *Pilbarophreatoicus platyarthricus* | 1 |
| | Ostracoda | - | - | *Unidentified Ostracoda* | 5 |
| | | Candonidae | Areacandona | *Areacandona scanloni* | 2 |
| | | Cyprididae | Cypretta | *Cypretta seurati* | 2 |
| | | Cypridopsidae | Sarscypridopsis | *Sarscypridopsis ochracea* | 1 |
| | | Darwinulidae | - | *Darwinulidae* | 1 |
| Gastropoda | Basom-matophora | Planorbidae | - | *Planorbidae* | 1 |
| Oligochaeta | Tubificida | Naididae | - | *Naididae (ex Tubificidae)* | 1 |
| | | | - | *Unidentified Tubificidae WA21* | 1 |
| | | | Allonais | *Allonais ranauana* | 1 |
| | | | Pristina | *Pristina aequiseta* | 2 |
| | | | Pristina | *Pristina longiseta* | 3 |
| | | Phreodrilidae | - | *Unidentified Phreodrilid with dissimilar ventral chaetae* | 3 |
| | | | - | *Unidentified Phreodrilid with similar ventral chaetae* | 2 |

Source: A. Pinder pers. comm., DEC November 2009
a – Search coordinates same as those used for the NatureMap database search, see section 3.1.

## 3.4 STYGOFAUNA HABITAT

Stygofauna are common and relatively abundant across much of the Pilbara and tend to show a change in species composition from the upper to the lower reaches of major creek systems.

There is currently no water quality data available from within the APP study area, however there is water quality and limited stygofauna data from the environmental studies carried out for the Cape Lambert Iron Ore project, which lies approximately 7-9 km to the south of the APP study area (Coffey 2007).

A low intensity stygofauna study was carried out at Cape Lambert in 2007. No stygofauna were recorded, however apparent hydrocarbon contamination in a number of bores meant that a cleansing operation had to take place and a six month settling period observed before additional sampling could be undertaken. Further data is not available.

The water quality at Cape Lambert does not discount the potential for the presence of stygofauna. The electrical conductivity at over 40 bores (measured as milli-siemens) ranged from 0.6 ms/cm to 47.5 ms/cm. These values are well within the upper boundary, beyond which the presence of stygofauna can usually be discounted (>60ms/cm). The same is true of the pH, which ranged from a minimum of 6.17 to a maximum of 8.27.

The coastal location of the APP study area means that the influence of a saltwater 'wedge' that typically moves inland from the coast cannot be discounted in the northern half of the study area. Such wedges tend to sit under freshwater aquifers and drive them inland and upwards due to their higher specific gravity. Stygofauna have however been recorded from the Goldfields and at the

periphery of the Carnarvon Basin north to the DeGrey River in saline aquifers. Such records further suggest that stygofauna are likely to be present within or very near to the APP study area, particularly in the southern half of the study area, through the unconsolidated quaternary geology. The basic volcanic geology, also largely located in the southern half of the study area, is more likely to harbour restricted species than at 'Anketell Point', especially where secondary porosity occurs in fractured, highly weathered zones or along bedding planes.

However, it is considered unlikely that geographically restricted or conservation significant stygobitic species would be found within the small extent of un-weathered basic volcanic rocks and the more widespread quaternary sands that surround the basic material of Anketell Point.

## 3.5 THREATS TO SUBTERRANEAN FAUNA

Clearing of native vegetation is one of the principal indirect threats to subterranean cave dwelling fauna. Clearing can change the cave microclimate due to altered nutrient input levels, hydrological regimes and water quality parameters, such as sedimentation, nutrient enrichment and pollutants (Eberhard and Hamilton-Smith 1997).

A loss of biodiversity may be experienced in karst dwelling communities from removal of overlying native vegetation which provides inputs of food, such as detrital matter and fauna (within the root and soil layers of the vegetation cover). Similarly, a change in the water table, water quality and flow regimes from a loss of vegetation would impact the stygobitic subterranean fauna (Eberhard and Hamilton-Smith 1997). Nutrient enrichment may displace stygobitic communities and facilitate colonisation by epigean (surface dwelling) taxa.

## 3.6 DATA LIMITATIONS

The recorded and available data pertaining to stygofauna and troglofauna abundance, species richness and distribution in the Pilbara is relatively limited and highly skewed in that samples are typically taken from relatively close proximity to one another, and in the context of mineral projects. Logistical constraints of distances between accessible water resources, the sampling of high yield aquifer bores/wells and inaccessibility or unavailability of caves for troglofauna sampling appears to form part of the general survey limitations for the subterranean fauna in the Pilbara.

Despite the skewed concentration of bores and wells sampled, sampling effort and abundance / species abundance in the Pilbara region, appear to be correlated (Eberhard et al 2005). Nonetheless, stygofauna species have been recorded in most groundwater environments in the Pilbara with nearly all major stygofauna groups represented by published or unpublished records (Humphreys 2001).

# 4 DISCUSSION

The Pilbara region of Western Australia contains one of the world's richest assemblages of subterranean fauna, both stygofauna and troglofauna. Unfortunately this information is still not available in a readily accessible database such as the Australian Museum's FaunaMap, which is available for terrestrial vertebrate species.

The proposed Anketell Point Port project involves the construction of a port and associated infrastructure 17km kilometres north of Roebourne on the Pilbara coast. The proposal involves the clearing and sealing of approximately 230.2 hectares of land for the port, stockyards, and associated infrastructure (2.3 $km^2$) and 12.2 ha in relation to the rail component.

It is considered very likely that a proportion of the study area overlies freshwater aquifers that harbour stygofauna. It is considered possible to likely that troglofauna are present under the proposed terrestrial component of the port facilities.

The unconsolidated quaternary sedimentary geology is considered most likely to contain stygofauna, but it is expected that any assemblages and species founds in this geological strata would not be restricted geographically.

The basic volcanic geology of the study area would be suitable for troglofauna habitation where weathering has been sufficient to create cavities and voids. In the absence of geological logging (or Electrical Resistivity Imaging or down-hole camera investigations), which provides localised geological information and access to the subterranean environment no definitive judgement may be made with respect to the likelihood of encountering conservation significant troglobitic species.

There are currently no plans to extract materials or develop a bore field (desalination of seawater will be used). Therefore, no direct impact on subterranean fauna via habitat loss is expected. There is some risk of indirect impacts to subterranean fauna from altered hydrology due to clearing and subsequent sealing of land, and potential pollution events that would adversely impact the underlying aquifers and subterranean habitats.

Sealing of the land surface could lead to compaction, sedimentation, a reduction in oxygen concentration and water infiltration and, an increase in nutrient inputs to each system. However, the area of proposed disturbance is small (230 ha) relative to the area of catchment upstream of the study area. Further, only a portion of the 230 ha is to be sealed. Consequently, the risk to any subterranean fauna present from this process is considered very low.

Pollution events, such as hydrocarbon spills, can be minimised and mitigated by standard operating procedures (SOPs) such as:

- Reporting of Environmental Hazards;
- Use of spill control stations;
- Control (Stop the source);
- Contain (Stop the immediate flow by preventing drainage using polypropylene and other absorbent materials); and
- Cleanup (thorough remediation of the contaminated area using appropriate methods and materials).

Therefore again, the risk to subterranean fauna and their habitats in relation to pollution is considered low where strict adherence to SOP's in maintained.

Noting the low level of risk to both troglofauna and stygofauna assemblages no field survey effort is considered necessary at this stage.

# 5 REFERENCES

Biota (2005). Barrow Island Gorgon Gas Development, Subterranean Fauna Survey. Unpublished report prepared for The Gorgon Venture. 51 pp.

CALM (2003). A biodiversity audit of Western Australia's 53 Biogeographical subregions in 2002. , Department of Conservation and Land Management, Perth.

Coffey (2007). Cape Lambert Water Management Study, Roebourne, W.A., Coffey Geotechnics. Unpublished report to Cape Lambert Iron Ore Ltd.

DEWHA (2009) 'Rangelands - Overview', Australian Natural Resources Atlas.

Eberhard, S. and E. Hamilton-Smith (1997). Conservation of Cave fauna in Australia in Cave and Karst Management in Australasia. ACKMA Conference XII, New Zealand.

Eberhard, S., N. Stevens, G. Perina and P. Bell (2009). Troglofauna in the Pilbara region, Western Australia - a remarkable hidden diversity poses a conservation challenge to the mining industry. *Delivered to The Combined Australian Entomological Society's 40th AGM & Scientific Conference / Society of Australian Systematic Biologists / 9th Invertebrate Biodiversity & Conservatio*n, , Darwin, Australia.

Eberhard, S. M., S. A. Halse and W. F. Humphreys (2005). "Stygofauna in the Pilbara region, north-west Western Australia: a review." Journal of the Royal Society of Western Australia **88**: 167-176.

Eberhard, S. M., S. A. Halse, M. D. Scalon, J. S. Cocking and H. J. Barron (2004). Assessment and Conservation of Aquatic Life in the Subsurface of the Pilbara Region, Western Australia. Symposium on World Subterranean Biodiversity, UWA, Perth, Western Australia.

EPA (2003). Guidance for the Assessment of Environmental Factors, Statement No. 54: Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia., EPA.

EPA (2007). Guidance for the Assessment of Environmental Factors, Statement No. 54a: Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia (Draft). Perth, W.A., Environmental Protection Authority.

Haig, T. G. (2009). Pilbara Coast Water Study. Hydrogeological Record Series. Perth, Department of Water. **Report No.HG34**.

Harvey, M. S. (2002). "Short-range endemism among the Australian fauna: some examples from non-marine environments." Invert. System., **16**: 555 - 570.

Humphreys, W. F. (1993). "Stygofauna in semi-arid tropical Western Australia: a Tethyan connection?" Memoire de Biospeleologie **20**: 111-116.

Humphreys, W. F. (2000). "Groundwater calcrete aquifers in the Australian arid zone: the context to an unfolding plethora of stygal biodiversity." Rec. W.A. Mus.: Supplement. **64**: 63 - 83.

Humphreys, W. F. (2001). "Groundwater calcrete aquifers in the Australian arid zone: the context to an unfolding plethora of stygal biodiversity." Records of the Western Australian Museum, Supplement No. 64: Subterranean Biology in Australia 2000: 63-83.

Johnson, S. L. and A. H. Wright (2001). Central Pilbara groundwater study. Perth., Water and Rivers Commission.

Thackway, R. and I. Cresswell (1995). An interim biogeographic regionalisation for Australia: a framework for setting priorities in the National Reserves System Cooperative Program. Canberra, Reserve System Unit, Australian Nature Conservation Agency.

Van Vreeswyk, A. M. E., A. L. Payne, K. A. Leighton and P. Hennig (2004). An inventory and condition survey of the Pilbara region, Western Australia. T. B. N. 92. South Perth, Department of Agriculture**:** 58.