Tectonic Resources NL

Phillips River Project

Subterranean fauna desktop risk assessment

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Phillips River subterranean fauna desktop risk assessment

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Executive Summary

Tectonic Resources NL (Tectonic) commissioned Outback Ecology to undertake a desktop assessment of the risk to subterranean fauna from the proposed Phillips River Project (PRP). The PRP is situated in the south-west of Western Australia, approximately 20 km south of Ravensthorpe and consists of two deposits; the Kundip gold and copper deposit and the Trilogy polymetallic deposit.

To date, subterranean fauna surveys in the south-west and surrounding regions have been limited. Of the stygofauna surveys conducted, particularly in fractured rock aquifers, stygofauna have generally been absent or of low diversity. The few troglofauna surveys carried out have also typically yielded few taxa.

Based on the findings of these studies and the site geology and hydrogeology, the probability of the Trilogy project area having significant stygofauna values is considered low. A contributing factor to this low likelihood is the low pH of the groundwater associated with the main water bearing zone (the mineralised zone). An additional factor is the low level of recharge to the aquifer (potentially <1 % of rainfall), which is likely to result in low inputs of energy and nutrients as organic matter, and limit the ability of the groundwaters to support diverse stygal communities.

Potential habitat for troglofauna in the Trilogy project area is limited, suggesting that the area is unlikely to have significant troglofauna values. This is attributed to the geology above the water table, specifically within the proposed pit outline, which generally appeared to lack vuggs.

The Kundip project area is also considered unlikely to contain rich stygofauna or troglofauna communities. For stygofauna, factors that support this notion include the low permeability of the rocks in the area and low inflows, potentially limiting energy inputs. Moreover, areas within Kundip have already been disturbed by previous mining activities, potentially decreasing the suitability of the area for rich stygofauna communities. In relation to troglofauna, with only limited potential habitat noted, the majority of geologies within the Kundip project area appear to be unsuitable for troglofauna. This suggests that the likelihood of significant troglofauna values in the Kundip project area is low.

Based on the findings of the desktop assessment, the risk to stygofauna and troglofauna in the Trilogy and Kundip project area as a result of the PRP is considered to be low. As such, it is not considered that pilot surveys are required.

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1. INTRODUCTION

1.1 Project Background

Tectonic Resources NL (Tectonic) commissioned Outback Ecology to undertake a desktop assessment of the risk to subterranean fauna from the proposed Phillips River Project (PRP). The PRP is situated approximately 20 km south of Ravensthorpe, in the south-west of Western Australia (**Figure 1**). The tenements cover more than 140 km^2 and encompass two deposits; the Kundip gold and copper deposit and the Trilogy polymetallic deposit. Mining at Kundip, the northern deposit, commenced in the early 1900's and included the Beryl, Harbour View and Flag underground workings (Rockwater 2004). The Trilogy deposit is located to the south on cleared farmland (Outback Ecology 2007).

Proposed developments for the Trilogy project area of the PRP include a processing plant, tailings storage facility (TSF), waste rock landforms and a pit. Mining is intended to last seven to eight years, with the pit extending to a depth of between 160 to 240 m (Rockwater 2009). Nine open pits and associated waste dumps are proposed for the Kundip project area, a number of which will extend below the water table. Three underground mines are also planned, and will be accessed through the base of the open pits (Outback Ecology 2005).

1.2 Scope and Objectives

This report presents the findings of a desktop risk assessment for subterranean fauna; stygofauna (aquatic fauna inhabiting groundwater) and troglofauna (fauna inhabiting air-filled caves or small voids underground) within the PRP area. The overall objective of the study was to assess the risk of the proposed PRP, specifically the Kundip and Trilogy project areas, to subterranean fauna.

The EPA (2007) states that the probability of rich communities of stygofauna and troglofauna occurring in the south-west is low for most geologies and where present, significant communities are likely to be associated with discrete geological features such as limestone formations. Accordingly, the PRP area was considered to have low prospectivity for significant stygofauna and trologfauna communities. To demonstrate this, the desktop risk assessment included:

1. An assessment of the influence of local water quality on the presence of stygofauna to occur in the PRP area;
2. A review of the local geology to identify potential stygofauna and troglofauna habitat ;
3. A review of regional information on subterranean fauna to provide a comparison with the PRP area.
4. An assessment of the likelihood of subterranean fauna occurring in the PRP area.

If required, a preliminary sampling plan for stygofauna and troglofauna pilot surveys has been prepared as a contingency and is presented in **Appendix A**.

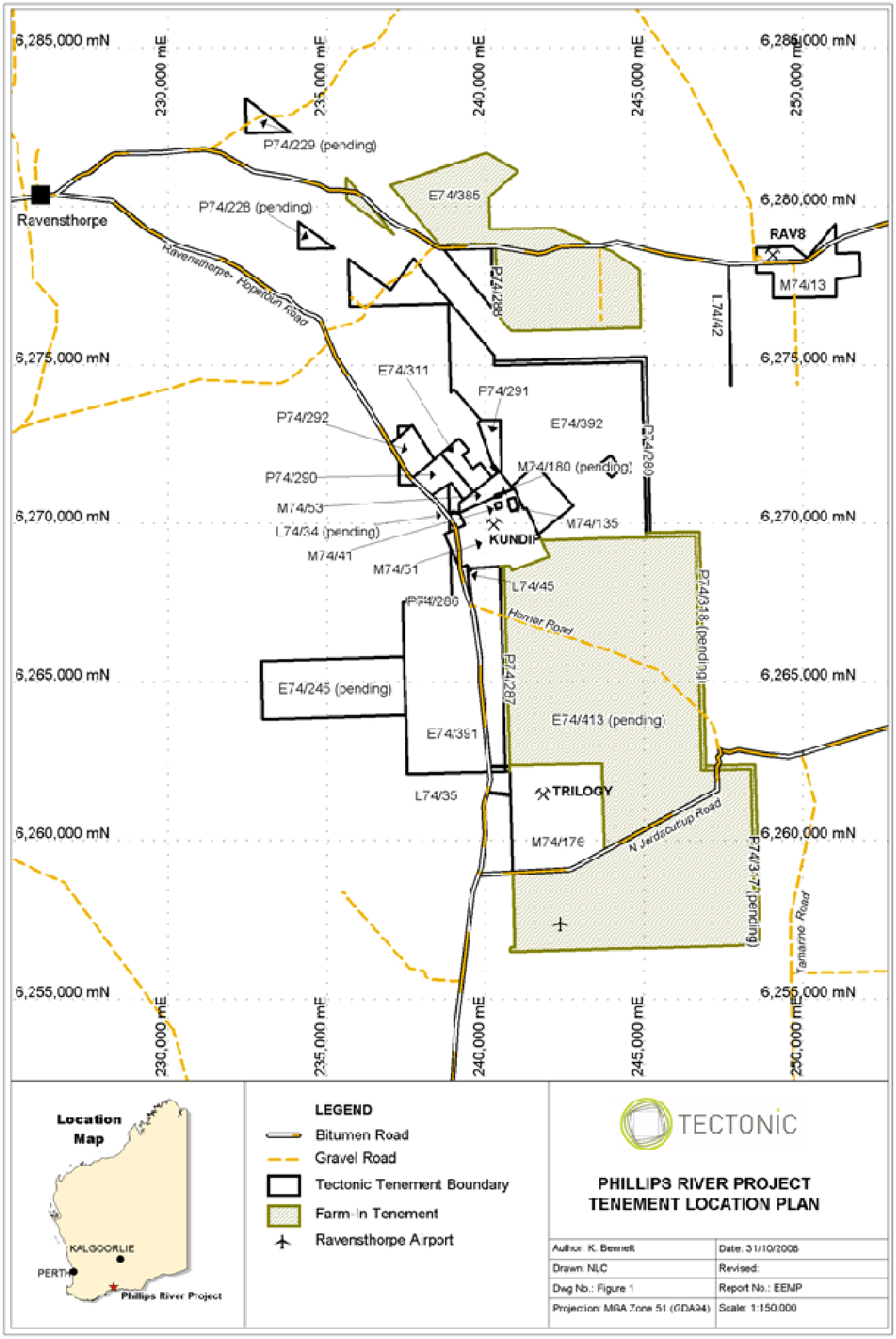

Figure 1: Location of the Tectonic Phillips River Project (PRP) (Source: Tectonic Resources NL).

2. EXISTING ENVIRONMENT

2.1 Biogeographical Region, Climate and Vegetation

The Interim Biogeographic Regionalisation for Australia (IBRA) is a bioregional framework which divides Australia into 85 bioregions and 403 subregions on the basis of climate, geology, landforms, vegetation and fauna. It was developed through collaboration between state and territory conservation agencies with coordination by the Department of Sustainability Environment Water Population and Communities (Department of Sustainability Environment Water Population and Communities 2010b).

As defined by IBRA, the PRP is located in the Fitzgerald subregion (ESP1) of the Esperance Plains Bioregion within south-western Australia **(Figure 2)** (McKenzie *et al.* 2003). Average rainfall for the PRP area is approximately 425 mm per annum with potential evaporation of approximately 2,000 mm (Bureau of Meteorology 2010).

The PRP is also situated within the zone of cooperation of the Fitzgerald Biosphere Reserve, an area established to help manage conservation efforts within the Fitzgerald River National Park. The Biosphere Reserve is functioning because of community recognition of land management systems and practices in both the buffer and co-operation zones. In recognition of this both UNESCO and Commonwealth funding has been available for management. Mining, subject to sound environmental management practices, is one of many human impacts considered to be acceptable in the zone of cooperation. The holistic ‘big picture’ approach adopted by the Biosphere concept is important for this and another reason; it acknowledges that man and his activities are part of the environment in which they live, but that they do require appropriate management. In addition to the Biosphere Reserve, the PRP is located within one of 15 national biodiversity hotspots as listed by the Department of Sustainability, Environment, Water, Population and Communities (2010a).

The Kundip project area specifically, lies at the southern end of the Ravensthorpe Range and within the vegetation corridor that links the Fitzgerald River National Park to Unallocated Crown Land (UCL) north of the South Coast Highway (Outback Ecology 2005). The area contains both disturbed land and remnant native vegetation, with low woodlands, dense heath and open mallee representing some of the dominant vegetation communities (Outback Ecology 2007). The Trilogy project area is located on cleared farmland south of the Kundip Nature Reserve (No. 31128). The area has little remaining perennial vegetation except for a narrow strip, including *Eucalyptus* species, along a drainage line east of the deposit (Outback Ecology 2005).

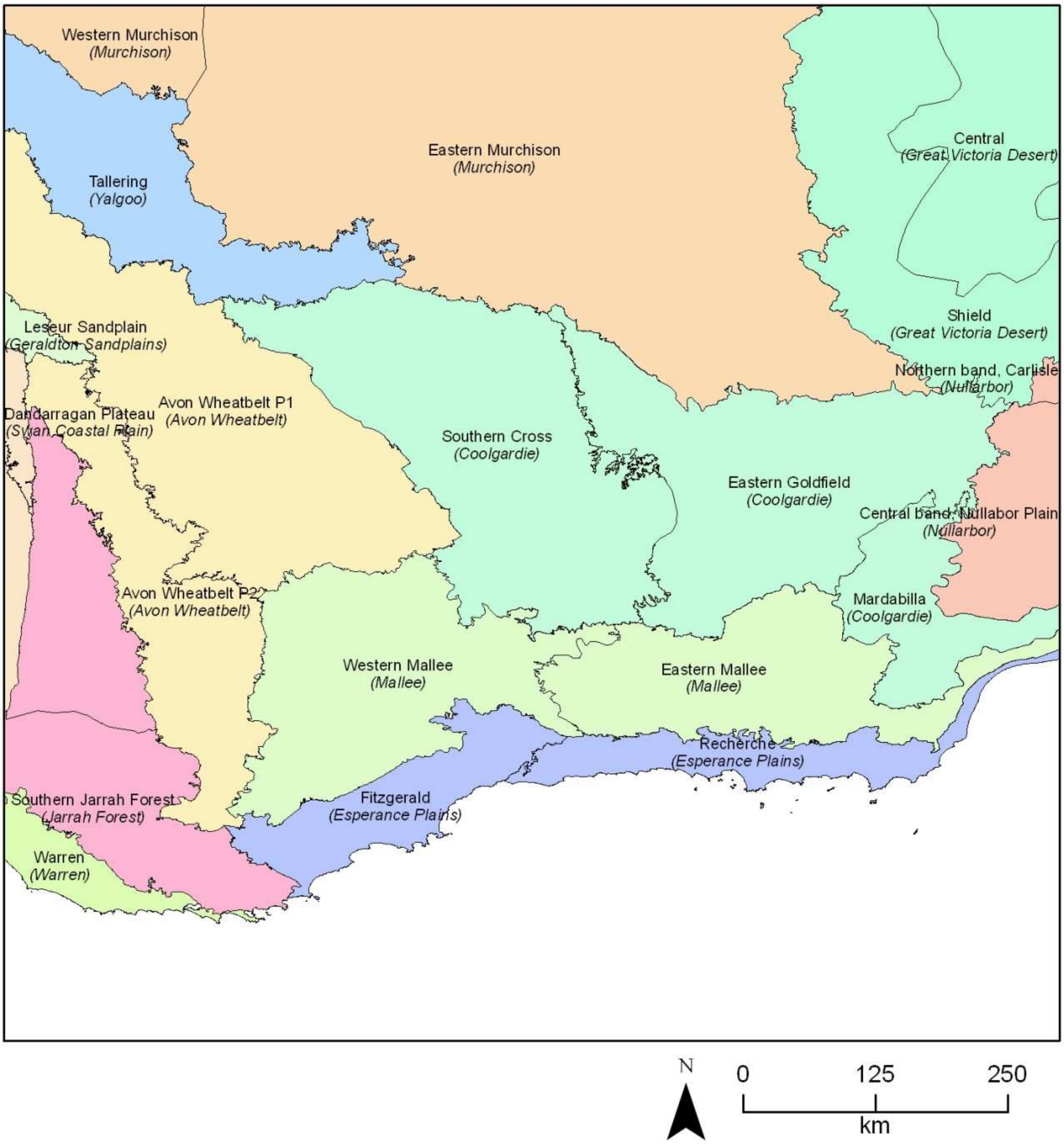

Figure 2: The location of the Fitzgerald subregion within the Esperance Plains bioregion (as defined by the IBRA).

2.2 Geology

The geology of the Ravensthorpe area consists of Precambrian basement rocks and Cenozoic sediments that have been emplaced and deposited over three geological periods; Precambrian, Tertiary and Quaternary (Simons 2006a). The basement rocks encompass three major Precambrian tectonic units. The Ravensthorpe greenstone belt is associated with the southern margin of the Archaean Yilgarn Craton and covers the northern portion of the area. The Archaean granite greenstone association which is overlain by metasedimentary rocks of the Proterozoic Mount Barren Group occurs further south. Most of the south-east is covered by the Munglinup Gneiss. The north-east trending Jerdacuttup Fault separates the Munglinup Gneiss from the Mount Barren Group and Archaean granite-greenstones.

Among the Tertiary sediments are those of the Plantagenet Group, including the Pallinup Siltstone and Werrilup Formation. The Pallinup Siltstone consists of siltstone and spongelite deposited in a marine environment while the Werrilup Formation is comprised of dark grey siltstone, claystone, lignite and limestone deposits associated with past fluvial environments (Short 2000).

The Trilogy deposit specifically is located in an area of the Proterozoic Mount Barren Beds comprised of phyllitic schist and carbonaceous shale with minor quartzite (**Figure 3**). The carbonaceous nature of the shale relates to its organic carbon content, and is not a reference to calcium carbonate content. The beds unconformably overlie Archaean rocks of the southern Yilgarn Block. The mineralisation occurs within a zone of silicified shale and minor sandstone which dips to the south-east at approximately 40 degrees. (Rockwater 2009). The deposit is hosted in a graphitic siltstone, occurring in both the hanging wall and footwall. Intense siliceous alteration surrounds the Lead Zinc mineralised core, at the northern end of the deposit. The lead - zinc core is a sulphide - silica matrix vent breccias, approximately 20 m true width, which comprises up to 70 % sulphides with remainder being silicified siltstone or (sulphidic) quartz matrix (A. Czerw pers. comm. 2010).

During drilling operations voids (vuggs) have been noted within the lead-zinc core, but never in the graphitic siltstone or silicified siltstone. The voids typically comprised a maximum 1 - 2 m wide zone of alternating solid and vuggy rock, the vuggs occurring as a result of the oxidation of sulphides and supported by quartz matrix. The areas of vugg are believed to have little to no connectivity (A. Czerw pers. comm. 2010). The graphitic siltstones at Trilogy deform ductilely with little if any brittle fracture. This translates into little or no opportunity for significant void or vugg development in this rock type (A. Czerw pers. comm. 2010).

The Kundip mining area is situated in a region of steeply-dipping mafic to intermediate volcanic rocks known as Annabelle Volcanics **(Figure 3**). Some ultramafic schists are also present (Witt 1997 cited in Rockwater Pty Ltd 2004). The Archaean volcanic rocks have been intruded to the west by some Archaean granitic rocks, with the contact between the two followed by the upper reaches of the Steere River. To the south, the Archaean rocks are overlain by the Proterozoic Mount Barren Group which includes the sediments of the Kundip Quartzite and the Kybulup Schist (**Figure 4**) (Rockwater 2004).

2.3 Regional Hydrology and Hydrogeology

2.3.1 Surface Water Hydrology

The major river systems in the Ravensthorpe area include the Oldfield River and its major tributary (the Munglinup River), the Jerdacuttup River, the Steere River and the Phillips River with its major tributary the West River (**Figure 5**). The West River flows into the Phillips River approximately 25 km from the coast. From there the river cuts through to Culham Inlet along a fault in the schist and quartzite geologies of the Mount Barren Group. The Steere River also discharges into the Culham Inlet, and is part of the estuarine system for approximately 2 km upstream (Massenbauer 2006).

2.3.2 Groundwater Hydrology

There are three main aquifer types in the Ravensthorpe region. These include the semi-confined and unconfined aquifers present in the regolith (sediments and weathered basement rocks), localised perched aquifers in area of deep sands overlying silcrete or clays of low permeability, and fractured rock aquifers. The latter occur in association with the greenstone belts and the Mount Barren Group rocks (Johnson 1998 and Dodd 1999 cited in Simons 2006b).

Among the primary aquifers are those associated with the sand and limestone geologies to the north of Hopetoun. Also of note are the aquifers within the Tertiary sediments: Pallinup Siltstone and Werrilup Formation, examples of which are located south of the Trilogy project area, to the north and north-east of Hopetoun (P. Wharton pers. comm. 2009). Variable depths to groundwater have been documented in the region, from ground level to depths of greater than 24 m. Groundwaters are generally saline. (Simons 2006b).

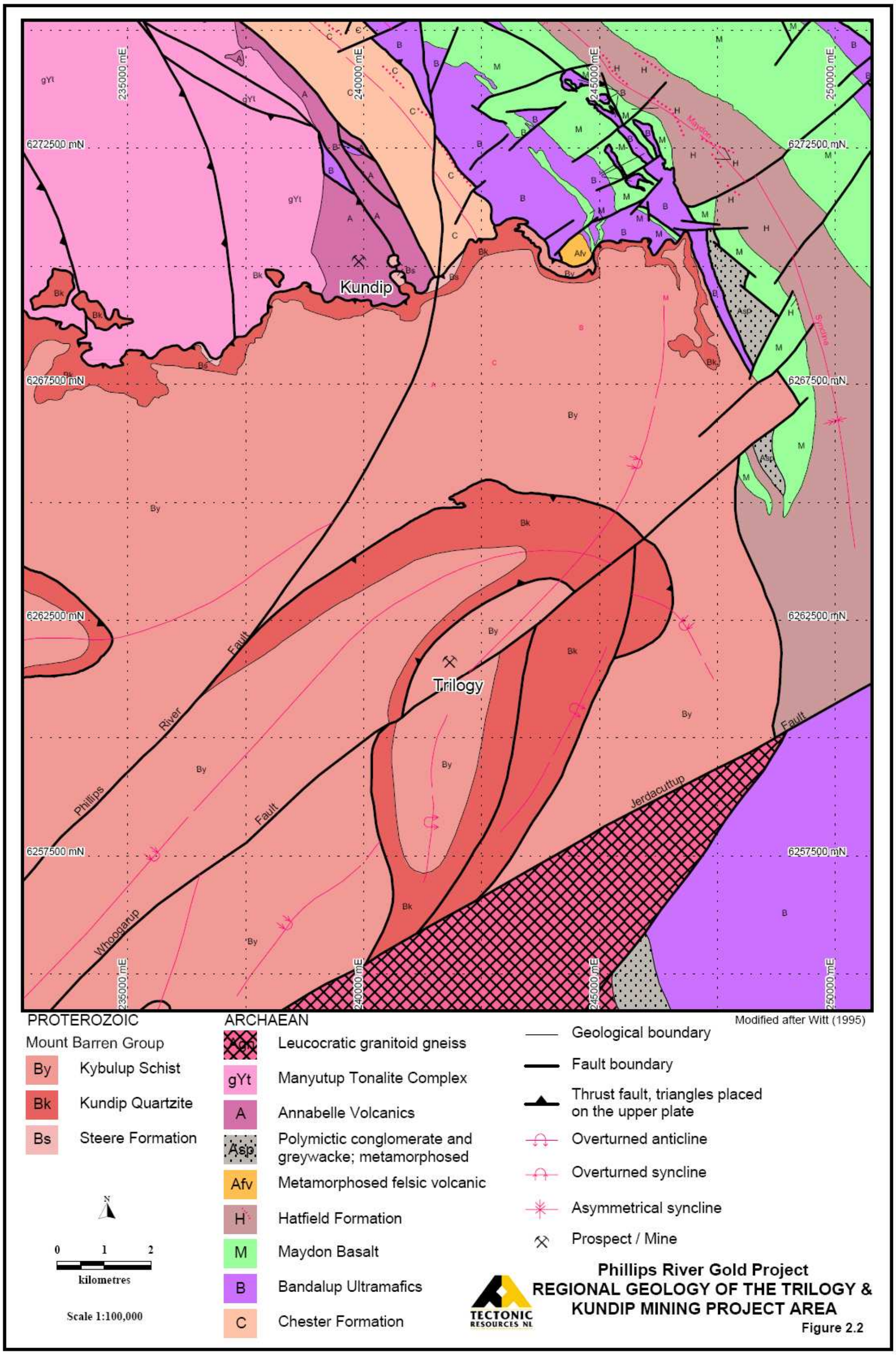

Figure 3: Regional geology of the Trilogy and Kundip project areas (Source: Tectonic Resources NL).

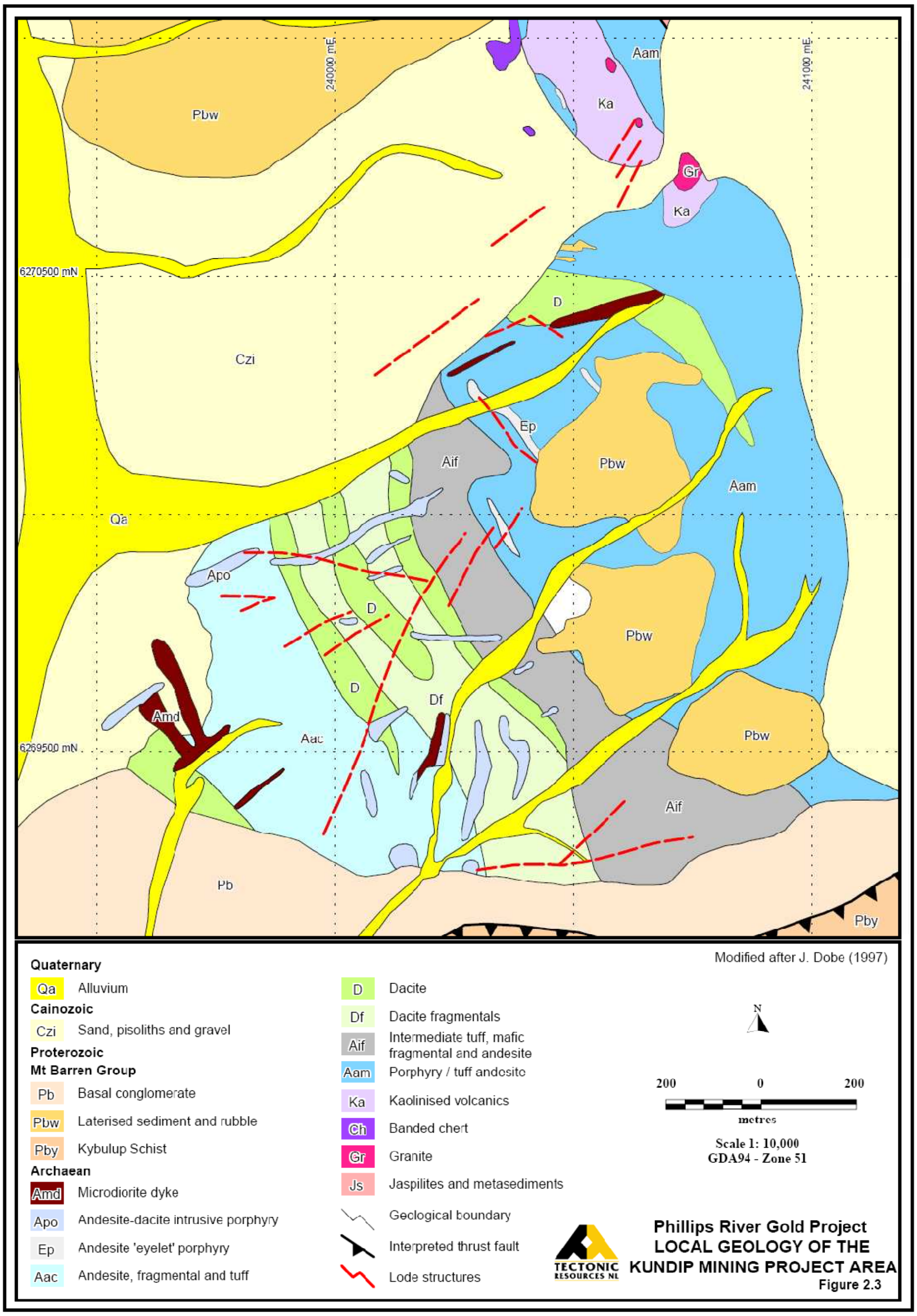

Figure 4: Local geology of the Kundip area (Source: Tectonic Resources NL).

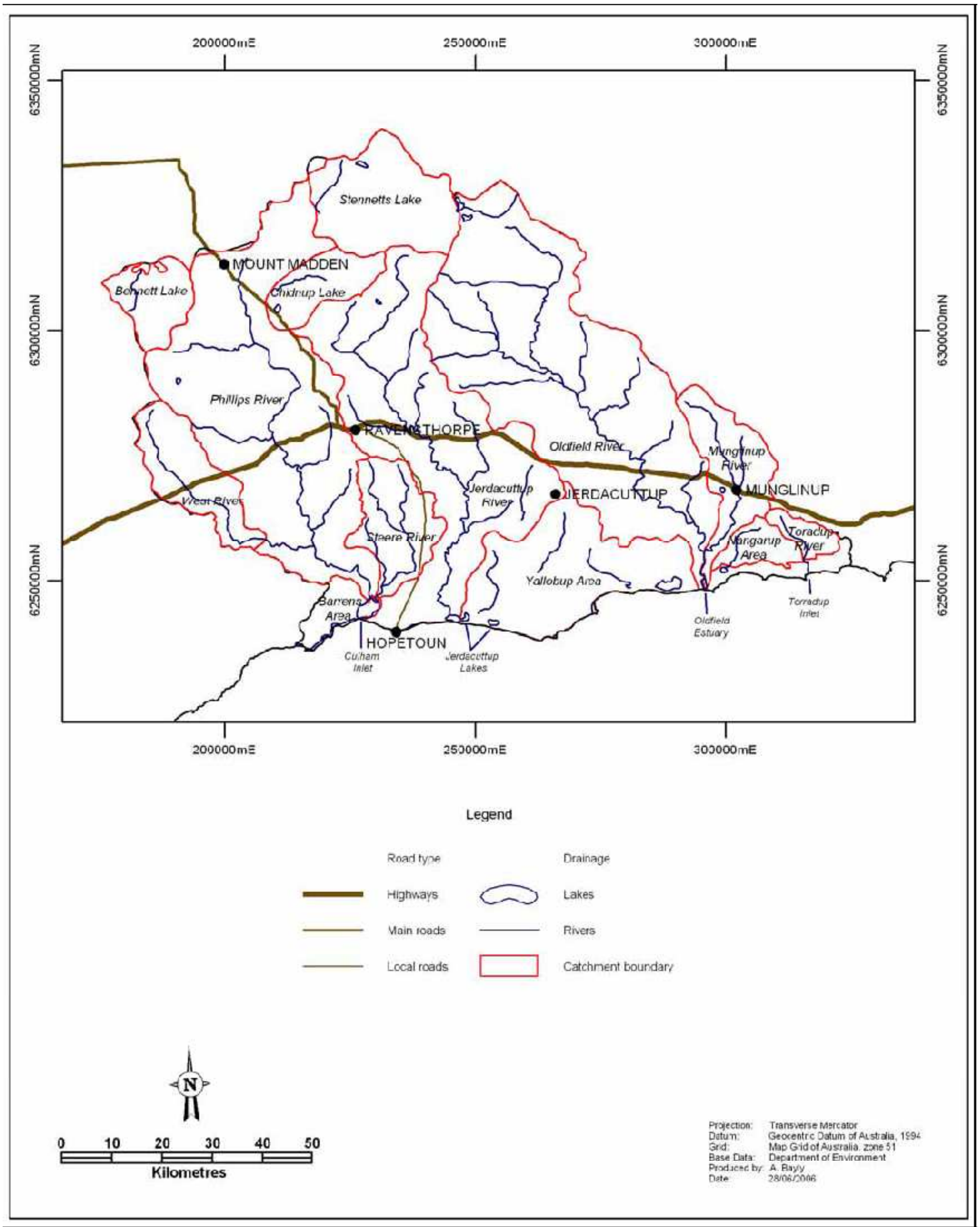

Figure 5: Catchments within the Ravensthorpe area (Source: Massenbauer 2006).

3. SUBTERRANEAN FAUNA

3.1 Risks and Relevant Legislation

Subterranean fauna are valued for their biodiversity and their contribution to ecological function, which includes nutrient and energy transfer within the environment (Tomlinson *et al.* 2007). They comprise of ancient lineages that have been protected underground, despite changes in surface climate, geomorphology and geographical position over thousands of years (Boulton *et al.* 2003). Many subterranean species are classified as short range endemics (SREs), which have a narrow habitat range of <10,000 km^2 (Harvey 2002), related to long periods of evolutionary isolation and a lack of connectivity between habitats. These taxa have high conservation significance, and may be at risk, or are considered vulnerable to, impacts associated with mining activities (EPA 2007).

In relation to mining, potential threats to subterranean ecosystems, which may support diverse stygofauna and troglofauna communities, include:

- lowering the water table, which may dry out subterranean habitats;
- altering the water quality, which may exceed species tolerance limits; and
- direct removal or disturbance to habitats (EPA 2003a).

Subterranean fauna are protected under State and Federal legislation including the:

- *Wildlife Conservation Act 1950 (WA)*;
- *Environmental Protection Act 1986 (WA)*; and
- *Environment Protection and Biodiversity Conservation Act 1999 (Cth)*.

With this legislation in mind, the Environmental Protection Authority (EPA) developed:

- *Guidance Statement No. 54: Consideration of Subterranean Fauna in Groundwater and Caves During Environmental Impact Assessment in Western Australia* (2003); and
- *Guidance Statement No. 54a Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia (Technical Appendix to Guidance Statement 54)* (2007).

These documents provide advice to proponents and the public on the EPA's minimum requirements for environmental impact assessment (EIA) and management of subterranean fauna.

New mining proposals that will potentially impact on groundwater or habitats that support subterranean fauna require a risk assessment to ensure mining operations do not threaten the viability of significant taxa. Proponents must demonstrate that any threatened species within the potential impact zone also occur outside this area. For taxa restricted to the impact zone a suitable management plan must be developed, which includes ongoing monitoring of subterranean fauna, ensuring the persistence of species (EPA 2003a).

The DEC, responsible for administering the *Wildlife Conservation Act 1950*, maintains a list of rare or threatened species of subterranean fauna, or those with high conservation value. These include; priority ecological communities (PECS), which are rare but not currently threatened, or those with insufficient information, and threatened ecological communities (TECs) (Department of Environment and Conservation 2010b). Definitions for these community types are presented in **Appendix B**.

TECs that occur in Western Australia may also be listed as nationally threatened under the federal *Environment Protection and Biodiversity Conservation Act 1999* (Department of Sustainability Environment Water Population and Communities 2010c). These state and federal lists are maintained by the DEC and DSEWPC and are available online (via database searches), providing important information on significant stygofauna and troglofauna communities that may be at risk from proposed mining activities.

4. DESKTOP REVIEW APPROACH AND METHODS

4.1 Literature Review

A literature review was undertaken to determine stygofauna and troglofauna communities that have been recorded from within the PRP area and surrounds. Information was compiled using internet searches for the south-west and other regions including the southern Yilgarn and Nullarbor. It should be noted that not all work that may have been carried out in these areas is publicly available.

4.2 Database Searches

- TEC and PEC lists provided by the Department of Environment and Conservation (Department of Environment and Conservation 2010a, b); and
- Threatened Species and Ecological Communities – list provided by the Department of Environment, Water, Heritage and the Arts (Department of Sustainability Environment Water Population and Communities 2010c).

5. RESULTS AND DISCUSSION

5.1 Stygofauna

5.1.1 Background

Stygofauna (groundwater fauna) are predominantly comprised of invertebrates. Crustaceans generally dominate stygal communities with other groups including worms, insects, gastropods and water mites occurring to a lesser extent. They can be further classified according to their level of dependency on the subterranean environment. Invertebrates that enter groundwaters passively or accidentally are referred to as stygoxenes, while those that inhabit groundwaters on a permanent or temporary basis are called stygophiles. It is only animals that are obligate groundwater dwellers that are termed stygobites. Stygobites are restricted to their subterranean environment and can be distinguished from surface dwelling animals ecologically and genetically (Cooper *et al.* 2002, Danielopol and Pospisil 2000). They display characteristics typical of a subterranean existence which include: a reduction or absence of pigmentation, absence or reduction of eyes, and the presence of extended locomotory and sensory appendages (Humphreys 2008).

Stygofauna occur in various types of aquifers which exhibit voids of a suitable size for biological requirements (Humphreys 2008). In Australia, increased research efforts and improved sampling techniques have demonstrated an increasingly rich stygal community. Previously believed to be restricted to karst landscapes, obligate groundwater inhabitants have now been found in alluvial sediments, fractured rock aquifers, pisolites and thin regoliths (Humphreys 2006, Humphreys 2008). In Western Australia, studies have shown that the calcretes and alluvial aquifers of the arid and semi-arid zones contain rich stygofaunal communities (EPA 2003a). The Pilbara and to a lesser extent the Yilgarn, stand out as global hotspots for stygofauna diversity (EPA 2007).

5.1.2 Ecological Requirements

Similar to surface water biota, the distribution of stygofauna is governed by historical factors including past climatic conditions and evolutionary changes. Groundwater quality, the geological structure and composition of aquifers, and biological interactions are also recognised as important influences (Humphreys 2009, Strayer 1994). One of the factors linked to changes in stygal distribution is depth. Diversity is often greater in surficial aquifers and tends to decline with increasing depth. A shift in community composition may also be evident, with more specialised subterranean fauna found at greater depths, potentially attributable to increasing environmental constraints (Strayer 1994).

A related factor is the flux of organic carbon. As a result of the perpetual darkness, groundwater systems generally rely on energy from external sources. One such example is dissolved organic carbon (DOC) which may be percolated down through the unsaturated zone or transported laterally via groundwater flow, dependent on the hydraulic conductivity of the aquifer (Humphreys 2009). This energy source is likely to support bacteria which are in turn grazed by stygofauna. Other stygofauna may feed on detritus, or in some cases predate on other invertebrates (Pain 2005).

Groundwater flow is affected by a number of factors such as sediment particle size. In subterranean environments with a small grain particle size, the likelihood of stygofauna is reduced due to a lack of voids and small interstitial spaces. In contrast, the diversity and abundance of stygofauna is higher in geologies with large voids such as within calcrete aquifers in the northern Yilgarn and coastal Pilbara regions. The colluviums and alluvium aquifers found in the palaeodrainages of the Murchison also provide a suitable habitat for many stygal taxa (Cooper *et al.* 2007, Cooper *et al.* 2002, Karanovic 2004).

Groundwater quality has a strong influence on stygal diversity. Similar to surface water invertebrates, salinity is a limiting factor, with many stygofauna showing a preference for salinities no greater than seawater (<35 g/L) (Strayer 1994). Stygofauna can however be found in hypersaline waters (>50 g/L)

(Hammer 1986), with the EPA Guidance Statement 54a (2007) suggesting that significant stygofauna communities may occur in salinities of up to 60 g/L. Groundwater pH also affects the distribution of stygofauna, with acidic waters, generally associated with igneous and metamorphic sedimentary rocks, providing less suitable habitats (Humphreys 2008). This usually leads to a reduction in species diversity, as found in stygal communities in low pH waters of the Pilbara (Reeves *et al.* 2007).

5.1.3 Regional Context

Literature Review

Little work has been conducted on stygofauna in the area immediately surrounding the PRP. In light of this, the literature review and summary table (**Table 1**) include work from other regions (the Nullarbor and southern Yilgarn) in addition to studies in the south-west.

In relation to the PRP, the nearest study conducted to date has been at the Ravensthorpe Nickel Project, approximately 30 km east of the PRP. A report, addressing changes to the environmental conditions for that project (EPA 2003b), noted that stygofauna were not found in the mining area.

In contrast, a three phase survey for Grange Resources Southdown Magnetite Project near Albany identified stygofauna from a number of sites in the Southdown and Redmond–King River areas. Of particular interest were stygobites such as syncarids and candonid ostracods recorded from the fine-grained Pallinup Siltstone aquifer. The stygofauna collected from the fractured bedrock aquifer consisted of taxa that were not obligate groundwater inhabitants (stygobites) (Eberhard 2006, Rockwater 2006).

The Pallinup Siltstone does not occur within the PRP project area, with the nearest known location to Trilogy approximately 7 km to the south-west. The occurrence is mapped south of the Jerdacuttup Fault. This fault is a regional feature which is thought to have a 30 m down throw (south block down) which has been subsequently filled with younger sediments. All of the PRP proposed workings occur north of the Jerdacuttup fault.

Rich stygofauna communities in the south-west are generally linked to groundwaters associated with karst formations, with the likelihood of such communities considered to be low for most non-karstic geologies (EPA 2007). Examples supporting this include the presence of stygofauna in streams or pools within limestone caves at Yanchep and the Leeuwin-Naturaliste Region, both of which are over 500 km from the PRP (English and Blyth 2000, English *et al.* 2000). These communities are currently listed as TECs under the EPBC Act. More recent work in the Leeuwin-Naturaliste region (Jewel Cave karst system) also identified stygofauna (Eberhard 2004). Of these, a small number of taxa from the groups Copepoda, Ostracoda and Amphipoda were considered to be stygobitic.

Again highlighting the presence of stygofauna in karstic systems, work by De Laurentiis and colleagues (2001) documented stygofauna from bores associated with the Tamala limestone, while surveys within the Cable Sands (WA) Pty Ltd Ludlow lease near Busselton, identified oligochaetes, copepods, ostracods and amphipods. The specimens were collected from a bore hole proximal to the Ludlow River, potentially near the outer limits of their habitat in the saturated limestones (Biota 2003).

Stygofauna have also been recorded from the groundwaters of the Nullarbor caves (Nullarbor Plains karst system). However, despite suggestions that the likelihood of abundant stygofauna communities occurring in the Nullarbor is high (EPA 2007), work to date has revealed a low stygal diversity, comprised solely of amphipods (Humphreys 2008).

The limited numbers of surveys conducted in the southern Yilgarn to date have not yielded abundant stygal communities, a finding which may be partially linked to the decline in valley calcretes below the Menzies Line (latitude 29°S) (Morgan 1993). Samples taken from the fractured rock aquifer at the Carina Iron Ore Deposit, 60 km north-east of Koolyanobbing and approximately 350 km north of the PRP, did not contain stygofauna. The presence of copepod fragments in troglofauna by-catch from nearby deposits, does however suggest that low numbers of stygofauna may occur in these geologies (Bennelongia 2009). Work at the Windarling iron ore mine (as part of the Koolyanobbing Iron Ore expansion Project) did not yield any stygofauna **(Table 1**) (Portman Iron Ore Limited 2008).

A stygofauna survey conducted at Lake Randall, approximately 80 km south-east of Kalgoorlie and 300 km north-east of the PRP collected low numbers of aquatic invertebrates including copepods, oligochaetes and rotifers. Of these, the copepods were confirmed as surface water inhabitants while the latter groups are known to occur in both surface and subterranean waters (Outback Ecology 2008). Another stygofauna assessment, 160 km south of Southern Cross and approximately 140 km north-west of the PRP, within the Spotted Quoll Nickel project area and surrounds, identified stygal copepods from the family Ameiridae (EPA 2009), consistent with the low diversity noted during other surveys in the region **(Table 1).**

These results tend to suggest that the non-karstic geologies of the southern Yilgarn and south-west are generally less conducive to significant stygofauna communities. As the number of studies conducted in these regions increase, greater insight into stygal distribution and diversity will be gained.

Database Searches

A search of the Western Australian TEC and PEC lists maintained by the Department of Environment and Conservation did not find any PECS of stygofauna in the PRP area or surrounds (Department of Environment and Conservation 2010a, b). Furthermore, a search of the federal Threatened Species and Ecological Communities database also did not identify any stygofauna TECs (as defined under the *EPBC Act 1999*), within the Project area (Department of Sustainability Environment Water Population and Communities 2010c).

Table 1: Summary of stygofauna studies conducted near the PRP and surrounding regions.

Area	Project	Distance from Project	Outcomes of the Study	Reference
South-west	Ravensthorpe Nickel Project	~30 km east	No stygofauna collected in mining area.	EPA 2003b
	Southdown Magnetite Project	~175 km south-west	Stygobites collected from the siltstone aquifer.	Eberhard 2006; Rockwater 2006
	Cable Sands Ludlow Lease	~400 km west	Stygofauna including oligochaetes, copepods, ostracods and amphipods.	Biota 2003
	Yanchep Caves Research	~600 km north-west	Stygofauna collected.	English *et al* 2000
	Leeuwin-Naturaliste Caves Research	~500 km west	Stygobitic copepods, ostracods and amphipods collected.	Eberhard 2004; English and Blyth 2000
Southern Yilgarn	Yilgarn Iron Ore Project - Carina Deposit	~350 km north	No stygofauna collected	Bennelongia 2009
	Yilgarn Iron Ore Project - Chamaeleon Deposit	~370 km north	Fragments of potential stygofauna (calanoid and harpacticoid copepods) were collected	
	Yilgarn Iron Ore Project - Mt Finnerty	~335 km north	Fragments of potential stygofauna (calanoid and harpacticoid copepods) were collected	
	Koolyanobbing Iron Ore Expansion Project - Windarling Iron Ore Mine	~380 km north	No stygofauna collected	Portman Iron Ore Limited 2008
	Randalls Project	~300 km north-east	Very low number of invertebrates. The copepods collected were surface water inhabitant. The habitat preference of the oligochaetes and rotifers could not be confirmed.	Outback Ecology 2008
	Spotted Quoll Nickel Project	~140 km north-west	Stygal copepods collected.	EPA 2009
Nullarbor	Nullarbor Caves Research	> 700 km east	Stygal amphipods collected.	EPA 2007; Humphreys 2008

5.2 Troglofauna

5.2.1 Background

Troglofauna (terrestrial subterranean fauna) are often relictual forms related to surface dwelling (epigean) groups and can be distinguished by characteristics associated with a below ground existence (Humphreys 2000). Similar to stygofauna, troglofauna can be further divided into troglophiles, which carry out most of their lifecycle underground however are able to survive in epigean (surface) habitats and trogloxenes which can enter subsurface habitats passively or incidentally. Obligate or permanent subterranean inhabitants are referred to as troglobites (Thurgate *et al.* 2001), and may comprise of species which have a restricted distribution. They generally lack pigmentation, are blind (or have reduced eyes), and have elongated limbs (Culver *et al.* 1995).

Troglofauna are found worldwide and were generally classified as cave or well-dwelling organisms (Culver and Sket 2000). However, the discovery of diverse troglofauna communities inhabiting subsurface rock fractures in non-karst areas in Europe in the 1980's prompted broader consideration of potential habitat (Juberthie 2000). It is only recently that troglofauna have become a focus of environmental assessment in Western Australia and there is still relatively little information on their distribution (Eberhard 2007, EPA 2007).

The most researched areas in WA is the Cape Range and Barrow Island karst cave systems, where large diverse communities have been discovered in extensive caves systems (Hamilton-Smith and Eberhard 2000). However, recent dedicated sampling in the Pilbara region has identified troglofauna from non-karstic geologies such as vuggy pisolite ore beds (Biota 2006) while in the Yilgarn, geologies including calcrete (Barranco and Harvey 2008) and metamorphic mafic rocks (Bennelongia 2009) have been found to contain troglofauna.

5.2.2 Ecological Requirements

Any stable subsurface air-filled cavities that are dark, maintain a high relative humidity and stable, cool-moderate temperatures, with an adequate supply of nutrients may be considered potential troglofauna habitat (Howarth 1983). The nature of the cavity development is important, with sediment filled spaces unlikely to support troglofauna. Internally sealed cavities which display no connectivity or have limited connectivity are also unlikely to be suitable habitats (Eberhard 2007).

The organic matter and nutrients present in these subterranean ecosystems are generally from external sources, which can be carried into cavities by water or plant roots, usually following large flooding events (Gibert and DeHarveng 2002). These nutrients represent a food resource which is exploited by troglofauna, and can affect their distribution in subterranean environments (Howarth 1983).

5.2.3 Regional Context

Literature Review

Little work has been conducted on troglofauna in the area immediately surrounding the PRP. Therefore, as with the stygofauna, the troglofauna literature review and summary table (**Table 2**) has been extended to include work from other regions (the Nullarbor and southern Yilgarn) in addition to studies in the south-west.

Limited work has been conducted on troglofauna in the south-west. One of the few publicly available studies which identified troglofauna was a stygofauna survey within the Ludlow mining lease. Stygofauna sampling in the area yielded a bycatch of troglobitic symphylans from six boreholes. These specimens were considered likely to belong to *Hanseniella*, a genus with known representatives in several locations within the south-west (Biota 2003).

Information on troglofauna in the southern Yilgarn is similarly sparse. One subterranean survey which has been undertaken in the area is a study for the Yilgarn Iron Ore Project (YIOP), north-east of Koolyanobbing (Bennelongia 2009), approximately 350 km north of the PRP (**Table 2**). A number of taxa were collected from fractured mafic schist in more than one deposit, indicating habitat continuity. In terms of abundance, only 24 specimens were collected from the YIOP area. More than half were singletons and the maximum count was 10.

Troglofauna have also been identified from the Nullarbor caves, with a number of troglomorphic taxa documented. These include troglobitic isopods, amphipods, beetles, arachnids and a cockroach (Morton *et al.* 1995). However, information on the presence of troglofauna in non-karstic geologies in the area is lacking.

As noted in relation to stygofauna, the low number of studies conducted to date means that knowledge of troglofauna in these areas is currently limited. Information on the diversity of troglofauna is likely to increase with further studies.

Database Searches

As with stygofauna, a search of the Western Australian TEC and PEC lists did not find any PECS of troglofauna in the PRP area or surrounds (Department of Environment and Conservation 2010a, b). A search of the federal Threatened Species and Ecological Communities database also did not identify any troglofauna TECs (as defined under the *EPBC Act 1999*), within the Project area (Department of Sustainability Environment Water Population and Communities 2010c).

Table 2: Summary of troglofauna studies conducted in the regions surrounding the PRP.

Area	Project	Distance from Project	Outcomes of the Study	Reference
South-west	Cable Sands Ludlow Lease	~400 km west	Troglobitic symphylans collected.	Biota 2003
Southern Yilgarn	Yilgarn Iron Ore Project - Carina Deposit	~350 km north	Low numbers of 6 troglofauna taxa including Isopoda, Diplura, Coleoptera and Symphyla were collected.	Bennelongia 2009
	Yilgarn Iron Ore Project - Chamaeleon Deposit	~370 km north	Low numbers of 6 troglofauna taxa including Isopoda and Diplura were collected.	
	Yilgarn Iron Ore Project - Mt Finnerty	~335 km north	A single troglofauna specimen was collected, belonging to the order Diplura.	
	Yilgarn Iron Ore Project - Vela	~360 km north	No troglofauna collected.	
Nullarbor	Nullarbor Caves Research	> 700 km east	Troglobitic specimens collected including isopods, archnids and a cockroach.	Morton *et al* 2005

6. HABITAT CHARACTERISATION:TRILOGY

6.1 Stygofauna

As previously noted, the Trilogy deposit is hosted in a graphitic siltstone, occurring in both the hanging wall and footwall, with intense siliceous alteration surrounding the Lead Zinc mineralised core at the northern end of the deposit. During drilling, vuggs have been observed within the lead-zinc core (the mineralized zone) however have not been noted in the graphitic or siliceous siltstone. These vuggs, which typically comprise of 1 - 2 m wide zones of alternating solid and vuggy rock, occur as a result of the oxidation of sulphides within the matrix. Groundwaters in the area are primarily associated with this mineralized zone and appear to flow to the north-west, towards the tributaries of the Steere River, as suggested by the static water levels of the bores in the area. Groundwater levels are approximately 34 m below ground level (Rockwater 2009).

Despite the presence of groundwaters, the Trilogy project area is unlikely to provide suitable habitat for significant stygofauna communities. Firstly, the vuggs in the mineralized zone (the main water bearing zone) are considered to have little to no connectivity, suggesting that they are geologically hostile for stygofauna. Moreover, the rockmass outside the mineralized zone is predominantly comprised of graphitic siltstone, a unit which characteristically shows little vugg development (A. Czerw pers. comm. 2010).

One of the other factors taken into account was groundwater quality. Groundwater salinities in the Trilogy project area ranged from 15,200 mg/L to 25,400 mg/L (Rockwater 2009) and were classified as hyposaline (3,000 - 20,000 mg/L) or mesosaline (20,000 - 50,000 mg/L) (Hammer 1986), suggesting that salinity would not be a limiting factor for stygofauna. However, the groundwater pH was considered likely to influence the distribution of stygofauna, with acidic groundwaters present in the main water bearing zone (the mineralised zone).

Specifically, TMB4, one of the monitoring bores associated with the mineralised zone (**Figure 6**), had field pH values ranging between 3.3 - 3.8 at depths below 90 m. Similar values were recorded at below 110 m for a second monitoring bore which coincided with the mineralised zone (TMB3). Waters higher in the mineralised zone of TMB4 had a pH of approximately 5.6. However, this may have been a reflection of high silt content and low flows rather than a pH gradient within the mineralised zone. Similar to TMB3 and TMB4, water within the test production bore TPB1 was acidic (laboratory pH of 2.8).

The low pH of groundwaters in the mineralised zone has been linked to high sulphur content with decaying oxidising sulphides causing localised lowering of the pH. Elevated levels of soluble iron, zinc and lead have also been noted (Rockwater 2009). It is considered that the low pH, in addition to the elevated metal concentrations, is likely to preclude stygofauna from the groundwaters associated with the main water bearing zone (the mineralised zone).

Groundwater pH values outside of the main water bearing zone were comparatively higher, with the average ranging from 6.2 at the regional monitoring bore TMB6 through to the alkaline value of 8.0 at the regional monitoring bore TMB2 (**Figure 6**), attributed to the lower sulphur content in the rocks. Higher pH values (6.8 - 7.4) were also noted at TMB1, a monitoring bore at the northern end of the pit outline (Rockwater 2009). However, as previously noted, the rockmass outside of the main water bearing zone is dominated by graphitic siltstones. This geological unit typically displays little if any vugg development and has low permeability rates (A. Czerw pers. comm. 2010), suggesting that it is unlikely to provide suitable habitat for rich stygofauna communities.

Another factor considered was the water volume. Maximum airlift yields, as measured across the eight monitoring bores (TMB1 - TMB8), ranged from a trace at TMB8 through to 240 m^3/day (TMB4). Only two of the eight bores exceeding >50 m^3/d. The comparatively high groundwater flows measured from TMB4 and, to a lesser extent, TMB3 (120 m^3/d) during drilling were closely correlated with the main water bearing zone (silicified mineralised zone), leading to the placement of a test production bore (TPB1) approximately 10 m north-east of TMB4 (Rockwater 2009).

These results indicate that the highest volumes of water (and main water bearing zone) are associated with the mineralised zone and are therefore unlikely to have pH values suitable for significant stygal communities. Furthermore, although pH values are higher outside the mineralised zone, the lower airlift yields reflect low permeability and low volumes of groundwater, potentially reducing prospectivity for abundant stygal communities.

Recharge to fractured rock aquifers such as Trilogy is typically low (potentially <1 % of rainfall), further compounding the low likelihood of significant stygal communities occurring in the Trilogy project area. As noted previously, subterranean communities are generally dependent on external sources of energy, with the quantity of imported materials linked to factors such as the dynamics of the water and the infiltration potential of the environment (Gibert *et al.* 1994). Therefore, it is probable that the low levels of recharge to the Trilogy aquifer are reflected in low energy inputs, decreasing the ability of the aquifer to support abundant populations of stygofauna.

Substantial lowering of the water table (groundwater drawdown) can have a significant impact on subterranean fauna and must be considered when investigating the risk of a proposal to subterranean communities (EPA 2003). In the Trilogy project area, water level drawdown was assessed through constant rate pumping tests. The test production bore TPB1 was pumped at a constant rate of 300 m^3/d for 48 hours, during which water levels were monitored in TMB1 to TMB6 and TMB8. Of these, significant drawdown was only documented from TMB3 (0.45 m), TMB4 (2.11 m) and TMB5 (0.96 m) (Rockwater 2009).

However, the drawdown amounts in the monitoring bores were low in compared to the drawdown of 23.2 m in the production bore TPB1. The differences in drawdown recorded between TPB1 and the closely situated TMB4 were attributed to reduced bore efficiency and potentially restricted hydraulic connection between the monitoring bore and the production bore. The drawdown observed in the production bore is typical of a laterally extensive aquifer (Rockwater 2009).

In addition to pumping tests, numerical groundwater modelling of pit dewatering was also conducted using an area 5.2 km east-west by 4.4 km north-south centred on Trilogy. Based on drawdown trends observed during pumping of the production bore, the model assumed that the aquifer was laterally extensive with permeability decreasing outside of the Trilogy area and that the aquifer level would fall 25 m each year over a seven year period (**Figure 7**)**.** However, as neither the fractured rock aquifers of the main water bearing zone (the mineralised zone), nor the surrounding geologies are considered likely to have significant stygofauna communities, the groundwater drawdown and permanent groundwater sink are not expected to have a significant impact on the stygofauna values of the area. Moreover, as the aquifer is thought to be laterally extensive, comparable and potentially more favourable habitat may exist outside the area of drawdown (Rockwater 2009), further mitigating the impacts of dewatering.

In addition, the drawdown cone lies within the Proterozoic rocks and is not expected to impact the Tertiary aquifers within the nearby Pallinup Siltstone and Werrilup Formations (P. Wharton pers. comm. 2010), examples of which were found to support stygal populations during a previous survey near Albany (Eberhard 2006, Rockwater 2006).

6.2 Troglofauna

Examination of the lithologies of the eight monitoring bores suggests that potential habitat for troglofauna within the Trilogy project area is limited. The surface lithologies of the bores were relatively similar, consisting of clay, weathered schist or a combination of both. This was typically followed by approximately 20 m of mostly fine-grained (phyllite) schist or quartzite?/schist (Rockwater 2009), a geology unlikely to contain vuggs or voids. The primary exception was TMB2 which contained small vuggs within the weathered schist between 7 and 11 m (Rockwater 2009), potentially indicating troglofauna habitat.

The remaining lengths were dominated by shale which represented at least 40 m of the lithology at each bore, extending below the water table. Of note were the comparatively higher intervals of pyrite mineralisation within the shale at bores TDMB3, TDMB4 and TDMB5 (Rockwater 2009).

Similar geological units were noted at the majority of bores outside the pit outline, indicating that the broader area is also unlikely to have significant troglofauna values. While the presence of small vuggs in the weathered schist at bore TMB2 (Rockwater 2009) was an exception to this, TMB2 is located to the north of the pit outline (**Figure 6**) and would not be impacted by habitat removal in the pit area.

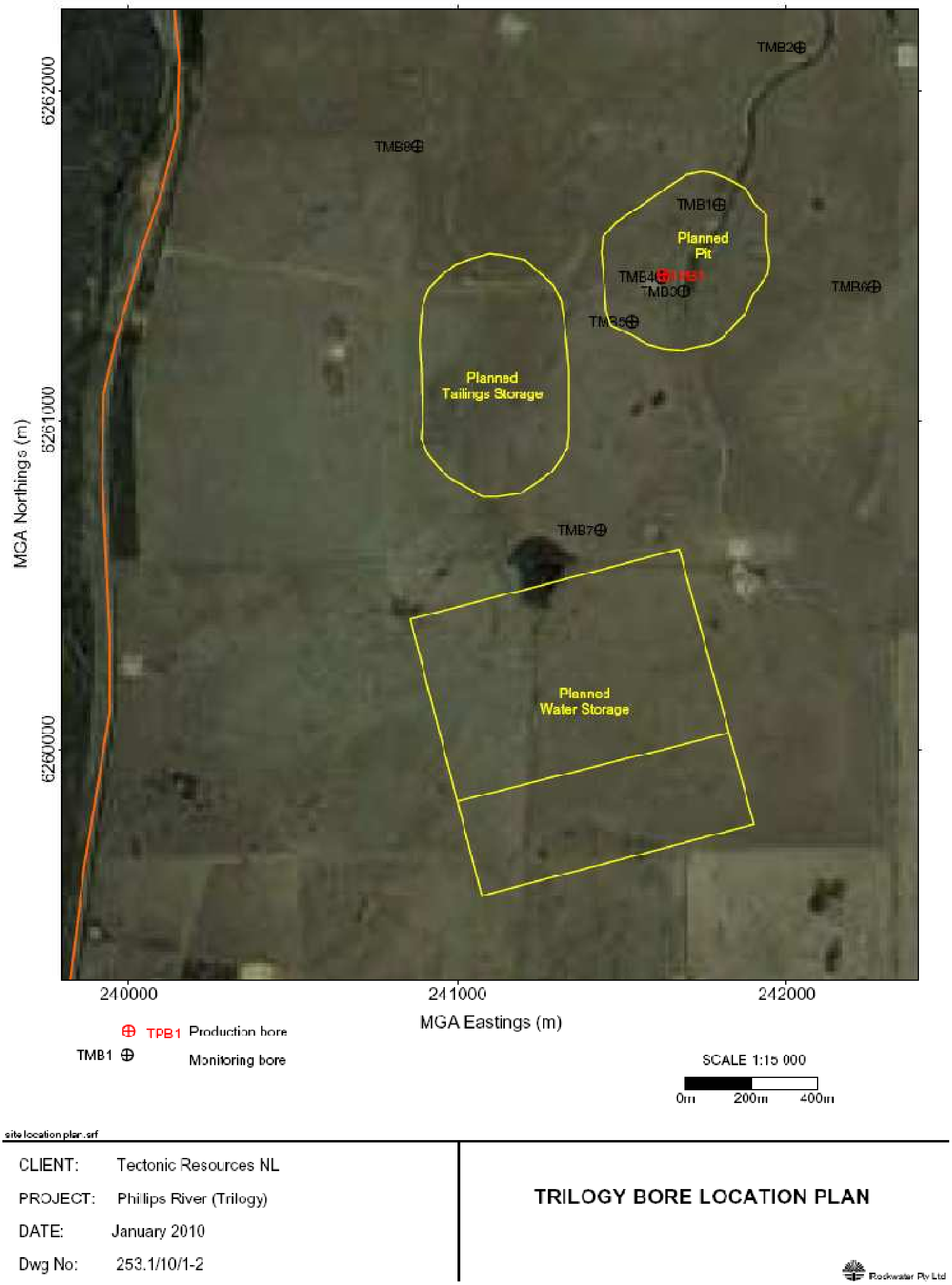

Figure 6: Trilogy bore location plan (Source: Rockwater 2009).

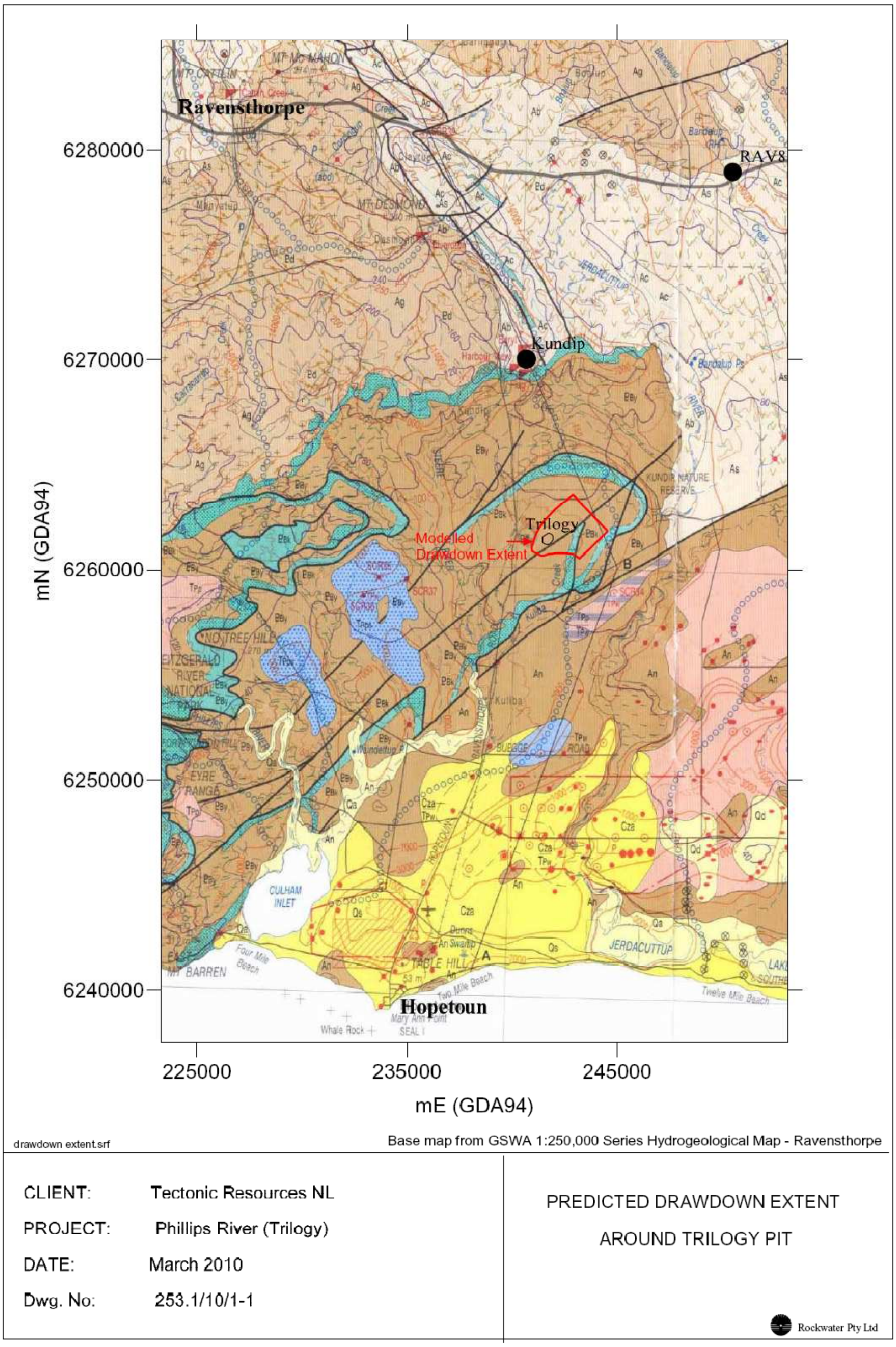

Figure 7: The predicted extent of drawdown around Trilogy pit (Source: Rockwater).

Another investigation examined seven diamond drill holes in the Trilogy pit area (Marjoribanks 2008). The main geological domains documented included ribbon banded siltstone, laminated graphitic siltstone, polymict breccia, silica alteration zones and quartz banded sulphide mineralised zones.

The ribbon banded siltstone was defined by alternating pale-grey phyllitic siltstone (60 % - 90 %) and minor dark-grey graphitic siltstone while the laminated graphitic siltstone was defined by dark-grey, very graphitic and strongly-fissile siltstone (**Plate 1**). Locally, variable amounts of quartz-sulphide veins were present in association with the latter, linked with anomalous gold and base metal values (Marjoribanks 2008). Both ribbon banded siltstone and laminated graphitic siltstone are highly ductile during deformation (no void formation) and weather to heavy clays. The two rock units have little structural strength and therefore lack the ability to hold voids open which may result from deformation or chemical weathering, resulting in a lack of vuggs or voids observed in the cores. Both rock units are also highly fissile, readily disking within the cores along lines of sedimentation (A. Czerw and B. Armstrong pers. comm. 2010).

Polymict breccia is a sedimentary breccia, typically massive, unfoliated rock in which distinct angular to sub-angular clasts are supported by a grey silt or sand sized matrix. The clasts within the breccia at Trilogy were comprised of a likely dark grey mudstone and a pale fine grained rock noted as a clay altered felsic volcanic. Reflecting the massive nature of the breccia (Marjoribanks 2008), there were no observable voids or vuggs in the cores (A. Czerw and B. Armstrong pers. comm. 2010), suggesting a lack of habitat for troglofauna.

The silica alteration zones were present in association with the polymict breccia, although to differing degrees. These zones appear to have developed by intense, pervasive silicification of that unit (Marjoribanks 2008). As noted with the polymict breccia, there were no observable voids or vuggs associated with the silica alteration zones within the cores (A. Czerw and B. Armstrong pers. comm. 2010).

The quartz banded sulphide mineralised zones, were anomalous in gold and base metal minerals and consistently occurred within the laminated graphitic siltstone lithology, below the water table (Marjoribanks 2008). Therefore while vuggs and voids were present (up to 10 %) in the oxide transition zone (A. Czerw and B. Armstrong *pers. comm*. 2010) this would not represent a habitat for troglofauna.

a)

b)

Plate 1: Diamond drill cores from the Trilogy pit area (MYD 203). a) ribbon banded siltstone at 0.0 - 7.3 m, b) laminated graphitic siltstone with angular siltstone clasts at 74.0 - 82.7 m.

7. HABITAT CHARACTERISATION:KUNDIP

7.1 Stygofauna

The permeability of the Archaean volcanic rocks present in the Kundip project area is generally low although fractures and joints in the rocks, and mineralised zones can be moderately permeable. Consistent with this, the groundwaters in the area appear to occur in association with the mineralised zones (Rockwater 2004), supported by the substantial volumes of water stored in the old mine workings.

Although records of dewatering rates for the Kundip mining area are limited, anecdotal evidence suggests that the Flag underground working had the highest volume of inflows, followed by Harbour View and to a lesser extent, Beryl. The required pumping rates for Harbour View as noted in 1903, for example, were approximately 25 m^3/d, corresponding with a shaft depth of 50 m (Montgomery 1903 cited in (Rockwater 2004). The water table at Harbour view is currently approximately 37 m deep (Rockwater 2004).

Seven monitoring bores have been developed within the Kundip project area. Bores KMB1 and KMB4 were located to intersect the Harbour View mineralised zone while KMB2, KMB3, KMB5 and KMB6 were intended as regional exploration holes/monitoring bores. The depths ranged between 70 - 76 m. The seventh bore (KMB7) was an existing exploration hole, drilled to a depth of 106 m and cased for groundwater monitoring (Rockwater 2004).

Only four of the six new bores intersected water during drilling. Of these, only three yielded trace amounts despite the relatively close proximity of KMB1 and KMB4 to the Harbour View workings. KMB6 was the only exception, situated in a drainage line along-strike of Harbour View, and exhibiting a maximum airlift yield of 60 m^3/d.

These findings indicated that the rocks in the area, including those within the Harbour View mineralised zone, are generally of low permeability (Rockwater 2004), suggesting that available habitat for significant stygofauna communities may be limited. Moreover, KMB6 (the only bore to yield more than trace amounts of water during drilling) was dominated by mafic geology which was fined grained, massive and hard below the water table and therefore unlikely to support stygofauna. As noted for Trilogy, the low permeability of the rocks within Kundip is also likely to be reflected in low inputs of organic matter into the system, potentially decreasing the ability of the groundwaters to support significant communities of stygofauna.

The hydraulic gradient of the Kundip project area, as measured by the static water levels in April 2004, trended downwards to the south south-east from 130.9 m AHD at KMB5 to 117.74 m AHD in KMB7. A low gradient was noted with between four of the bores with less than 1 m difference in static water levels despite a difference of 20 m in topography. This was attributed to increased permeability at the water table, linked to open mine voids at the water table (Rockwater 2004).

The comparatively high water table at KMB5 (130.9 m AHD and less than 5 m bgl) is potentially indicative of shallow groundwater perched on a clay layer (Rockwater 2004) and could represent a possible stygofauna habitat. However, it is probable that if perched aquifers such as these are present in the Kundip project area, the clay layer would act as an aquitard, preventing impacts from drawdown of the fractured rock aquifer.

Groundwaters in the Kundip project area ranged between approximately 22,000 and 38,000 mg/L TDS (classified as mesosaline) (Hammer 1986). Groundwater pH was documented as 6.8 (Rockwater 2004). Based on these measurements, the groundwater quality of Kundip is unlikely to be a limiting factor for stygofauna. Therefore, the assessment that the Kundip project area has a low probability of containing significant stygofauna communities has been attributed to low permeability of the rocks in the area and low energy inputs rather than groundwater quality.

A further consideration when characterising the habitat of the Kundip project area is the influence of past mining activities. As parts of the area have been excavated and dewatered previously, potential stygofauna habitat, if present, may have already been disturbed, potentially mitigating the impacts of renewed mining activities.

7.2 Troglofauna

Examination of bore lithologies from the Kundip project area indicate that, similar to Trilogy, potential habitat for troglofauna in the geological profile is limited. The upper lithology was mostly fine-grained and massive, predominantly clay and/or highly weathered bedrock or quartz. For most bores, this was generally followed by massive geologies including weathered to weathered BIF/chert, quartz sand or aggregate, colluvium, ultramafic, mafic or phyllite (Rockwater 2004).

KMB2 for example, had highly weathered BIF/chert between 5 - 33 m followed by clay (33/34 m), highly weathered BIF (34 - 38 m) and intermediate volcanics to end of hole (EoH) (38 - 76 m). KMB6 was dominated by mafic geology (4 - 70 m) while the lithology at KMB7 was predominantly weathered phyllite and phyllite (0 - 64 m) (Rockwater 2004). These geologies do not appear to support voids or vuggs and would therefore be unlikely to contain habitat for significant troglofauna communities.

An exception was KMB1 which had a layer of basalt with fine fractures from 6 - 27 m followed by 2 m of BIF/quartz geology which was slightly vuggy in part. These fractures and vuggs occur above the water table (which was noted as approximately 37 m in the Harbour View Workings) and could potentially represent limited troglofauna habitat.

Similar to the stygofauna, another consideration for troglofauna in the Kundip project area is the potential impact of previous mining activities. Disturbance and dewatering from past workings may have resulted in habitat removal and changes in humidity, potentially reducing the suitability of the area for troglofauna.

Therefore, taking into account the general geology of the Kundip project area (as noted from the majority of bore lithologies) and previous mining activities, the likelihood of the area having significant troglofauna values is considered to be low, with only limited potential habitat noted.

8. RISK ASSESSMENT AND SUMMARY

Although recent studies, particularly in the Pilbara, have identified stygofauna from fractured rock aquifers (Eberhard *et al.* 2005), surveys in the southern Yilgarn and south-west have not yielded significant stygal communities from these aquifer types (Bennelongia 2009; Eberhard 2006). Consistent with this, the likelihood of the Trilogy project area having significant stygofauna values is considered low. This has been attributed to little connectivity and low pH values within the primary water bearing zone (the mineralised zone), and a lack of vugg development and low volumes of water outside of the mineralised zone, along with low inputs of energy. These factors coupled with the laterally extensive nature of the aquifer and the associated potential for comparable habitat outside of the drawdown area suggests that the risk to stygofauna within the Trilogy project area is low.

For troglofauna, the presence of limited potential habitat within the geological profile strata suggests that the Trilogy project area is unlikely to support significant troglofauna communities. Therefore similar to the stygofauna, the risk of the PRP to troglofauna within the Trilogy project area is considered to be low.

In relation to Kundip, low permeability of the rocks, low recharge and inputs of energy and previous mining activities are factors which contribute to the low likelihood of the area supporting significant stygofauna communities. Taking into account the general geology of the Kundip project area (as noted from the majority of bore lithologies) and the limited troglofauna habitat, the probability of the area having significant troglofauna values is also considered to be low.

Therefore, based on the available geological and hydrogeological information for the Kundip and Trilogy project areas of the PRP, neither area is considered likely to have significant values for stygofauna or troglofauna. As a result, it is not considered that pilot surveys are required.

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Appendix A

Subterranean Fauna Pilot Survey Plan

A pilot survey is recommended by the EPA (2007) to determine whether subterranean fauna are present in areas which are considered to have a little likelihood of supporting such communities. They are generally implemented when further evidence is required to support the findings of a desktop assessment. As the primary objective of a pilot survey is to establish the presence or absence of subterranean fauna in a given area, the required sampling effort required tends to be comparatively lower than surveys aimed at documenting all species (EPA 2007).

Stygofauna and troglofauna pilot survey plans which can be applied in both Trilogy and Kundip project areas of the PRP have been outlined below. These plans have been prepared as a contingency and will not be implemented unless further evidence is required to support the findings of the desktop assessment.

The stygofauna pilot survey would involve:

1. Selection of at least six suitable bores from the project area. Features which govern the suitability of bores, as outlined by the EPA (2007), have been presented below are:
    - Fauna must have access to the bore hole from the target geology. For example, cased bores must be slotted to coincide with the target geology,
    - Vertical, cased bores with appropriated slotting (>0.5 mm) provide greatest ease of sampling however uncased vertical drill holes can also be used.
    - Ideally bores should be at least six months old,
    - Bores must be free of drilling muds, hydrocarbons and other contaminants,
2. Collection of groundwater samples from the selected bores and measurement of basic water quality data (SWL, temperature, salinity, dissolved oxygen, pH),
3. Haul net sampling for stygofauna at each of the six bores. Methods follow that of the Guidance Statement 54a (EPA 2007),
4. Sorting and examination of the samples in the laboratory,
5. Identification of invertebrates at basic level to ascertain whether any potential stygofauna have been collected.

The troglofauna pilot survey would involve:

1. Selection of at least 10 suitable bores from the project area. Uncased bores are most appropriate for troglofauna sampling, however cased bores with slotting intercepting the target geology can also be used.
2. Placement of troglofauna traps in selected bores for a period of six to eight weeks. Scraping of the uncased bores using a net will be conducted prior to trap deployment as a supplementary sampling technique,
3. Sorting of samples collected in the laboratory,
4. Processing of troglofauna litter traps through Berlese funnels
5. Identifications of invertebrates to ascertain whether any potential troglofauna have been collected.

Appendix B

Definitions and Categories for Threatened and Priority Ecological Communities

The Department of Environment and Conservation (DEC) recognises four categories of Threatened Ecological Communities (TECs) within WA. These include: “Presumed Totally Destroyed”, “Critically Endangered”, “Endangered” and ‘Vulnerable’. Other ecological communities that do not meet the survey criteria for TECs yet are possibly under threat are documented as Priorities1, 2 and 3 under the Department’s Priority Ecological Community (PEC) List. Those ecological communities considered to be adequately known and rare but not threatened, or those that have been recently removed from the threatened list, are classified as Priority 4. Conservation Dependent ecological communities are placed in Priority 5. More detailed definitions of the TEC and PEC categories (as defined by the Department of Environment and Conservation) have been provided below.

Categories and Definitions of Threatened Ecological Communities (Department of Environment and Conservation (Department of Environment and Conservation 2007).

Category	Code	Definition
Presumed Totally Destroyed	PD	An ecological community for which no representative occurrences have been located despite adequately searching. The community has been found to be totally destroyed or so widely modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the forseeable future.
Critically Endangered	CR	An ecological community that has been adequately surveyed and has been found to be subject to a major contraction in area or was of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range however is capable of being substantially restored or rehabilitated.
Endangered	EN	An ecological community that has been adequately surveyed and has been found to be subject to a major contraction in area or was of limited distribution orginally and is in danger of significant modification throughout its range, or severe modification or destruction over most of its range in the near future.
Vulnerable	VU	An ecological community that has been adequately surveyed and has been found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is currently widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.

Categories and Definitions of Priority Ecological Communities (Department of Environment and Conservation (Department of Environment and Conservation 2007).

Category	Code	Definition
Priority 1 (Poorly known ecological communities)	Priority 1	Ecological communities with apparently few, small occurences, all or most not actively managed for conservation (eg. within agricultural or pastoral lands, urban areas, active mine leases) and for which current threat exists. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority 2 (Poorly known ecological communities)	Priority 2	Ecological communities that are known from a few, small occurences, all or most of which are actively managed for conservation (eg. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves) and are not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
Priority 3 (Poorly known ecological communities)	Priority 3	(i) Ecological communities that are known from several to many occurences, a significant number or area of which are not under threat of habitat destruction or degradation or; (ii) communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it is not under imminent threat ,or; (iii) communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements, and/or are not well defined, and known threatening processes exist that could potentially affect them.
Priority 4 (Poorly known ecological communities)	Priority 4	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or have been recently removed from the threatened list. Communities such as these require regular monitoring.
Priority 5 (Conservation Dependent ecological communities)	Priority 5	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.