Appendix 3
Supporting Technical Studies

Bennelongia Environmental Consultants

Earl Grey Lithium Project

Subterranean Fauna

Desktop Assessment

Prepared for:

Kidman Resources Limited

October 2018

Final Report

Short-Range Endemics I Subterranean Fauna

Waterbirds I Wetlands

Earl Grey Lithium Project Subterranean Fauna Desktop Assessment

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EXECUTIVE SUMMARY

Kidman Resources Limited proposes to mine lithium at the Earl Grey deposit (the Proposal) approximately 100 km southeast of Southern Cross in Western Australia. This desktop review assesses the likelihood of subterranean fauna (stygofauna and troglofauna) occurring in the Proposal area and whether these species and communities are likely to be impacted by proposed developments.

Previous records of subterranean fauna in the vicinity of the Proposal (a 100 km x 100 km search area) were collated and the prospectivity of subterranean habitats in the Proposal area are evaluated based on geology and hydrogeology.

Stygofauna have not been recorded in the search area (10,000 km^2 surrounding the proposal), reflecting a combination of few surveys and the generally poor prospectivity of the hydrogeological landscape in the vicinity of the Proposal. Stygofauna records in the Yilgarn are for the most part confined to calcrete aquifers, with surveys in consolidated geologies in the southern Yilgarn recording no stygofauna or only depauperate communities.

Eleven species of troglofauna have been recorded in the search area. All records of troglofauna came from survey in banded iron formation (BIF) geology at Mt Caudan in the Parker Range, approximately 60–70 km north of the Proposal area. These species are likely to be confined to BIF of the Parker Range.

The potential occurrence and distribution subterranean fauna species were examined in relation to three areas: the proposed pit; the proposed/existing borefield; and palaeochannel units to the east of the Proposal, primarily regional calcretes.

It is unlikely that stygofauna occur in either the proposed pit or the borefield because of the combination of unsuitable geologies, high salinities, and in the case of the proposed pit, large depth to the watertable.

Based on geology, it is unlikely that troglofauna occur in the proposed pit. Due to extensive weathering in some areas, it is possible, but unlikely, that troglofauna occur in the borefield. Any troglofauna community that does occur is likely to be depauperate. Furthermore, activities in the borefield will not threaten troglofauna because there will be no excavations.

Surficial deposits in the palaeochannel to the east of the development envelope, particularly calcrete, are considered prospective for subterranean fauna, especially stygofauna, which may occur in fresh and brackish surficial aquifers. Calcretes in the Yilgarn typically provide good habitat for subterranean fauna and have been found to host rich communities. Based on the results of numerical modelling, the connectivity between these calcrete aquifers and fractured rock aquifers at the Proposal, including both the mine pit and proposed/existing borefield, is low. Potential subterranean fauna habitat in palaeochannel units, including calcrete, will not be removed through excavations. The inferred risk of drawdown in these units is low. Overall, the Proposal is not considered to pose a significant threat to subterranean fauna.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Kidman Resources Limited (the Proponent) propose to mine lithium at the Earl Grey deposit (the Proposal) via an open pit. The Proposal is located approximately 100 km southeast of Southern Cross in Western Australia (Figure 1) and is part of the historic Mt Holland Project that comprises several deposits.

This desktop review assesses the likelihood of subterranean fauna (stygofauna and troglofauna) occurring in the Proposal area and examines whether these species and communities are likely to be impacted by proposed developments.

The specific aims of the assessment are:

- To describe and evaluate the prospectivity of subterranean fauna habitat in the Proposal area;
- To review records of subterranean fauna species in the vicinity of the Proposal area;
- To determine the likelihood that subterranean fauna occur in the Proposal area based on the types of habitat present and richness of subterranean species in surrounding areas; and
- To determine if Proposal is likely to have significant conservation impacts on any subterranean species and communities.

1.1. Proposal Description

The Earl Grey lithium deposit (Figure 2) is proposed to be mined via an open pit with an area of approximately 166 ha and maximum depths of approximately 250 mbgl in the south and 300 mbgl in the north. The volume of groundwater potentially entering the pit is expected to be relatively low (inflow rates of approximately 3–4 L s^{-1}) but a dewatering system will be installed within the pit to remove this water, which will be predominantly used in processing and dust suppression. The total area required for the Proposal is 610 ha, of which 245 ha is already disturbed.

Overall, the Proposal requires about 1.0 GL of water per annum. This requirement will be met by pit dewatering (approximately 130 ML/year), groundwater abstraction from either the existing Mt Holland borefield or Bounty pit and underground operation (0.87–1.0 GL/year) and water recycling within various process water circuits.

Mining will produce approximately 200 million cubic metres of waste rock over the 30 to 40 year life of mine. This will be managed using three waste rock landforms. These are a permanent waste rock dump covering the historic Mt Holland TSF1 (WRD1), progressive backfilling of the pit to produce a permanent, raised waste rock landform (WRD2) and a permanent waste rock dump to the immediate east of the pit (WRD3) (Figure 2).

Approximately 12 MT of fine tailings will also be produced. Two tailings storage facility (TSF) options will be considered. These are either refurbishment of the existing Mt Holland TSF2 with a 5 m increase to the wall, or development of a new TSF in the historic Bounty mine area encompassing the existing in-pit TSF3 (Figure 2). Both options make efficient use of existing disturbed landforms.

Additional infrastructure and development included in the Proposal include an ore processing plant, power supply, workshops, washdown facilities, miscellaneous plant buildings, accommodation, water treatment facilities, fuel storage, airstrip, communications infrastructure, explosive storage, laydown areas, landfill and roads.

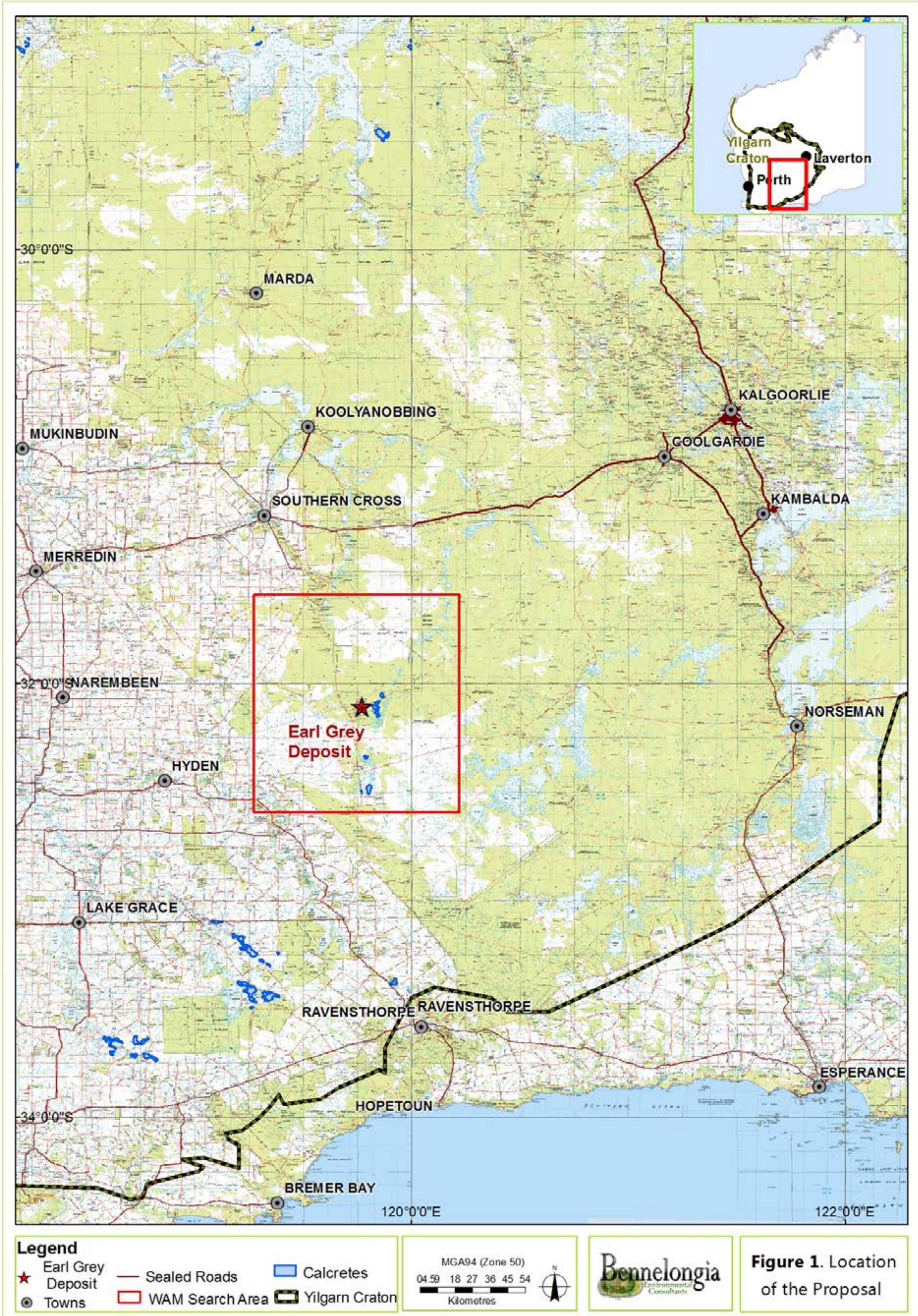

Figure 1. Location of the Proposal and the search area encompassed by desktop review.

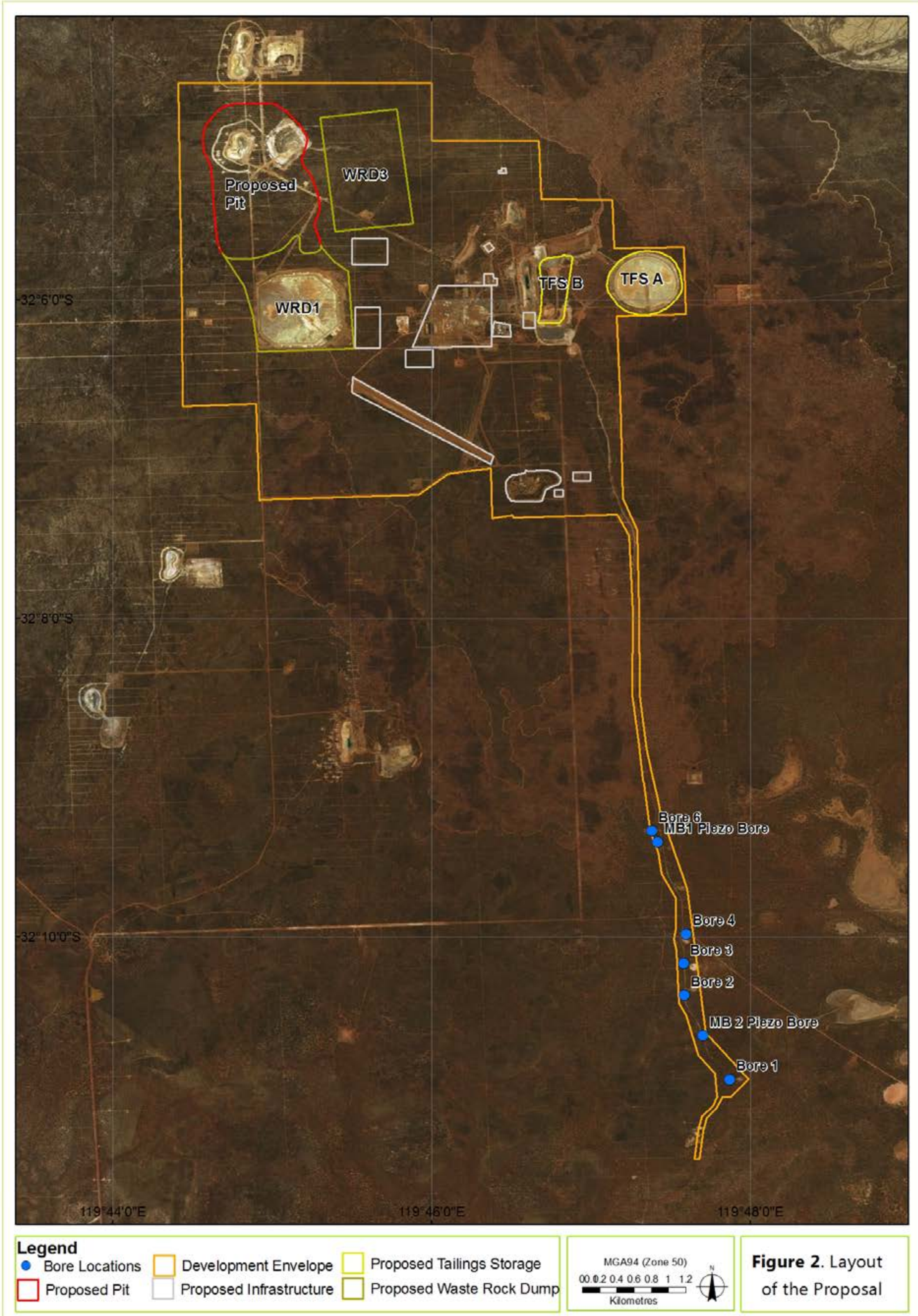

Figure 2. Layout of the Proposal.

2. SUBTERRANEAN FAUNA FRAMEWORK

Subterranean fauna can be divided into aquatic stygofauna and air-breathing troglofauna. Both groups typically lack eyes and are poorly pigmented due to lack of light. Other characteristic morphological and physiological adaptations such as vermiform bodies, elongate sensory structures, loss of wings, increased lifespan, a shift towards K-selection breeding strategy and decreased metabolism reflect low inputs of carbon and nutrients in subterranean habitats and the requirement to navigate enclosed spaces (Gibert and Deharveng 2002). With the exception of several species of stygofaunal fish in the north of the state, all subterranean fauna in Western Australia are invertebrates.

Geology influences the presence, richness and distribution of subterranean fauna by providing different types of habitat (Eberhard *et al.* 2005; Hose *et al.* 2015). Geologies with larger internal spaces support larger assemblages of subterranean fauna, both in terms of abundance and diversity, than consolidated geologies.

Stygofauna communities tend to be richest in calcrete and alluvial aquifers (Humphreys 2001), while less transmissive geologies such as banded iron formations (BIF), saprolite, mafic and ultramafic usually contain depauperate communities (Ecologia 2009; GHD 2009). They are usually absent from silt and clay (Korbel and Hose 2011). Both the Pilbara and Yilgarn are particularly rich in stygofauna and a large number of calcrete aquifers in the Yilgarn have accordingly been listed as Priority Ecological Communities (PECs).

Stygofauna occur in varying salinities, but are mostly found in fresh to brackish waters with conductivities of less than 5,000 µS cm^{-1} (approximately 640 mg L^{-1} TDS). While oxygen levels are typically not measured during stygofauna surveys for environmental impact assessments in WA, stygofauna are reported to be uncommon in hypoxic groundwater (<0.3 mg O_2 L^{-1}; Hose *et al.* 2015).

Troglofauna have been found to occur widely in mineralised iron formations (especially BIF), calcretes and alluvial-detrital deposits in the Pilbara (e.g. Biota 2006; Bennelongia 2008a, b; Edward and Harvey 2010). Troglofauna surveys in Western Australia outside the Pilbara have been limited but surveys in BIF in the Yilgarn at Koolyanobbing, Mt Jackson and Mt Dimmer have yielded depauperate to moderately rich troglofauna communities (Bennelongia 2008a; Bennelongia 2008b). Significant troglofaunal communities have also been recorded in calcretes of the Yilgarn, with Bennelongia (2015) recording 45 species of troglofauna from the Yeelirrie calcrete, while Outback Ecology (2012) recorded 20 species in calcretes around Lake Way.

Owing to the isolation of prospective subterranean fauna habitats throughout the Western Australian landscape there is a very high incidence of short-range endemism amongst the Western Australian subterranean fauna. In Western Australia the Environmental Protection Authority (EPA) requires consideration of subterranean fauna as part of environmental impact assessment (EPA 2016a, c).

3. PREVIOUS RECORDS OF SUBTERRANEAN FAUNA

Records of subterranean fauna were compiled from Western Australian Museum (WAM) and Bennelongia databases for a square search area of approximately 10,000 km^2 surrounding the Proposal (defined by 31.59°S, 119.28°E and 32.59°S, 120.22°E). Published research papers, available environmental reports and online resources such as the Atlas of Living Australia (ALA 2017) and the Australian Faunal Directory (ABRS 2009) were also reviewed. Higher-order identifications were generally not included in the final list of recorded species unless they belonged to taxonomic units that were otherwise not recorded.

3.1. Stygofauna

Stygofauna have not been recorded in the search area, reflecting a combination of few surveys and the generally poor prospectivity of the hydrogeological landscape in the vicinity of the Proposal (see

Section 4). Stygofauna records in the Yilgarn are largely confined to calcrete aquifers, with surveys in consolidated geologies in the southern Yilgarn recording depauperate or absent stygofaunal communities (e.g. Bennelongia 2009, 2013; Cazaly 2010).

3.2. Troglofauna

Eleven species of troglofauna have been recorded in the search area, including a spider, three pseudoscorpions, two beetles, four isopods and a symphylan (Table 1). All records of troglofauna came from survey in BIF geology at Mt Caudan in the Parker Range approximately 60–70 km north of the Proposal area (Cazaly 2010). Troglofauna species are typically restricted to single geological formations or else are limited to associated geological structures that share connectivity (Edward and Harvey 2010; Halse *et al.* 2014a). All troglofauna species from the search area are likely to be confined to BIFs of the Parker Range.

Table 1. Troglofauna recorded in the search area around the Proposal.

Higher Classification	Lowest Identification	No. of Records	Comments on Distribution
Arachnida			All records are from Mt Caudan, approximately 60–70 km north of the Proposal. All species currently only known from Mt Cauden in BIF and likely to be confined to that formation.
Araneae	Araneomorphae sp. B16	1	
Pseudoscorpiones			
Chthoniidae	*Austrochthonius* \`PSE034\`	1	
	Tyrannochthonius \`PSE048\`	1	
	Tyrannochthonius \`PSE049\`	3	
Insecta			
Coleoptera			
Curculionidae	Curculionidae Genus 3 sp. B06	1	
Staphylinidae	Staphylinidae sp. B02	1	
Crustacea			
Isopoda			
Armadillidae	*Buddelundia* sp. B03	1	
	Buddelundia sp. B04	1	
Philosciidae	nr *Andricophiloscia* sp. B14	1	
Platyarthridae	*Trichorhina* sp. B06	8	
Symphyla			
Scutigerellidae	*Hanseniella* sp. B05	4	

4. SUBTERRANEAN HABITAT

4.1. Geological Setting

The Proposal is located on the Forrestania greenstone belt in the Southern Cross Domain of the Archean Youanmi Terrane, one of several major crustal blocks that form the Archean Yilgarn Craton of southwestern Australia. The Forrestania greenstone belt and its northern extension, the Southern Cross greenstone belt, form a 5–30 km wide curvilinear belt trending north-south over a distance of 250 km. The belt comprises mafic-ultramafic volcanic and an upper sedimentary succession intruded and bound by granitoid batholiths (Chin et al. 1984; Doublier 2013). Narrow horizons of sedimentary rock consisting of banded iron formation, chert, psammite and quartz-muscovite schist are intercalated with the mafic-ultramafic succession.

Rare-element granitic pegmatites occur regionally and are primary structures of interest for mining development. The Mount Holland pegmatite field is located around the historic Bounty gold mining centre, extending from the Prince of Wales pegmatite group in the northwest to the Mount Hope pegmatite group in the southeast, and potentially further north to the Texas pegmatites. The Earl Grey pegmatite intrudes into the mafic and ultramafic lithologies of the Mid-Eastern ultramafic belt in the central Forrestania greenstone belt. The Archaean stratigraphy becomes younger to the west, displaying the typical mafic-ultramafic-sedimentary succession of the belt. The Mid-Eastern ultramafic belt is overlain to the west by a porphyroblastic garnet-actinolite schist, presumed to be a deformed basal unit of the upper sedimentary succession.

The weathered zone around the Earl Grey pegmatite is around 30-40 m deep, with few instances of outcrop or subcrop in the area. The area is mostly covered by a thin (up to 5 m) veneer of laterite which is underlain by a 10-15 m deep eluvial zone of pallid grey to mottled clay. The regolith becomes increasingly iron-rich toward the base of the weathered profile, with ferric induration common.

There is a clear thickening of the main pegmatite body as it approaches the western shear contact, where it averages 70 m in width and has a maximum known thickness of 90 m. The pegmatite thins to around 50 m in average thickness through the central zone before splitting into several bodies that average 25 m thickness in the eastern extent of the deposit. Faulting within the pegmatite has been observed in diamond drill core, however no major offsets have been definitively observed.

4.2. Hydrogeological Setting

The Proposal occurs in the Westonia Groundwater Area of the Southern Cross Province. The main regional groundwater sources are catchment-controlled flow systems in weathered and fractured rock, Tertiary palaeochannel sands, calcretes overlying palaeochannel deposits and shallow alluvial aquifers.

Deep weathering of ultramafic and basaltic sequences of the region results in a thick siliceous caprock and only modest groundwater resources occur in these weathered zones. Fractured basement aquifers are subject to complex fracturing and chemical dissolution, resulting in secondary permeability. The storage capacity and hydraulic conductivity of these basement aquifers are largely related to the degree of fracturing. In the vicinity of the Proposal, sub-caprock fracturing is prevalent and saline to hypersaline aquifers occur, notably in the area of the historic borefield. No fresh water supplies have been identified near the Project area.

The water table in the Proposal area lies 58–70 mbgl and permeability is low across the proposed pit footprint, with airlift yields of 0.2–4.0 L s^{-1} and permeability estimates of 6 x 10^{-6}–0.02 m d^{-1}. Two of the 14 holes sampled in initial investigations were found to be dry. Aquifers in the pit area are saline to hypersaline at 17,000–120,000 mg L^{-1} (c. 26.6–150 mS cm^{-1}).

Palaeochannel sands occur to the east of the Proposal area, represented at the surface by a series of saline playas. An area of calcrete occurs in association with the palaeochannel approximately 5 km east of the Proposal. Hydrogeological properties of the calcrete and other surficial palaeochannel units, including the extent of connectivity between these units and the fractured rock aquifers at the Proposal, appear to be low based on numerical modelling (GRM 2017). This is presumably due the geological confinement of the fractured rock aquifers.

4.3. Mt Holland Borefield

The existing Mt Holland Borefield comprises seven production bores 4–8 km south of the main development envelope. The borefield draws from a fractured, silicified, vuggy ultramafic caprock aquifer that has a known strike length of 4.5 km and is 20–40 m thick. Static water levels (SWL) in production bores measured in 1988–1989 were 6.60–18.23 mbtc (metres below top of casing), while groundwater depths in observation bores in May 2002 were 5.29–17.52 m. Fractures and shear zones in adjacent strata may increase the extent of the aquifer and volume of available groundwater. The borefield aquifer has been crosscut by a vertical dolerite dyke that is 30–50 m wide and may form a barrier to lateral groundwater flow. Aquifer salinity in 2002 was 100,000–120,000 mg L^{-1} (ca. 156–150 mS cm^{-1}). During the last pumping period in December 2001, abstraction totalled 6,199 kL. This yield came from two actively pumped bores, while several bores were converted for groundwater re-injection. The borefield aquifer responded well to groundwater re-injection, with water levels increasing in all observation bores (URS 2002).

4.4. Assessment of Habitat

The occurrence of subterranean fauna depends on the presence of suitable underground spaces, such as those formed by interstices, voids, vughs, cavities and fissures. Consolidated geologies do not offer such habitats and additionally limit movement of carbon, nutrients and oxygen into the subterranean environment. Potential occurrence of subterranean fauna was examined in relation to three areas: the proposed mine pit; the proposed/existing borefield; and surficial aquifers in palaeochannel units, especially calcretes (Figure 3).

The proposed pit consists of laterite, saprolite, saprock, and mafic and ultramafic rock intruded by veins of pegmatite. As determined by initial hydrogeological investigations (GRM 2017), permeability is low (0.2–4.0 L s^{-1}) across the deposit and pit. While previous surveys in mafic, ultramafic and saprolite have sometimes recorded both troglofauna and stygofauna, yields have been low and the geologies are generally considered to provide poor habitat for subterranean fauna (Bennelongia 2016; Ecologia 2009; GHD 2009; EPA 2016c). The weathered zone of the pegmatite vein is unlikely to provide suitable habitat given its depth and the overlying consolidated strata. Based on the habitat characteristics described above it is considered unlikely that troglofauna occur in the proposed pit. If a community does exist it is likely to be depauperate.

Stygofauna are also unlikely to occur for habitat reasons, especially when the water table sits 58–70 mbgl and is saline to hypersaline (up to 17,000–120,000 mg L^{-1}). Depth to groundwater is a major constraint on the complexity and abundance of stygofauna communities, with reduced richness observed in the Pilbara where groundwater was more than 32 mbgl (Halse *et al.* 2014b). It is also uncommon for stygofauna to be found in salinities >50,000 mg L^{-1}, which is the case for much of the aquifer. In combination, the lack of subterranean spaces, high salinity and depth to groundwater make the occurrence of stygofauna within the proposed pit highly unlikely.

The existing borefield occurs in fractured ultramafic overlain by clay. The depth to water based on historic records from production and monitoring bores is approximately 5–18 m. Both stygofauna and troglofauna have been recorded in fractured mafic and ultramafic geologies elsewhere, although yields have tended to be low. Despite the relatively shallow depth of the water table, stygofauna are likely to be excluded from this aquifer by high salinity (≥100,000 mg L^{-1}). It is unlikely that stygofauna occur in the borefield aquifer.

It is unlikely that troglofauna occur in the borefield. While the geology is, in places, extensively weathered (URS 2002), there are probably insufficient spaces to support troglofauna in the laterite and clay that occupy the upper subterranean strata of the borefield. If troglofaunal species do occur, the operation of the borefield is unlikely to affect their habitat and, therefore, their persistence.

The hydrogeological units in the vicinity of the Proposal that are most likely to support subterranean fauna are surficial palaeochannel deposits, particularly calcretes, of the Deborah palaeovalley (Figure 3). Mapped geologies at the 1:500,000 scale (Marnham and Morris 2003) depict the nearest such calcrete at approximately 5 km to the east of the development envelope (Figure 3). This area has not been surveyed for subterranean fauna and its hydrogeology is uncertain. However, numerical modelling (GRM 2017) predicts that due to low permeability drawdown will only extend to around 400 m from the proposed pit, with the drawdown cone predicted to develop around the proposed borefield likely to be elongated along the axis of the caprock aquifer. At the end of 12 years of pumping the drawdown is predicted to extend to around 0.7 km east and west, 2.8 km south and 2.2 km north of the borefield. Therefore, based on numerical modelling results provided to Bennelongia, drawdowns from both pit dewatering and borefield production are unlikely to reach prospective subterranean fauna habitats in regional calcretes and the wider palaeochannel.

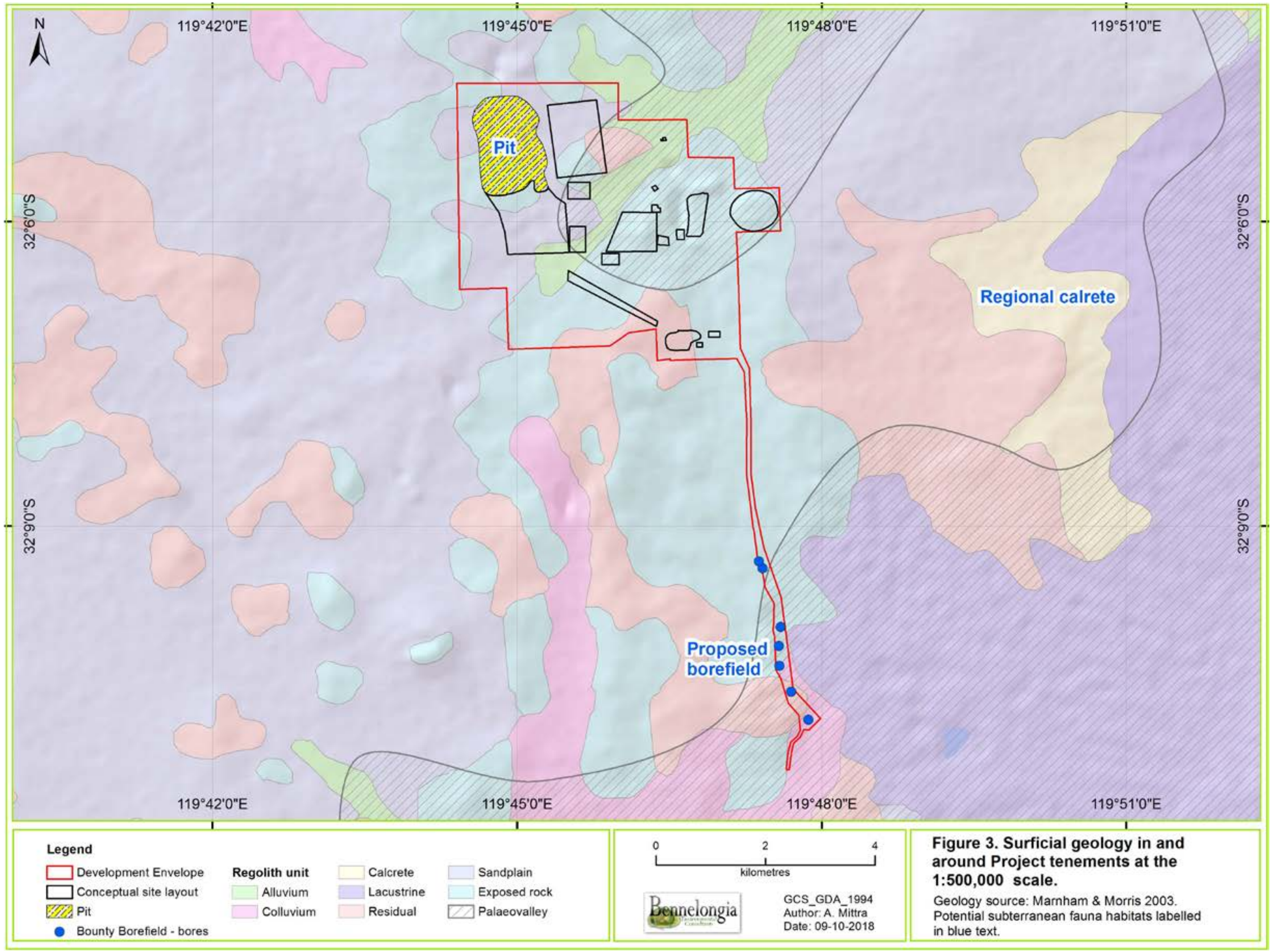

Figure 3. Potential subterranean fauna habitat in the Proposal area.

5. POTENTIAL IMPACTS

The effects of developing mining infrastructure and subsequent mining operations on subterranean fauna communities can be broadly divided into two categories:

1. Primary impacts – possible extinction, or threat to the persistence of local populations, of subterranean fauna through the direct removal of habitat; and
2. Secondary impacts – reduction of population densities of subterranean fauna through a range of environmental factors, for example pollutants and increased turbidity (Appendix 2).

This report does not consider the possible effects of secondary impacts, which requires detailed information about mine operations. However, some background information on factors causing secondary impact is given in Appendix 1.

5.1. Impacts on Stygofauna

Open cut and underground mining often requires a dewatering program to enable access to the mineral resource and to prevent the mine being flooded. Abstracted groundwater is typically also used in ore processing. The consequent drawdown of aquifers poses a primary threat to stygofauna communities that occur within the dewatering footprint. In particular, species restricted to the impact footprint face possible extinction. Besides dewatering, the excavation of the pit itself causes complete loss of stygofauna habitat within the pit area, while construction of other infrastructure such as tunnels, drainage and tailing dams may degrade or remove networks of suitable habitat within the mine area, or could disrupt connectivity between populations on either side of the disturbance.

5.2. Impacts on Troglofauna

The direct habitat loss from mine pit excavation is the primary mine-related threat to troglofauna in the Proposal area. The extent of habitat loss will depend on the area and depth of mine pits and other excavations, as well as the occurrence and connectivity of suitable habitat outside the impact zone. Animals utilising small isolated pockets of habitat are more vulnerable to significant primary impacts than those inhabiting more extensive geologies.

5.3. Potential Impacts of the Proposal

The main sources of potential impacts to subterranean fauna at the Proposal are:

- Mine pit excavation - total area of approximately 166 ha to depths of 250–300 mbgl; and
- Dewatering of the mine pit; and
- Groundwater abstraction from either the existing Mt Holland borefield or from Bounty pit – estimated volumes of 0.87 – 1.0 GL/year.

As outlined in Section 4.4, it is considered unlikely that troglofauna occur in the proposed pit due to the lack of suitable geology. Although troglofauna have been recorded relatively nearby at Mt Caudan, approximately 60–70 km to the north, those species are highly likely to be confined to BIF features around collection locations and will not occur at the Proposal. Should an assemblage of troglofauna occur at the Proposal, it is likely to be depauperate, as has been found in other analogous geologies. The ranges of any troglofauna species present are likely to exceed proposed excavations that cover an area of approximately 166 ha (Halse *et al.* 2014a) due to the extension of geological units outside the Proposal (Kidman 2017). Due to the limited extent of excavations, any troglofauna in the borefield or calcrete will not be threatened, as no removal of habitat through excavations will occur. Overall, it is unlikely that the Proposal will significantly impact the conservation of troglofauna either locally or regionally.

Given the lack of suitable groundwater habitat due low transmissivity, the depth to groundwater and high salinity (Section 4.4), it is considered unlikely that stygofauna occur in the proposed pit.

Stygofauna are also unlikely to occur in the borefield aquifer due to both tight geology and high salinities. Any communities present in these areas are likely to be depauperate and species are likely to be widespread, as has been found in other fractured rock aquifers in the Yilgarn. Excavations and groundwater abstraction are therefore unlikely to threaten stygofauna in the development area.

Both stygofauna and troglofauna may occur in calcrete to the east of the Proposal. Excavations will not extend to this unit and therefore any troglofauna are likely to remain unaffected by the development of the mine. Numerical modelling results predict that the spatial extent of drawdowns associated with both pit dewatering and groundwater production from the proposed borefield will be small and will not reach regionally prospective stygofauna habitats in calcretes and other palaeochannel deposits. The inferred risk to subterranean fauna in regional calcretes and the wider palaeochannel is therefore low.

6. CONCLUSIONS

The desktop review of subterranean fauna aimed to determine the likelihood that stygofauna or troglofauna occur in the Proposal area based on habitat information and previous regional records of subterranean fauna. Additionally, the likelihood for the Proposal significantly impacting the conservation of subterranean fauna was assessed.

Three potential habitats for subterranean fauna were identified in the Proposal area; the proposed pit, the existing borefield and the external calcrete.

It is unlikely that stygofauna occur in either the proposed pit or the borefield due to the combination of unsuitable geologies, high salinities and in the case of the proposed pit, great depth of the groundwater table.

Based on habitat characteristics, it is unlikely that troglofauna occur in the proposed pit. Due to extensive weathering in some areas, it is possible, but considered unlikely, that troglofauna occur in the borefield. Should troglofauna occur in either of these potential habitats, communities are likely to be depauperate, as has been found in equivalent geologies elsewhere in the Yilgarn. Any troglofauna in the borefield will not be threatened by proposed developments, as no excavations will occur in this area.

Surficial deposits in the palaeochannel to the east of the development envelope, particularly calcrete, are considered prospective for subterranean fauna, especially stygofauna, which may occur in fresh and brackish surficial aquifers. Calcretes in the Yilgarn typically provide good habitat for subterranean fauna and have been found to host rich communities. Based on the results of numerical modelling, the connectivity between these calcrete aquifers and fractured rock aquifers at the Proposal, including both the mine pit and proposed/existing borefield, is low. Potential subterranean fauna habitat in palaeochannel units, including calcrete, will not be removed through excavations. The inferred risk of drawdown in these units is low. Overall, the Proposal is not considered to pose a significant threat to subterranean fauna.

7. REFERENCES

ABRS (2009) Australian Faunal Directory. Australian Biological Resources Study, Canberra. http://www.environment.gov.au/biodiversity/abrs/online-resources/fauna/afd/index.html

Atlas of Living Australia (ALA) (2017) Available: http://www.ala.org.au/. Accessed April 2017.

Bennelongia (2008a) Troglofauna survey of the Orebody 18 Mine Modification. Report 2008/27. Bennelongia Pty Ltd, Jolimont, 21 pp.

Bennelongia (2008b) Troglofauna Survey: Area C Mine – E and F Deposits. Report 2008/39. Bennelongia Pty Ltd, Jolimont, 35 pp.

Bennelongia (2009) Yilgarn Iron Ore Project: Carina Deposit, subterranean fauna assessment. Report 2009/69, Bennelongia Environmental Consultants, Jolimont WA, 31 pp.

Bennelongia (2013) Marda Gold Project (mining leases M77/394, 646, 931 and 962): Subterranean fauna risk assessment. Report 187/2012, Bennelongia Environmental Consultants, Jolimont WA, 13 pp.

Biota (2006) BHP Biliton Iron Ore Regional Subterranean Fauna Study Project No. 312, Biota Environmental Sciences, Leederville, 32 pp.

Cooper, S.J.B., Hinze, S., Leys, R., Watts, C.H.S., and Humphreys, W.F. (2002) Islands under the desert: molecular systematics and evolutionary origins of stygobitic water beetles (Coleoptera: Dytiscidae) from central Western Australia. *Invertebrate Systematics* **16**, 589-598.

Cazaly (2010) Parker Range Iron Ore Project Mt Caudan Deposit – Public Environmental Review. Cazaly Resources Limited, November 2010

Chin, R. J., Hickman, A. H., Thom, R. (1984) Hyden, WA Sheet SI50-4: Geological Survey of Western Australia, 1: 250,000 Geological Series - Explanatory Notes, 21 pp.

Doublier, M. P. (2013) Geological setting of mineral deposits in the Southern Cross district - a field guide: Geological Survey of Western Australia Record 2013/11, 55 pp.

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

Ecologia Environment (2009) Tropicana Gold Project - Stygofauna Survey Report. ecologia Environment, West Perth, 40 pp.

Edward, K.L., and Harvey, M.S. (2010) Short-range endemism in hypogean environments: the pseudoscorpion genera Tyrannochthonius and Lagynochthonius (Pseudoscorpiones: Chthoniidae) in the semiarid zone of Western Australia. *Invertebrate Systematics* **22**, 259-293.

EPA (2016a) *Environmental Factor Guideline: Subterranean fauna*. EPA, Western Australia.

EPA (2016c) *Technical Guidance: Subterranean fauna survey*. EPA, Western Australia.

GHD (2009) Report for Jack Hills expansion project regional stygofauna phase 1 survey. GHD, Perth.

Gilbert, J., and Deharveng, L. (2002) Subterranean ecosystems: a truncated functional biodiversity. BioScience **52**, 473-481.

GRM (2017) Report on Mount Holland Lithium Project Hydrogeological Study. Groundwater Resource Management, Fremantle, 27 pp.

Halse, S., and Pearson, G. (2014a) Troglofauna in the vadose zone: comparison of scraping and trapping results and sampling adequacy. *Subterranean Biology* **13**, 17-34.

Halse, S.A., Scanlon, M.D., Cocking, J.S., Barron, H.J., Richardson, J.B., and Eberhard, S.M. (2014) Pilbara stygofauna: deep groundwater of an arid landscape contains globally significant radiation of biodiversity. Records of the Western Australian Museum Supplement **78**, 443-483.

Hose, G.C., J. Sreekanth, O. Barron and C. Pollino (2015) Stygofauna in Australian Groundwater Systems: Extent of knowledge. CSIRO, Australia.

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* **64**, 63-83.

Kidman Resources Limited (2017) The geological setting, mineralogy, and geochemistry of the Earl Grey Lithium pegmatite. Internal technical report, Kidman Resources Limited.

Korbel, K.L., and Hose, G.C. (2011) A tiered framework for assessing groundwater ecosystem health. Hydrobiologia **661**, 329-349.

Marnham, J.R., and Morris, P.A. (2003) Regolith geology of Western Australia (1:500 000 scale; preliminary edition): Geological Survey of Western Australia.

Outback Ecology (2012) Toro Energy Ltd Wiluna Uranium Project subterranean fauna assessment. Outback Ecology (MWH Australia Ltd), Jolimont, 95 pp.

URS (2002) Bounty Gold Mine Borefield Aquifer Review. July 2001 to June 2002. URS Australia Pty Ltd, Perth WA, 13 pp.

APPENDIX 1. SECONDARY IMPACT OF MINING ON SUBTERRANEAN FAUNA.

Mining activities that may result in secondary impacts to subterranean fauna include:

1. *De-watering below troglofauna habitat*. The impact of a lowered water table on subterranean humidity and, therefore, the quality of troglofauna habitat is poorly studied but it may represent risk to troglofauna species in some cases. The extent to which humidity of the vadose zone is affected by depth to the water table is unclear. Given that pockets of residual water probably remain trapped throughout de-watered areas and keep the overlying substrate saturated with water vapour, de-watering may have minimal impact on the humidity in the unsaturated zone. In addition, troglofauna may be able to avoid undesirable effects of a habitat drying out by moving deeper into the substrate if suitable habitat exists at depth. Overall, de-watering outside the proposed mine pits is not considered to be a significant risk to troglofauna.
2. *Percussion from blasting*. Impacts on both stygofauna and troglofauna may occur through the physical effect of explosions. Blasting may also have indirect detrimental effects through altering underground structure (usually rock fragmentation and collapse of voids) and transient increases in groundwater turbidity. The effects of blasting are often referred to in grey literature but are poorly quantified and have not been related to ecological impacts. Any effects of blasting are likely to dissipate rapidly with distance from the pit and are not considered to be a significant risk to either stygofauna or troglofauna outside the proposed mine pits.
3. *Overburden stockpiles and waste dumps*. These artificial landforms may cause localised reduction in rainfall recharge and associated inflow of dissolved organic matter and nutrients because water runs off stockpiles rather than infiltrating through them and into the underlying ground. The effects of reduced carbon and nutrient input are likely to be expressed over many years and are likely to be greater for troglofauna than stygofauna (because lateral movement of groundwater should bring in carbon and nutrients). The extent of impacts on troglofauna will largely depend on the importance of chemoautotrophy in driving the subterranean system compared with infiltration-transported surface energy and nutrients. Stockpiles are unlikely to cause species extinctions, although population densities of species may decrease under them.
4. *Aquifer recharge with poor quality water*. It has been observed that the quality of recharge water declines during, and after, mining operations as a result of rock break up and soil disturbance. Impacts can be minimised through management of surface water and installing drainage channels, sumps and pump in the pit to prevent of recharge though the pit floor.
5. *Aquifer salinisation*. This may result from aquifer mixing during reinjection or from the disposal of high salinity water into fresher aquifers. Most freshwater invertebrates are not able to maintain body fluid solute concentrations lower than the external aquatic environment, making them vulnerable to dehydration, as salinity increases. Rare species tend to be more sensitive with narrower ranges of salinity tolerance than common species and are therefore more likely to drop out of assemblages following salinisation. Prolonged (chronic) exposure to sub-lethal doses of salinity has been shown to affect a range of ecologically-significant biologically responses in aquatic invertebrates. The level of risk posed by aquifer salinisation to each stygofauna species that is potentially unable to withstand increased salinity will depend on the spatial distribution of that species relative to the spatial extent of elevated salinity.
6. *Contamination of groundwater by hydrocarbons*. This may occur as a result of the drilling process. The spatial extent of contamination around each hole is usually unclear but is likely to depend on the volume of contaminant, its viscosity and toxicity, and aquifer characteristics including transmissivity and rates of lateral movement. Contamination may be minimised by engineering and management practices to ensure the removal or containment of hydrocarbon products.