Baralaba South Project Stygofauna Assessment

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Executive Summary

Mount Ramsay Coal Company Pty Ltd is proposing an open cut coal mine near Baralaba, Southern Qld. The proposed location for the Baralaba South Project is adjacent to the Dawson River, approximately 6 kilometers (km) south-east of Baralaba in the lower Bowen Basin region of Central Queensland (Qld).

The Terms of Reference for the Baralaba South Project Environmental Impact Statement (DEPH, 2017) sets the scope of critical matters that should be addressed in the EIS. Stygoecologia was commissioned to assess whether subterranean groundwater dependent ecosystems occur within the area of the Project and if they exist, whether the Project is likely to have a significant impact on them. This assessment includes a baseline aquifer ecosystem evaluation of stygofauna across the area of impact and provides a risk assessment of the proposed development to this ecosystem. Five sampling surveys for stygofauna were conducted in the area of the development by this study.

The survey of bores in and adjacent to the area of the proposed operations found a depauperate community of stygofauna associated only with the alluvial aquifer adjacent to the Dawson River. It is therefore likely that they are present within the study area although they appear to be restricted to the close proximity of the river due to the fine-grained nature of the sediments and the poor water quality in the downstream area of the valley even though water quality within a number of the bores was considered suitable. The low diversity and abundance are likely to be influenced by the fine-grained nature of the aquifer sediments. The groundwater fauna found in the phreatic zone of the shallow groundwater of the aquifer consist predominantly of Oligochaetes (worms).

A total of 12 sites were sampled for stygofauna and water quality using rapid assessment techniques. These sites were selected within and outside the proposed area of operations and within each of the major geological units. The fine-grained nature of the geology and sediments and poor water quality, at least in the lower alluvium, appears to be the limiting factors.

A total of 3 taxa and 24 individuals were collected during the 5 surveys. The depauperate, sporadic and localised nature of the community across this study are assessed as having a low ecological value based on the community composition and number of taxa for the sites surveyed.

Drawdown and water chemistry changes are identified as the main potential impacts associated with this project although these only presenting as a moderate ecological risk. The potential impacts include:

- Lowering water table levels;
- Alteration of aquifer flow paths;
- Reduction in aquifer discharge volume to off-site GDEs including river baseflows and phreatic vegetation;
- Changes in the frequency/timing of water table level fluctuations; and
- Reductions in shallow groundwater water quality.

The alluvial aquifer geology consists of fine-grained sands and clays which limit or prohibit the occurrence of stygofauna. The river alluvium subsurface environment and the bores sampled are assessed as having a low risk of mine related impacts.

1. Introduction

The uniqueness of Australia's biodiversity is encapsulated and magnified tenfold by its groundwater dependent biodiversity. Groundwater in an aquifer is a body of underground water but it is not isolated or stationary. Neither is it devoid of life or an inexhaustible supply of clean water. It flows in much the same way as a river from its surface recharge zone to its surface discharge areas along defined flow paths and will transport impacts such as pollutants or reductions of quantity and quantity throughout the subsurface environments to the surface land and waters. Therefore, there is always a flow-on effect from one point of impact on the groundwater quantity or quality to the rest of the landscape (Serov & Kuginis 2017). The parameters that make groundwater environments a separate entity to many surface water environments and which has contributed to the development of many specialised, highly endemic ecosystems, communities and species, is the relatively consistent nature of its flow, pressure, level, and water chemistry.

The Baralaba South Project lies between the Baralaba North Mine (approximately 11 km to the north) and Baralaba Coal's existing Train Loadout Facility (TLO) (approximately 30 km to the south). The proposed location for the Baralaba South Project is on the floodplain of the Dawson River catchment. This study aimed to assess the presence of stygofauna across aquifers within and adjacent to the Baralaba South Project area and highlight the stygofauna community composition and distribution. It also aimed to examine the environmental factors contributing and possibly controlling the presence of this community.

This study is the first stygofauna assessment conducted within the area of the Baralaba South Project and the upper Dawson River. The main aquifer unit examined in this study is the Dawson River Quaternary Alluvium. The area is highly modified for agriculture, particularly cattle farming with small predominantly native vegetation patches along the riparian zones and native woodlands on the hill tops surrounding the Baralaba South Project.

1.1. Purpose of this Report

Project Objectives

The primary objectives of the study are to:

1) Determine whether any substantial stygofauna communities exist within the aquifer associated with the area of proposed development as well as in both the upstream and downstream of the likely area of influence of any groundwater impact;
2) Determination of species ranges if stygofauna exist, identifying conservation values such as short-range endemics;
3) Determine the factors influencing stygofauna distribution such as water quality (DO, pH, conductivity, temperature), aquifer structure, and connectivity to rivers;
4) Assess the potential impacts of the Project on stygofauna and recommend any future work programs to potentially investigate and/or monitor this ecosystem over time. In preparing for each round of stygofauna sampling it is necessary to keep in mind the needs of a future monitoring program that will be required to determine if there have been any significant changes to either the water resource or the dependent ecosystems. This is best done by using a BACI (Before/After Control/Impact) experimental design i.e. before and after sampling at experimental and control (reference) sites.

1.2. Impact Assessment Objectives

The aim of the stygofauna baseline surveys and impact assessment is to determine the presence of stygofauna within the area of the proposed future development and to assess the potential impacts of the proposed development on groundwater including aquatic threatened species, populations, communities or their habitats that are dependent on groundwater. Although it is never possible to be completely exhaustive in such an investigation due to the complexity of geologies, habitat formation, habitat availability and the hydrogeological flow paths, the following process ensures the results will be as comprehensive and reliable as possible. The assessment addresses the impacts of the open cut mining operations on any stygofauna communities that may be present within the associated aquifers. This assessment includes a baseline aquifer ecosystem evaluation for stygofauna across the area of impact and provides a risk assessment of the proposed development to this ecosystem.

The specific objectives of this study are to:

- Describe the natural/pre- development characteristics of the groundwater ecology through quantitative and qualitative monitoring of stygofauna, water chemistry and water levels;
- Identify or determine the likelihood of occurrence of threatened species, populations, habitat and/or communities within the study area;
- Determine if the mining of coal could affect groundwater ecology;
- Assess the likelihood that any identified potential impacts will cause significant adverse effects to groundwater ecology using a Risk based assessment designed specifically for Groundwater Dependent Ecosystems and Stygofauna
- Determine whether these impacts will significantly impair any identified threatened species, populations, habitat or communities.

1.3. Legislation, Policy, Criteria and/or Guidelines

The key information requirements of the *Environmental Protection Act 1994 (*EP Act) that must be addressed in this EIS are:

- the requirements of section 40 of the EP Act, which specifies the purpose of an EIS and of the EIS process;
- sections 125 and 126 which set out the general information requirements for applications for an environmental authority;
- section 126A which sets out the information requirements for a project involving the exercise of underground water rights; and
- the environmental objectives and performance outcomes specified in schedule 5, part 3, table 1 of the Environmental Protection Regulation 2008 (EP Regulation).

1.3.1 Critical Matters Relevant to this Study

Groundwater ecosystem dependence is an increasingly important component of surface and groundwater impact assessment initiatives in Qld. The impact assessment for the Baralaba South Project will be assessed as a State Significant Development 'controlled action' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which requires assessment by an EIS process accredited under the environmental assessment Bilateral Agreement (section 45 of the EPBC Act). As such, the EIS must address the 'controlling provisions' and all matters relating to them. The controlling provisions for the project, with regard to its potential impacts on matters of national environmental significance (MNES) are:

- listed threatened species and communities (sections 18 and 18A);

- listed migratory species (Sections 20 and 20A); and
- water resources (24D and 24E).

The critical matters outlined within the Terms of Reference that are relevant to the investigation of the subterranean groundwater dependent ecosystem known as Stygofauna are as follows:

Water quality (critical matter)

The environmental objectives to be met under the EP Act are that the activity (project) be operated in a way that:

- protects the environmental values of waters;
- protects the environmental values of wetlands (including soaks and springs) and **groundwater dependent ecosystems**; and
- protects the environmental values of groundwater and any associated surface ecological systems.

1.4. Stygofauna Ecology

Stygofauna are animals that live in underground water. They are generally comprised of invertebrates including crustaceans and other invertebrate groups such as worms, snails, mites and even blind insects. Stygofauna are animals that spend their entire lives in groundwater and due to their specific habitat requirements, the species are generally highly endemic. As such, these organisms have highly specialised adaptations to survive in relatively resource-poor aquifers, where there is limited light, space, and food supply (Humphreys 2008).

Stygofauna are blind, colourless, have slow metabolisms, reduced body size, specialised anatomies and low reproduction rates (Coineau 2000). As there is no photosynthesis below ground, these groundwater environments rely on inputs of organic matter from the surface to provide the basis of the food web on which stygofauna depend. Despite their small size, the cumulative effect of stygofauna activity plays an important part in maintaining groundwater quality. This process is evident in alluvial aquifers where water flowing though sediment particles is cleaned during transit by stygofauna, in much the same way as water moving through slow sand filters or trickle filters in water and sewage treatment (Hancock et al. 2005). Stygofauna therefore play a functional role in aquifers and are also considered a direct and sensitive indicator of the quality of an underground water source.

1.4.1. Stygofauna ecological requirements

Stygofauna are intricately linked both ecologically and physiologically to the aquifer environment and are adapted to the relative stability of their surroundings. Compared to surface environments, groundwater fluctuates less both in level and physico-chemical variables such as electrical conductivity, temperature, and pH (Hancock et al. 2005). Groundwater is also generally lower in dissolved oxygen and has less readily available organic matter than surface water environments (Humphreys 2002). As there is no direct photosynthesis in aquifers, stygofauna rely on connections to the land surface to provide them with food. These connections may be hydrological, with infiltrating water bringing dissolved or particulate organic matter to form the basis of subterranean food webs, or it may be more direct, with tree roots that extend below the water table providing leachates, organic carbon or fine rootlets for food (Hancock et al. 2005). Generally, stygofauna biodiversity is highest near the water table and declines with depth (Datry et al. 2005).

Stygofauna biodiversity is also higher in areas of recharge where the water table is close (< 20 m) to the land surface (Humphreys 2001, Hancock and Boulton 2008). This is because the water table is likely to have the highest concentration of oxygen and organic matter. Stygofauna can occur at considerable depth below the water table, but are fewer in number, have lower diversity, and may change in community composition (Datry et al. 2005).

In Australia, stygofauna are known from alluvial, limestone, fractured rock, and calcrete aquifers (Hancock et al. 2005; Humphreys 2008). Most aquifers occur as confined aquifers and as such have very low dissolved oxygen, high salinity and have a general lack of connectivity with surface environments. Stygofauna require space to live, which is dependent on the porosity of the sediments, degree of fracturing, or extent of cavity development. These requirements must be sufficient to enable fauna to move through the substrate.

The most biodiverse subterranean ecosystems in Australia are recognised to occur within the alluvial aquifers. Alluvial aquifers are unconsolidated aquifers consisting of particles of gravel, sand, silt or clay (Tomlinson & Boulton, 2008). Within alluvial aquifers, groundwater is stored in the pore spaces in the unconsolidated floodplain material. Shallow alluvial groundwater systems are associated with coastal rivers and the higher reaches of rivers west of the Great Dividing Range. These groundwater systems are often in direct connection with surface water bodies such as rivers and wetlands. Alluvial aquifers are generally shallower than sedimentary and fractured rock aquifers. Due to their shallow and unconfined nature, alluvial aquifers are highly susceptible to contamination/pollution and excessive drawdown of the watertable from pumping.

Research in Australia on these stygofaunal communities have until recently, been concentrated within Western Australia (WA) (Humphreys, 2002) with far less attention being given to the stygofauna of Eastern Australia. However, surveys conducted by government agencies (NSW Office of Water, DECCW), Universities (University of New England, NSW Institute of Technology, Sydney University and Macquarie University) as well as individual researchers and consultancies (Eberhard et al., 1991, Eberhard and Spate, 1995; Serov, 2002; Thurgate et al, 2001; Tomlinson et al., 2007; Tomlinson & Boulton 2008) have found that eastern Australia, and in particular Qld and NSW, is at least as diverse as the regions previously recognised as biodiversity hotspots or centres of high stygofauna biodiversity such as WA.

The findings have found that the most significant and potentially sensitive groundwater organisms are those in aquifers and cave GDEs (i.e. those that are totally dependent on groundwater). These invertebrate communities are intrinsically adapted to these very specialised environments.

These ecosystems and organisms have many values including the following:

- Most are rare or unique;
- Retain phylogenetic and distributional relictual species and communities;
- the ecosystems surviving in aquifers and caves are amongst the oldest surviving on earth;
- High proportion of short-range endemics;
- Develop or retain narrow range habitat requirements (i.e. narrow range endemic species). To survive, these species and communities continue to rely on the continuance of certain groundwater levels/pressure and water chemistry; and
- Develop specialised morphological and/or physiological adaptations to survive in groundwater environments;
- They have water quality functions, biodiversity value and add to the ecological diversity in a region.

The other important characteristic of alluvial aquifer communities is that their dispersal capabilities are entirely dependent on the subsurface hydrological connectivity of the alluvial aquifer with other aquifers and has narrow physiological tolerance ranges in water chemistry. As this community is adapted with specialized morphological features, narrow environmental tolerances and have no desiccation tolerant life stages (i.e. they cannot disperse via surface rivers and streams or via aerial dispersal of eggs) they are solely restricted to this habitat (Gibert et al. 1994; Gibert & Deharveng, 2002; Marmonier et al, 1993; Rouch and Danielopol, 1997; Sket 1999b; Danielopol et al., 2000; Serov, 2002; Tomlinson & Boulton, 2008). Tomlinson & Boulton (2008) outline the characteristics of subsurface aquifer communities. These communities can be isolated by a number of barriers including geological, hydrogeological, climatic and differences in water chemistry. Due to these barriers to dispersal, subterranean communities in general have a high potential for speciation and very short-range endemism and are highly vulnerable to habitat change resulting in local or total extinction of species.

Stygofauna surveys in Qld, and more specifically within and around the Dawson catchment have identified the karst or carbonate aquifers as well as the alluvial aquifers as the main aquifer types to contain a stygofauna community.

1.4.2. Processes that Threaten Stygofauna

There are three critical factors that are essential requirements for stygofauna communities in aquifers. These include:

1) Stable water quality/physicochemical parameters;

Many groundwater species have evolved under strict physiochemical constraints and require a level of stability of these parameters for their continued existence. Stygofauna can tolerate natural fluctuations in water parameters such as level, electrical conductivity, and temperature, and this has been demonstrated experimentally (Tomlinson et al. 2007) for stygofauna such as amphipods, copepods, and syncarids. However, changes outside the natural range of water quality, water chemistry and levels such as rapid drawdown or changes to water chemistry such as a pollution plume is likely to have significant impacts on the community composition, biodiversity and overall sustainability of the community.

2) Surface connectivity;

Groundwater communities require links to the surface environment to provide organic matter and oxygen. If that linkage is broken or disrupted, the stygofauna community in the area affected could decline over time.

3) Subterranean connectivity.

The third critical factor is their high degree of endemicity (Humphreys 2008). This comes about because, unlike many surface-dwelling aquatic invertebrates, stygofauna do not have aerially dispersing life stages. To migrate between areas, stygofauna must be able to swim or crawl through the aquifer matrix. However, as aquifers are not homogenous in porosity and change over geological time, natural hydrological barriers within the matrix restrict their movement. Over time, these natural barriers encourage genetic isolation and ultimately, speciation. Barriers, however, can also be created rapidly by changes in water levels or water chemistry/quality such as an area of lower porosity and sections of poor water quality. If any area is impacted by a disturbance that results in a loss of biodiversity, these new barriers to dispersal may prevent recolonization of the habitat.

Many species of stygofauna are restricted to small geographical areas. This is particularly the case in non-alluvial aquifers such as some of the limestone karsts of NSW (Eberhard & Spate 1995; Thurgate et al. 2001), and calcrete aquifers in WA, where one or more species are known only from a single aquifer, or part of an aquifer (Humphreys 2002). This means that any process that threatens the aquifer, potentially threatens an entire species and community. There is also a high degree of endemism in alluvial aquifers, even between adjacent systems (Hancock and Boulton 2008). However, providing there is sufficient hydrological connectivity within the aquifer, and physico-chemical conditions are suitable, the distribution of species will not be restricted to small parts of an aquifer.

Stygofauna are potentially threatened by activities that change the quality or quantity of groundwater, disrupt connectivity between the surface and aquifer, or remove living space. These impacts to groundwater and aquifer conditions have become an issue for mining proponents over the last decade or so, principally because of the biodiversity value of stygofauna and the fact that little is known of their environmental water requirements at each specific location.

1.4.3. Potential impacts of mining on stygofauna

Mining operations in general may incorporate a range of activities in their operations that may result in impacts on water resources and subsequently, stygofauna communities and species, including some or all the following (Serov et al. 2012):

- ❑ Below water table mining;
- ❑ Water supply development (e.g. groundwater, dewatering, surface water);
- ❑ Desalination for potable supply (with subsequent brine disposal);
- ❑ Dust suppression;
- ❑ Tailings disposal;
- ❑ Overburden storages;
- ❑ Backfilling and rehabilitation works;
- ❑ Water diversions and surface sealing;
- ❑ Hazardous and dangerous goods storage;
- ❑ Water storages including waste water ponds; and
- ❑ Disturbance/removal of terrestrial vegetation.

In recognition of the above mining activities, potential direct effects on GDEs may be as follows:

- ❑ Quantity (groundwater levels, pressures and fluxes);
- ❑ Quality (changes outside of natural ranges, concentrations of salts, heavy metals and other toxic water quality constituents);
- ❑ Groundwater interactions (interactions between groundwater systems and between groundwater and surface systems); and
- ❑ Physical disruption of aquifers (excavation of mining pits and underground workings, compaction of aquifer matrix through dewatering, increase in porosity by blasting, or overburden compaction).

The existence and extent of these water affecting activities, and their potential impact on local to regional scale groundwater resources will depend largely on the scale of the mining operation, mining method, and process water requirements, as well as the climatic and geological setting.

1.4.4. Other studies

The National Water Commission (NWC) has reported (RPS 2011) that extensive gaps exist in our knowledge of the distribution, composition and biodiversity value of Australian stygofauna. Despite this incomplete inventory it is apparent that stygofauna are present across a variety of Australian subsurface environments and are generally characterised by high diversity and local-scale endemicity.

In Australia, at least 750 stygofauna species have been described (Humphreys 2008). However, more than 66 % of known species come from just two regions of WA, which suggests that the total continental biodiversity is much higher (Humphreys 2008) and large parts of Australia remain un-surveyed. In NSW there are approximately 400 species of stygofauna known, but this estimate is likely to increase as more surveys are conducted and taxonomic knowledge improves.
Stygofauna has previously been recorded at both Baralaba South in 2012 (SKM 2013) and Baralaba North in 2014 (EcoLogical 2014) approximately 10 km north in the alluvial aquifer of the Dawson River Anabranch.

Sampling of stygofauna was conducted from seven (7) of the alluvial groundwater monitoring bores (A-PB1, A-OB1, A-OB2, A-OB3, A-OB4, A-OB8 and A-OB10) and four (4) of the groundwater monitoring bores screened in the Permian coal measures (P-PB1, P-OB1, P-OB2 and P-OB3) at the Baralaba South Project area or surrounds. The previously collected fauna at Baralaba South has consisted entirely of Cyclopoida Copepoda, in bores (AOB1, AOB3, AOB8, APB01), and a damaged mite in AOB04. Based on the results of the 2012 stygofauna sampling program, it was concluded that stygofauna were present in the alluvium, and the absence of stygofauna detected in the Permian coal measures was consistent with other studies that have sampled similar coal seam aquifers in the Bowen Basin.

At Baralaba North the fauna consisted of both Cyclopoida Copepoda and Bathynellacea Syncarida which were collected exclusively from Dawson River Alluvial Aquifer. In the broader regional context of the Bowen Basin, stygofauna are known from the alluvial aquifer Devlin Creek (ALS 2011), the Bowen River (GHD 2012), and Mackenzie River (ELA unpublished), and are likely to occur in many alluvial aquifers present in the Basin (4T Consultants 2012). The fauna generally, consists of cyclopoid and harpacticoid copepods, as well as Bathynellacea (GHD 2012). Amphipoda have been collected from northern aquifers with coarse sediments and high hydraulic conductivity (GHD 2012). Stygofauna have also been recorded in a shallow sandstone seam in the Gallilee Basin (4T Consultants 2012).

In terms of previous records of stygofauna in the Dawson River catchment (i.e. prior to the studies described above), stygofauna have not previously been collected from the area within or surrounding the project area prior to these surveys.

1.5. Terminology used in this Report

Stygofauna is an all-encompassing term for animals that occur in subsurface waters (Ward et al. 2000). They are classified by the degree to which they are dependent on groundwater. Those that are completely dependent on groundwater are termed stygobites or phreatobites and consist predominantly of crustaceans. Those that rely on groundwater to a lesser extent and can live in mixed surface and groundwater are termed stygoxenes or stygophiles depending on their adaptation to the subterranean environment (Marmonier et al. 1993). The distinction is often ambiguous because it is difficult to know the degree of surface/groundwater mixing in an aquifer, and the classifications are regularly disputed (Sket 2010). However, classifications based on affiliation to groundwater can be useful when assessing the conservation status of species and their vulnerability to potential impacts. In this report we adopt the following definitions:

Stygoxenes - organisms that have no affinities with groundwater systems but regularly occur by accident in caves and alluvial sediments. Some planktonic groups (e.g. Calanoida Copepoda) and a variety of benthic crustacean and insect species (e.g. Simullid larvae, Caenidae Mayflies) may passively infiltrate alluvial sediments (Gibert et al.1994).

Stygophiles - organisms that have greater affinities with the groundwater environment than stygoxenes because they appear to actively exploit resources in the groundwater system and/or actively seek protection from unfavourable surface water conditions. Stygophiles can be divided into occasional/temporary hyporheos and permanent hyporheos.

Stygobites - obligate subterranean species, restricted to subterranean environments and typically possessing specialised character traits related to a subterranean existence (troglomorphisms), such as reduced or absent eyes and pigmentation, and enhanced non-optic sensory structures.

Phreatobites - stygobites that are restricted to the deep groundwater substrata of alluvial aquifers (phreatic waters). All species within this classification have specialised morphological and physiological adaptations (Gibert et al 1994).

1.6. Assumptions and Limitations

This report is a baseline assessment, which focuses on identifying the presence and biodiversity of stygofauna within the Study Area. The Study Area has been assessed using monitoring and in-situ field information.

Groundwater bore sites sampled are assumed to be representative of the aquifer types and groundwater ecosystems present across the Study Areas. Every effort was given to maximize the representativeness of the aquifer types across the study area with each of the major aquifers and geology types surveyed.

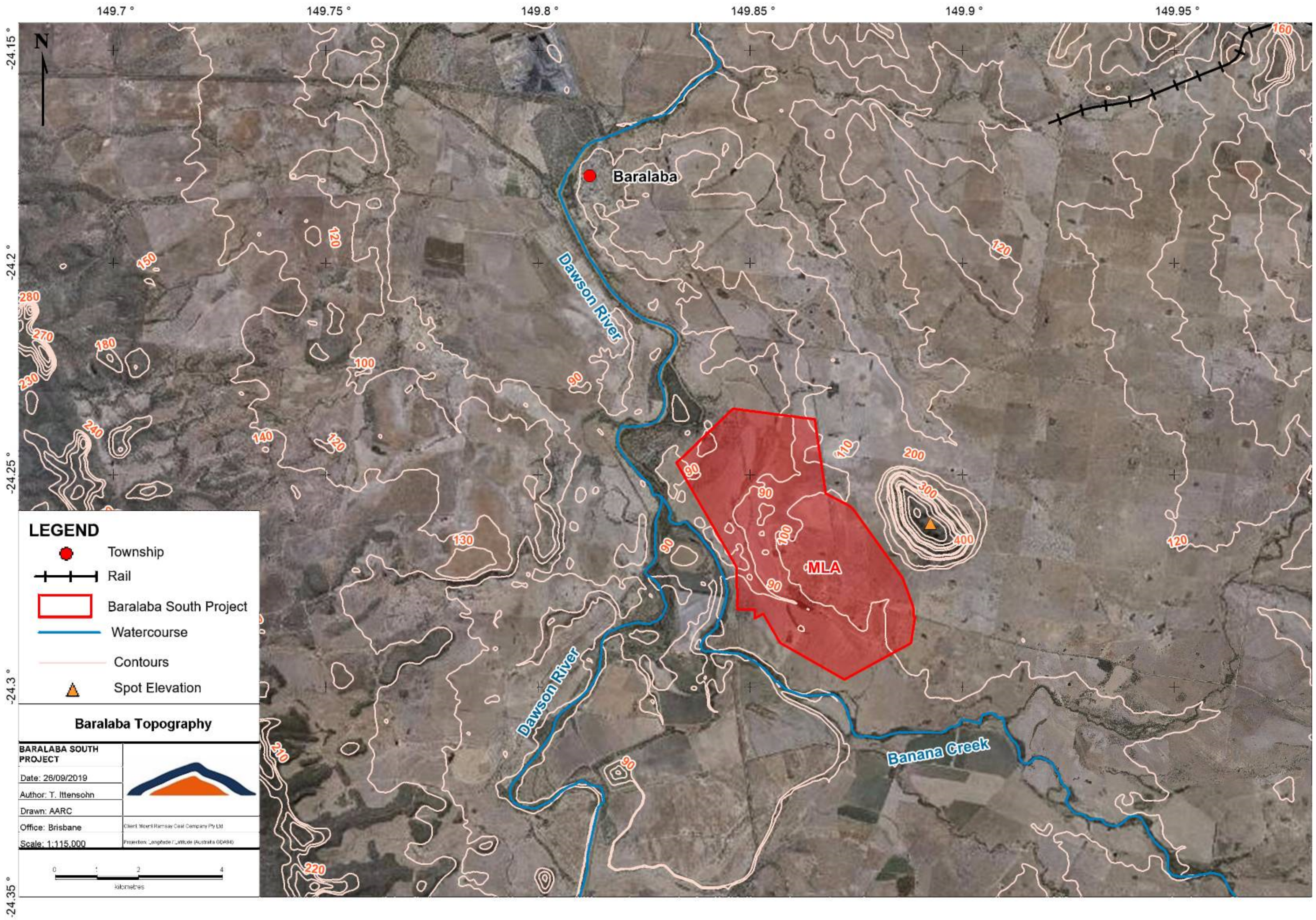
2. Study Area and Sampling Sites

The Study Area for the purposes of this report encompasses the Baralaba South Project Area and surrounding lands, with sampling of alluvial aquifers adjacent to the Dawson River and Banana Creek (refer to Map 1).

2.1. General Description

The study area covers Baralaba South Project area and surrounding lands and is located within the floodplain of the Dawson River catchment. The Baralaba South Project is located 6km to the south of Baralaba. The area is intensively agricultural with the primary industry being beef production. This study aims to determine the presence of stygofauna across aquifers within and adjacent to the Baralaba South Project area through the assessment of bores of the Dawson River and its tributary, Banana Creek for stygofauna community composition and distribution.

The topography of the Baralaba area is dominated by the Dawson River floodplain to the west of the proposed development. The area is relatively flat with only slight undulation, with ground elevations ranging between 75 m and 110 m Australian Height Datum (AHD), rising towards Mt Ramsay in the east and bordered by Banana Creek to the south. The Dawson River is located to the west of MLA 700057 and Mt. Ramsay east of the Project.



Map 1. Baralaba South Project Area

2.2. Site Data

Twelve bores were selected as representatives of each of the major habitats and aquifers (Table 1 and Maps 2, 3 and 4). All sites sampled are located within, adjacent as well as upstream and downstream of the proposed area operations and selected based on suitability for stygofauna for the following reasons: they were shallow monitoring piezometers of less than 100 m, they accessed groundwater situated in the unconsolidated alluvial sediments. The design of the sampling regime also considered the direction of the shallow groundwater flow which, as described earlier flows in a south west direction from and along the course of the Dawson River valley. The sites ranged in altitude from 86.2m (A-OB11) to 91.4 mAHD (a-)B6) on the Dawson River to the west of MLA 700057.

Table 1. Bore locations and details. The highlight shows the sites that recorded stygofauna.

Baralaba South Alluvium Monitoring Network	Easting	Northing	Alt (MAHD)	Total Depth (m)
A-PB1, Quaternary alluvium	787806	7314088	88.4	22.3
A-PB2, Quaternary alluvium	791931	7309808	88.9	29.1
A-OB1, Quaternary alluvium	787440	7314586	88.9	29.1
A-OB2, Quaternary alluvium	787802	7314105	88.3	20
A-OB3, Quaternary alluvium	788393	7314309	87.9	30
A-OB4, Quaternary alluvium	789290	7314733	875	17
A-OB6, Quaternary alluvium	791402	7309557	91.4	29
A-OB7, Quaternary alluvium	791935	7309829	91.7	26
A-OB8, Quaternary alluvium	792501	7310136	91.4	23
A-OB10, Quaternary alluvium	789247	7313094	87.5	23
A-OB11, Quaternary alluvium	787270	7313771	86.2	17
A-OB12, Quaternary alluvium.	787220	7313767	87.2	18

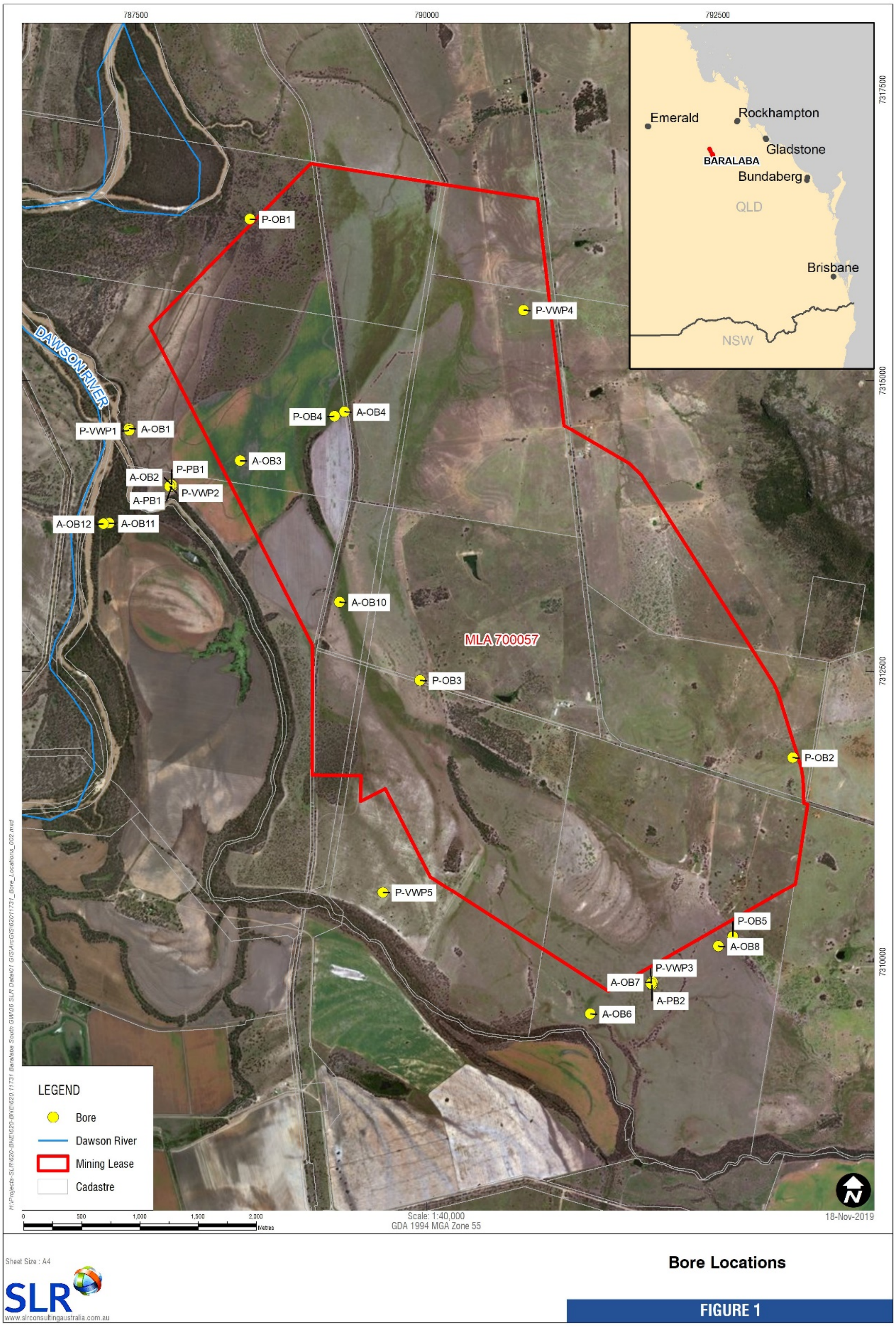
2.3. Groundwater

The main aquifer units include the Dawson River Alluvium and the underlying Blackwater Group Coal Measures. The assessment for stygofauna has only examined the Dawson River Alluvium. The alluvium and surface soils in the local area of the development appear to include clays overlying sandstone with some sandstone outcrops. There are some small alluvial flats in proximity to topographical depressions in the proposed mining lease (Baralaba Coal, 2017).

Water levels and bore depths are illustrated in Figure 1 and groundwater column thickness is illustrated in Figure 2. Hydrographs for the bores show very consistent water levels over the period of monitoring with a small response to rainfall. The groundwater flow direction within the coal seam is shown to be towards the west and southwest, consistent with the dip of the Blackwater Group (i.e. groundwater flow is down-dip) but also towards the Dawson River (Baralaba Coal, 2017).

The bores with the highest groundwater elevations are those in proximity to the Dawson River (i.e. A-OB12, AOB11, A-OB1, A-OB2 and A-OB3). Stygofauna were collected from bores A-OB1, A-OB2 and A-OB3. Groundwater elevations within the alluvium reduce with distance from Dawson River, indicating potential recharge to the alluvium i.e. the river is losing to the groundwater along this section of the river. The potential implication for the river post development is the potential development or increase of the cone of depression resulting in greater draw from the river. Bores A-OB11and A-OB12 recorded a decline in groundwater levels from March 2018, which appears to correlate to declining rainfall and streamflow (SLR 2018).

Map 2. Bore locations with MLA 700057 and surrounds (SLR, 2018).



Map 3. Close-up of the Baralaba South Project Area showing the Northern bore complex.

Map 4. Close-up of the Baralaba South Project Area showing the Southern bore complex.

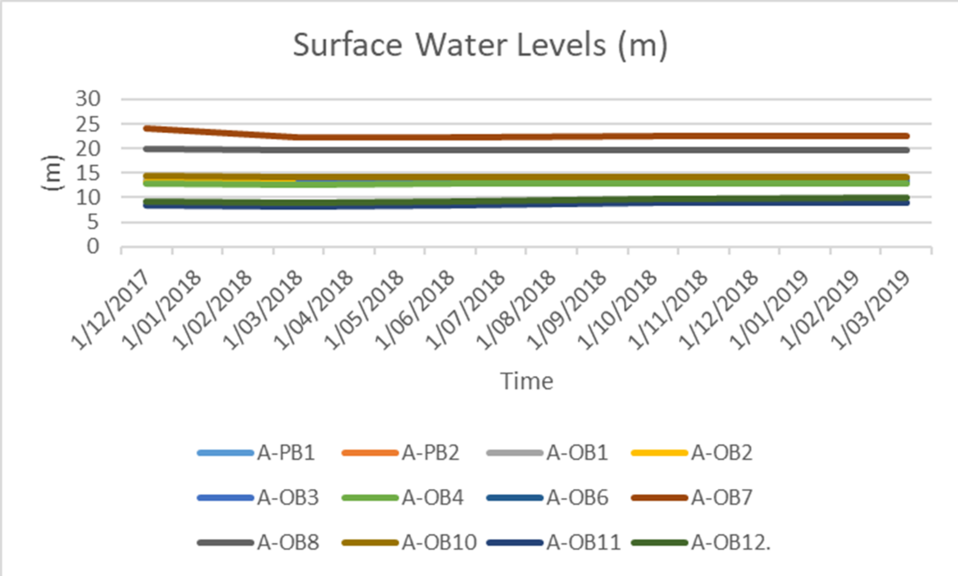


Figure 1. Water level depths recorded at each bore over time.

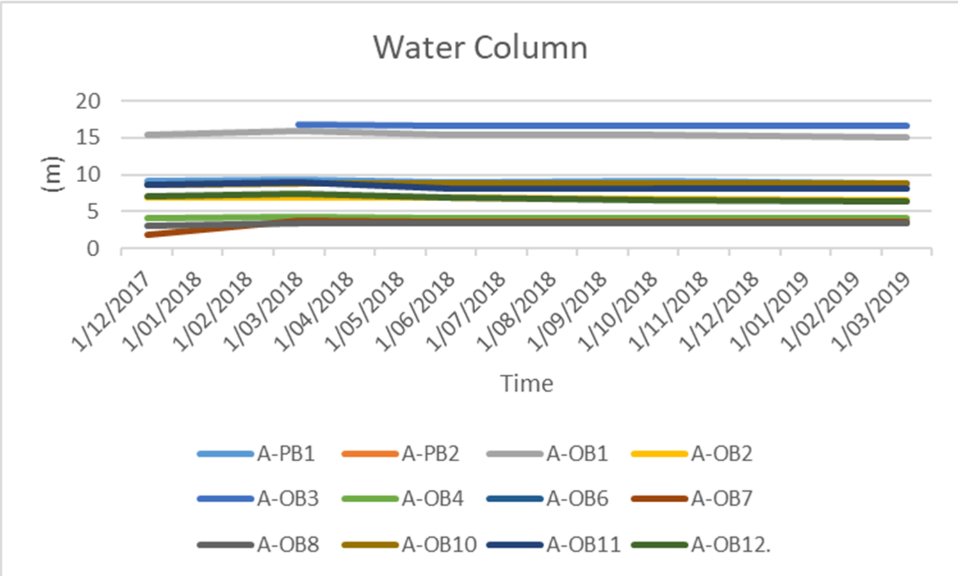


Figure 2. Water column thickness recorded at each bore over time.

The groundwater characteristics of the Dawson River Alluvium

The Dawson River Alluvium bores is a shallow groundwater system that has a water level between 19.93 – 8.07mbgl. This provides a water column thickness of between 15.97 – 1.8 m. The sediments within the profile are predominantly clays with small lenses of fine sands. The bores that recorded stygofauna have a water level between 13.84 – 13.03mbgl. This provides a water column thickness of between 6.6 – 16.78 m.

2.4. Groundwater Water Quality

Overall, the available data (Table 2 and Table 3) on groundwater quality show that groundwater within the Dawson Alluvium has a range of electrical conductivities (Figure 3) ranging from fresh (defined as > 500 µS/cm) for the bores adjacent to the Dawson River up to hyposaline (38087µS/cm) for more distant bores. The pH (Figure 4) is generally slightly acidic to neutral across the floodplain with an average pH of 6.42

Table 2. Electrical Conductivity data (µS/cm) from each site collected. The highlight shows the sites that recorded stygofauna.

Bores	Total Depth (m)	Recorded Total Depth (m)	20/12/2017	22/03/2018	22/06/2018	29/10/2018
A-PB1	22.3	27		646	630	610
A-PB2	29.1	24				
A-OB1	29.1	29	570	466	486.4	493.2
A-OB2	20	20	657	617	686	565
A-OB3	30	30		561	593	489.9
A-OB4	17	17	37011	35920	37557	40022
A-OB6	29	18.88				
A-OB7	26	26	15681	16809	16637	18390
A-OB8	23	23	26260	25877	26194	27752
A-OB10	23	23	31708	36433	38097	38786
A-OB11	17	17	425	405	434	376.7
A-OB12.	18	16.25	381	354	327.7	3225

Note: highlighted cells indicate bores containing stygofauna

Table 3. pH data (pH units) from each site collected. The highlight shows the sites that recorded stygofauna.

Bores	Total Depth (m)	Actual Depth (m)	20/12/2017	22/03/2018	22/06/2018	29/10/2018
A-PB1	22.3	27		6.07	6.12	6.19
A-PB2	29.1	24				
A-OB1	29.1	29	6.42	6.49	6.26	6.16
A-OB2	20	20	6.41	6.48	7	6.27
A-OB3	30	30		6.75	6.55	6.54
A-OB4	17	17	6.31	6.29	6.3	6.43
A-OB6	29	18.88				
A-OB7	26	26	6.62	6.95	6.64	6.92
A-OB8	23	23	6.89	6.94	6.57	6.47
A-OB10	23	23	6.42	6.2	6.15	6.36
A-OB11	17	17	6.08	6.14	6.37	6.23
A-OB12.	18	16.25	6.17	6.25	6.25	6.28

Note: highlighted cells indicate bores containing stygofauna

The groundwater chemistry for the sites that recorded stygofauna (bores OB1, OB2 and OB3) had an EC range of 686-466 µS/cm and pH range from 6.16-7.0.

Figure 3. Electrical Conductivity for each bore over time.

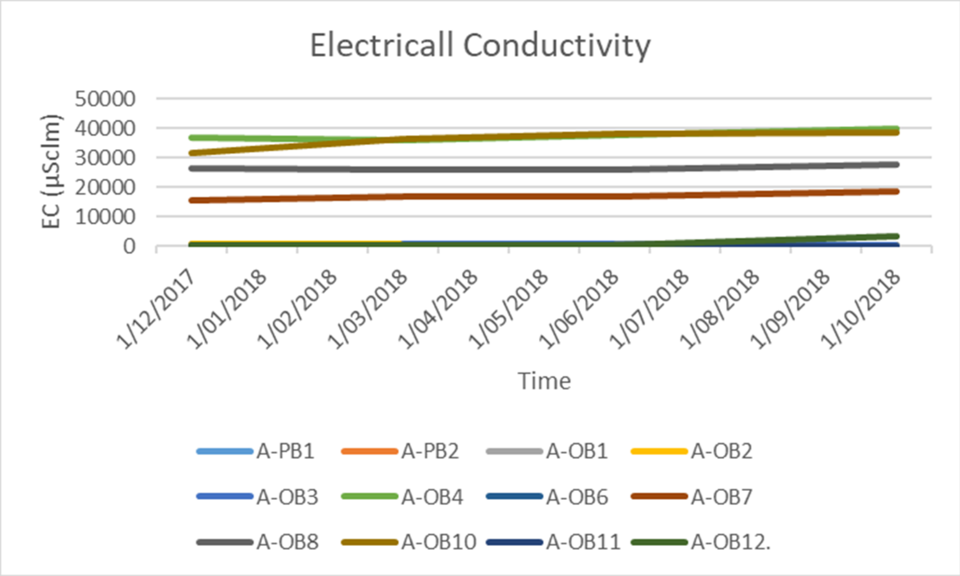
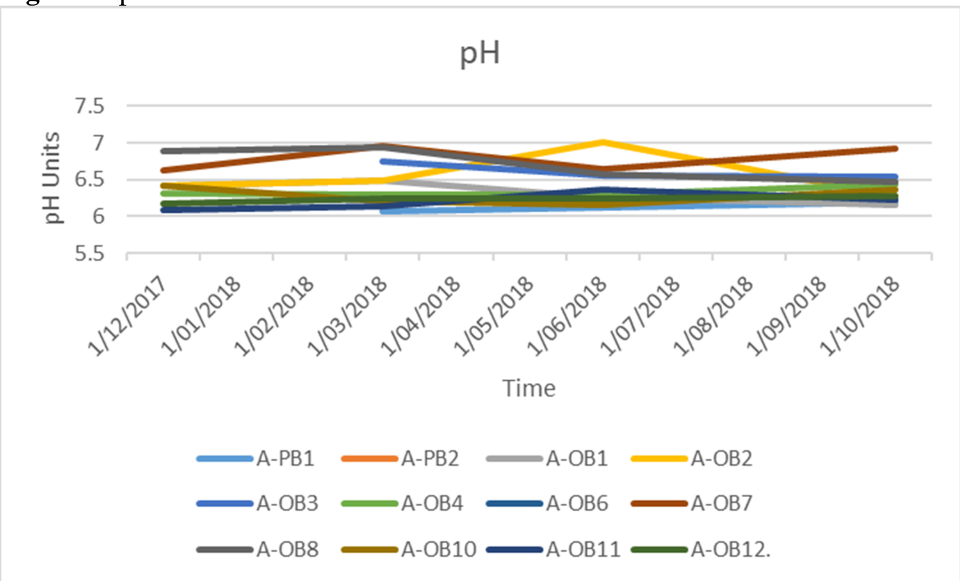


Figure 4. pH for each bore over time.



3. Methodology

In preparing for each round of stygofauna sampling it is necessary to keep in mind the potential need for future monitoring. Any proposed future monitoring would be best done by using a BACI (Before/After Control/Impact) experimental design i.e. before and after sampling at experimental and control (reference) sites. The development of any sampling protocol involves:

- Selecting sampling location points (bores, wells, piezometers, etc.);
- Deciding on an appropriate sampling method (pumps, bailers, plankton nets, Bou Rouche pump etc.);
- Determining sample handling procedures (such as filtration, transfer, preservation, etc.); and minimum disturbance to biological specimens.

3.1. Stygofauna and Spring Sampling

In order to sample a habitat effectively it is often necessary to use a combination of techniques to comprehensively collect all possible biota as the stygofauna community occupies a range of habitat niches. For routine surveying or monitoring of bores and wells, a submersible pump or hand pump, bailer and/or plankton nets (Mathieu et al. 1991) are the preferred devices. The sampling techniques used for the stygofauna surveys are described below.

The Phreatic/hypogean zone

The phreatic zone is the subsurface area within an aquifer where voids in the rock are completely filled with water. This zone is typically occupied by phreatobites. The stygofauna community was sampled using three standardised methods and one non-standard method.

The first technique is the Phreatobiology Net. This is the standard technique that has been used successfully overseas and in Australia (Bou, 1974). This method involves using a weighted long haul or plankton net with a 150 µm mesh. Sampling consisted of dropping the net down to the bottom of the bore and taking at least three consecutive hauls from the entire water column at each bore. Upon removal from the bore the net is washed of sediment and animals and the contents of the sampling jar (the weighted container at the bottom of the net) are decanted through a 150 µm mesh sieve. The contents of the sieve are then transferred to a labelled sample jar and preserved with 100% ethanol.

The second standard method is the use of a groundwater bailer. A bailer is typically used by hydrogeologists to take water samples from bores for water quality/water chemistry analysis. The bailer used for this study is 1 m long by 40 mm clear plastic tube with a running ball valve at the bottom. The advantage of using a bailer is twofold. The main reason for using a bailer is that it is able to sample the bottom sediment of a bore that cannot be sampled by a haul net and therefore enables the collection of cryptic invertebrates that do not inhabit the water column or sides of the bore. The second advantage is that in shallow bores down to five meters in sediments with low transitivity porosity, a bailer is able to empty the entire contents of a bore and thereby confidently collect all animals within the bore. The contents of the bailer are emptied into a cleaned bucket from which the water is then decanted through a 150 µm mesh sieve. The contents of the sieve are transferred to a labelled sample jar and preserved with 100% ethanol. Following sampling and preservation of the sample and prior to the next sampling, all equipment including the bailer, net and sieves must be rinsed clean with clean water via a spray bottle to remove any sediment and animals that may have remained attached to the sampling devices. This is to reduce the possibility of cross contamination of organisms (stygofauna or bacteria) or pollutants from one aquifer or bore to another.

3.2. Laboratory Methods

3.2.1. Identification

All samples are preserved in the field with 100% ethanol and returned to the laboratory where each sample is sorted under a stereomicroscope and stored in 100% alcohol. All specimens are identified to the lowest possible taxonomic level, generally to genus, where possible. Specimens are identified under a compound microscope using a combination of current taxonomic works and keys such as Williams (1981) and the taxonomic identification series (Serov 2002) produced by the Murray Darling Freshwater Research Centre as well as the authors taxonomic expertise and experience.

3.2.2. Physico-Chemical Data

Physical and chemical parameter data was supplied by SLR Consulting during each round of survey and their regular water quality monitoring program. Water quality parameters including electrical conductivity, pH was collected in the field using a water quality multimeter. Bore depth and water level (SWL) data was collected at each site during each survey using a depth probe in the field during the survey.

3.3. Data Analysis

3.3.1. Risk Assessment Methodology

The "Risk Assessment Guidelines for Groundwater Dependent Ecosystems" (Serov et al. 2012) were prepared for the NSW Department of Primary Industries, Office of Water to support the requirements of the NSW *Water Management Act, 2000*. The Guidelines provide an ecological valuation and risk assessment process to assess the risk and potential impacts for identified GDEs. In summary, GDEs are first identified and classified and the level of dependency on groundwater for individual GDEs inferred. Once the ecological value of individual aquifers has been determined, the ecological value of the GDEs associated with that aquifer can then be assessed. The individual value of each GDE within the aquifer can also be assessed as a stand-alone unit. Following an assessment of the aquifer and associated GDEs current value, the potential future impact of a proposed activity on the aquifer and associated GDEs can then be assessed. The Guidelines include a Risk Matrix which can be applied to determine the most appropriate management response for a given environmental value. This risk assessment framework has been used to guide the ecological valuation and assessment of potential impacts on stygofauna for the Baralaba South Project.

3.3.2. Aquifer Risk Assessment

The aquifer risk assessment considers the risk that groundwater extraction and open cut mining places on the groundwater source and its GDEs. In this process the ecological value of a GDE is assessed in association with the risk that a groundwater source and associated GDEs would be under from these impacts, which in turn informs the likely level of management required. That is, if the aquifer has a high conservation value or a number of high priority GDEs and therefore is of high ecological value, its value has a high risk of being altered by extraction. Conversely if a groundwater source/GDE has low ecological value then there is a low risk of altering its value by extraction. This assessment was completed for each groundwater source and identifies risks to three main aquifer assets according to several attributes as follows:

❑ Ecological Assets;

- Risk of a change in groundwater levels/pressures on GDEs,
- Risk of a change in the timing of groundwater level fluctuations on GDEs,
- Risk of changing base flow conditions on GDEs.
- Risk of changing aquifer flow paths.

❑ Water Quality Assets;

- Risk of changing the chemical conditions of the water source,
- Risk on the water source by a change in the freshwater/salt water interface, and
- Likelihood of a change in beneficial use of the water source.

❑ Aquifer Integrity Assets;

- Risk of substrate compaction.

Table 4. Risk Matrix.

Category 1 High Ecological Value (HEV) Sensitive Environmental Area (SEA)	**A**	**B**	**C**
Category 2 Moderate Ecological Value (MEV) Sensitive Environmental Area (SEA)	**D**	**E**	**F**
Category 3 Low Ecological Value (LEV)	**G**	**H**	**I**
	Category 1. Low Risk	**Category 2. Moderate Risk**	**Category 3. High Risk**

Risk Matrix Box	Descriptor
A	High value/Low risk
B	High value/Moderate Risk
C	High Value/High Risk
D	Moderate Value/Low Risk
E	Moderate Value/Moderate Risk
F	Moderate Value/High Risk
G	Low value/Low risk
H	Low Value/Moderate Risk
I	Low Value/High Risk

4. Results

4.1. Ecological Response - Stygofauna Data

4.1.1. Community Structure

The survey sampled 12 bores across the Study area. The fauna surveys conducted by Ecological Australia in 2014 at Baralaba South consisted entirely of Cyclopoida Copepoda, in bores (AOB1, AOB3, AOB8, APB01), and a damaged mite in AOB04. Neither of these two groups have been recorded in five rounds over 2017-2019. The results of the current surveys are listed in Table 5. There are 4 sites that recorded fauna including 3 sites that recorded stygofauna and 3 sites that recorded stygophiles. The bores contained a total of one aquatic invertebrate family and two terrestrial invertebrate families. The aquatic fauna was present within three of the shallow bores in close proximity to the Dawson River. The bores were situated close together at the north west corner of the mining lease adjacent to the Banana Creek/Dawson River confluence. Sites A-OB3 is inside the lease area and A-OB1 and A-OB2 are just outside the lease.

The stygofauna community composition included one family of aquatic worms (Oligochaeta), whereas the Stygophiles/Edaphobites (soil dweller terrestrial fauna consisted of 1 family of Diplura (primitive insects) and one family of Diplopoda (Centipedes). There were no listed threatened species collected, however, as is the case with most assessments in this emerging field, some species are likely to be new to science and may have restricted distributions.

The sites can be delineated by the fauna present. The bores in which the Oligochaetes were found at the proposed Baralaba South Project can be characterised by the shallow depth of the surface water levels, the low electrical conductivity and the slightly acidic to neutral pH as well as the high sand/low clay composition of the substrate.

Table 5. Species list by site.

			Locality	A-OB1	A-OB1	A-OB1	A-OB2	A-OB2	A-OB3	A-OB3	A-OB8
Phylum	**Class**	**Order**	**Family**	**Jun-18**	**Oct-18**	**Mar-19**	**Oct-18**	**Mar-19**	**Mar-18**	**Jun-18**	**Jun-18**
Annelida	Clitellata	Oligochaeta	Naididae	1	2	2	2	0	12	1	0
Arthropoda	Diplopoda	Polydesmida	Haplodesmidae	0	2	0	0	0	0	0	1
Arthropoda	Entognatha	Diplura	Campodeidae	0	0	0	0	1	0	0	0
			No. Taxa	1	2	1	1	1	1	1	1
			No. Animals	1	4	2	2	1	12	1	1
			Phreatobites sp.	1	1	1	1	0	1	1	0
			Stygoxenes sp	0	0	0	0	1	0	0	1

Ecotone 1 - Phreatobites – Sites: A-OB1, A-OB2, A-OB3.

The obligate groundwater/aquifer fauna recorded during the surveys belonged to the Oligochaeta (aquatic worm) Family Naididae (aquatic worms). All samples contained very fine sand and clay sediments of between approximately 50-300µm. The low number of taxa and specimens collected at each site indicates that dispersal through the aquifer is limited by the fine-grained nature of the unconsolidated sediments.

The taxon collected belongs to the hypogean (true groundwater) ecosystem, which typically has relatively low DO, permanent darkness, highly stable water quality, and low energy levels from allochthonous input and bacteria. The presence of Oligochaeta within the groundwater indicates that the stratum was unconsolidated and is probably a paleochannel of an ancient river bed consisting of inter-bedded medium to course grained sands and gravels. Oligochaeta are usually associated with finer unconsolidated substrates that act as slow to trickling filters and play an important role in increases the efficiency of bacterial growth and maintain open interstitial spaces through their feeding activities (Danielopol, et al, 2000). The family Naididae is a common aquatic family of freshwater worms, which currently contains approximately 23 genera and 59 species. In terms of their use within current environmental sensitivity indices such as the SIGNAL Index ranking, they can only be assessed at the Order level of Oligochaeta which has a ranking of 2. This equates to a family which is quite tolerant of environmental disturbance. This, however, is misleading as the family is usually associated with high water quality environments.

The Naididae typically inhabit and swim in the water column just above the substratum, whereas other aquatic oligochaetes that do not burrow, crawl along the substratum. The feeding habit of most aquatic oligochaetes is to ingest detritus and sediments although some species of Naididae may be carnivorous, while others are parasitic. Naididae species reproduce by a process of budding from a special segment (Pinder & Brinkhurst, 1994).

The Australian naidid fauna consists mostly of cosmopolitan species, although there are indications of greater endemicity than currently recognised. Increasingly, new Naidid species are being collected from seasonal habitats on granite outcrops in the south-west and from refugial habitats (caves, groundwater and permanent river pools) in drier regions. A complete picture of oligochaete distributions will require much more work and patterns suggested by current data are presented here as hypotheses. (Pinder, 2001).

The presence of worms and a general paucity of large crustaceans at these sites indicates that the water quality is characterised by elevated organic carbon, and possibly high levels of dissolved iron, lower (acidic) pH levels ranging from approximately 6-4 pH units and relatively low DO. The relatively small size (1-2mm) of the Oligochaete (worm) species present indicates a low to moderate connectivity within the river/aquifer environment. The shallow water table levels within the riverine hyporheic zone suggests a direct association/connectivity with a slow base flow river system with a shallow alluvial water table. The direction of flow discussed earlier i.e. away from the river into the aquifer suggests that the stygofauna recorded are associated with and limited to the hyporheic river channel sediments i.e. the narrow alluvium along the river rather than the alluvial plain which has higher EC and finer sediments. Although primarily phreatobites i.e. belonging to the shallow groundwater ecotone, this family can also be found within the riverine, hyporheic zones in areas of groundwater discharge where the discharge can be either point source springs or diffuse discharge through a moderate to course grained substrate such as sand or gravels (Gilbert 1994).

Subterranean Oligochaetes are an increasingly important component of Australia's groundwater fauna that contain a large number of short-range endemic species with large faunas along the continental marginal areas, particular in the southwest and eastern seaboards. They are a poorly known group that requires further taxonomic work (Pinder & Brinkhurst, 1994).

Ecotone 2 – Stygophiles/Edaphobites – Soil Fauna. Sites: A-OB1, A-OB2, A-OB8

A number of sites recorded the presence of terrestrial invertebrates. These sites offer a reliable source of moisture in a semi-arid region. These humic rich, moist environments harbor a rich community of soil and leaf litter invertebrates that are closely associated with the edge of the water and are often collected in bores. As they have physiological requirements for high humidity, they occupy the transition zone between the terrestrial and aquatic environments and other refugial environments such as inside bores. Their presence in these habitats including bores is therefore regarded as incidental.

The dominant group collected belonged to the primitive soil insects, the Diplura and Diplopoda (Centipedes). They are common in leaf litter. They are typically detrital or fungal feeders associated with the ground litter layer and tree bark. Their presence in the samples is most likely coincidental either by falling in or occupying the vegetation adjacent to the bore or living within the bore above the water table, as they have a preference for humid environments. As they are terrestrial soil and leaf litter fauna and not associated with groundwater environments no further description will be given.

4.1.2. GDE risk assessment results

The assessment of the value and risk to stygofauna community at each of the sites surveyed as well as an overall assessment of the shallow aquifers that supply the water to the identified GDEs of the groundwater dependent ecosystems is presented below in Table 6. The blue colour represents the bore sites that registered positive to stygofauna, and white represent negative results.

Table 6 Risk assessment results

Locality Name	Habitat	Survey Result	Ecological Value	Ecological Risk	Matrix Ranking
A-PB1	Bore	Negative	Low	Low	G
A-PB2	Bore	Negative	Low	Low	G
A-OB1	Bore	Stygofauna	Low	Low	G
A-OB2	Bore	Stygofauna	Low	Low	G
A-OB3	Bore	Stygofauna	Low	Low	G
A-OB4	Bore	Hyporheic	Low	Low	G
A-OB6	Bore	Hyporheic	Low	Low	G
A-OB7	Bore	Hyporheic	Low	Low	G
A-OB8	Bore	Hyporheic	Low	Low	G
A-OB10	Bore	Negative	Low	Low	G
A-OB11	Bore	Negative	Low	Low	G
A-OB12.	Bore	Negative	Low	Low	G

The ecological value and risk value assessment undertaken for the Project was based on current data collected over two years. This period of survey is a snapshot of the current condition of the subterranean environments. The overall value and risk assessment were conducted by focusing on the stygofauna within the shallow aquifer of the Study Area as a whole in order to place the sites into a landscape perspective and to demonstrate the condition and ecosystem function performed by these aquifers.

The ecological value of the subterranean ecosystem for the bores that recorded a positive value is given as low due to the low numbers of taxa and specimens collected. The ecological value for the terrestrial ecosystem is also given as low due the reliance of the river water to sustain the limited riparian zone although this is based on the understanding that the river is a losing system i.e. that supplies water to the aquifer. The groundwater of the alluvial plain is generally too deep for access by the very limited and predominantly introduced species of terrestrial vegetation and too salty to sustain either aquatic or terrestrial GDE's.

The Risk value of the possible mining activities for the sites that recorded stygofauna is low to minimal as the mine is unlikely to alter the direction of flow of the shallow groundwater as it is moving from the river into the alluvium. This mitigates the impacts to water chemistry, water level changes. As the stygofauna is indicated to be associated with the river channel section of the alluvium and not the broader floodplain, there is little likelihood that the population will be impacted by the mine.

The results of this assessment demonstrated that currently the alluvial aquifer, in general, is in good condition close to the river in regard to water levels, water quality, as well as supporting a range of GDE types. The aquifer of the flood plain however has no stygofauna, very limited terrestrial vegetation (what is present is predominantly introduced), high EC. Therefore, the alluvial aquifer water source is therefore of low ecological value to subterranean ecosystems.

Those bores that did not contain fauna are assessed as also having low ecological value. The reason for the fauna absence is most likely to involve the substrate porosity that precluded the migration of fauna. The Study Area recorded an overall low risk value for the ecological risk assessment for those sites that recorded stygofauna, as there was a low potential for impact from the proposed coal development as a result of the modelled drawdown levels as well as the potential for aquifer contamination via inter-aquifer connectivity. This risk value also recognizes that the stygofauna populations were likely to be tolerant to changes in water chemistry.

In summary, in terms of the stygofauna community across the Study Area, the following points are noted:

- The existence of stygofauna within the aquifers was recorded in limited locations associated with the river channel;
- A low diversity of subterranean ecosystems and low diversity of groundwater dependent fauna exists in the shallow, unconfined alluvial aquifers of the Dawson River Alluvium close to the river but not into the floodplain *per se*.
- None of these species are currently **listed** as endemic, relictual, rare, or endangered biota (fauna or flora) populations or communities as listed under the TSC Act, FM Act or the Commonwealth EPBC Act. They do however have a very high potential to be short range endemic, relictual and rare species.
- The ecological value of the alluvial groundwater is considered low due the restricted nature of the habitat and the low number of disturbance tolerant taxa collected;
- The presence of the same or similar species in all the borers indicate a direct connectivity between the shallow alluvial aquifers and the Dawson River.
- The risk of the proposed development to these subterranean ecosystems was rated as low based on the modelled drawdown and the proposed water quality changes to Dawson River as the flow path of the shallow alluvium is suggested to be from the river into the alluvial floodplain as indicated by the water chemistry, water levels and locality of the stygofauna.

- ❑ There was insufficient long-term data to determine whether past land use practices have impacted aquifers and associated GDEs. However, as the fauna and water quality were relatively consistent across the Baralaba South Project it is a strong indication that the aquifers were in good condition. As a result, the confidence of the overall risk assessment is moderate to high.

It is also noted that alluvium is not limited to the Project area and would occur along the Dawson River and lower reaches of the creeks at the confluence with the Dawson River. Potential habitat for stygofauna is much more extensive than the alluvium within the area of influence associated with the Project.

5. Conclusions

The low numbers of taxa and specimens collected during the baseline surveys is suggested to be as a result of either a single or combination of factors.

The possible factors include:

- the fine-grained nature of the substrates;
- the elevated electrical conductivity of the distant bores within the floodplain;
- the slow hydraulic conditions of the aquifer.

The fine-grained nature of the sediments within the aquifer is likely to be the limiting factor for the bores that recorded low levels of salinity. This is particularly the case for the bores with a high clay content. The lower porosity within the sediment will limit both water movement and fauna dispersal capabilities within the aquifer.

The relative consistency of the faunal composition across the bores sampled suggests that the subterranean community diversity is naturally low with the high potential for biodiversity hotspots that may be comparable with other regions in Qld. The fauna composition indicates a consistent shallow groundwater system which is directly connected to the river system.

The low porosity of the aquifer substrate appears to be one of the significant factors in determining the fauna composition of the bores close to the river as well as the absence of fauna from the more distant bores. The low porosity in the clays and finer alluvial sediment prohibits movement within the substrate. In addition, the high electrical conductivity within the floodplain alluvial aquifer will also be detrimental to stygofauna as it has been demonstrated in previous studies in Australia and overseas that stygofauna have a low tolerance for electrical conductivities exceeding 1000µS/cm.

The baseline sampling and assessment of the groundwater ecosystems within the Study Area has demonstrated that:

- ❑ Stygofauna were present within the alluvial aquifer associated with the river channel adjacent to the Baralaba South Project but were absent from the floodplain;
- ❑ The biodiversity of the stygofauna community within the Baralaba South Project is low with some taxa having a possibly high degree of endemism.
- ❑ There is an apparent connectivity between aquifers and the associated watercourses;
- ❑ The ecological value of the fauna community GDE is classed as low; and
- ❑ The ecological risk from the Baralaba South Project development is classed as low.

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