Vulcan South Project

Stygofauna Pilot Study

Prepared for:

Vitrinite Pty Ltd

frc environmental

PO Box 2363, Wellington Point QLD 4160
Telephone: + 61 3286 3850

Facsimile: + 61 3821 7936

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Summary

frc environmental was commissioned by METServe Pty. Ltd. on behalf of Vitrinite Pty. Ltd., owner of Qld Coal Aust No.1 Pty. Ltd. and Queensland Coking Coal Pty. Ltd. (Vitrinite), to assess the potential impacts to stygofaunal values within and surrounding the proposed Vulcan South Project (the Project), to support the Project mining lease and environmental application approvals processes. The assessment comprised a stygofauna pilot study in accordance with the Queensland *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna*.

The scope of this study was to:

- describe the stygofaunal values of the Broader Study Area,
- assess the potential adverse Project impacts on the stygofaunal values, and
- present mitigating measures for avoiding or reducing significant potential Project impacts on stygofaunal values.

Overall, the stygofauna community of the Project Area was assessed as having *low* environmental value based on:

- absence of any listed stygofauna taxon
- absence of any stygobitic (i.e. obligate groundwater dependent) taxon
- the occurrence of only a single, widely distributed *stygoxene* (i.e. not groundwater dependent) taxon
- the depth to water table in the Project Area is deeper than the typical depth from which stygofauna have been reported in Queensland (i.e. <15 m), and
- the concentration of total dissolved solids and electrical conductivity of groundwater in the Broader Study Area commonly higher than the range reported for groundwater from which stygofauna are typically found.

The following sources of potential Project impact on stygofauna were identified:

- vegetation clearing
- contamination of groundwater
- physical disturbance of groundwater ecosystems by:
  - removal of topsoil and overburden from development areas
  - open cut coal mining
  - drawdown of water tables
  - compaction of shallow aquifers below haul roads, and
  - cumulative impacts of the Project interacting with other nearby existing and proposed mines.

However, a risk-based assessment determined that the mitigated risk of impact was *low* for each of these potential sources of impact.

1 Introduction

frc environmental was commissioned by Vitrinite to assess the potential impacts to stygofaunal values within and surrounding the Project, to support the Project mining lease and environmental application approvals processes. The assessment comprised a stygofauna pilot study in accordance with the Queensland *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DoSITIA 2015).

The scope of this study was to:

- describe the stygofaunal values of the Broader Study Area,
- assess the potential adverse Project impacts on the stygofaunal values, and
- present mitigating measures for avoiding or reducing significant potential Project impacts on stygofaunal values.

This report presents:

- an overview of stygofauna,
- the survey methods and results of the pilot study,
- an assessment of the stygofaunal values of the Broader Study Area, and
- an assessment of the significance of potential Project impacts on the stygofaunal values, noting mitigating measures for avoiding or reducing impacts.

As part of project planning and feasibility assessment, Vitrinite has completed environmental assessments of a considerably larger study area than the proposed Project mining lease application (MLA). Baseline data has been collected within this larger study area and has been used in the assessment of the Project, for context as required. Subject to further project planning, Vitrinite may, in future, utilise this baseline information to assess the potential impacts of additional project development opportunities with the study area.

Consequently, in this report:

- ‘Project Area’ is the proposed Project MLA area (refer to Map 2.1 and
- ‘Broader Study Area’ encompasses the Project Area and surrounding environs (refer to Map 4.1).

2 Project Description

Vitrinite have proposed the Vulcan South Project, located north of Dysart and approximately 35 kilometres (km) south of Moranbah in Queensland's Bowen Basin (Map 2.1). The Project lies to the immediate west of several established mining operations including BHP's Peak Downs and Saraji mines.

The Project is located immediately to the south of Vitrinite's initial mining Project, the Vulcan Coal Mine (VCM), located on ML700060. The proposed Project MLA area abuts ML700060; however, proposed activities will be implemented separately.

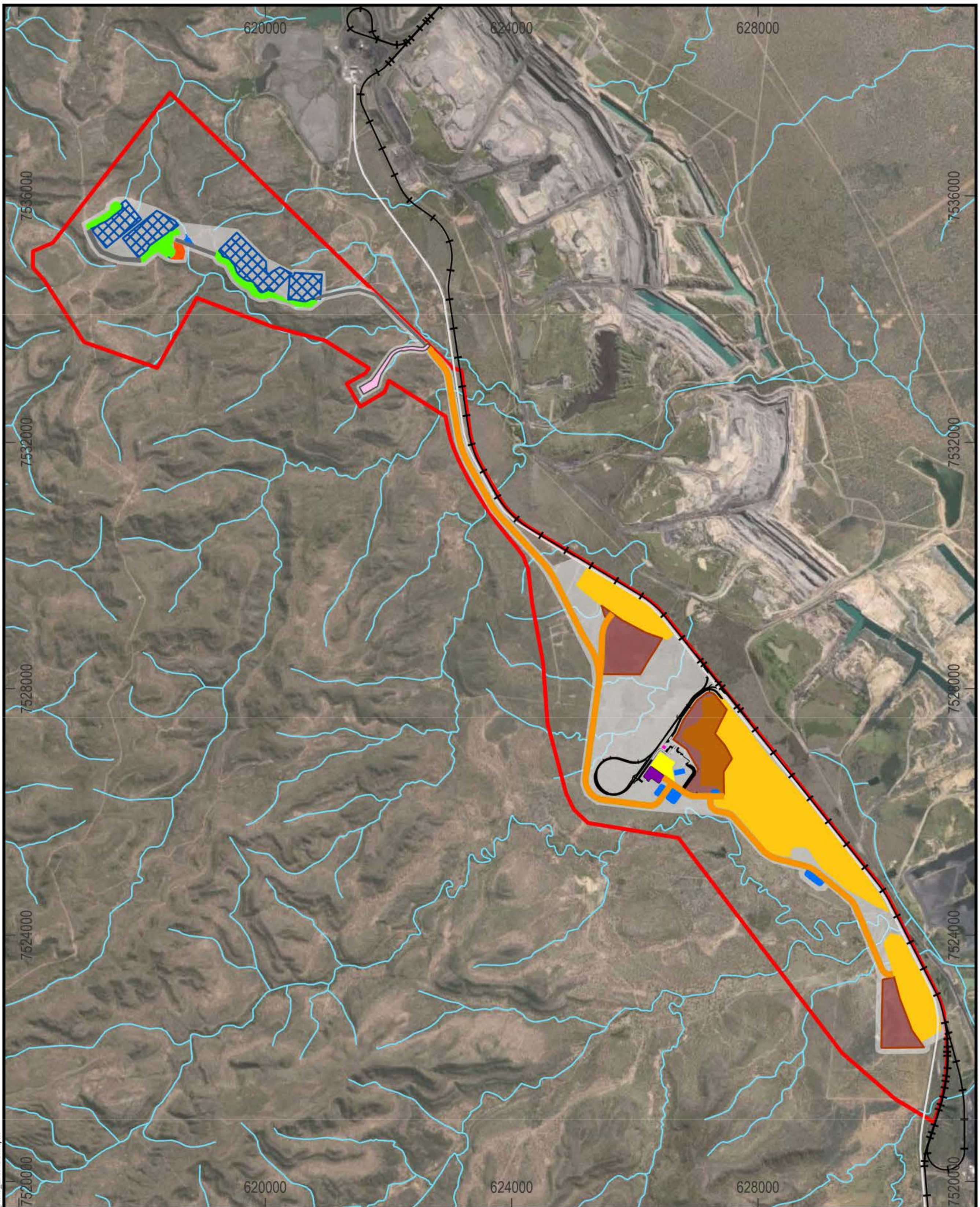
The Vulcan hard coking coal target has been defined and selected for open cut development via three separate open cut pits that form the primary mining focus of the Project. The Project will operate for approximately nine years, including primary rehabilitation works, following a two-year construction period and will extract approximately 13.5 Mt of run of mine (ROM) coal consisting predominately of hard coking coal with an incidental thermal secondary product at a rate of up to 1.95 Mtpa. The Project will target the Alex and multiple Dysart Lower coal seams. Truck and shovel mining operations will be employed to develop the pits. A mine infrastructure area (MIA) will be established along with a modular coal handling and preparation plant (CHPP), rail loop and train load-out facility (TLO) at a location between the northern and central pits. The CHPP will include solid bowl centrifuges to maximise water recycling and to produce a dry tailings waste product for permanent storage within active waste rock dumps.

Out-of-pit waste rock dumps will be established prior to commencing in-pit dumping activities that will continue for the life of the operation. Ancillary infrastructure, including a Run of Mine (ROM) pad, offices, roads and surface water management infrastructure will be established to support the operation.

A realignment of the existing Saraji Road and services infrastructure to the eastern boundary of the proposed MLA area, adjacent to the existing rail easement, is also proposed in several locations. The re-alignment will occur within the MLA area.

In-pit dumping will fill most of the pit volumes during operations with the remaining final voids to be backfilled upon cessation of mining, resulting in the establishment of low waste rock dump landforms over the former pit areas. Following backfill of the final voids, the remaining material stored in the initial out-of-pit waste rock dumps will be rehabilitated in-situ.

The Project includes a small-scale highwall mining trial program in the north of the MLA. The trial will involve the establishment of four highwall mining benches across several hillsides to facilitate extraction of coal utilising a CAT HW300 highwall miner. The highwall mining trial will target up to 750 kt of coal which will be transported by truck to the Project CHPP via a dedicated haul road within the MLA area. The trial is scheduled to be completed within the first year of mining operations.



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Legend

- Railway
- Saraji Road
- Mine Access Road
- Rail Loop and Mine Roads
- Drainage Lines
- Highwall Mining Haul Road
- CHPP
- Magazine
- MIA
- Dams
- Office
- Haul Road and Drainage Infrastructure
- Ex-pit Dump
- In-pit Dump
- Highwall Mining Bench
- Highwall Rock Dump
- Highwall Plunge
- Vulcan South Maximum Disturbance Footprint
- MLA Boundary

Source: State of Queensland (Department of Resources) 2021, Vitrinite 2020-2022, METServe 2022, Earthstar Geographics.

Vulcan South Project

Proposed Project Layout

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Kilometers

Scale: 1:90,000 (A4)

11/02/2022

Datum: GDA94
Projection: MGA55

Map 2.1

VITRINITE BRIGHTER COAL

METSERVE Mining & Energy Technical Services Pty Ltd

3 Overview of Stygofauna

3.1 Description

Stygofauna are subterranean aquatic animals that live in the pores, voids and cavities of aquifers and other groundwater ecosystems. Many species of stygofauna have specialised adaptations to underground life, including:

- small body size (e.g. many species have a total body length <1 mm)
- lack of pigmentation
- absence of eyes, and
- elongated appendages (for tactile sensing of the surrounding environment).

Crustaceans, including copepods, amphipods, isopods and syncarids, typically dominate the composition of stygofaunal communities, although oligochaetes, molluscs, mites, insects and rotifers are also common. Blind fish and eels are also known from some cave systems, such as those in Western Australia.

Stygofauna taxa are grouped into one of several classes based on the degree of their requirement for subterranean life (Tomlinson & Boulton 2008). For the purpose of this assessment, two classes of stygofauna are considered:

- stygobites: obligate groundwater aquatic fauna that have specialised adaptations to underground life and that live within groundwater systems for their entire life, and
- stygoxenes: aquatic fauna that facultatively use groundwater ecosystems but are not dependent on groundwater to complete their life cycle.

3.2 Status under Commonwealth and State Legislation

At the Commonwealth level, only the Cape Range Remiped (*Kumonga exleyi*) in Western Australia is listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). At the state level, the presence of stygofauna (especially stygobitic taxa), indicate groundwater ecosystems where protection of the aquatic ecosystems EVs, as defined in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (WWB)), is mandated in the legislative framework set out under the *Environmental Protection Act 1994* (EP Act).

3.3 Distribution

Stygofauna communities are widely distributed across Australia (Tomlinson & Boulton 2008), and have been found in temperate, sub-tropical and tropical regions of eastern Australia (Hancock & Boulton 2008; Cook et al. 2012). At the family level, stygofauna are widespread and many families that include stygofaunal species also include surface water and marine species (e.g. copepods, rotifers and mites).

However, at the species level many taxa have a narrow distributional range (i.e. stygofauna communities contain species that occur exclusively within a small area), and thus stygofauna communities are generally thought to have high endemism (Boulton et al. 2010; Harvey et al. 2011). For example, 23% of the stygofauna species that were sampled on two or more occasions in a long-term study of stygofauna in the Pilbara region were sampled from within the same sub-region, and the median area of distribution of these stygofaunal species was 683 km^2 (Halse et al. 2014), with almost all stygofaunal species having distributions of less than 1,000 km^2 (Eberhard et al. 2009). A species of Parabathynellidae was recorded from three bores in the Burdekin River Alluvial Aquifer in Queensland, with two of these bores located approximately 20 km apart (Cook et al. 2012), suggesting a potential distribution of approximately 400 km^2. Additionally, studies in both Western Australia and Queensland have found evidence that sub-catchment boundaries can demarcate locations of turn-over of stygofaunal species (Finston et al. 2007; Little et al. 2016). Therefore, areas of approximately 400 – 600 km^2 within a single sub-catchment may represent reasonable estimates of distribution of most stygofaunal species, acknowledging that site-specific factors (e.g. highly confined aquifers) may impose further restrictions on distribution in some cases, or create strong population subdivision within species on smaller spatial scales (Cook et al. 2012; Little et al. 2016).

3.4 Ecology and Habitat

Stygofauna are thought to provide important ecosystem services relating to the maintenance of hydrological connectivity and groundwater quality by consuming the microbial communities that form biofilms on the substrate matrix of the aquifer (Boulton et al. 2008; Hancock & Boulton 2008). Therefore, despite the short length of food webs in groundwater ecosystems (i.e. biofilm ⇒ stygofauna), stygofauna occupy a critical trophic position in these food webs that likely sustains the health of groundwater ecosystems.

The suitability of a groundwater ecosystem to provide habitat for stygofauna is dependent on several environmental factors, including:

- geology
- groundwater hydrology, and
- groundwater quality.

For example, stygofauna are generally thought to prefer shallow aquifers with high secondary porosity in groundwater recharge areas, with groundwater of high quality (specifically neutral pH and low electrical conductivity) intersecting the root zone of terrestrial vegetation[1] (Eamus et al. 2006; Tomlinson & Boulton 2008; Schulz et al. 2013). While there are clear associations between stygofauna diversity and generalised assumptions of stygofauna habitat suitability, there are also notable exceptions that demonstrate that almost any groundwater ecosystem has the potential to provide habitat for stygofauna (Glanville et al. 2016). For example, in Queensland stygofauna have been found in areas of natural vegetation, intensively cultivated vegetation (e.g. sugar cane) and in heavily cleared (or very sparsely vegetated) areas (Hancock & Boulton 2008; Cook et al. 2012; GHD 2013); indicating that water tables that intersect the root zone of terrestrial vegetation are not an essential habitat characteristic of aquifers containing stygofauna.

Further discussion of the geological, hydrological and water quality characteristics of groundwater ecosystems that generally provide suitable habitat for stygofauna is presented below.

[1] < 8m below ground is considered likely that the water table intersects root zone of terrestrial vegetation; < 20 m below ground is considered possible that the water table intersects the root zone of terrestrial vegetation; > 20m below ground is considered unlikely that the water table intersects the root zone of terrestrial vegetation (Eamus et al. 2006).

3.4.1 Geology

Stygofauna have the potential to occur in aquifers composed of any geological unit with sufficient pore space to complete their life cycle (Tomlinson & Boulton 2008). Consequently, stygofauna are less likely in geological units with relatively small pore spaces, such as those dominated by mudstone, siltstone and clays. Preliminary discovery rates of stygofauna in Queensland indicate that (Glanville et al. 2016):

- no stygofauna have been recorded in mudstone and siltstone to date
- stygofauna are less common in clay, coal and basalt dominated lithologies, and
- stygofauna are most common in alluvium, granite, gravel, sand, sandstone, silt, and volcanic geological units.

The diversity of stygofauna in Queensland is highest in alluvium, with 14 described families in alluvial geological units; five in both basalt and coal; four in both gravel and sand; two in sandstone; and one in silt (Glanville et al. 2016). Limestone reportedly has diverse stygofauna communities (Tomlinson & Boulton 2008), with preliminary data indicating the presence of stygofauna in limestone geological units in Queensland (EPA 2006).

3.4.2 Groundwater Hydrology

Geological units with large pore spaces also provide for hydrological connectivity through groundwater ecosystems, which influences how quickly organic matter and oxygenated water are replenished and may also determine the extent to which stygofauna can move through groundwater ecosystems. In alluvial aquifers in eastern Australia the average number of stygofauna taxa was higher within 6 m from the water table level, and where the water table level was less than approximately 15 m below the ground (Hancock & Boulton 2008). Other studies have shown similar results, with a statistically lower diversity of stygofauna in deeper aquifers than shallow aquifers (Halse et al. 2014). However, in Queensland, stygofauna have been recorded from over 60 m below ground (Glanville et al. 2016), indicating that deep groundwater ecosystems can also support stygofaunal communities.

The general trend of higher diversity of stygofauna in shallow aquifers is speculated to be because most shallow groundwater systems have higher concentrations of organic matter and oxygenated water than deeper groundwater, as a virtue of proximity to the surface. Proximity to groundwater recharge areas may also represent a favourable habitat characteristic for stygofauna, due to greater organic matter availability and concentration of dissolved oxygen in water. In aquifers with poor to very poor recharge, stygofauna abundance is low, and is typically higher in aquifers with good to very good recharge (Schulz et al. 2013). Thus, alluvial aquifers close to watercourses that function as groundwater recharge zones often have high abundance and diversity of stygofauna (Hancock & Boulton 2008).

3.4.3 Groundwater Quality

While the mean electrical conductivity of water from which stygofauna have been sampled is less than 4,000 µS/cm, they have been recorded from a broad range of electrical conductivities (11.5 – 54,800 µS/cm) (Glanville et al. 2016). Tolerance to high electrical conductivity is likely to vary among taxa, with only crustaceans (i.e. copepods and syncarids) reported from the upper end of this range (Glanville et al. 2016). Crustaceans found in surface water habitats commonly have a higher salinity tolerance than other taxa (e.g. insects, mites, gastropods) (Dunlop et al. 2008); thus, crustacean taxa may be more likely to occur in groundwater with high electrical conductivity than other stygofaunal taxa.

The minimum concentration of dissolved oxygen needed to support stygofauna communities is unknown. Some taxonomic groups are likely to be tolerant of relatively low dissolved oxygen, and others requiring higher dissolved oxygen concentrations (Halse et al. 2014). However, bores with the highest diversity of stygofauna had dissolved oxygen levels ranging from approximately 20 to 60% saturation (Halse et al. 2014).

Stygofauna have been recorded from groundwater with pH ranging from 3.5 to 10.3, with diversity highest when pH is between 6.5 and 7.5 (average of 7.0) (Hancock & Boulton 2008). Total dissolved solids (TDS) may influence the diversity of stygofauna, with stygofauna in Western Australia almost always absent where TDS is higher than 15 mg/L (Halse et al. 2014), although syncarids in Queensland have been reported from groundwater systems where TDS was 1090 mg/L (frc environmental, unpublished data). However, as the concentration of TDS is approximately electrical conductivity x 0.68, stygofauna in Queensland would likely tolerate TDS concentrations of approximately 2,720 mg/L (i.e. 4,000 µs/cm x 0.68). Other water quality parameters, such as ionic composition, may also influence the diversity and taxonomic composition of stygofauna (Halse et al. 2014).

3.5 Threats to Stygofauna

Stygofauna are threatened by activities that impact:

- the quantity of groundwater (i.e. reduced groundwater level and pressure via groundwater extraction or aquifer dewatering). Reduced water levels reduce the amount of habitat available for stygofauna. Reduced groundwater pressure reduces the rate of groundwater flow, which may in turn reduce the recharge of oxygen-rich water or water with high organic matter concentrations (which supports groundwater food webs).
- the quality of groundwater (e.g. contamination from above ground sources, including nutrient enrichment and spills of pesticides and hydrocarbons). Impacts may be lethal (i.e. mortality of stygofauna) or sub-lethal (i.e. reduced rate of reproduction, impacted physiology).
- patterns of recharge and discharge from groundwater ecosystems, such as a reduction in flow in a watercourse that provides recharge to the underlying aquifer. This may reduce the recharge of oxygen-rich water or water with high organic matter concentrations (which supports groundwater food webs), and may result in lowering of the water table, which reduces habitat availability.
- permeability and void spaces of the aquifer matrix (e.g. compaction of soil by heavy machinery), which reduces habitat quality and habitat availability.
- physical habitat of the aquifer (e.g. excavation of mine pits), which reduces the available habitat for stygofauna.

4 Assessment of Stygofauna Habitat Suitability, Community Composition and Environmental Values

4.1 Assessment Methods

Stygofauna were assessed using a 'desktop review' and 'field survey', as described for stygofauna pilot studies in the *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DoSITIA 2015); see also DES (2018).

4.1.1 Desktop Review

A desktop review was undertaken to determine the suitability of groundwater ecosystems within the Broader Study Area to provide habitat for stygofauna based on geological, hydrological and water quality characteristics. This included:

- review of previous studies to determine the recorded presence and distribution of stygofauna in the region
- review of hydrogeological data for the Broader Study Area, and
- review of groundwater pH, electrical conductivity and TDS data within the Broader Study Area.

4.1.2 Field Survey

Six bores were surveyed for stygofauna on 04 December 2019 (Table 4.1; Map 4.1), with all other bores in the Broader Study Area dry at the time of survey. In March 2020 ten bores were sampled for stygofauna across the Broader Study Area.

The full water column in each bore was sampled using six hauls of a weighted phreatobiological net (like a plankton net). Three of the hauls were with a very fine net (mesh size 50 µm), and three hauls were with a fine net (mesh size 150 µm). Samples were preserved in 100% ethanol and transported to frc environmental's laboratory where stygofaunal specimens were identified to Order or Family using available taxonomic keys. Each specimen was then identified to morpho-species as taxonomic keys are not available for species-level identification of stygofauna. All laboratory analyses were completed by trained and experienced aquatic ecologists.

Table 4.1 Bores sampled for stygofauna.

Bore	Easting	Northing	Survey dates	Geological unit	Drilled depth (m)
V-MB4	622016	7536148	Dec-19; Mar-20	DLL coal seam	21.5
V-MB5	621965	7534904	Dec-19; Mar-20	MAT coal seam	40.9
V-MB7	628692	7526260	Dec-19; Mar-20	Weathered Permian	43.0
V-MB9	629511	7525225	Dec-19; Mar-20	DLL coal seam	34.4
V-MB10	628125	7526470	Dec-19; Mar-20	DLL coal seam	40.3
V-MB12	625252	7526409	Dec-19; Mar-20	Permian underburden	38.2
V-MB1	625608	7529692	Mar-20	DLL coal seam	24.9
V-MB2	622515	7534485	Mar-20	DLL coal seam	12.0
V-MB3	622665	7535021	Mar-20	DLL coal seam	33.8
V-MB6	628121	7526477	Mar-20	Weathered Permian	24.6

4.1.3 Assessment of Environmental Value

The environmental values of stygofauna of the Broader Study Area were determined using the following criteria:

- high value: threatened species listed under State or National legislation
- moderate value: non-listed stygobites and / or *suitable*[2] habitat for stygofauna present (as defined in Section 3.0), and
- low value: only non-listed stygoxenes and / or *potentially suitable*[3] habitat for stygofauna present (as defined in Section 3.0).

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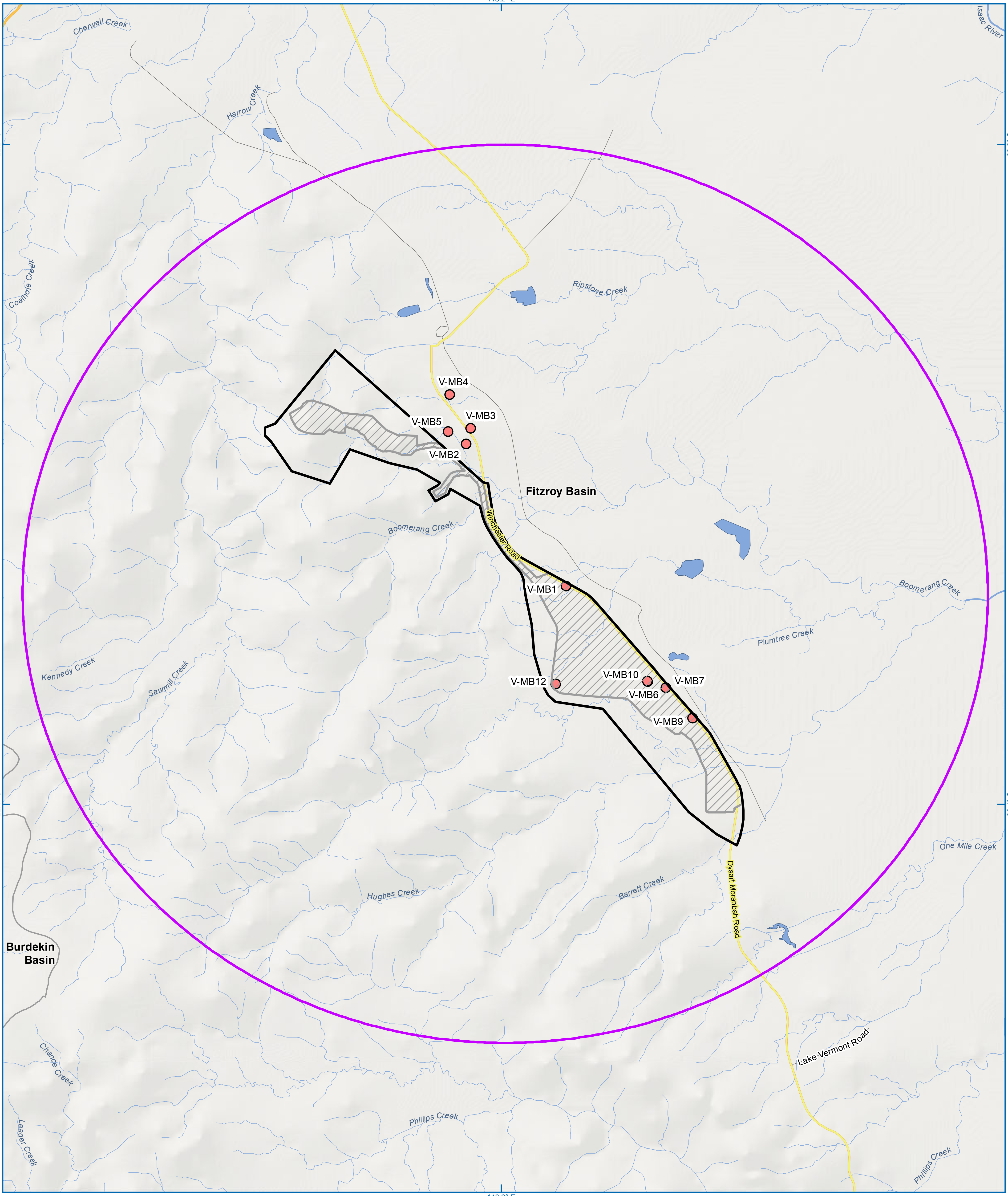
2 suitable habitat means geological, hydrological and water quality characteristics of groundwater ecosystems that are generally known to support high diversity of stygofauna, as described in Section 2.4.

3 potentially suitable habitat means geological, hydrological and / or water quality characteristics of groundwater ecosystems that are outside the general habitat characteristics known to support diverse stygofauna communities, but within the range from which stygofauna have been recorded.



Vulcan South Project: Stygofauna Pilot Study

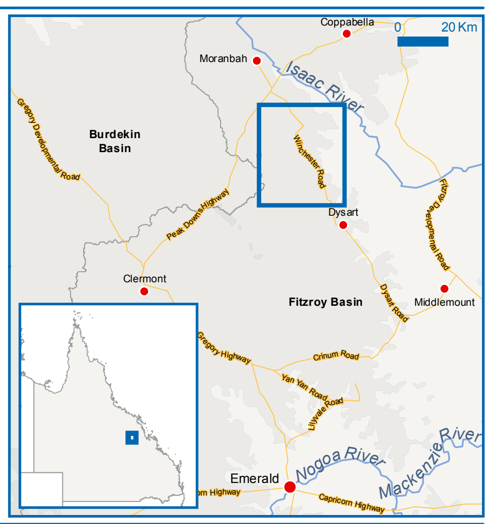
Map 4.1
Bores sampled for stygofauna

LEGEND

- Broader Study Area
- Bores
- Mining Lease Application Boundary
- Conservative Disturbance Footprint

Road Network

- Highway
- Main Road
- Local Road
- Lake/Reservoir
- Watercourse



frc environmental
AQUATIC ECOLOGISTS
deep thinking. science.

PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
www.frcenv.com.au

SOURCES

DATE	DRAWN BY	VERSION	PROJECTION
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4.2 Results of Desktop Assessment

4.2.1 Stygofauna of the Region

The diversity and biogeography of stygofauna in Queensland have been synthesised by Glanville et al. (2016), with key findings being:

- A total of 24 described families and 23 described genera have been recorded from Queensland across numerous bioregional areas. The Broader Study Area is located near the boundary of the Isaac-Comet Downs and Northern Bowen Basin sub-bioregions, with five described families from eight samples reported from the Isaac-Comet Downs subregion, and five families from six samples reported from the Northern Bowen Basin subregion.
- Syncarid shrimps (families Parabathynellidae and Bathynellidae) are the two most widespread families in Queensland, followed by Cyclopidae (copepods) and Naididae (clitellate oligochaete worms). All these taxa are reported from a wide range of lithology types, including alluvium, gravel, sand, sandstone and fractured basalt.
- Of all described stygofauna families recorded from Queensland to date, 36% are crustaceans, with the taxonomic richness of syncarid crustaceans higher in Queensland than the global average, but the richness of amphipods in Queensland lower than the global average.

4.2.2 Geology

The geology of the Broader Study Area comprises Tertiary weathered sediments at surface that overlie Permian Coal Measures that are composed of sandstone, siltstone, mudstone and coal seam (Hydrogeologist.com.au 2019).

The geology of the Broader Study Area includes units that are known to provide habitat for stygofauna, as well as units from which stygofauna have not been reported, e.g. mudstone (Glanville et al. 2016). On the basis of those units that are known to provide habitat for stygofauna, the geology of the Broader Study Area is considered to be *suitable* for providing habitat for stygofauna.

4.2.3 Hydrology

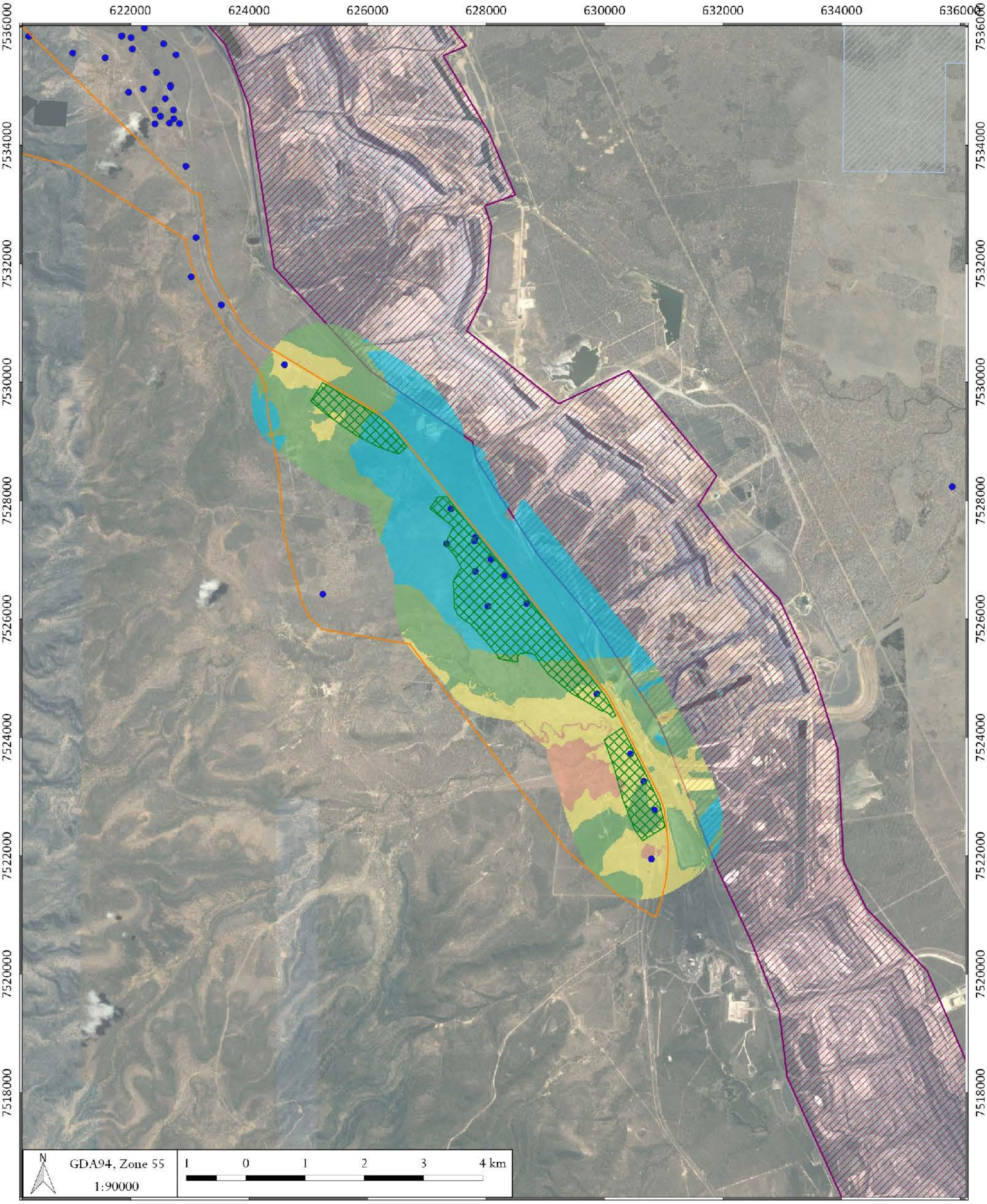
In eastern Australia the average number of stygofauna taxa was higher when the samples were collected where the water table was less than approximately 15 m below ground (Glanville et al. 2016). The depth to water table is > 15 m below ground at most bores (i.e. all bores except bores V-MB4 and V-MB5) (Table 4.2). Hydrogeological studies completed for the Project indicate that depth to the groundwater table is <5 m along Hughes Creek, moderate in the southern and northern ends of the Project Area, and relatively deep (>10 to >20 m) for the central part of the Project Area (Map 4.2). Therefore, the shallow groundwater ecosystems of the Project Area have *potentially suitable* hydrological characteristics to provide habitat for stygofauna.

4.2.4 Water Quality

The mean electrical conductivity of water from which stygofauna have been sampled, generally, is less than 4,000 µS/cm; however, the range of electrical conductivity concentrations of groundwater that stygofauna have been sampled from is very large (11.5 – 54,800 µS/cm) (Glanville et al. 2016). Electrical conductivity recorded from bores in the Broader Study Area ranged from 2,280– 21,600 µS/cm (Table 4.2) and was therefore consistent with the preferred range of electrical conductivity for stygofauna at only two bores (i.e. bores V-MB4 and V-MB5). Therefore, the electrical conductivity of groundwater of the Project Area is generally *unsuitable* for stygofauna.

Stygofauna have been recorded from groundwater with pH ranging from 3.5 to 10.3, but diversity is highest between 6.5 and 7.5 (mean of 7.0) (Hancock & Boulton 2008). The pH of groundwater from the Broader Study Area ranged from 7.81 – 8.31, and typically aligned with the range known to support diverse stygofaunal communities (Table 4.2). The pH of groundwater of the Project Area is *suitable* for stygofauna.

In Western Australia, stygofauna were almost always absent where TDS was higher than 15 mg/L (Halse et al. 2014); however, a recent study in Queensland found stygofauna where TDS was 1090 mg/L (frc environmental unpublished data). However, as the concentration of TDS is approximately electrical conductivity x 0.68, stygofauna in Queensland would likely tolerate TDS concentrations of approximately 2,720 mg/L (i.e. 4,000 µs/cm x 0.68). TDS of groundwater from the Broader Study Area ranged from 1,480 – 14,000 (Table 4.2), indicating that TDS of the Broader Study Area is generally *unsuitable* for stygofauna.



LEGEND

Depth to groundwater (m)

- < = 0
- 0 - 5
- 5 - 10
- 10 - 20
- 20 - 50

- Groundwater elevation data point
- Proposed pit
- Highwall mining area

Mining lease application area

- Established mining operation

DATE
29/06/2020

hydrogeologist.com.au

Vulcan South Project - Groundwater Impact Assessment

Depth to groundwater

Map 4.2

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.

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Table 4.2 Environmental characteristics of bores from the Broader Study Area.

Bore	Drilled depth (m)	Depth to water (m)	Geology	Electrical conductivity (µS/cm)	TDS (mg/L)	pH
V-MB4	21.5	5.83	DLL coal seam	2,280	1,480	7.94
V-MB5	40.9	14.53	MAT coal seam	2,680	1,740	8.17
V-MB7	43.0	34.80	Weathered Permian	5,430	3,530	8.31
V-MB9	34.4	27.41	DLL coal seam	16,200	10,500	7.95
V-MB10	40.3	32.51	DLL coal seam	–	–	–
V-MB12	38.2	26.82	Permian underburden	21,600	14,000	7.81
V-MB1	24.9	–	DLL coal seam	–	–	–
V-MB2	12.0	–	DLL coal seam	–	–	–
V-MB3	33.8	>30	DLL coal seam	–	–	–
V-MB6	24.6	–	Weathered Permian	–	–	–

Source of all data: Hydrogeologist.com.au (2019) – laboratory water quality results shown here

– no data

4.3 Results of the Field Surveys

Of the six bores that had groundwater present in December 2019, two bores (i.e. V-MB5 and V-MB12) contained stygofauna (Table 4.3): a single ostracod species. This same taxon was found in the March 2020 survey at two additional bores (i.e. V-MB3 and V-MB7).

This taxon is a stygoxene (i.e. not an obligate inhabitant of groundwater ecosystems; that is, it is not a taxon that is dependent on groundwater). Bores V-BM5, V-MB12, V-MB3 and V-MB7 are widely spaced, indicating this species occurs widely through the Broader Study Area, and likely beyond as ostracods are ubiquitous throughout Australian inland waters.

The geologies targeted by the bores from which this taxon was found were DLL Coal Seams, MAT Coal seams, Weather Permian and Permian Underburden, indicating that this taxon does not have specific habitat requirements with respect to geological units.

Bore V-MB12, from which the ostracod was found in December 2019, had the highest electrical conductivity and TDS of all the bores of the Broader Study Area with available water quality data, indicating that this taxon is tolerant of the full range of groundwater quality conditions reported throughout the Broader Study Area.

The depth to the water table at the bores from which the ostracod was found ranged from 14.5 m at bore V-MB5 (possibly within the root zone of terrestrial vegetation) to >20 m at bores V-MB12, V.MB3 and V-MB7 (deeper than the likely root zone of terrestrial vegetation; see Eamus et al. (2006). Therefore, the root zone of terrestrial vegetation in the Broader Study Area does not provide key habitat for the ostracod taxon.

The results of this assessment indicate that groundwater in shallow alluvium throughout the Project study area, particularly locally around bores V-MB3, V-MB5, V-MB7 and V-MB12, have EVs, as defined in the EPP (WWB), with protection of these EVs mandated in the legislative framework set out under the EP Act.

Table 4.3 Results of the stygofauna pilot study.

Bore ID	Stygofaunal taxon	Common name	Class	Abundance
December 2019				
V-MB4	–	–	–	–
V-MB5	Ostracod 1	seed shrimp	stygoxene	1
V-MB7	–	–	–	–
V-MB9	–	–	–	–
V-MB10	–	–	–	–
V-MB12	Ostracod 1	seed shrimp	stygoxene	1
March 2020	–	–	–	–
V-MB4	–	–	–	–
V-MB5	–	–	–	–
V-MB7	Ostracod 1	seed shrimp	stygoxene	1
V-MB9	–	–	–	–
V-MB10	–	–	–	–
V-MB12	–	–	–	–
V-MB1	–	–	–	–
V-MB2	–	–	–	–
V-MB3	Ostracod 1	seed shrimp	stygoxene	2
V-MB6	–	–	–	–

– No stygofauna recorded.

4.4 Environmental Values of Stygofauna of the Project Area

The stygofauna community of the Project Area and Broader Study Area was assessed as having *low* environmental value based on:

- absence of any listed stygofauna taxon
- absence of any stygobitic (i.e. obligate groundwater dependent) taxon
- the occurrence of only a single, widely distributed *stygoxene* (i.e. not groundwater dependent) taxon; and
- the concentration of TDS and electrical conductivity of groundwater in the Broader Study Area commonly higher than the range reported for groundwater from which stygofauna are typically found.

5 Impact Assessment and Mitigation

5.1 Potential Sources of Impact to Stygofauna

The following potential sources of impact from the Project on stygofauna were identified:

- vegetation clearing
- localised contamination of groundwater
- physical disturbance of groundwater ecosystems, and
- cumulative impacts of the Project interacting with other nearby existing and proposed mines.

Vegetation Clearing

Terrestrial vegetation overlying shallow groundwater ecosystems, where the water table intersects the root zone of the vegetation, is thought to provide favourable habitat conditions for stygofauna (Eamus et al. 2006; Hancock & Boulton 2008). Clearing of vegetation may therefore reduce the habitat quality of shallow groundwater ecosystems for stygofauna. Potential impacts would be localised to immediate area of clearing.

However, the depth to water table through the Broader Study Area was typically below the root zone of terrestrial vegetation; thus, the water table does not intersect the root zone in the Project Area. Furthermore, most of the bores from which the ostracod taxon was caught have a depth to water table well-below the likely root zone of terrestrial vegetation, indicating that roots of terrestrial vegetation does not provide a key habitat for this taxon.

Contamination of Groundwater

Contamination of groundwater includes leakage of toxicants from fuels, oils and other lubricants required for the operation of vehicles and machinery. Chemicals, fuel and oil are toxic to aquatic flora and fauna at relatively low concentrations. Spilt chemicals, fuel and oils have potential to seep into shallow groundwater ecosystems, where they can impact the condition of the groundwater ecosystem and cause lethal or sub-lethal impacts to stygofauna. Potential impacts would depend on the magnitude of any chemical, fuel or oil spill, but a small chemical, fuel or oil spill from a processing area or vehicle would likely cause impact on a relatively local scale within the potential impact area.

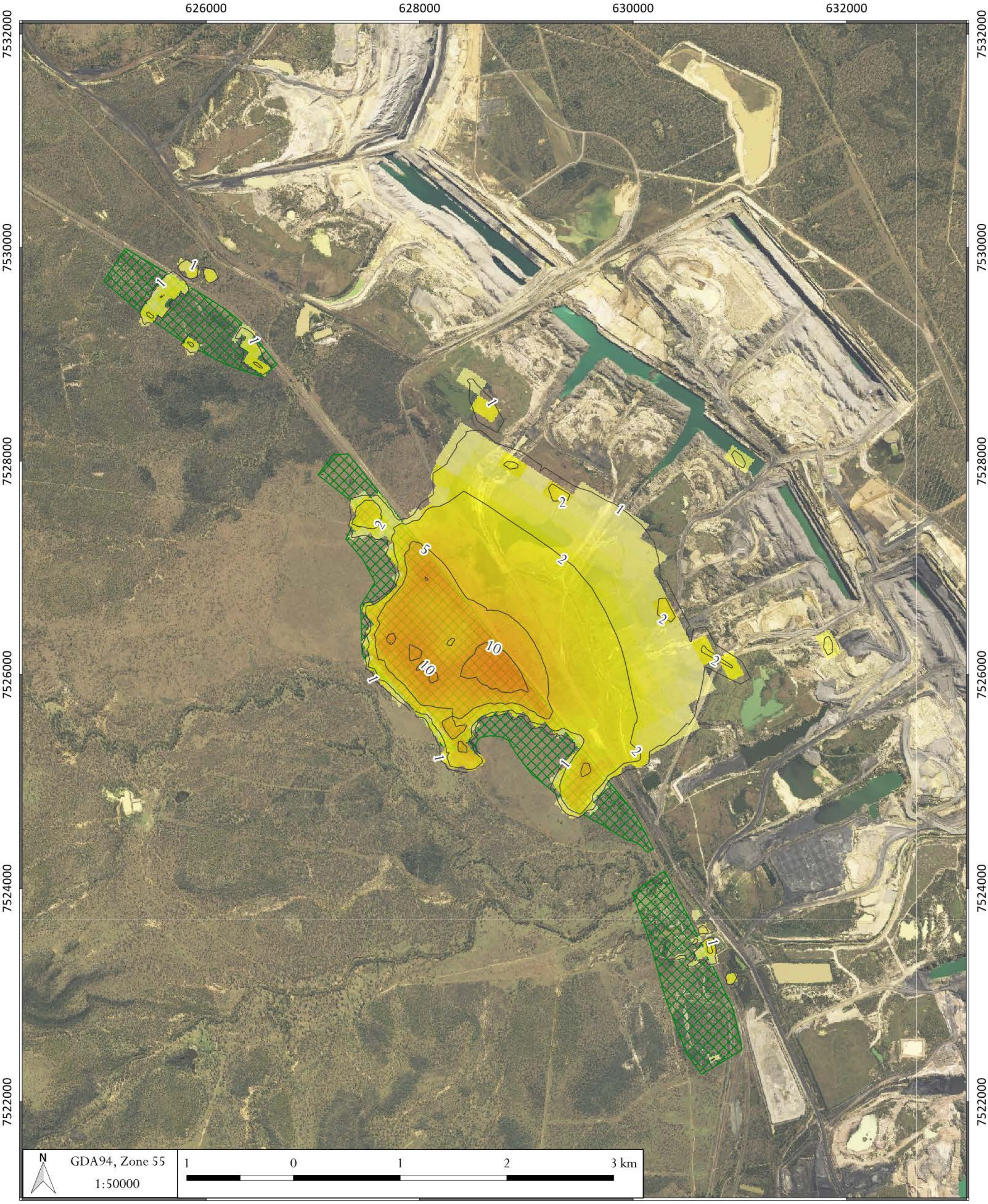
Physical Disturbance of Groundwater Ecosystems

The following mining activities have the potential to impact stygofaunal communities in the Project Area by directly disturbing groundwater ecosystems:

- removal of topsoil and overburden from mining areas and transport corridors
- open cut coal mining
- drawdown of water tables in surface geological units, with small areas of aquifer drawn down in the central part of the Project Area where natural depth to water table is greatest; there is no predicted drawdown of water tables along or near Hughes Creek where the shallowest groundwater systems in the Project Area occur (Map 5.1), and
- road transportation of coal, which may lead to compaction of soil and aquifers and reduce habitat quality of groundwater ecosystems for stygofauna (i.e. compress voids, pores and cavities within the ground matrix where stygofauna live).

Cumulative Impacts

Cumulative impacts of the Project within other nearby mining projects on aquifer draw down was assessed by Hydrogeologist.com.au (2022), with the results of the assessment indicating less than a 1% increase on groundwater drawdown due to the Project compared to the effects of historical mining in the Broader Study Area.



LEGEND

Maximum drawdown (m):
- 1
- 2
- 5
- 10

Proposed pit

DATE
09/06/2020

Vulcan South Project - Groundwater Impact Assessment

Predicted drawdown in Tertiary / weathered zone (L02)

Map 5.1

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.
Z:\4000_Projects\4027_Metserve_Vulcan_GIA\3_GIS\Workspaces\06_07_4027_Stage2_Predicted drawdown in weathered zone.qgz

5.2 Risk-based Impact Assessment

The risk assessment determines the level of risk as an outcome of the consequence and likelihood of the potential impact (Table 5.1 to Table 5.3). The 5 x 3 risk matrix (Table 5.3) gives risk scores ranging between one and 15, with risk being:

- low, when the score is <5
- medium, when the score is >5 but <10, and
- high, when the score is >10.

Table 5.1 Ratings used to assess the likelihood of potential impacts.

Rating	Likelihood of occurrence
Very high (5)	Almost certain to occur frequently
High (4)	Probably would happen sometimes to frequently
Moderate (3)	Could happen sometimes
Low (2)	Remote possibility of occurring or not expected to occur
Very low (1)	Would not happen at all

Table 5.2 Ratings used to assess the consequence of potential impacts.

Rating	Consequence of potential impacts
High	Catastrophic, irreversible or critical long-term environmental harm or loss; significant harm or loss of sensitive components of the environment; significant harm or loss of protected components of the environment, such as protected wetlands or MNES.
Moderate	Significant short-term but reversible harm of the environment; minor environmental harm to sensitive or protected components of the environment, such as protected wetlands or MNES.
Low	Unfavourable impact with no material harm to the environment and no impact on sensitive or protected components of the environment.

Table 5.3 Environmental risk matrix.

		Likelihood				
		Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Consequence	Low (1)	1	2	3	4	5
	Moderate (2)	2	4	6	8	10
	High (3)	3	6	9	12	15

Table 5.4 Risk-based Impact Assessment.

Source of Potential Impact	Mitigations	Consequence of Impact	Likelihood of Impact	Mitigated Risk to stygofauna
Vegetation clearing leading to impacts on stygofauna habitat	Clearing only the area needed for Project operations Revegetating and / or grassing areas as part of rehabilitation	Low (1) Occurrence of impacts to stygofauna habitat considered low. Groundwater systems of the Broader Study Area have low environmental value for stygofauna. Ostracod taxon was found at a depth to water table well-below the root zone of terrestrial vegetation, indicating roots of terrestrial vegetation does not provide a key habitat for this taxon here.	Low (2) Limited vegetation clearing, as most of the area to be developed is already heavily cleared Groundwater tables of the Broader Study Area, and most occurrences of the ostracod, are well below the likely root zone of terrestrial vegetation and the zone of potential impact.	Low (1 x 2 = 2)
Localised contamination of groundwater	All applicable materials will be stored and handled in accordance with the relevant legislative requirements and Australian Standards, including but not limited to the provisions of: AS 3780:2008 – The storage and handling of corrosive substances AS 1940:2017 – The storage and handling of flammable and combustible liquids AS 3833:2007 – Storage and handling of mixed classes of dangerous goods in packaged and intermediate bulk containers Refuelling will be in designated bunded areas or contained within the pit Runoff from workshop areas will be managed in the mine water management system. A spill response protocol will be developed and implemented	Low (1) Groundwater systems of the Broader Study Area have low environmental value for stygofauna	Low (2) Not expected to occur	Low (1 x 2 = 2)
Physical disturbance of groundwater ecosystems leading to impacts on stygofauna	Disturbing only areas needed for Project operations Restricting transportation of coal to specific haul roads Appropriate storage and stockpiling of topsoils to avoid compaction and maintain quality for rehabilitation Implementing water level and quality monitoring across an appropriately designed bore field	Low (1) Groundwater systems of the Broader Study Area have low environmental value for stygofauna No drawdown is predicted along or near Hughes Creek, where the shallowest groundwater systems of the Project Area occur	Moderate (3) Low value of groundwater ecosystems and the adopted mitigations greatly reduce the likelihood of impact to any stygofauna community	Low (1 x 3 = 3)

Source of Potential Impact	Mitigations	Consequence of Impact	Likelihood of Impact	Mitigated Risk to stygofauna
Cumulative drawdown of alluvial and coal seam aquifers	Disturbing only areas needed for Project operations Implementing water level and quality monitoring across an appropriately designed bore field	Low (1) Groundwater systems of the Broader Study Area have low environmental value for stygofauna	Low (2) Very limited (i.e. <1%) cumulative influence on aquifer water levels	Low (1 x 2 = 2)

6 Conclusions

The stygofauna community of the Project Area and Broader Study Area was assessed as having *low* environmental value based on:

- absence of any listed stygofauna taxon
- absence of any stygobitic (i.e. obligate groundwater dependent) taxon
- the occurrence of only a single, widely distributed *stygoxene* (i.e. not groundwater dependent) taxon; and
- the concentration of TDS and electrical conductivity of groundwater in the Broader Study Area commonly higher than the range reported for groundwater from which stygofauna are typically found.

The following sources of potential Project impacts on stygofauna were identified:

- vegetation clearing
- contamination of groundwater
- physical disturbance of groundwater ecosystems by:
  - removal of topsoil and overburden from development areas
  - open cut coal mining
  - drawdown of water tables
  - compaction of shallow aquifers below haul roads, and
  - cumulative impacts of the Project interacting with other nearby existing and proposed mines.

However, a risk-based assessment determined that the mitigated risk of impact was *low* for each of these potential sources of impact.

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