14.0 Aquatic ecology

14.1 Introduction

This chapter provides an assessment of the potential impacts of the Ensham Life of Mine Extension Project (the proposed project, hereafter referred to as 'the Project') on aquatic ecological and stygofaunal values in the Project Site and the receiving environment in and adjacent to the Project Site (study area). The main topics addressed include identification of aquatic ecological and stygofaunal environmental values (EVs), identification of potential impacts on these values, proposed mitigations and the residual risks applicable to each potential impact.

Detailed technical reports are attached in **Appendix D-1** (Aquatic ecology) and **Appendix D-2** (Stygofauna).The supporting Aquatic Ecology and Stygofauna reports in **Appendix D-1** and **Appendix D-2** have been prepared based on an earlier project definition. The project definition presented in this chapter supersedes that definition and does not require any additional changes to the Aquatic Ecology and Stygofauna reports.

Environmental objectives and outcomes

The Project seeks to protect environmental values in the vicinity of the Project Site relating to aquatic ecology and stygofauna which are established under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (Qld) (EPP WWB) pursuant to the *Environmental Protection Act 1994* (Qld) (EP Act). Two aquatic matters of national environmental significance (MNES) species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EBPC Act) are known to occur within the waterways of surrounding the Project. The Project is underground with flaring infrastructure proposed on disturbed land in Zone 2 and Zone 3. Impacts to surface aquatic values are not considered to be significant. Therefore, aquatic ecology is not considered a critical matter in the environmental impact statement (EIS).

The existing Ensham Mine currently manages impacts to aquatic ecology and stygofauna in accordance with Environmental Authority (EA) conditions (Schedule C) under EA EPML00732813 with management measures included in the water management plan.

14.1.1 Scope of assessment

The scope of this chapter is to:

- describe the EVs of the study area relating to aquatic ecology and stygofauna
- identify the potential sources of adverse ecological impact from the Project on the EVs of aquatic ecology and stygofauna
- assess the impact of the Project on aquatic ecology and stygofauna EVs values using risk-based impact assessment and the significant impact criteria.

The scope of this assessment addresses surface water ecology and stygofauna. The assessment of water quality is presented in **Chapter 10** (Surface water resources), the assessment of groundwater is presented in **Chapter 12** (Groundwater) and the assessment of terrestrial ecology in **Chapter 13** (Terrestrial ecology).

14.2 Legislation and policy

14.2.1 Commonwealth legislation

14.2.1.1 Commonwealth Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) provides the legal framework for the protection and management of nationally and internationally threatened flora and fauna (including migratory species), ecological communities, internationally important wetlands, heritage places, the Great Barrier Reef, and Commonwealth marine areas, which are collectively defined as matters of national environmental significance (MNES). Water resources in relation to coal seam gas and large mining projects, and nuclear actions, are also regulated under the EPBC Act.

The EPBC Act provides protection for threatened flora, fauna and ecological communities by:

- identifying and listing of species and ecological communities as threatened
- developing conservation advice and recovery plans for listed species and ecological communities
- developing a register of critical habitat
- recognising key threatening processes
- where appropriate, reducing the impacts of these processes through threat abatement plans and non-statutory threat abatement advices
- requiring approval for certain actions or activities that will, or are likely to, have a significant impact on an MNES or other protected matter.

Thirty-seven threatened species of freshwater fish species, seven threatened freshwater turtle species and 16 species of freshwater invertebrate (i.e. 13 crayfish, two mussels and one stonefly)[1] are listed under the EPBC Act. Of these, two species of turtle were identified in the EPBC Act online search tool as potentially occurring in the study area (see **Appendix D-1** (Aquatic ecology)).

The EPBC Act provides guidance on whether an action (e.g. a proposed development) is likely to have a significant impact on a MNES. Significant Impact Guidelines 1.1 (Department of the Environment (DotE), 2013) provide guidance, in the form of assessment criteria, in relation to significant impacts on threatened species under the EPBC Act.

14.2.1.2 Stygofauna status under Commonwealth Legislation

At the Commonwealth level, the following stygofauna communities are listed:

- the Cape Range Remiped (*Kumonga exleyi*) in Western Australia, which is listed as Vulnerable under the EPBC Act
- stygofauna communities associated with Great Artesian Springs (i.e. the community of native species dependent on natural discharge of groundwater from the Great Artesian Basin), which is listed as Endangered under the EPBC Act.

The study area is not within the Great Artesian Basin, and is outside the known range of the Cape Range Remiped. Therefore, listed species of stygofauna do not occur in the study area.

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[1] EPBC Act list of threatened fauna (https://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=fauna); viewed November 2019.

As stygofauna diversity and distribution is poorly understood compared to surface water fauna, the National Water Quality Management Strategy recommends the appropriate management of groundwater ecosystems to ensure the ongoing protection of stygofaunal communities (Water Quality Australia (WQA), 2018).

14.2.2 State legislation

14.2.2.1 Queensland Environmental Protection Act 1994

The *Environmental Protection Act 1994* (Qld) (EP Act) provides the legislative framework for ecologically sustainable development in Queensland, requiring people, companies and government to take all reasonable and practical steps to protect EVs i.e. avoid harm to the environment. The EP Act provides a range of mechanisms to achieve this objective, including establishing Environmental Protection Policies that present the strategies for protecting EVs.

14.2.2.2 Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP WWB) is a strategy for achieving the object of the EP Act (in relation to water EVs). The EPP WWB:

- identifies high ecological value (HEV) waters
- identifies EV and management goals for water
- provides water quality guidelines and water quality objectives (WQO) to enhance or protect the identified EV
- provides a framework for decision making in relation to Queensland waters
- requires monitoring of, and reporting on, the condition of Queensland waters.

EVs for Queensland waters include the protection of aquatic ecosystems. The components of aquatic ecosystems to be protected are generally specified under the EPP WWB for a given waterway if WQOs have been listed under Schedule 1 of the EPP WWB. For example, the EPP WWB may require existing (i.e. 20th, 50th and 80th percentiles) water quality, habitat, biota (fish and macroinvertebrates, flow and riparian areas) to be protected for HEV waters. For other waters, the EPP WWB generally requires:

- the median concentration of several independent samples to achieve the scheduled WQO for the appropriate water type for physico-chemical water quality parameters
- the 95th percentile concentration of several independent samples to achieve the National WQO for the appropriate water type for toxicant water quality parameters, and
- riparian vegetation to achieve the applicable vegetation code under the *Vegetation Management Act 1999* (Qld) (VM Act).

An assessment of the EVs for water within the framework established by the EPP WWB for water may also include assessment of protected matters relevant to aquatic ecology, such as matters protected under the EPBC Act, but also matters protected under Queensland legislation, including the *Nature Conservation Act 1992* (Qld) (NC Act), *Fisheries Act 1994* (Qld) (Fisheries Act) and VM Act[2].

[2] These and other protected matters also comprise MSES, which are components of Queensland's biodiversity of state interest defined under the State Planning Policy and the *Environmental Offsets Regulation 2014*. MSES comprise certain EVs protected under Queensland Legislation, including the EP Act, NC Act, Fisheries Act and VM Act.

14.2.2.3 Queensland Nature Conservation Act 1992

The NC Act provides for the conservation of Queensland's nature by declaring and managing a protected area network, protecting threatened species (wildlife) and their habitats, regulating the taking of wildlife and co-ordinating nature conservation with Traditional Owners and other land owners. Several freshwater species are protected wildlife under the NC Act.

Protected wildlife listed under the NC Act must be protected from threatening processes, and critical habitat for protected wildlife is required to be protected to the greatest extent possible.

14.2.2.4 Queensland Vegetation Management Act 1999

The VM Act, as updated by the *Vegetation Management and Other Legislation Amendment Act 2018*, regulates the clearing of vegetation to conserve threatened regional ecosystems, protect biodiversity and maintain ecological processes, amongst other purposes.

14.2.2.5 Queensland Fisheries Act 1994

The Fisheries Act provides for the management and protection of fisheries resources, including regulating development that might impact declared fish habitat areas, and fish passage. Several fish species of special interest are listed as 'no take' species under the Fisheries Act, including Australian lungfish.

Fisheries resources, including declared fish habitat areas which are matters of state environmental significance (MSES), contribute to the EVs of waterways and wetlands.

14.2.2.6 Stygofauna status under state legislation

Stygofauna have no conservation listing under Queensland state legislation. The adequate assessment of stygofauna for environmental assessment of resource development projects is a requirement in Queensland under the Guideline for the Environmental Assessment of Subterranean Aquatic Fauna (Department of Science, Information Technology, Innovation and the Arts (DoSITIA), 2015), with this guideline now incorporated in the EPP WWB pursuant to the EP Act.

14.3 Methodology

14.3.1 Surface water ecology

14.3.1.1 Desktop approach

A desktop approach was used to provide a description of the aquatic ecology and aquatic EVs in the study area. This included review of:

- aquatic MNES under the EPBC Act
- aquatic matters protected under Queensland legislation, including:
  - threatened freshwater species under the NC Act
  - features that support fisheries resources (e.g. waterway barrier risk layer), pursuant to the Fisheries Act
  - wetland protection areas as shown on the map of Referable Wetlands under the Environmental Protection Regulation 2008 (Qld) (EP Regulation)
  - HEV waters as defined under the EPP WWB
  - freshwater-dependent regulated vegetation, listed under the VM Act.
- mapped aquatic ecological features, including floodplains, wetlands and surface-expression groundwater dependent ecosystems

- hydrological data recorded at the Department of Natural Resources, Mines and Energy (DNRME) gauging station 130219a (Nogoa River at Duck Ponds)
- relevant literature, including published and unpublished technical reports, scientific papers, and conservation advice statements for any MNES identified
- relevant studies supplied by Ensham Resources Joint Venture, including recent Receiving Environment Monitoring Program (REMP) reports.

14.3.1.2 Field survey

Survey design

The survey was completed in the pre-wet season (4 – 9 November 2019) with minimal rainfall in the month leading up to the survey (5.6 millimetres (mm)) and the last significant rainfall event approximately four months prior (18.2 mm on 5 July 2019).

The assessed aquatic ecological components of the field survey were:

- water quality (measured in situ and in the laboratory)
- sediment quality (measured in the laboratory)
- aquatic habitat
- aquatic plants
- macroinvertebrates
- fish
- turtles.

The study design comprised assessment of all aquatic ecological components at six sites, and aquatic habitat, aquatic plants and in-situ water quality at an additional four sites within and upstream of the Project Site (**Table 14-1**). A detailed description of surface water ecology survey methods is provided in **Appendix D-1** (Aquatic ecology).

Table 14-1 Aquatic ecology survey sites

Site	Site description	Latitude	Longitude	Full aquatic survey	Aquatic habitat only
WC1	Winton Creek upstream of all Ensham mining leases (MLs) at the Lagoon	-23.487101	148.411265	✓	
WC2	Winton Creek downstream within Mining Lease ML 70365	-23.497200	148.488881	✓	
BC1	Boggy Creek upstream of all Ensham MLs	-23.337400	148.523577	✓	
BC2	Boggy Creek upstream of confluence with Nogoa River within ML 7459	-23.485800	148.508537	✓	
NR1	Nogoa River at Bridge Flats Road upstream of all MLs	-23.430201	148.335144		✓
NR2	Nogoa River at upstream edge of ML 70326 boundary	-23.442101	148.456393	✓	

Site	Site description	Latitude	Longitude	Full aquatic survey	Aquatic habitat only
MP5	Nogoa River at downstream edge of ML 7459 boundary	-23.496700	148.514902	✓	
MP6	Mackenzie River at Rileys Crossing Road downstream of all Ensham MLs	-23.543501	148.605288		✓
UNC2	Nogoa River tributary upstream of all Ensham MLs	-23.448700	148.409682		✓
MP2	Nogoa River tributary within ML 70365	-23.481600	148.472669		✓

14.3.1.3 Survey methods

Water quality

Water quality was measured at all sites that held water, in accordance with the Queensland Monitoring and Sampling Manual (Department of Environment and Science (DES), 2018). Water quality was measured in situ for the following parameters:

- water temperature (degrees centigrade (°C))
- pH
- dissolved oxygen (milligrams (mg)/ litre (L) and per cent saturation)
- electrical conductivity (microsiemens (µS)/ centimetre (cm))
- turbidity (Nephelometric Turbidity Unit (NTU)).

Water samples were analysed by a NATA-accredited laboratory for:

- major ions (sodium, potassium, calcium, magnesium, hardness, chloride, sulfate, alkalinity) (micrograms (µg)/L)
- nutrients (total nitrogen, total kjeldahl nitrogen, oxides of nitrogen (nitrate and nitrite), ammonia, total phosphorous and reactive phosphorous (µg/L)
- total dissolved and suspended solids (mg/L)
- turbidity, pH and conductivity
- oil and grease (Total Petroleum Hydrocarbons (TPH), benzene, toluene, ethylbenzene and zylene (BTEX) and Polycyclic Aromatic Hydrocarbons (PAH) (µg/L)
- total and dissolved metals and metalloids (Aluminium (Al), Arsenic (As), Boron (B), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Selenium (Se), Silver (Ag), Uranium (U), Vanadium (V), Zinc (Zn)) (µg/L).

Water quality results were compared to WQO presented in:

- Australian & New Zealand Guidelines for Fresh & Marine Water Quality (WQA), 2018)
- Queensland Water Quality Guidelines (DES 2009)
- Queensland Department of Environment and Heritage Protection (DEHP) Environmental Protection (Water) Policy 2009 relating to the Lower Nogoa/Theresa Creek sub-basin (Department of Environment and Heritage Protection (DEHP) 2013).

Sediment quality

Sediment quality was assessed in November 2019 in accordance with the Monitoring and Sampling Manual 2009 (DES 2018). Sediment samples were collected from the channel bed at each site, with samples collected from sections of the bed where sediment deposits were present, where possible.

Sediment samples were analysed by a NATA-accredited laboratory for the following parameters:

- particle size distribution
- total metals (Al, As, B, Cr, Co, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, U, V, Zn) (mg/kilogram (kg)).

Aquatic habitat

The in-stream habitat attributes and condition were assessed using a method based on the Australian River Assessment System (AUSRIVAS) protocol described in the Queensland AUSRIVAS Sampling and Processing Manual (Department of Natural Resources and Mines (DNRM), 2001a). The following parameters were assessed:

- channel shape and pattern
- bank slope, composition, stability and vegetative cover
- bed substrate composition and stability
- in-stream habitat features, including submerged or emergent aquatic plants, large woody debris, undercut banks, boulders
- water velocity, depth and width
- riparian vegetation composition, extent and condition.

A Riverine Bioassessment Score (DNRM, 2001b) was calculated for each site where macroinvertebrates were collected. This score is a numerical index of aquatic habitat condition that enables a direct comparison of habitat quality between sites. The method scores habitat quality from zero to 20 for each of nine criteria with the sum of the scores giving the overall habitat score. This was used to allocate sites to one of four categories:

- excellent habitat condition (overall score greater than 110)
- good habitat condition (overall score 75 to 110)
- moderate habitat condition (overall score 39 to 74)
- poor habitat condition (overall score less than or equal to 38).

The Riverine Bioassessment method was designed for perennially flowing stream and river systems in southern Australia, and as such is not directly applicable to ephemeral systems in Queensland or non-flowing waterbodies. Using this method, even pristine ephemeral streams or wetlands are rarely classed as being in excellent condition. Nonetheless it is a useful system for comparing between sites where macroinvertebrates have been collected within a region.

Existing disturbances to riparian vegetation, bed and bank stability, flow and instream habitat were noted, including the presence of any existing barriers to fish passage.

Photographs of aquatic habitat were taken to establish a record of current condition.

Aquatic plants

Aquatic plants were surveyed at each site using a timed meander survey (i.e. 15 to 20 minutes per site) across in-stream and riparian habitats, as recommended in the *Flora Survey Guidelines – Protected Plants* (DES 2019b). Plants were identified to species if they were flowering, otherwise they were identified to genus. It was noted if plants were growing in the water, in the dry in-stream or in riparian areas. The growth form of plants growing in water was recorded (**Table 14-2**).

There are no published biological objectives for aquatic plants to compare results against.

Table 14-2 Growth forms of aquatic plants growing in water

Growth form	Description
Submerged	Submerged aquatic plants are rooted in the bed of the stream or wetland, with leaves totally covered by water most of the time. Some species may have underwater flowers, whereas other species may require water levels to decrease to trigger flowering and have flowers above the water level.
Attached floating	Attached floating aquatic plants are rooted in the bed of the stream or wetland, with leaves typically floating on top of the water. Flowers are usually above the water.
Free floating	Free floating plants float on top of the water, or in the water column, with roots trailing into the water column. Flowers are typically above the water.
Emergent	Emergent plants are rooted in the bed of the stream or wetland, with leaves and flowers above the water.

Macroinvertebrates

Macroinvertebrates were sampled from edge habitat at each site that was holding water during the field survey using the AUSRIVAS sampling method as described in the AUSRIVAS manual (DNRM 2001a) and the Monitoring and Sampling Manual (DES 2018). Samples were collected by disturbing a 10 metre (m) long section of edge habitat with a standard triangular-framed dip net (250 micrometres (µm) mesh size), preserved using ethanol, and transported to a biological laboratory. A detailed description of macroinvertebrate survey methods is provided in **Appendix D-1** (Aquatic ecology).

Standard freshwater macroinvertebrate indices were calculated for macroinvertebrate communities in edge habitat: taxonomic richness, Plecoptera/Ephemeroptera/Trichoptera (PET) richness, and Stream Invertebrate Grade Number – Average Level-2 (SIGNAL-2) scores.

The macroinvertebrate indices were compared to the biological objectives for moderately disturbed waters in the lower Nogoa/Theresa Creek (DES 2009) (**Table 14-3**).

Table 14-3 Default biological guidelines for macroinvertebrates

Index	Edge Habitat
Taxonomic richness	23 – 33
PET richness	2 – 5
SIGNAL-2 Scores	3.31 – 4.20

Fish and Turtles

Fish were surveyed using a combination of fyke nets and seine netting depending on the conditions at the site, in accordance with recommendations in the Commonwealth's *Survey Guidelines for Australia's Threatened Fish* (Department of Sustainability, Environment, Water, Population and Communities (DSEWPC), 2011), Terrestrial Vertebrate Fauna Survey Guidelines for Queensland (which includes turtles) and the Commonwealth's Survey Guidelines for Australia's Threatened Reptiles.

Fish and turtles were identified to species and counted, with native species released unharmed to the place of capture and pest species euthanised using methods approved under our animal ethics approval.

The WQO for fish is based on a ratio of the number of observed to expected (O/E) native species, which should be at least 1 (i.e. O/E greater than or equal to 1) (DEHP 2013). The number of expected species is the number of species caught on 50 per cent or more survey events.

The number of expected species of native fish in the Lower Nogoa/Theresa Creek Sub-basin main trunk is 8 (DEHP 2013). That is, to achieve the WQO for the Lower Nogoa River main trunk the observed number of native species is greater than or equal to 8.

The WQO for the number of species of exotic fish in the Lower Nogoa River main trunk is no more than one exotic fish species (DEHP 2013). The exotic fish *Poecilla reticulata* (guppy) was the only exotic fish species found to be present in the Nogoa River main trunk.

There are no published biological objectives for turtles.

14.3.2 Stygofauna

14.3.2.1 Desktop assessment

A desktop review was used to determine the suitability of groundwater ecosystems of the study area to provide habitat for stygofauna on the basis of geological, hydrological and water quality characteristics of local groundwater ecosystems, and included:

- review of previous studies to determine the recorded presence and distribution of stygofauna in the region
- review of hydrogeological data for the Project
- review of groundwater pH and electrical conductivity data within the study area.

14.3.2.2 Pilot study

Fifteen bores were surveyed for stygofauna between 6 and 10 November 2019 (**Table 14-4**).

A detailed description of stygofauna survey methods is provided in **Appendix D-2** (Stygofauna).

Table 14-4 Bores sampled for stygofauna

Bore	Easting	Northing	Geological unit	Drilled depth (m)
EC01	650018	7403058	Nogoa River Alluvium	17.2
EC03	650338	7402547	Nogoa River Alluvium	16.6
EC07	650972	7401746	Nogoa River Alluvium	18
EC09A	651353	7401504	Nogoa River Alluvium	18

Bore	Easting	Northing	Geological unit	Drilled depth (m)
EC11	651517	7401192	Nogoa River Alluvium	17.4
EC13	651517	7400776	Nogoa River Alluvium	16
EC14	651676	7400652	Nogoa River Alluvium	12
GW01	653926	7400422	Nogoa River Alluvium	19.79
RB1	650016	7412833	Rangal Coal Measures – Coal (A2C)	97
RB2	647785	7410364	Rangal Coal Measures - Coal	149.5
RB5	646207	7395310	Rangal Coal Measures – Coal (A21)	230.3
RB6	648834	7392167	Rangal Coal Measures – Coal (A2C)	60
WSMB2D	649058	7397630	Rangal Coal Measures – Coal	108
WSMB2S	649061	7397630	Rangal Coal Measures – Overburden	50
WSMB3D	647826	7396410	Rangal Coal Measures – Overburden	102

14.3.3 Assessment of Environmental Values

The aquatic ecology EVs in the study area were assessed using the criteria in **Table 14-5**. In-stream and riparian areas were assessed separately. The stygofauna EVs in the study area were assessed using the criteria in **Table 14-6.**

Table 14-5 Criteria used to assess aquatic environmental value of each site

Aquatic ecological value	Criteria/description
High	Known or likely occurrence of aquatic MNES and/or aquatic MSES
Moderate	Aquatic MNES and MSES unlikely to occur, however suitable habitat for non-listed aquatic species of turtles and fish is present
Low	Ephemeral watercourse without refugial pools; limited aquatic habitat features present; likely to provide low quality habitat for non-listed aquatic species during high flow events only.

Table 14-6 Criteria used to assess stygofauna environmental value of each site

Aquatic ecological value	Criteria/description
High	Threatened species listed under State or National legislation
Moderate	Non-listed stygobites and/or suitable habitat for stygofauna present (as defined in **Appendix D-2** (Stygofauna))
Low	Only non-listed stygoxenes and/or potentially suitable habitat for stygofauna present (as defined in **Appendix D-2** (Stygofauna))

14.3.4 Impact assessment

The assessment of impacts comprised:

- a risk-based assessment, with the level of risk being an outcome of the consequence and likelihood of the potential impact (refer to **Table 14-7** to **Table 14-9**)
- specific assessment of potential impacts to aquatic MNES using the Significant Impact Guidelines 1.1 (DotE 2013).

To determine the applicable aquatic MNES species and ecological communities, the EPBC Protected Matters database was searched on 22 November 2019 (**Appendix D-1** (Aquatic ecology)) and the following aquatic MNES were listed as occurring in the study area:

- white-throated snapping turtle (*Elseya albagula*) (critically endangered)
- Fitzroy River turtle (*Rheodytes leukops*) (vulnerable).

All other MNES that the EPBC search identified were considered to be outside the scope of this study (i.e. not aquatic species). Further information on other MNES can be found in **Chapter 25** (Matters of national environmental significance).

Table 14-7 Ratings used to assess the likelihood of potential impacts

Rating	Likelihood of potential impacts
High	Almost certain or high likelihood of the impact occurring; has occurred recently in a similar scenario; likely to happen commonly.
Moderate	Likely or probably could happen; would not happen very commonly.
Low	Possible but unlikely to happen; would happen rarely if at all.

Table 14-8 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 sensitive components of the environment; minor environmental harm to protected components of the environment, such as protected wetlands or MNES.

Rating	Consequence of potential impacts
Low	Unfavourable impact with no lasting harm to the environment, excluding sensitive and protected components of the environment.

Table 14-9 Environmental risk matrix

		Likelihood		
		Low	**Moderate**	**High**
Consequence	**High**	Moderate	High	High
	Moderate	Low	Moderate	High
	Low	Low	Low	Moderate

14.4 Description of environmental values

14.4.1 Surface Water Ecology

14.4.1.1 Aquatic matters of national environmental significance

White-Throated Snapping Turtle

The white-throated snapping turtle (*Elseya albagula*) is listed as critically endangered under the EPBC Act and endangered under the NC Act. This species is restricted to the Fitzroy, Burnett and Mary Basins, and adjacent coastal basins (e.g. Kolan and Gregory-Burrum systems) (Hamann et al. 2007). This species is a habitat specialist, preferring permanent, flowing, clear and well oxygenated water with moderate to high cover of aquatic habitat (i.e. large woody debris and undercut banks) (Todd et al. 2013). Within the greater Fitzroy, Burnett and Mary river catchments, this species has been recorded almost exclusively in close association with permanent flowing stream reaches that are typically characterised by a sand-gravel substrate with submerged rock crevices, undercut banks and/or submerged logs and fallen trees (Hamann et al. 2007). A full description of white-throated snapping turtle is presented in **Appendix D-1** (Aquatic ecology).

The white-throated snapping turtle was last recorded adjacent to the Project Site in 1998 at Duckponds, Nogoa River (Atlas of Living Australia (ALA), 2019; DES 2019d), a waterbody that is no longer present. However, it is considered likely that a population of white-throated snapping turtle is still present within the main channel of the Nogoa River within the Project Site, where there are permanent pools, flows are regular (i.e. flows occur 99 per cent of the time; gauging station 130219A (DNRME 2019)) and extensive aquatic habitat is present.

Fitzroy River Turtle

The Fitzroy River turtle (*Rheodytes leukops*) is listed as vulnerable under the EPBC Act and vulnerable under the NC Act. This species is restricted to the Fitzroy River Basin (Department of Agriculture, Water and the Environment (DAWE), 2015), where it occurs in permanent freshwater rivers from the Fitzroy Barrage to Theodore Weir and Duck Ponds, upstream of the Comet-Mackenzie River confluence, as well as through Marlborough Creek (Limpus et al. 2007). It has also been found in isolated permanent waterholes on the Connors River (Limpus et al. 2007; frc environmental 2010). However, the species is not known to inhabit small farm dams or ephemeral waterways (Limpus et al. 2007). A full description of Fitzroy River turtle is presented in **Appendix D-1** (Aquatic ecology).

The Fitzroy River turtle was last recorded adjacent to the Project Site in the Nogoa River in 1998 (ALA. 2019; DES 2019d). However, it is considered likely that a population of Fitzroy River turtle still remains within the main channel of the Nogoa River within the Project Site, where there are permanent pools, flows are regular (i.e. flows occur 99 per cent of the time; gauging station 130219A (DNRME 2019)) and the aquatic habitat is consistent with the preference for the species.

14.4.1.2 State-level Protected Matters Relevant to Aquatic Ecology

White-throated snapping turtle and Fitzroy River turtle are threatened species, protected under the NC Act (see **Appendix D-1** (Aquatic ecology) for further description of these species).

The riparian vegetation of the Project Site is mapped as regulated vegetation intersecting a watercourse, with some riparian vegetation also mapped as category B, category C and category R vegetation. Small patches of regulated vegetation within 100 m of a wetland occur upstream of the Project Site on Boggy Creek and Nogoa River, and downstream of the Project Site on Mackenzie River, but do not occur in the Project Site A full description of regulated vegetation in the study area is presented in **Appendix D-1** (Aquatic ecology).

Mapped High Ecological significance wetlands, which are protected under the EPP WWB, are present upstream of the Project Site on Boggy Creek, Corkscrew Creek and Nogoa River, but do not occur in the Project Site (**Figure 14-1**). The watercourses of the study area are mapped riverine wetlands.

The relevant fisheries resource in the study area, protected under the Fisheries Act, relates to the provision of fish passage and the associated risks to fish passage from waterway barrier works on different sized watercourses. Watercourses of the study area range from stream order 8 (Nogoa River) to stream order 3 (Mosquito Creek), with the Mackenzie River (stream order 8) downstream and Winton Creek (stream order 7) adjacent to the Project Site. The main stem of watercourses within the study area are mapped as having major (mapped as purple: Nogoa River, Mackenzie River, Comet River and the downstream reach of Winton Creek and Boggy Creek), high (mapped as red: Mosquito Creek, Corkscrew Creek and the upstream reach of Boggy Creek and Winton Creek) and moderate (mapped as amber: unnamed tributaries of the Nogoa River) risk of impact to fish passage by waterway barrier works. Smaller upstream tributaries of these watercourses have low (mapped as green) risk of impact from waterway barrier works. A full description of fisheries resources in the study area is presented in **Appendix D-1** (Aquatic ecology).

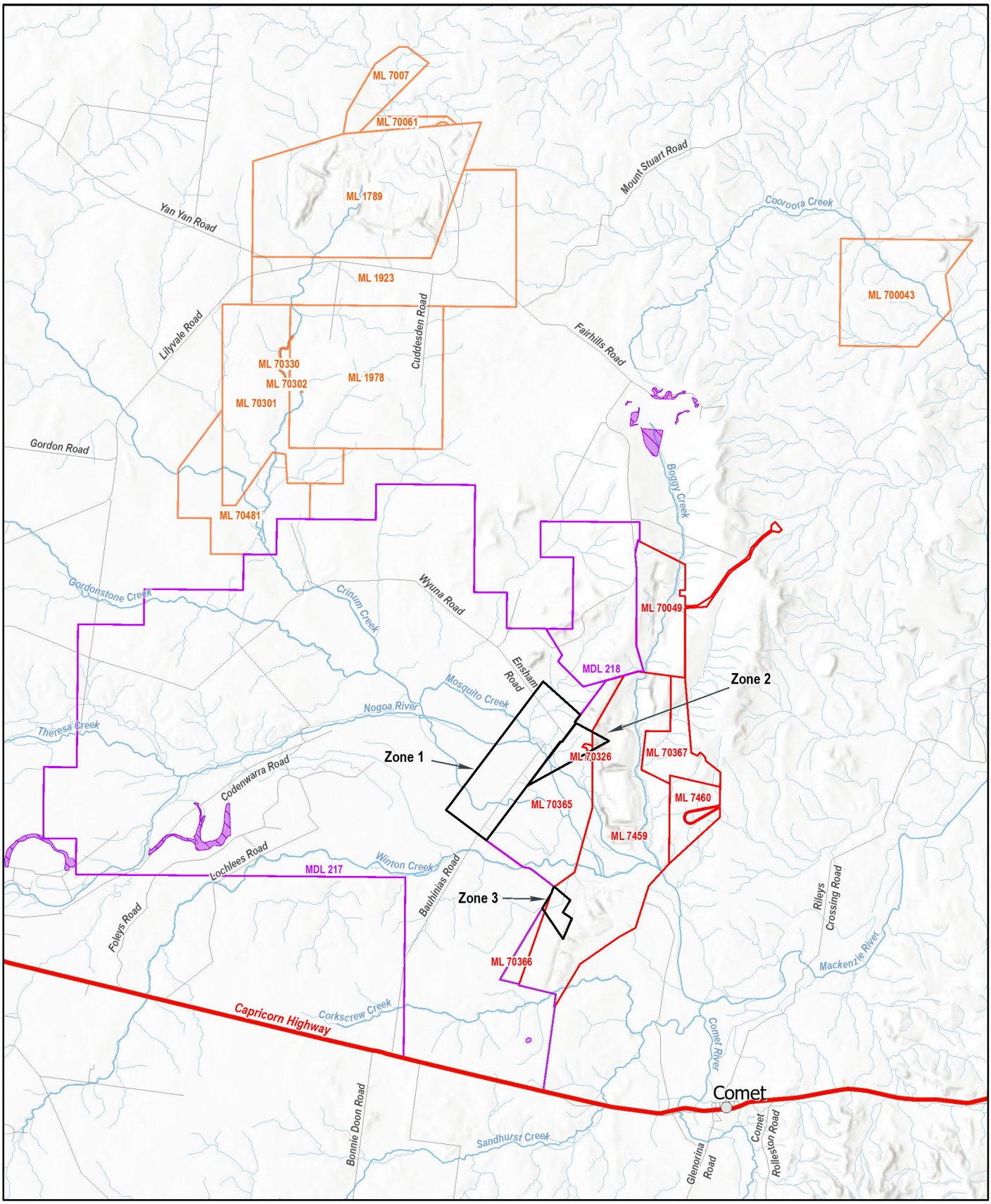

Figure 14-1
High ecological significance wetlands

Ensham RESOURCES

0 4 8 km

Legend

- Project Area
- Watercourse
- Minor watercourse
- Main Road
- Other Road

Ensham MLs MDLs

- Mineral development licence
- Mining leases

- High ecological significance wetlands
- Other Mining leases

ENSHAM LIFE OF MINE EXTENSION PROJECT

Projection: GDA 1994 MGA Zone 55 Scale: 1:275,000
Source: State of Queensland, 2019. Indemitsu RFI 2019

14.4.1.3 Water quality

Water quality measured within the scope of this aquatic ecology study was similar to results recorded in previous REMP surveys (4T Consultants 2012; Hydrobiology 2014; 2016b; a; 2017; 2018; 2019) with:

- electrical conductivity naturally high throughout the study area
- turbidity and total suspended solids high, particularly in Boggy Creek and following recent rainfall
- total aluminium, iron and copper was frequently high and likely a natural occurrence for the region
- nutrient concentrations variable and dependent on recent flows and local agricultural practices.

14.4.1.4 Sediment quality

Sediment quality measured within the scope of this aquatic ecology study was similar to results recorded in previous REMP surveys (4T Consultants 2012; Hydrobiology 2014; 2016b; a; 2017; 2018; 2019) with:

- total concentration of nickel frequently exceeding the sediment quality objective (SQO) at sites within each catchment
- total concentration of aluminium, iron, manganese and vanadium in sediment frequently high at most sites but with no available SQO.

14.4.1.5 Aquatic habitat and natural flow regime

The Project is located on the Nogoa River floodplain, with a series of well-defined braided channels of the Nogoa River intersecting the study area from the west to the east. Other watercourses within the study area are typically well-defined channels that follow an irregular sinuous pattern. There are no high ecological value waters or surface expression groundwater dependent ecosystems in or surrounding the study area (**Figure 14-2**). There are mapped lacustrine and palustrine wetlands in the study area, but relatively few mapped wetlands in the Project Site (refer to **Figure 14-1**). The watercourses of the study area are mapped as a riverine wetlands with the Nogoa River, Mosquito Creek, Winton Creek, Corkscrew Creek and other Nogoa River tributaries mapped as riverine regional ecosystems in their riparian zones.

Land use in the study area is dominated by low intensity dryland cattle grazing with some irrigation/cropping also prevalent between the Nogoa River and Winton Creek. Much of the native catchment and riparian vegetation has been cleared, with stock access to watercourses contributing to bank erosion at some locations.

Flow in the Nogoa River occurs approximately 99 per cent of the time, with flows dependent on the release of irrigation water by Sunwater from the Fairbairn Dam upstream. Flow intensity can therefore vary significantly throughout the day, with water levels increasing by more than 0.5 m when release flows are increased. Flows in Winton Creek, Boggy Creek, Mosquito Creek and Corkscrew Creek are likely to be infrequent short-duration events, following significant rainfall. Consequently, these watercourses are highly ephemeral, and aquatic habitat is dominated by small isolated pools within the channel interspersed with large areas of dry stream bed, with larger pools typically found in artificial waterbodies. Larger pools are likely to be perennial or near-perennial and important refugial habitat for aquatic fauna. Smaller shallower pools provide aquatic habitat for briefer periods after rainfall.

Bed substrate within the tributaries of Nogoa River were mostly comprised of silt/clay, with a high proportion of rocky substrate (such as bedrock, boulders and cobble) or sand recorded at sites on the Nogoa River. The cover of large wood debris (i.e. logs and branches) and fine organic matter (i.e. twigs and leaves) was typically low, with some increase in cover recorded within the Nogoa River at sites NR2 and MP2. In-stream vegetation (such as *Potamogeton crispus*, *Ludwigia peploides* and *Azolla pinnata*) was present at sites WC2 (submerged and floating) and MP5 (submerged). Detailed habitat descriptions are presented in **Appendix D-1** (Aquatic ecology).

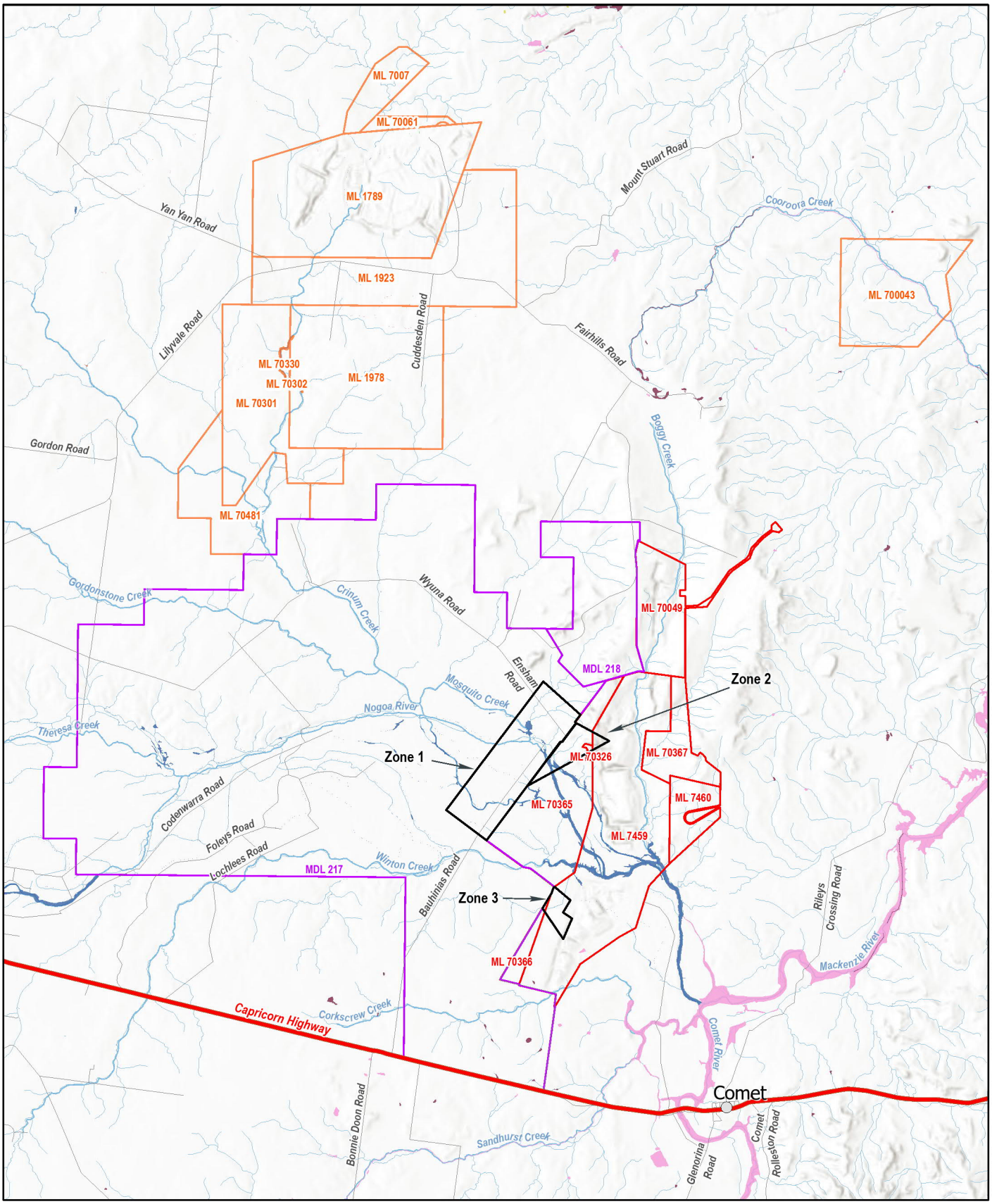

Figure 14-2
Groundwater dependent ecosystem potential

Ensham RESOURCES

0 4 8 km

ENSHAM LIFE OF MINE EXTENSION PROJECT

Legend

- Project Area
- Watercourse
- Minor watercourse
- Main Road
- Other Road

Ensham MLs MDLs

- Mineral development licence
- Mining leases
- Other Mining leases

Groundwater Dependent Ecosystem Potential

- High potential GDE - from national assessment
- High potential GDE - from regional studies
- Moderate potential GDE - from regional studies
- Moderate potential GDE - from national assessment
- Low potential GDE - from national assessment
- Low potential GDE - from regional studies

Projection: GDA 1994 MGA Zone 55 Scale: 1:275,000
Source: State of Queensland, 2019. Indemitsu RFI 2019

14.4.1.6 Aquatic biota of the study area

Aquatic plants

Aquatic plant communities of the region are typically species-poor and have low per cent cover, which is likely due to the naturally harsh environmental conditions of the ephemeral watercourses in the region. The Nogoa River sub-catchment covers an area of 27,690 square kilometres ($km^{2)}$ upstream of the Project Site, and is home to ~104 wetland indicator plant species (DES 2019d). Submerged aquatic plants were uncommon due to the ephemeral nature of the watercourses, with the aquatic plant communities mostly comprised of species with emergent growth, such as smartweeds (*Persicaria* spp.), rushes (*Typha* spp., *Eleocharis* spp. and *Juncus* spp.), lignum (*Doma florulenta*) and sedges (*Cyperus* spp.). However, the permanent water present within the Nogoa River and its' channels provide habitat for aquatic plants not of emergent growth form, with floating species such as lilies (*Nymphoides exiflora* and *Nymphae caerulea*), nardoo (*Marsilea* spp.) and azolla (*Azolla pinnata*), and submerged species such as pondweed (*Potamogeton* spp.), bladderwort (*Utricularia caerulea*) and Vallisneria (*Vallisneria nana*) known to inhabit that catchment (Wetland info).

None of the recorded aquatic plant species are listed as threatened species under the Commonwealth's EPBC Act or Queensland's NC Act.

Hymenachne (*Hymenachne amplexicaulis*), which is a restricted biosecurity matter under the *Biosecurity Act 2014* (Qld), is known from the region.

The aquatic plant survey found:

- aquatic plants at each site and aquatic plants in water at sites MP5, MP6 and WC2
- 17 aquatic plant species, with six species in water and 14 species out of water
- the cover of aquatic plants at each site ranged from two (site BC1) to 151 (site WC1), with cover high at site WC1 due to aquatic plants growing on-top of each other in the riparian vegetation
- three common aquatic plant species, with attenuated smartweed (*Persicaria attenuata*) and lignum (*Muehlenbeckia florulenta*) relatively widespread and ferny azolla (*Azolla pinnata*) found only at site WC2
- aquatic plants were mostly on dry bed and banks, with in-stream cover only higher at sites MP5 (high cover of curly pondweed; *Potamogeton crispus*) and WC2 (high cover of ferny azolla).

Macroinvertebrates

Aquatic macroinvertebrates of the region are dominated by insects (frc environmental unpublished data; 4T Consultants 2012; Hydrobiology 2014; 2016b; a; 2017; 2018; 2019) and include:

- seven families of beetles (Coleoptera)
- seven families of flies and midges (Diptera)
- four families of bugs (Hemiptera)
- four families of dragonflies and damselflies (Odonata)
- three families (sensitive taxa) of mayflies (Ephemeroptera)
- seven families (sensitive taxa) of caddisflies (Trichoptera).

Other macroinvertebrate taxa recorded in in the region include:

- four families of mussels and clams (Bivalvia)
- earthworms (Oligochaeta)
- flatworms (Dugeslidae)

- leeches (Hirudinea)
- mites (Acarina)
- four families of crustacea (Decapoda):
  - glass shrimp (Atyidae)
  - isopods (Cirolanidae)
  - copepods (Copepoda)
  - freshwater prawns (Palaemonidae).

REMP monitoring data for Ensham from 2010 to 2019 for five sites within the study area (4T Consultants 2012; Hydrobiology 2014; 2016b; a; 2017; 2018; 2019) had:

- abundance ranging from:
  - 36 to 416 in run/composite habitat
  - 78 to 322 in edge habitat.
- taxonomic richness ranging from:
  - 6 to 28 in run/composite habitat
  - 7 to 28 in edge habitat.
- PET richness ranging from:
  - 0 to 10 in run/composite habitat
  - 0 to 7 in edge habitat.
- SIGNAL-2 scores ranging from:
  - 2.47 to 4.60 in run/composite habitat
  - 2.71 to 4.43 in edge habitat.

The field survey results show that:

- the abundance of macroinvertebrates was highest at sites WC1 (1,012 macroinvertebrates) and WC2 (1,337 macroinvertebrates) on Winton Creek, but PET richness and Signal-2 Scores were lower than at sites on the Nogoa River (MP5 and NR2)
- Taxonomic richness was typically lower than the default biological objective range, with taxonomic richness only within the guideline range at site WC2
- PET richness and SIGNAL-2 scores were lower than the default biological objective range at both sites on Winton Creek, where aquatic habitat was restricted to isolated pools.

Fish

Eighteen native species of fish are known from the region[3] (frc environmental unpublished data; DES 2019d; c):

- Agassiz's glassfish (*Ambassis agassizii*)
- barred grunter (*Amniataba percoides*)
- longfin eel (*Anguilla reinhardtii*)
- flyspecked hardyhead (*Craterocephalus stercusmuscarum*)

[3] An additional nine species were listed to be within the Nogoa River catchment, but not in the study area, these include: Aru gudgeon, flathead gudgeon, mouth almighty, silver perch, Murray cod, barramundi, bullrout, Pacific blue eye and southern saratoga.

- empire gudgeon (*Hypseleotris compressa*)
- carp gudgeon (*Hypseleotris* spp.)
- spangled perch (*Leiopotherapon unicolor*)
- golden perch (*Macquaria ambigua*)
- eastern rainbowfish (*Melanotaenia splendida splendida*)
- southern purplespotted gudgeon (*Mogurnda adspersa*)
- bony bream (*Nematalosa erebi*)
- blue catfish (*Neoarius graeffei*)
- Hyrtl's catfish (*Neosilurus hyrtlii*)
- sleepy cod (*Oxyeleotris lineolata*)
- Rendahl's catfish (*Porochilus rendahli*)
- leathery grunter (*Scortum hillii*)
- freshwater longtom (*Strongylura krefftii*)
- freshwater catfish (*Tandanus tandanus*).

These are all common species that are tolerant of relatively harsh environmental conditions (e.g. variable flow, fluctuating water quality) that are typical of ephemeral watercourses of the region. All species are potadromous (i.e. they migrate to various extents within freshwaters), except Empire gudgeons which are diadromous (i.e. migrate between freshwater and saltwater), longfin eels which are catadromous (i.e. migrate to marine habitat to breed) and blue catfish which are anadromous (i.e. migrate to freshwater habitat to breed). None of these species are listed as threatened species under the EPBC Act or NC Act.

The field survey results show:

- twelve native fish species and two exotic fish species (eastern Gambusia and platy) were caught
- Agassiz's glassfish, carp gudgeon and eastern rainbowfish were the most widespread species, occurring at each site
- eastern rainbowfish (770 individuals), carp gudgeon (298 individuals) and flyspecked hardyhead (190 individuals) were the most abundant species
- native fish species richness at sites WC2 and MP5 were below the default biological guideline value (expected richness of ≥ 8 native species), with bony bream, eel-tailed catfish and spangled perch not recorded at sites WC2 and MP5 and yellowbelly (*Macquaria ambigua oriens*) and leathery grunter (*Scortum hillii*) not recorded at any site
- exotic fish species richness at site WC2 did not comply with the default biological guideline value (expected richness of ≤ 1 exotic species), with two species recorded at the site.

All native species are common and widespread in the region, and none are listed species. Eastern Gambusia is a restricted biosecurity matter under the *Biosecurity Act 2014* (Qld).

Turtles

Five species of turtle are known from the region: eastern long-necked turtle (*Chelodina longicolis*), Krefft's river turtle (*Emydura macquarii krefftii*), broad-shelled river turtle (*Chelodina expansa*), Fitzroy River turtle and white-throated snapping turtle (DES 2019; wildlife online; frc environmental unpublished data). The white-throated snapping turtle and Fitzroy River turtle are listed as critically endangered (white-throated snapping turtle) and vulnerable (Fitzroy River turtle) under the Commonwealth's EPBC Act and are expected to still inhabit the main channels of the Nogoa River where permanent water is present. However, the white-throated snapping turtle and Fitzroy River turtle are unlikely to inhabit other smaller watercourse in the study area, such as Winton Creek, Boggy Creek, Corkscrew Creek and Mosquito Creek.

Seven Krefft's river turtles (*Emydura Macquarii krefftii*) were caught during the field survey, with a majority (six individuals) caught at site NR2. No turtles were caught at site WC2, where the water level and available habitat was unfavourable for a turtle population. No listed species of turtle were caught during the field survey, however favourable habitat for the species' was observed within the Nogoa River main channel.

14.4.2 Stygofauna

14.4.2.1 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 study area is located within the Isaac-Comet Downs, with five described families from eight samples reported from the Isaac-Comet Downs 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 of 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 per cent 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.

Geology

The geology of the study area, from shallowest to deepest, comprises:

- unconsolidated quaternary sediments in the river alluvium
- tertiary sediment
- Triassic Rewan Group sediment
- Permian age Rangal Coal Measures, including:
  - sandstone, siltstone, mudstone, tuff and conglomerate within the Burngrove, Fair Hill and Macmillan Formations
  - Aries Coal Seam
  - Castor Coal Seam
  - Pollux Coal Seam
  - Orion Coal Seam.

The geology of the 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 study area is considered to be *suitable* for providing habitat for stygofauna.

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 typically less than 15 m below ground at all alluvium bores in the study area. Therefore, the shallow alluvium groundwater ecosystem of the study area have likely *suitable* hydrological characteristics to provide habitat for stygofauna, but the Rewan and Coal Measure groundwater systems have hydrological characteristics *potentially suitable* for stygofauna.

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). The median electrical conductivity recorded from bores in the study area ranged from 5,825 – 13,150 µS/cm and the 20th percentile ranged from 3,496 – 4,340 µS/cm. Therefore the electrical conductivity of water in the bores was consistent with the preferred range of electrical conductivity for stygofauna less than 20 per cent of the time and consequently *potentially suitable* 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 median pH of groundwater from the study area ranged from 7.1 – 7.9 and typically aligned with the range known to support diverse stygofaunal communities. The pH of groundwater of the study area is *suitable* for stygofauna.

14.4.2.2 Stygofauna of the study area

Of the 15 bores surveyed in the pilot study, two bores (EC13 and EC14) contained stygofauna: Oligochaeta. Oligochaetes are stygoxenes (i.e. not obligate inhabitants of groundwater ecosystems).

14.4.3 Assessment of aquatic ecological value

14.4.3.1 Surface water ecology

The aquatic ecological value of the Nogoa River and its' tributaries was assessed as *high* using the criteria presented in **Table 14-5**, as aquatic MNES are known to occur within the Nogoa River and the main channel provides favourable habitat for foraging and potential habitat for breeding.

The aquatic ecological value of Winton Creek was assessed as *moderate*, as Winton Creek provides favourable habitat for common species of fish and invertebrates, noting that in-stream aquatic habitat is often restricted to temporary, isolated pools.

The aquatic ecological value of Boggy Creek, Corkscrew Creek and Mosquito Creek was assessed as *low - moderate*, as these were dry at the time of the survey and are unlikely to provide habitat for fish or aquatic invertebrates most of the year based on their high degree of ephemerality.

Regulated vegetation types occur in the riparian zone and watercourses of the study area and watercourses provide important corridors for fish passage during times of flow.

14.4.3.2 Stygofauna

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

- the limited occurrence of one *stygoxene* taxa
- water quality of groundwater being only *potentially suitable* for stygofauna on the basis of high electrical conductivity and high depth to water table.

14.5 Potential impacts

The Project will utilise existing mine infrastructure, with minor surface disturbance (exploration) required in zones 1, 2 and 3 and there may be need for minor support surface infrastructure in Zone 2. The major phases of the Project are:

- project operation (approximately 2021 – 2037)
- underground decommissioning (approximately 2038 – 2039).

The following potential sources of impact on aquatic ecological values associated with the Project were identified:

- subsidence
- localised contamination of watercourses or groundwater from spills of hydrocarbons and chemicals from vehicles and machinery
- physical disturbance of groundwater ecosystems
- cumulative impacts of the Project interacting with nearby operational mines and proposed mining projects (e.g. Kestrel Coal Project, Wilton and Fairhill Project and Curragh Project).

14.5.1 Subsidence

Underground mining operations associated with the Project are proposed beneath the lower reaches of Mosquito Creek, the Nogoa River main channel and a number of tributaries of the Nogoa River. Subsidence of these watercourses may result in lowered sections of stream bed with abrupt changes in bed level or bank failure and in-filling of the channel. This may alter natural water flow patterns and restrict the movement of fish, especially during low flow conditions, potentially resulting in fish being stranded in impacted areas.

The Project will operate using the same bord and pillar mining method associated with the existing operations, with a regular array of stable coal pillars and roadways. The subsidence predictions for the Project coal pillars have been verified to a high level of confidence using information from the existing bord and pillar operations at Ensham. Using a minimum pillar factor of safety of 1.6, the subsidence is predicted to be less than 40 mm in the Project Site, with subsidence a result of elastic compression of the strata (i.e. compression due to the additional load on the pillars after the coal has been extracted).

The predicted subsidence as a result of the Project is less than the DAWE's estimated seasonal variation in surface levels as a result of changes in moisture content (50 mm), and is therefore unlikely to form surface cracks or significant depressions in surface topography where ponding of the surface water may occur. This is consistent with experience for the current existing operations where no surface cracking or ponding has been observed above the bord and pillar mined areas.

14.5.2 Localised contamination of watercourses or groundwater

Fuels, oils and other chemicals (e.g. lubricants and solvents) required for the operation of vehicles and machinery or maintenance of underground operations are toxic to aquatic flora and fauna at relatively low concentrations. Spilt fuel is most likely to enter watercourses via an accidental spill on the roads or when there are operational activities adjacent to watercourses and/or groundwater. A significant fuel spill (in the order of tens or hundreds of litres) is likely to have a locally significant impact on both flora and fauna, with the size of spill and the volume of water being the most significant factors influencing the length of stream impacted. Other wastes associated with vehicle and machine maintenance also have the potential to contribute to the degradation of aquatic ecosystems.

14.5.3 Fish passage

The Project does not propose to alter any waterways that provide fish passage.

14.5.4 Physical disturbance of groundwater ecosystems

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

- drawdown of water tables, with additional groundwater inflow estimated after 2028 compared to the existing operations (SLR Consulting 2020):
  - alluvial take (alluvial water seeping into lower formations) magnitude is estimated to increase by 0.01 megalitres (ML)/day, but with no change to the Nogoa River baseflow
  - the maximum additional drawdown extent in the coal seam aquifer extends 10 km to the west of the underground mining operations.
- mining operations within stygofauna habitat, which may lead to removal and compaction of soil and aquifers and reduce habitat quality of groundwater ecosystems for stygofauna.

Results indicate limited influence on the alluvial aquifer water levels, with a more notable influence on coal seam water levels. However, stygofauna of the study area were only found in the alluvium and were assessed as having low ecological value, indicating that there is unlikely to be an increased risk of physical disturbance to the groundwater ecosystem or stygofauna habitat.

14.6 Mitigation measures

14.6.1 Subsidence

As the predicted subsidence as a result of the Project is less than that estimated from seasonal variation, and therefore negligible, no mitigation measures specific to aquatic ecology are proposed.

14.6.2 Localised contamination of watercourses or groundwater

The Project will operate using the same procedures and requirements associated with the existing Ensham Mine operations, specifically existing environmental impact management plans for water management and hydrocarbons, standard operating procedures for handling hazardous substances, and relevant legislative requirements and Australian Standards. In particular, refuelling will be completed in designated bunded areas away from watercourses and spill response procedures will be followed. As there will be minor surface disturbance and construction and no increase in mine traffic as a result of the Project, it is therefore unlikely to be an increased risk of localised contamination of watercourses.

14.6.3 Fish passage

As the Project does not propose to alter any waterways that provide fish passage, no mitigation measures are proposed.

14.6.4 Physical disturbance of groundwater ecosystems

Minor temporary surface disturbance associated with exploration activities on zones 1, 2 and 3 and surface disturbance in Zone 2 (if required) are unlikely to have an impact on groundwater ecosystems. Potential groundwater related impacts are related to indirect take from the alluvium and potential impacts on landholder bores. As discussed in **Appendix F-1** (Groundwater impact assessment), the potential for aquifers in the Project Site to support high stygofauna diversity are low.

14.6.5 Cumulative impacts

Ensham manage mine-affected water releases in accordance with EA EPML00732813 and this has ensured that Ensham has complied with the defined EA water quality triggers and limits. Mine-affected water releases are managed within an existing and overarching strategic framework for the management of cumulative impacts of mining activities (i.e. Model Water Conditions for Mines in the Fitzroy Basin and the EPP WWB for the Fitzroy Basin); thus, the proposed management approach for mine water is expected to have negligible cumulative impact on surface water quality and associated environmental values.

Changes in flows in the Nogoa River due to drawdown of the water table and loss of catchment area from the multiple mining operations would be undetectable as flow is managed by Sunwater from the Fairbairn Dam upstream.

14.7 Residual impacts

Under the EPBC Act, an action is considered likely to have a significant impact on a threatened species if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of a population (important population for vulnerable species)
- reduce the area of occupancy of the species (important population of a vulnerable species)
- fragment an existing population (important population of a vulnerable species) into two or more populations
- adversely affect habitat critical to the survival of a species
- disrupt the breeding cycle of a population (important population of a vulnerable species)
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

- result in invasive species that are harmful to a critically endangered, endangered or vulnerable species becoming established in the endangered, critically endangered or vulnerable species' habitat
- introduce disease that may cause the species to decline, and/or
- interfere with the recovery of the species.

Although two aquatic MNES species are known to occur within the waterways of the study area (white-throated snapping turtle and Fitzroy River turtle), the Project is highly unlikely to have a significant impact on their population as there will be:

- no clearing of riparian vegetation or aquatic habitat resulting from minor temporary surface disturbance associated with exploration activities in all three zones and some minor surface construction in zone 2
- no change in the release process for mine affected water from existing operations ie water will continue to be released in accordance with the EA
- very low likelihood of subsidence, with the predicted subsidence (40 mm) also unlikely to form a barrier for freshwater turtle dispersal
- no impact on water level or flow in the Nogoa River, with flow dependent on the release of irrigation water by Sunwater from the Fairbairn Dam upstream.

Thus, populations of these MNES species are sufficiently isolated from the Project to have no risk of direct or indirect impact from the Project.

A risk-based assessment also determined that the mitigated risk of potential impact to the stygofauna of the Project Site was 'low' based on:

- the limited occurrence of one stygoxene taxa
- water quality of groundwater being only 'potentially suitable' for stygofauna on the basis of high electrical conductivity and high depth to water table
- minor surface disturbances described above are unlikely to impact stygofauna
- underground disturbances limited to areas needed for Project operations, primarily within the coal seam where Stygofauna are unlikely.

14.8 Summary and conclusions

14.8.1 Surface water ecology

The aquatic ecological value of the Nogoa River and its' tributaries was assessed as high using the criteria presented in **Table 14-5**, as aquatic MNES are known to occur within the Nogoa River and the main channel provides favourable habitat for foraging and potential habitat for breeding.

The aquatic ecological value of Winton Creek was assessed as moderate, as Winton Creek provides favourable habitat for common species of fish and invertebrates, noting that in-stream aquatic habitat is often restricted to temporary, isolated pools.

The aquatic ecological value of Boggy Creek, Corkscrew Creek and Mosquito Creek was assessed as low - moderate, as these were dry at the time of the survey and are unlikely to provide habitat for fish or aquatic invertebrates most of the year based on their high degree of ephemerality.

Regulated vegetation types occur in the riparian zone and watercourses of the study area and watercourses provide important corridors for fish passage during times of flow.

Potential sources of impact on aquatic ecological values associated with the Project include subsidence, and the potential for localised contamination of watercourses from spills of hydrocarbons and chemicals from vehicles and machinery.

Two aquatic MNES species are known to occur within the waterways of the Project Site (white-throated snapping turtle and Fitzroy River turtle), however the Project is highly unlikely to have a significant impact on their population as there will be:

- minor surface disturbance for flaring infrastructure which will not result in clearing of any vegetation (riparian vegetation or aquatic habitat).
- no change in the release process for mine affected water from existing operations although the Project will extend the discharge duration by approximately up to nine years. The Receiving Environment Monitoring Program (REMP) annual reports for the last three years indicate that a comparison of assessed parameters downstream of the mine to upstream results indicate the suitability of current release contaminant limits to protect downstream EVs. The monitored variables (habitat, stream flow, water quality, sediment and macroinvertebrates) have typically remained similar or improved since 2017, highlighting the correct operation of managed releases. The EA conditions for which releases were made between 2017 and 2020 allowed the downstream trigger level to be up to 1,440 µS/cm (1,200 µS/cm 80th percentile) and a minimum flow of 10m^3/sec. Considering that the Project will result in no changes to managed releases (refer to **Section 10.6.2**, **Chapter 10** (Surface water resources)), and more stringent conditions were applied in the EA issued 19th March 2020, it is concluded that no negative impacts to EVs are to be expected.
- very low likelihood of subsidence, with the predicted subsidence (40 mm) also unlikely to form a barrier for freshwater turtle dispersal (refer to **Appendix D-1** (Aquatic ecology)).
- no impact on water level or flow in the Nogoa River, with flow dependent on the release of irrigation water by Sunwater from the Fairbairn Dam upstream.

Thus, populations of these MNES species are sufficiently isolated from the Project to have no risk of direct or indirect impact from the Project.

As all potential sources of impact to the aquatic ecological values as a result of the Project was assessed as low and the two MNES species known to occur in the vicinity of the Project Site are sufficiently isolated from the Project, monitoring and management plans associated with existing operations are therefore adequate for the ongoing monitoring of impacts to aquatic ecological values.

14.8.2 Stygofauna

Stygofauna were assessed using a ‘desktop review’ and ‘pilot study’, as described in the *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DoSITIA 2015); DES (2019a).

The stygofauna that were collected (oligochaetes; stygoxenes) are not protected under the EPBC Act unless the Project is likely to have a significant impact on the hydrology or water quality of the groundwater water resource and therefore trigger the Water Trigger amendment. Outside of the Water Trigger amendment, only specific stygofauna (cape range remipede) and specific GDEs (e.g. Karst springs and associated alkaline fens of the Naracoorte Coastal Plain Bioregion; River Murray and associated wetlands, floodplains and groundwater systems, from the junction with the Darling River to the sea) are listed as MNES species/ecological communities.

The assessment identified a low risk of impact to the stygofauna community of the Project Site as:

- The stygofauna community had a low environmental value based on the potentially suitable groundwater water quality and the limited occurrence of one stygoxene taxa; aquatic fauna that

facultatively use groundwater ecosystems, but are not dependent on groundwater to complete their life cycle

- The stygoxene taxa was only caught at two bores within the alluvium water table adjacent to the Nogoa River
- The modelling estimated alluvial take to increase by 0.01 ML/day but with no change to the Nogoa River baseflow
- Majority of drawdown was to occur within the coal seam and below the alluvium, where stygofauna are not estimated to occur
- Water level and quality monitoring across an appropriately designed bore field will be continued using the same procedures and requirements associated with the existing operations and Environmental Authority.

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

- contamination of groundwater
- physical disturbance of groundwater ecosystems by:
  - drawdown of water tables
  - removal and compaction of soil and aquifers and reduce habitat quality of groundwater ecosystems for stygofauna.
- cumulative impacts of the Project interacting with other nearby, existing mines such as the Kestrel Coal Project, Wilton and Fairhill Project and Curragh Project.

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

As the stygofauna community of the Project Site was assessed as having low environmental value and the overall mitigated risk of impact to the stygofauna community as a result of the Project was assessed as low, monitoring and management plans associated with existing operations are therefore adequate for the ongoing monitoring of impacts to the stygofauna community, with a 'comprehensive survey', as described in DoSITIA (2015), not recommended.

14.9 References

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