LAKE VERMONT MEADOWBROOK PROJECT

AQUATIC ECOLOGY ASSESSMENT

PREPARED FOR
BOWEN BASIN COAL PTY LTD

November 2022

aarc
ENVIRONMENTAL SOLUTIONS

BRISBANE OFFICE
164 Wharf Street
Spring Hill QLD 4000
P +61 7 3217 8772

E info@aarc.net.au
AARC.NET.AU

ABN. 71 620 818 920
ACN. 620 818 920

Document Control

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Project Manager:	Rod Hailstone

Aspect of assessment	Name, Qualification	Experience
Field personnel	Caitlin Fleck Meghan Barnard David Toms	3 years 3 years 14 years
Report Authors	Caitlin Fleck David Toms Bethany Ward Aiden Campbell	3 years 14 years 3 years 10 years

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List of Abbreviations

AARC	AARC Environmental Solutions Pty Ltd
AHD	Australian Height Datum
ALA	Atlas of Living Australia
ANZECC	Australia and New Zealand Environment and Conservation Council
ANZECC Guidelines	ANZECC Guidelines for Fresh and Marine Water Quality
AusRivAS	Australian River Assessment System
BoM	Bureau of Meteorology
Bonn Convention	Convention on the Conservation of Migratory Species of Wild Animals
CAMBA	China–Australia Migratory Bird Agreement
BMA	BHP Mitsubishi Alliance
CE	Critically Endangered
DAF	Department of Agriculture and Fisheries
DAWE	Department of Agriculture, Water and the Environment
DES	Department of Environment and Science
DoEE	Department of the Environment and Energy
E	Endangered
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EO Act	*Environmental Offsets Act 2014*
EP Act	*Environmental Protection Act 1994*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPBC Referral	Environment Protection and Biodiversity Conservation Act 1999 Referral
EPP (Water)	Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (Qld)
EVs	Environmental Values
EVNT	Endangered, Vulnerable or Near Threatened
GDE	Groundwater dependent ecosystems
GDE Atlas	National Atlas of Groundwater Dependent Ecosystems
ISQG	Interim Sediment Quality Guidelines
JAMBA	Japan–Australia Migratory Bird Agreement
Jellinbah	Jellinbah Group Pty Ltd
LOR	Limit of Reporting

MDL	Mine Development Licence
ML	Mining Lease(s)
MLES	Matters of Local Environmental Significance
MNES	Matters of National Environmental Significance
MSES	Matters of State Environmental Significance
Mtpa	million tonnes per annum
NATA	National Association of Testing Authorities
NC Act	*Nature Conservation Act 1992*
NCWR	Nature Conservation (Wildlife) Regulation 2006
NL	Not Listed
NT	Near Threatened
NTU	Nephelometric Turbidity Unit
PCI	Pulverised Coal Injection
PSMT	Protected Matters Search Tool
the Project	Meadowbrook Project
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SLC	Special Least Concern
SPRAT	Species Profile and Threats Database
V	Vulnerable
VM Act	*Vegetation Management Act 1999*
WoNS	Weeds of National Significance
WQO	Water Quality Objective(s)

1 Introduction

1.1 Background

AARC Environmental Solutions Pty Ltd (AARC) was commissioned by Bowen Basin Coal Pty Ltd (Bowen Basin Coal) (the Proponent) to prepare an Aquatic Ecology Assessment for the Lake Vermont Meadowbrook Project (the Project) Environmental Impact Statement (EIS).

The Project is located approximately 160 km south-west of Mackay and approximately 25 km north-east of Dysart, in the Bowen Basin of central Queensland (Figure 1).

The Project represents an extension of mining activities at the existing Lake Vermont Mine and involves underground longwall mining and open cut mining activities and the development of supporting infrastructure. The existing Lake Vermont Mine operates within Mining Lease (ML) 70331, ML 70477 and ML 70528 (Figure 2) in accordance with Environmental Authority (EA) Permit No. EPML00659513.

The Project maximises the use of Bowen Basin Coal owned land and infrastructure at the Lake Vermont Mine to minimise the environmental impacts from additional infrastructure and provide Project efficiencies. The proposed Project extension footprint lies within Mineral Development Licence (MDL) 303 and MDL 429 held by the proponent. Bowen Basin Coal has submitted a Mining Lease Application over a portion of MDL 303 and MDL 429.

The key components of the Project include:

- underground longwall mining of the Leichardt Lower Seam and Vermont Lower Seam; the depth and thickness of the coal seams in the Project area means the coal resource can be extracted using underground mining methods;
- an open cut satellite pit to mine the Leichardt Lower Seam, Vermont Seam and Vermont Lower Seam;
- development of a new infrastructure corridor linking the new mining area to the existing infrastructure of the Lake Vermont Mine;
- development of a mine infrastructure area (MIA);
- construction of drifts and portal to provide access to underground operations; and
- development of other supporting infrastructure and associated activities.

The Project involves the extraction of up to 7 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal, equivalent to approximately 5.5 Mtpa of metallurgical product coal (for the export market). The Project addresses the forecast decline in coal output from the Lake Vermont Mine, by maintaining existing (approved [up to 12 Mtpa ROM]) production levels across an extended life of the mine. The anticipated extension to the life of the Lake Vermont Mine is approximately 25 years. A detailed description of the Project is provided in the EIS.

The conceptual layout of the Project is shown in Figure 3.

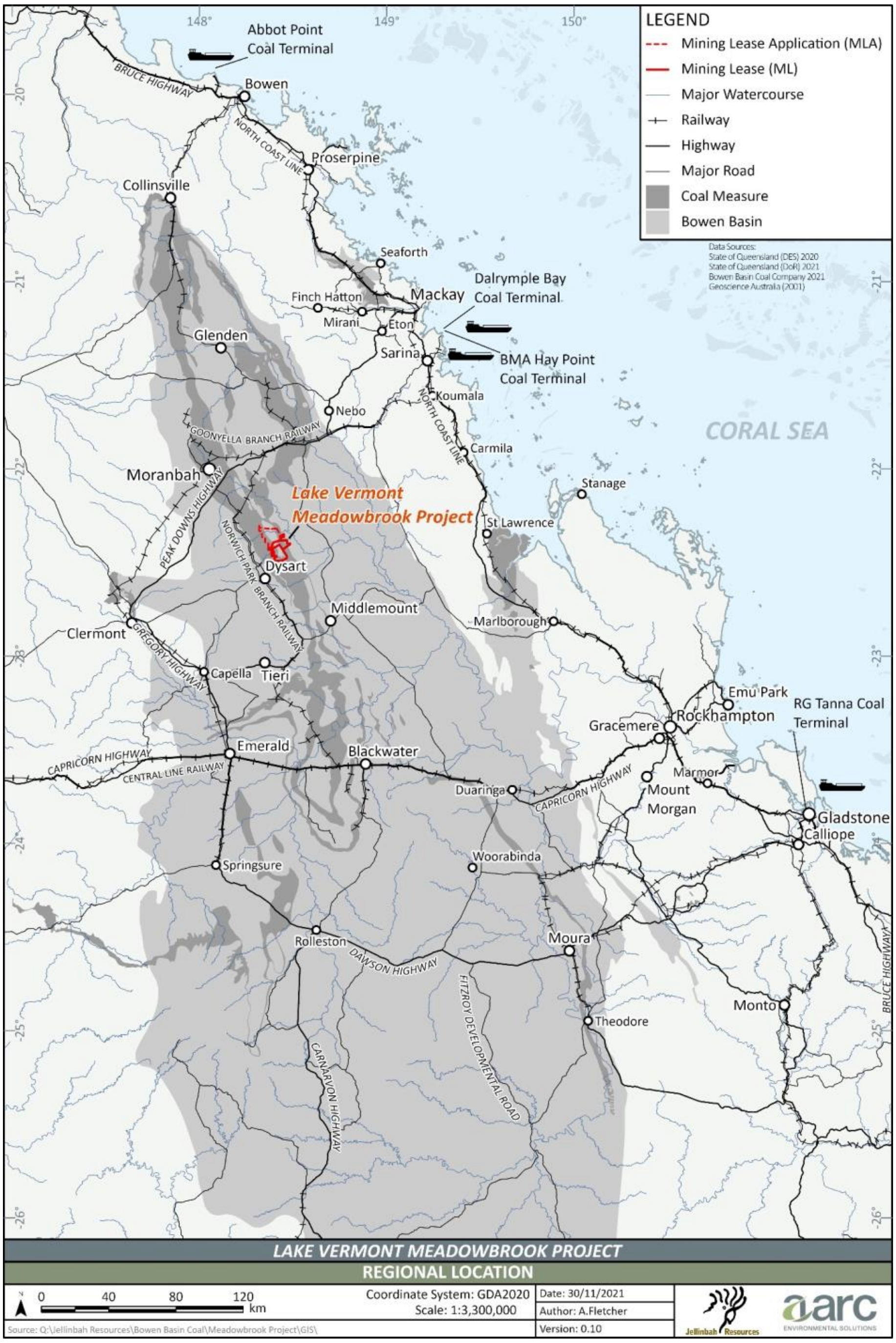


Figure 1: Regional location

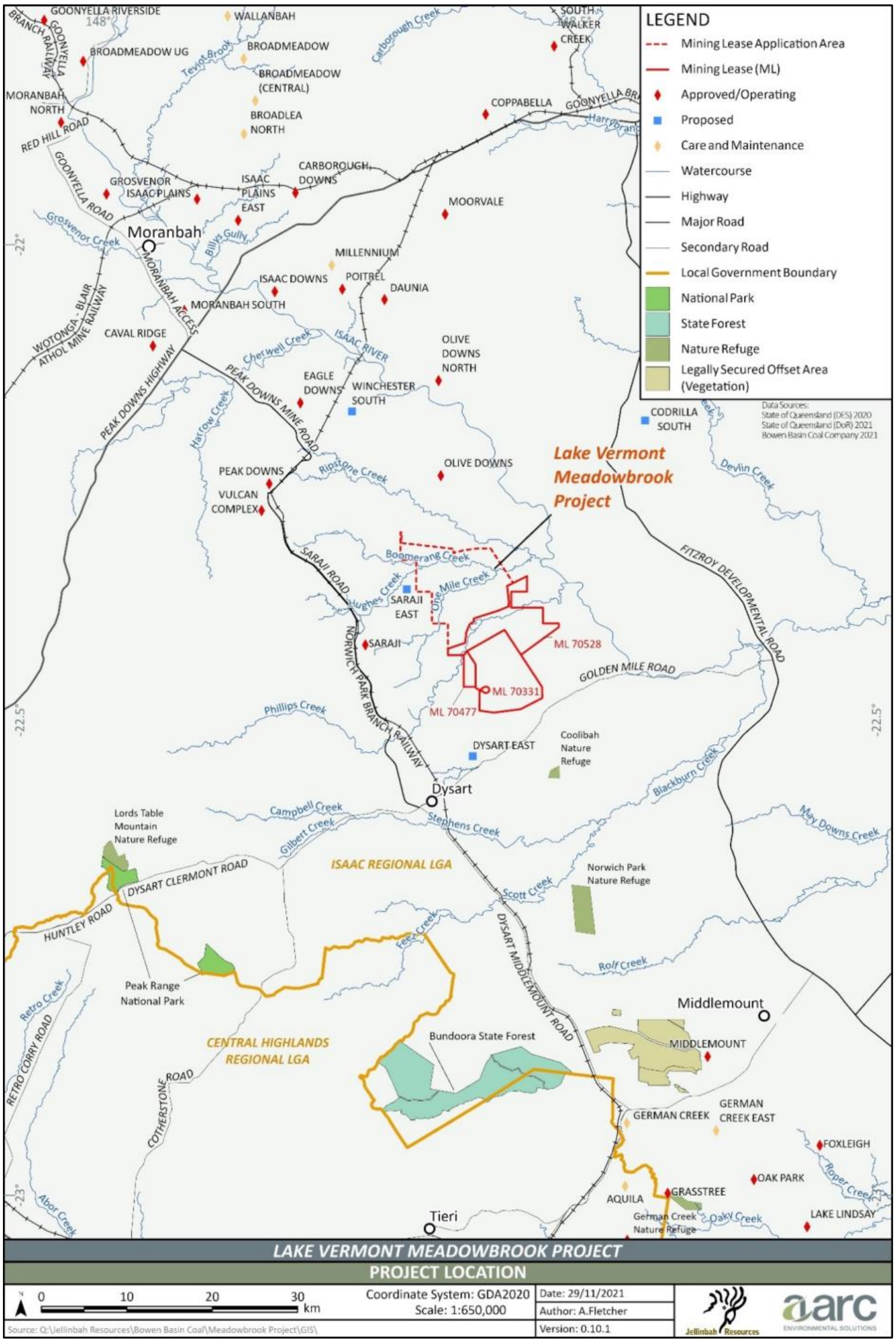


Figure 2: Project location

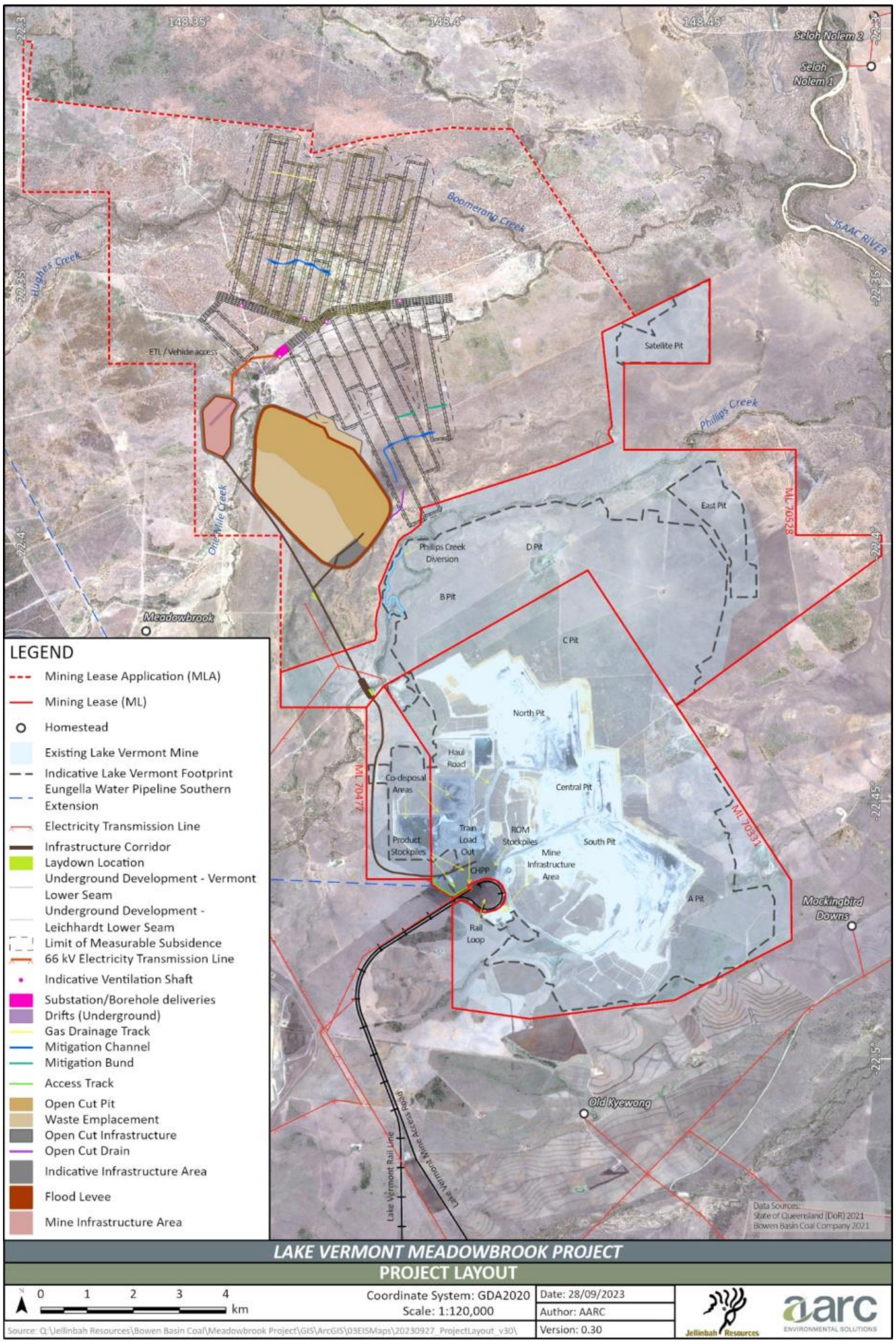


Figure 3: Conceptual Project layout

1.2 Study objectives

This report assesses the aquatic ecological values of the Project and surrounds and the potential impacts of the Project on these values. Specifically, this report:

- identifies legislation and policies applicable to the Project and aquatic flora and fauna;
- describes the desktop assessments conducted for the Project to identify conservation significant species and ecological communities that have potential to occur within the study area;
- describes the seasonal and targeted terrestrial flora and fauna surveys conducted for the Project and the results of the surveys;
- identifies significant species and ecological communities within the study area (i.e. on the Project site and in its vicinity), including:
    - Matters of State Environmental Significance (MSES);
    - Matters of National Environmental Significance (MNES);
    - native and introduced flora and fauna species; and
- assesses the integrity of ecological processes and landscapes (including the habitats of listed Endangered, Vulnerable, Near Threatened or Special Least Concern species, and habitat and ecosystem connectivity);
- identifies the potential direct and indirect impacts of the Project on aquatic species and ecosystems, and proposes measures to avoid, minimise or mitigate the impacts; and
- identifies any offsets requirements under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) and/or the Queensland *Environmental Offsets Act 2014* (EO Act), if any.

The Project Terms of Reference (DES 2020a) addressed by this report are provided in Appendix A. Appendix A outlines the sections of the report in which the Terms of Reference are addressed.

1.3 Aquatic ecology study area

The aquatic ecology study area for the Project is shown in Figure 4. The study area includes the waterways and wetlands within, adjacent to, upstream and downstream of the Project footprint. Specifically, the study area includes:

- the three watercourses which cross the Project footprint, namely
    - One Mile Creek;
    - Boomerang Creek; and
    - Phillips Creek;
- the section of the Isaac River at, and downstream of, the confluence of Boomerang Creek;
- a section of Ripstone Creek (north of the Project footprint);
- the wetlands shown within the aquatic ecology study area on Figure 4.

Section 2 describes the regional setting in which the study area is situated and Section 3 provides an overview of the study area and surrounds.

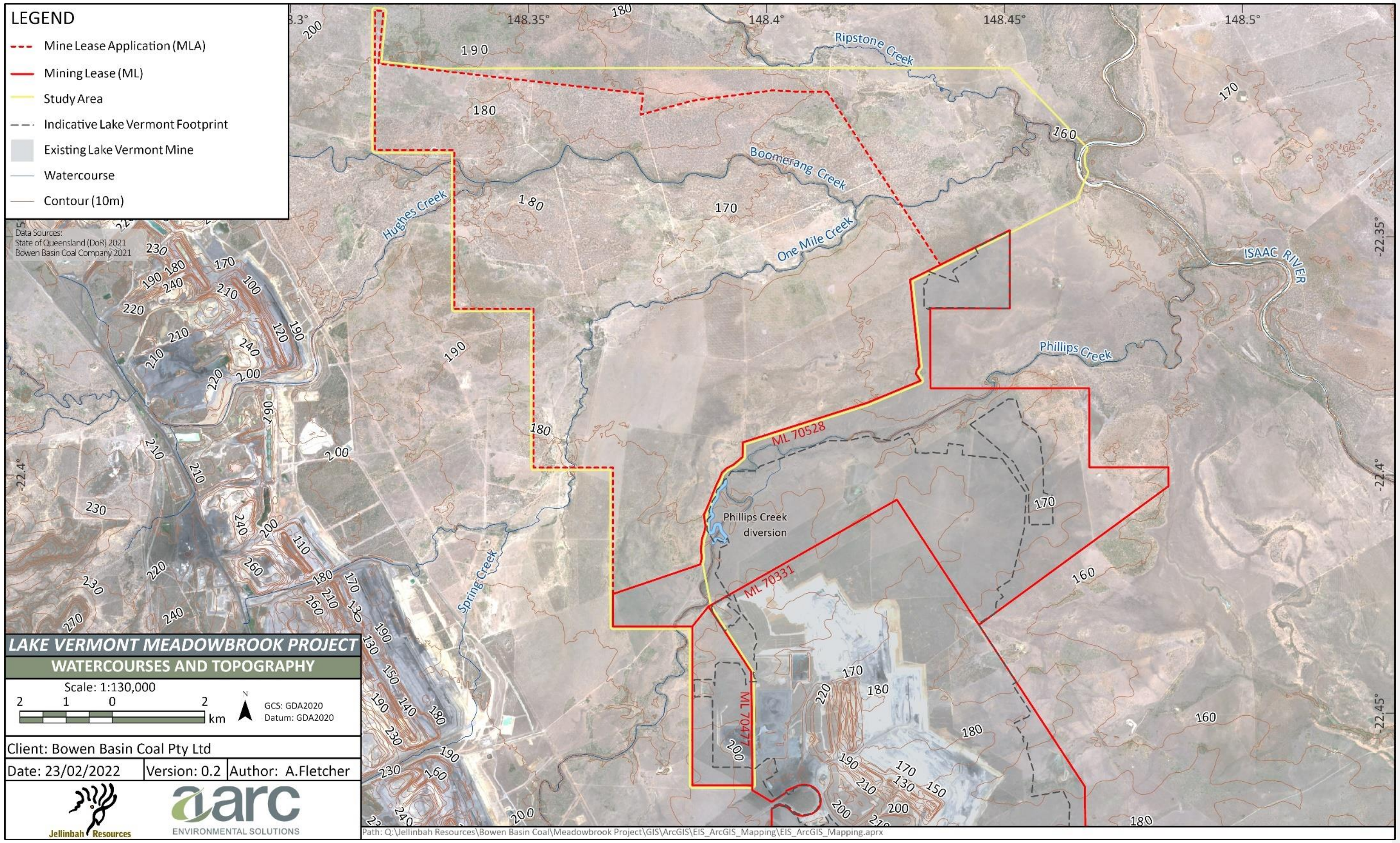


Figure 4: Aquatic ecology study area

2 Regional Setting

The Project is located within the Fitzroy River Basin, which encompasses an area of 142,545 km^2 and contains the Comet, Dawson, Fitzroy, Isaac, Nogoa, and Mackenzie River sub-catchment areas (BoM 2020a) (Figure 5). The Project lies within the Isaac River Sub-catchment, which covers a total area of 22,364 km^2, and comprises the catchments of the Isaac and Connors Rivers. The Isaac River is situated approximately 5 km to the east of the Project footprint. The Isaac River flows south from north of Moranbah and converges with the Mackenzie River approximately 107 km south-east of the study area. The Mackenzie River converges with the Dawson River to form the Fitzroy River, which eventually discharges into the Coral Sea south-east of Rockhampton.

The Project is located within the Brigalow Belt Bioregion (Figure 6). This bioregion occupies over a fifth of Queensland; extending from Townsville in the north to near the border of New South Wales in the south. The Brigalow Belt Bioregion encompasses a broad climatic gradient and a diversity of soils and topography; and is host to a high diversity of flora and fauna (DES 2018). The Brigalow Belt Bioregion is divided by the Great Dividing Range into the Brigalow Belt South Bioregion and the Brigalow Belt North Bioregion. The Project is situated within the Brigalow Belt North Bioregion (DoEE 2016). The Brigalow Belt North Bioregion is characterised by woodlands of Ironbark's *(Eucalyptus melanophloia*, *E. crebra*), Poplar Box (*E. populnea*), Browns Box (*E. brownii*), Brigalow (*Acacia harpophylla*), Blackwood *(A. argyrodendron*) and Gidgee *(A. cambagei*) (NRS 2000).

The region is described as subhumid, semi-tropical to semi-arid with predominantly summer rainfall (DEWHA 2008a, DoEE 2016). Based on data sourced from the Bureau of Meteorology (BoM) Weather Station at the Moranbah Airport (BoM station 034035), mean maximum monthly temperatures range between 24.1°C in June and 35.4°C in December and the mean minimum monthly temperatures between 8.5°C (July) to 21.5°C (January) (Figure 7). Mean maximum and minimum monthly temperatures recorded at the Clermont Airport (BoM station 035124) show a similar trend in temperature (Figure 7).

The Booroondarra BoM weather station (035109) is located approximately 30 km south of Dysart and approximately 45 km south of the study area. Mean monthly rainfall recorded at the Booroondarra BoM station indicates April to September are typically drier months with mean monthly rainfall ranging from 16.1mm to 33.8 mm (Figure 8). October through to March signifies the wet season with mean monthly rainfall ranging from 41.3 to 73.7mm. Rainfall is considered a major trigger for increased activity in many species within the Brigalow Belt Bioregion (Eyre *et al.* 2018).

Land use within the Brigalow Belt North Bioregion is primarily beef cattle grazing on pastoral leases; however, coal mining is a major regional economic driver (DEWHA 2008a). The resource developments (approved and pending) that occur within 50 km of the study area are provided in Figure 7.

Protected areas in Queensland include National Parks and nature refuges, and other areas established under the Queensland *Nature Conservation Act 1992*. No protected areas occur within the Project area. The Coolibah Nature Refuge, Norwich Park Nature Refuge and Peak Range National Park are located approximately 12 km to the south, 25 km to the south and 50 km to the south-west, respectively (Figure 2). There are no World Heritage areas within the Project area or surrounds.

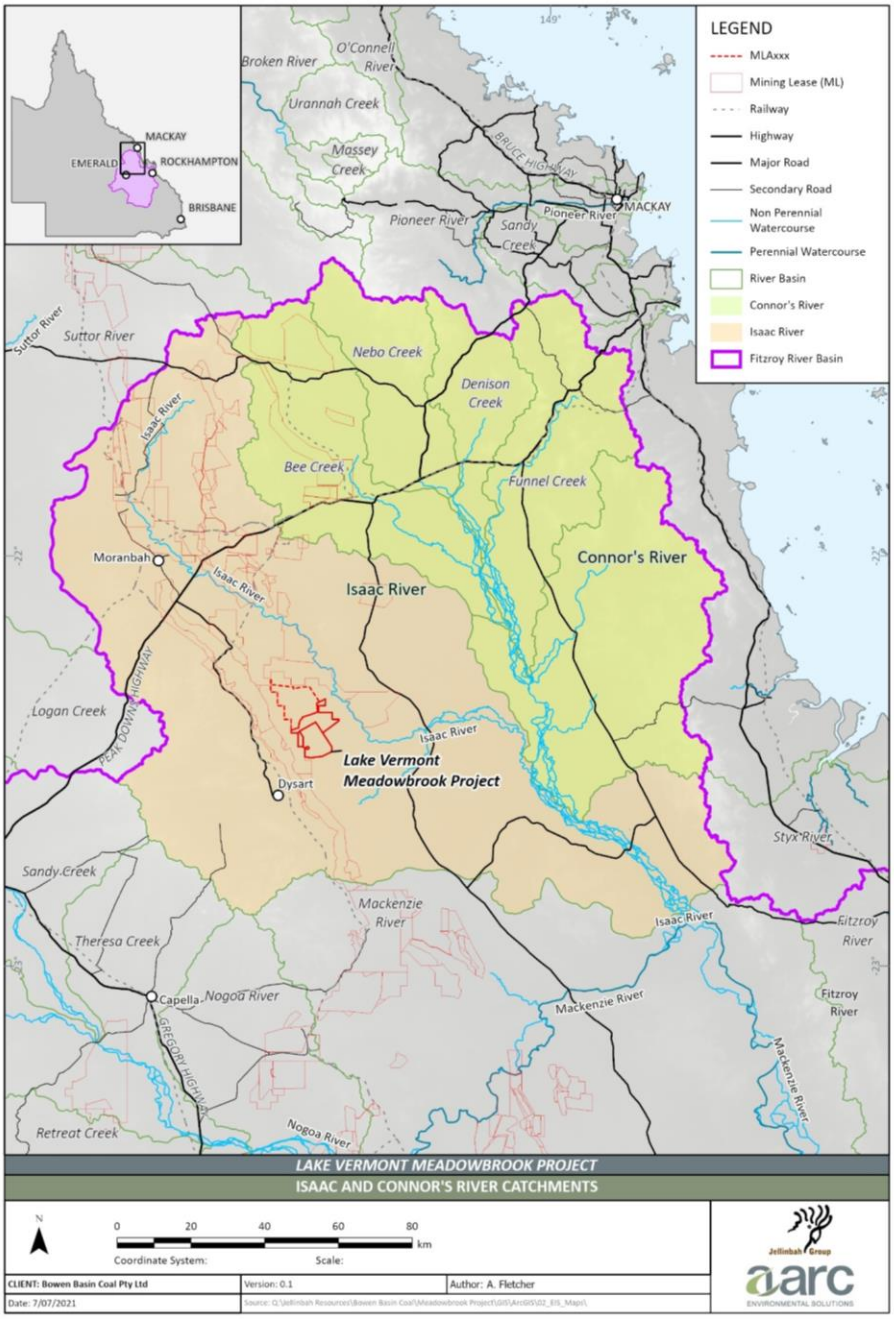


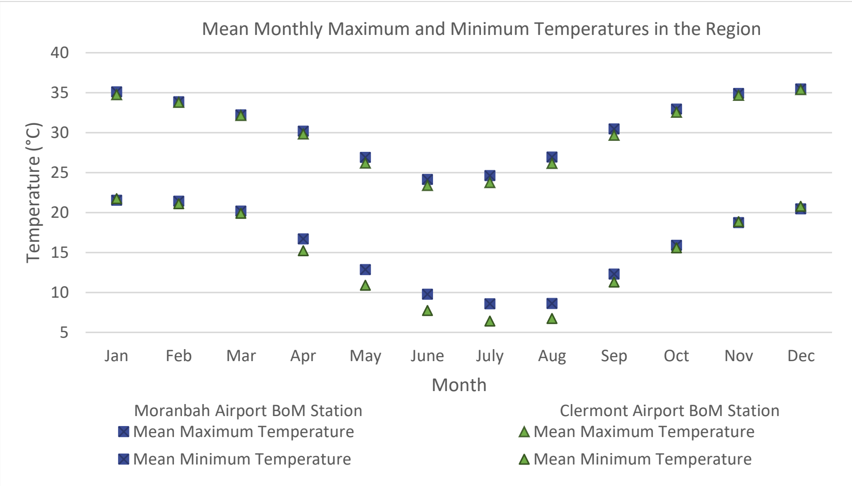
Figure 5: Fitzroy River Basin

Figure 6: Brigalow Belt Bioregion

3 Description of study area and surrounds

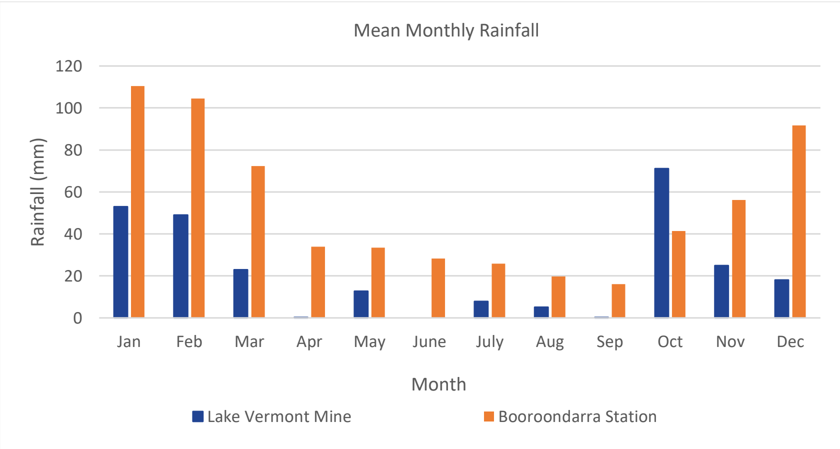
3.1 Climate

The climate of the study area is typical of the surrounding region. The rainfall recorded by the Lake Vermont Mine rainfall gauge (July 2017 to June 2020) reflects the wet and dry seasons of the Brigalow Belt Bioregion (Figure 8).



Source: Moranbah Airport BoM Station 034035, February 2012 - September 2020.
Clermont Airport BoM Station 035124, March 2010 - September 2020.

Figure 7: Regional mean monthly maximum and minimum temperatures



Source: Lake Vermont Mine Rainfall, July 2017 - June 2020
Booroondarra BoM Station 035124, March 1929 - September 2020

Figure 8: Regional mean monthly rainfall

3.2 Hydrology

The Isaac River is situated approximately 5 km to the east of the Project footprint. The Isaac River flows south from north of Moranbah and converges with the Mackenzie River approximately 107 km south-east of the study area. The Mackenzie River converges with the Dawson River to form the Fitzroy River, which eventually discharges into the Coral Sea south-east of Rockhampton (Hatch 2018a).

A number of tributaries traverse the study area and flow in an easterly direction to the Isaac River. The tributaries include Boomerang Creek, Hughes Creek, One Mile Creek, Phillips Creek, and Ripstone Creek (Figure 9). Boomerang Creek is an ephemeral fifth order stream that traverses the northern portion of the study area upstream of its confluence with the Isaac River (Figure 9). Hughes Creeks flows into Boomerang Creek near the western boundary of MDL 429. The headwaters of Boomerang Creek and Hughes Creek occur to the west of the study area and traverse the tenure of the Saraji Mine (ML 1775).

One Mile Creek, a third order stream, traverses the study area from the south-west until its confluence with Boomerang Creek towards the north-eastern boundary of the study area. Ripstone Creek, also a third order stream, occurs to the north of the study area and flows eastward before flowing into Boomerang Creek to the east of the study area. The Olive Downs Coking Coal Project has approval to divert a section of Ripstone Creek near the northern boundary of MDL 429. The surface water assessment for the Olive Downs Coking Coal Project concluded the hydraulic properties of the Ripstone Creek diversion were within the parameters set by the relevant guidelines (Hatch 2018).

Phillips Creek is a fourth order stream that traverses a portion of the southern study area within ML 70528. Phillips Creek meanders along the northern boundary of ML 70528 outside of the study area before converging with the Isaac River (Figure 9).

Aerial imagery taken of areas to the west of the study area shows that the upstream reaches of all four watercourse which traverse the study area (Boomerang Creek, Hughes Creek, One Mile Creek, Phillips Creek, and Ripstone Creek) have been heavily modified by mining activities resulting in the removal of catchment, changes in drainage pathways and modified runoff characteristics.

Boomerang Creek, Hughes Creek, One Mile Creek, Ripstone Creek, Phillips Creek, and the Isaac River are defined watercourses under the *Water Act 2000* (Qld).

3.3 Topography, Land zones and soils

The topography of the study area is generally flat to gently undulating, with elevations ranging between 160 m and 190 m Australian Height Datum (AHD) (Figure 9). The topography of the study area is representative of the surrounding region.

The following land zones (and associated soil types) occur within the study area:

- Land Zone 3: Recent Quaternary alluvial systems, including closed depressions, paleo-estuarine deposits currently under freshwater influence, inland lakes, and associated wave-built lunettes (Wilson and Taylor 2012). Land Zone 3 excludes colluvial deposits such as talus slopes and pediments. This Land Zone includes a diverse range of soils predominantly Vertosols and Sodosols (Wilson and Taylor 2012). Land Zone 3 also occurs with Dermosols, Kurosols, Chromosols, Kandosols, Tenosols, Rudosols and Hydrosols; and Organosols in high rainfall areas (Wilson and Taylor 2012).
- Land Zone 4: Tertiary-early Quaternary clay deposits, usually forming level to gently undulating plains not related to recent Quaternary alluvial systems (Wilson and Taylor 2012). This Land Zone mainly occurs with Vertosols with gilgai microrelief. Land Zone 4 also includes thin sandy or loamy surfaced Sodosols and Chromosols with the same paleo-clay subsoil deposits (Wilson and Taylor 2012).
- Land Zone 5: Tertiary-early Quaternary loamy and sandy plains and plateaus (Wilson and Taylor 2012). Land Zone 5 consists of extensive, uniform near level or gently undulating plains with sandy or loamy soils and includes dissected remnants of these surfaces. oils are usually Tenosols and Kandosols, also minor deep sandy surfaced Sodosols and Chromosols (Wilson and Taylor 2012).

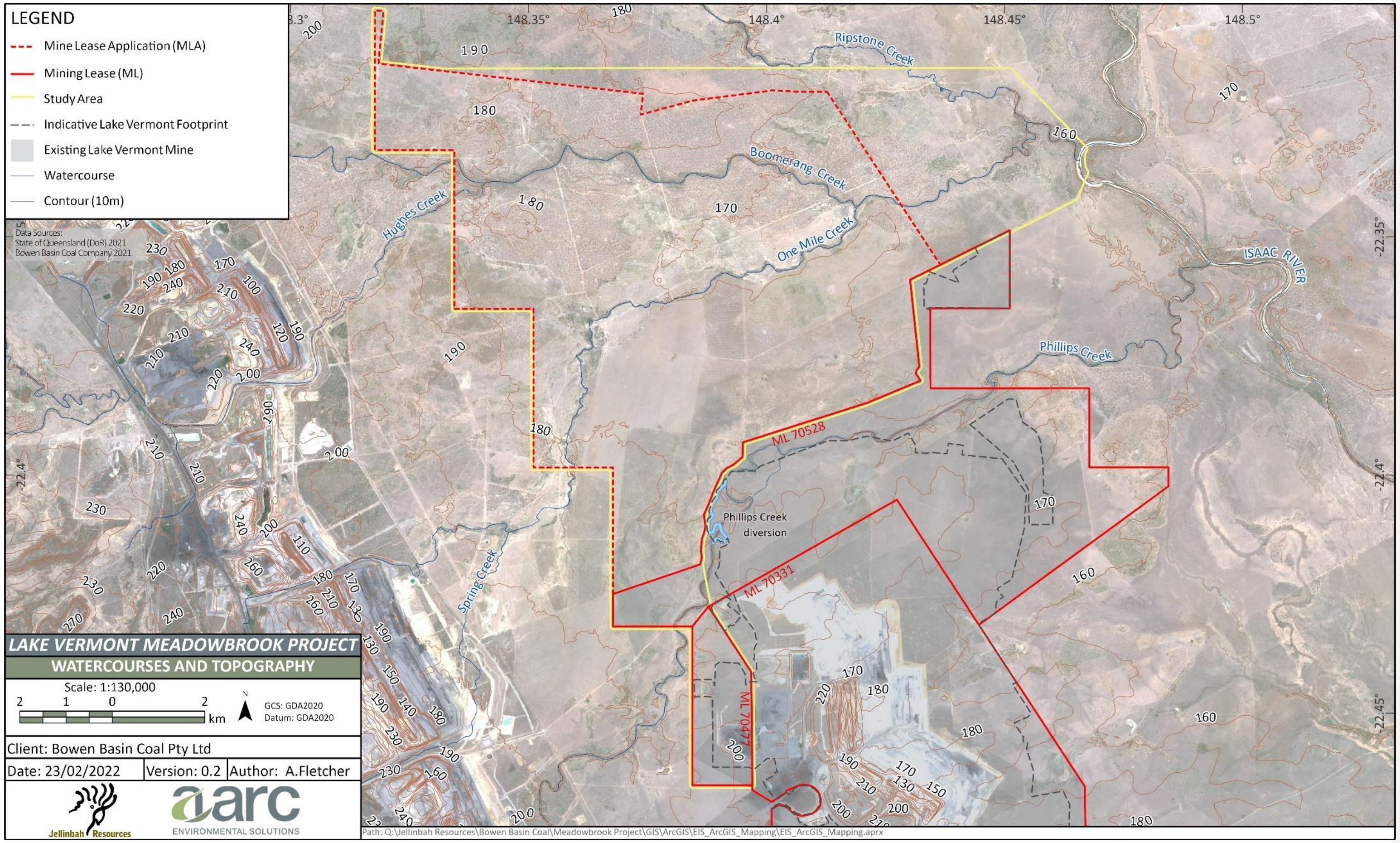


Figure 9: Waterways and topography of the study area and surrounds

3.4 Land use

The land within the study area is currently used for low intensity cattle grazing of native pastures and resource exploration activities. Queensland Land Use Mapping classifies the study area as 'Grazing Native Vegetation'. Other dominant land uses in the Projects' vicinity include 'Mining' and 'Cropping'.

The Lake Vermont Mine owned by Bowen Basin Coal is an operation that produces primarily hard coking coal and low volatile Pulverised Coal Injection (PCI) coal. Product coal is transported direct from the mine by rail to the Gladstone Port and Dalrymple Bay and Abbott Point Coal Terminals. An 18 km rail spur and balloon loop were constructed for the mine from the main Dysart railway to a train loader constructed beside the CHPP.

The Vermont Coal Project EIS for the Lake Vermont Mine was submitted in 2004 (Minserve 2004), with approval granted in 2005. The Lake Vermont Mine has undergone two extensions since its original approval; the Western Infrastructure Extension (2012) and the Lake Vermont Northern Extension Project (2015). The Western Infrastructure Extension provided for the construction of new supporting infrastructure for the Lake Vermont Mine within ML 70477. The Lake Vermont Northern Extension Project provided for open cut mining of coal resources located on ML 70528.

There are several other coal mining projects on adjacent or nearby tenure (Table 1). The Saraji Mine and the associated Saraji East Project and Caval Ridge Coal Mine border the Project tenure to the west, while the Olive Downs Coking Coal Project borders MDL 429 to the north and north-east. The Peak Downs Mine occurs approximately 4.1 km to the west of the study area, The study area overlaps with existing petroleum tenements in the region, specifically those for the Arrow Bowen Gas Project.

Table 1: Nearby mining developments

Project Name	Proponent	Distance/ Direction from study area
Saraji Mine	BHP Coal Pty Ltd	3.2 km west
Saraji East Project	BHP Billiton Mitsubishi Alliance Coal Operations	Borders the western boundary of the study area and Lake Vermont Mine
Caval Ridge Coal Mine	BHP Billiton Mitsubishi Alliance Coal Operations	3.2 km west
Peak Downs Mine	BM Alliance Coal Operations Pty Ltd	4.1 km west
Olive Downs Coking Coal Project	Pembroke Olive Downs Pty Ltd	< 1 km north
Eagle Downs Coal Mine	Bowen Central Coal Joint Venture Parties	12.6 km north-west
Moranbah South Project	Anglo Coal (Grosvenor) Pty Ltd and Exxaro Australia Pty Ltd	21.2 km north-west
Isaac Downs Project	Stanmore IP South Pty Ltd	22 km north north-west
Millennium Expansion Project	Millennium Coal Pty Limited	31 km north north-west
Isaac Plains East	Stanmore IP Coal Pty Ltd	38 km north north-west
Grosvenor Coal Mine	Anglo Coal (Grosvenor) Pty Ltd	38 km north north-west

4 Relevant legislation and policy

Commonwealth and Queensland legislation and policies relevant to the assessment of aquatic ecological values on the study area are discussed in the following sub-sections.

4.1 Queensland

4.1.1 *Environmental Protection Act 1994*

The objective of the Environmental Protection Act 1994 (Queensland) (EP Act) and its associated Regulations and Policies are to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. This is commonly referred to as ecologically sustainable development. The EP Act addresses the following areas that are relevant to the Project:

- notifiable activities, that are listed in Schedule 3 of the EP Act;
- environmental protection policies for water and wetland biodiversity, noise and air which are intended to enhance or protect Queensland's environment and list relevant environmental outcomes and performance criteria;
- Environmental Regulated Activities defined within the EP Act and listed in schedule 2 of the Environmental Protection Regulation 2019;
- EAs which are required to carry out an environmentally relevant activity including a resource activity, and which will include conditions that will regulate the Project activities; and
- duties of care associated with environmental harm.

The EP Act also prescribes the EIS process which is managed by the Queensland Department of Environment and Science (DES), which will decide the EA application for the Project. Following any grant of an EA, the DES would subsequently monitor and regulate the Project's mining activities, in accordance with the EA conditions, throughout the life of the Project.

4.1.2 *Nature Conservation Act 1992*

The Queensland *Nature Conservation Act 1992* (NC Act) and its associated Regulations provide a framework for the creation and management of protected areas (such as National Parks) and for the protection of native and threatened species. The Regulations include the Nature Conservation (Animals) Regulation 2020 and the Nature Conservation (Plants) Regulation 2020.

The Nature Conservation (Animals) Regulation 2020 and the Nature Conservation (Plants) Regulation 2020 prescribe the following classes of protected wildlife[1]:

- Extinct;
- Extinct in the wild;
- Critically Endangered;
- Endangered;
- Vulnerable;
- Near Threatened; and

1 Under the NC Act the term wildlife refers to any native taxon or species of an animal, plant, protista, procaryote or virus.

- Least Concern.

The Nature Conservation (Animals) Regulation 2020 prescribes Least Concern wildlife as a Special Least Concern wildlife for the following species:

- Short-beaked Echidna (Tachyglossus aculeatus).
- Platypus (Ornithorhynchus anatinus).
- A Least Concern bird to which any of the following agreements apply: China–Australia Migratory Bird Agreement, Japan–Australia Migratory Bird Agreement, Republic of Korea–Australia Migratory Bird Agreement or the Convention on the Conservation of Migratory Species of Wild Animals.

Under the NC Act a Regulation may prescribe a Least Concern plant as a Special Least Concern plant if the taking or use of the plant is at risk of not being ecologically sustainable. The aim of the protected plants legislative framework under the NC Act is to ensure the survival of viable populations of protected plants in the wild as well as to identify and reduce threatening processes.

Permits and licences may be required to authorise impacts to, or the handling of native flora and fauna. For example, if there is a requirement for the clearing of Endangered, Vulnerable or Near Threatened plants protected under the NC Act a Protected Plant Clearing Permit may be required.

4.1.3 *Biosecurity Act 2014*

The *Biosecurity Act 2014* (Qld) (Biosecurity Act) provides comprehensive biosecurity measures to safeguard our economy, agricultural and tourism industries, environment and way of life, from pests, diseases, and contaminants.

Biosecurity matters are separated into two broad categories:

1) A 'prohibited matter' is a biosecurity matter that is not found in Queensland but would have a significant adverse impact on our health, way of life, and the economy or the environment if it entered the state. Prohibited matters must be reported to Biosecurity Queensland within 24 hours and all reasonable steps taken to minimise the risks of the prohibited matter and not make the situation worse.
2) A 'restricted matter' is a biosecurity matter found in Queensland and has a significant impact on human health, social amenity, the economy, or the environment. Restricted matters are further broken down into seven categories, with each category placing restrictions on the dealings with the biosecurity matter or actions required to be taken to minimise the spread and adverse impact of the biosecurity matter.

Everyone is obligated to take all reasonable and practical steps to minimise the risks associated with other biosecurity matters under their control. The Biosecurity Act is relevant to the Project in regard to the control and management of invasive plant and animal species

4.1.4 *Environmental Offsets Act 2014*

The Queensland environmental offsets framework consists of the EO Act, Environmental Offsets Regulation 2014, and the 'Queensland Environmental Offsets Policy (Version 1.10)' (DES 2021). The offsets framework requires environmental offsets to be delivered where an activity is likely to result in a significant residual impact on a prescribed environmental matter. The 'Significant Residual Impact Guideline' (DEHP 2014) is used to determine whether a residual impact is significant.

Prescribed environmental matters include:

- matters of national environmental significance (MNES);
- matters of state environmental significance (MSES); and
- matters of local environmental significance (MLES).

These prescribed environmental matters are outlined in the Environmental Offsets Regulation 2014.

MNES are matters that are protected and regulated under the EPBC Act, which are listed in section 5 of the Environmental Offsets Regulation. MSES are matters protected and regulated under Queensland legislation and are listed in schedule 2 of the Environmental Offsets Regulation. A MLES, cannot replicate a MNES or MSES, and is a matter that is prescribed under a local planning instrument as a prescribed environmental matter.

MSES comprise:

- regulated vegetation including:
  - Endangered and Of Concern REs;
  - REs that intersect areas shown as wetlands on the Vegetation Management Wetlands map;
  - REs located within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature; and
  - REs mapped as essential habitat for Endangered and Vulnerable flora and fauna;
  - areas that provide connectivity and maintain ecosystem functioning;
- mapped wetlands and watercourses;
- designated precincts in a strategic environmental area under the Regional Planning Interests Regulation 2014;
- protected wildlife habitat;
- protected areas and highly protected zones of State marine parks;
- fish habitat areas;
- waterways providing for fish passage;
- marine plants; and
- legally secured offsets.

4.1.5 *Fisheries Act 1994*

The main purpose of the *Fisheries Act 1994* is to provide for the use, conservation and enhancement of the community's fisheries resources and fish habitats in a way that seeks to apply and balance and the principles of and promote ecologically sustainable development. The Fisheries Act provides for:

- the management and protection of fish habitats;
- the management of commercial, recreational and indigenous fishing; and
- the management of aquaculture.

Several fish species of special interest are listed as 'no take' species under the Fisheries Act, including the Australian lungfish.

Fisheries resources, including declared fish habitat areas which are MSES, contribute to the environmental values of waterways and wetlands.

The Fisheries Act also requires waterway barrier works approvals where waterway crossings are constructed or upgraded. For mining developments, where works are undertaken within a mining lease and according to the conditions of an Environmental Authority, waterway barrier works impacts to fish passage are considered as a MSES and a waterway barrier works approval under the Planning Act 2016 will not be required. Works undertaken off-lease under a development approval will require an approval under the Planning Act 2016.

4.1.6 Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (Water)) is subordinate legislation under the *Environmental Protection Act 1994*. The EPP (Water and Wetland Biodiversity) provides a framework for:

- identifying environmental values (EVs) for Queensland waters, and deciding water quality objectives (WQOs) to protect or enhance those EVs; and
- including the identified EVs and WQOs under Schedule 1 of the EPP (Water and Wetland Biodiversity).

The EPP (Water and Wetland Biodiversity) is relevant to the Project with regard to the protection of EVs occurring in the Mackenzie River sub-basin and associated tributaries.

The EVs and WQOs for waters occurring on or surrounding the study area are provided in the document titled *Environmental Protection (Water) Policy 2009; Isaac River Sub-basin Environmental Values and Water Quality Objectives* (DES, 2013). The EVs and WQOs are detailed in Section 6.

4.1.7 *Water Act 2000*

The *Water Act 2000* (Water Act) provides the framework for the sustainable management of Queensland's water resources and quarry material, through establishing a system for the planning, allocation and use of water; and the allocation of quarry material and riverine protection. The Water Act also has the purpose of securing water supply and demand management for the south-east Queensland region and other designated regions and the management of impacts on underground water cause by the exercise of underground water rights by the resource section.

Under the Water Act, a person must not take or interfere with water unless authorised under the Water Act, or another Act. There are a number of watercourses within the Project area that are subject to the provisions of this Act.

Under the Water Act, a riverine protection permit may also be required to enable the placement of any fill, or for the undertaking of any excavation within a watercourse. This may be relevant in relation to potential vehicle crossings required for the Project.

4.2 Commonwealth

4.2.1 *Environment Protection and Biodiversity Conservation Act 1999*

The EPBC Act provides a framework to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage places, which are defined in the EPBC Act as MNES. The EPBC Act applies to nine MNES:

1) world heritage properties;
2) national heritage places;
3) wetlands of international importance (Ramsar wetlands);
4) nationally listed threatened species and ecological communities;
5) migratory species;
6) Commonwealth marine areas;
7) the Great Barrier Reef Marine Park;
8) nuclear actions (including uranium mines); and
9) a water resource, in relation to coal seam gas development and large coal mining development.

The EPBC Act requires assessment and approval for any activity that has, or is likely to have, a significant impact on a MNES. The Project was determined to be a controlled action (EPBC Referral 2019/8485) under the EPBC Act on 22 November 2019 (DoEE 2019). The relevant controlling provisions for the Project under the Act are:

- listed threatened species and communities (sections 18 and 18A);
- listed migratory species (sections 20 and 20A); and
- a water resource in relation to coal seam gas development and large coal mining development (sections 24D and 24E).

4.2.2 International conventions and agreements

Providing critical habitat for millions of migratory birds each year, Australia is party to international conventions and agreements to protect migratory species. These include the:

- China–Australia Migratory Bird Agreement (CAMBA);
- Japan–Australia Migratory Bird Agreement (JAMBA);
- Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA); and
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

Each of these agreements provides for the protection and conservation of migratory birds and their important habitats, protection from take or trade except under limited circumstances, the exchange of information, and building cooperative relationships (DAWE 2020). Bird species listed within the appendices/annexes of these agreements/conventions, are subsequently listed as migratory species under the EPBC Act.

4.2.3 Environmental offsets policy

The 'Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy' outlines the Australian Government's position on the use of environmental offsets (DSEWPC 2012). Environmental offsets can be used under the EPBC Act to maintain or enhance the health, diversity and productivity of the environment as it relates to matters protected by the EPBC Act.

Section 4 and section 5.2 of the 'Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy' states that offsets under the EPBC Act are required if residual impacts to MNES are 'significant' (DSEWPC 2012). The ''Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy' provides guidance on the role of offsets in environmental impact assessments and how the Department of Agriculture, Water and the Environment (DAWE) considers the suitability of a proposed offset package (DSEWPC 2012).

5 Desktop Assessment and preliminary survey

5.1 Desktop assessment methods

Desktop assessments were conducted to collate information on the aquatic ecological values within the study area and surrounds. A review of Government mapping, database searches and a review of available literature was conducted to inform the aquatic ecology assessment and field survey techniques to be used to target conservation significant species known from the region.

The review of government mapping included:

- The DES Environmental Report: Matters of State Environmental Significance, to identify known MSES within the study area and surrounds (DES 2018-2021a) (Appendix A).
- The DES Environmental Report: Regional Ecosystems Biodiversity Status, to identify remnant Regional Ecosystems within the study area and surrounds (DES 2018-2021b) (Appendix A).
- The Department of Resources (DoR, previously the Department of Natural Resources Mines and Energy, DNRME) Vegetation Management Report to identify areas of regulated vegetation, Vegetation Management Regional Ecosystems mapping (VM Act), and essential habitat for protected wildlife (NC Act) within the study area and surrounds (DoR 2018-2021a).
- The Queensland Government's Wetlands Maps Report, to identify wetland waterbodies and protected areas within the study area and surrounds (Queensland Wetlands Program 2018-2020).
- The DES Modelled Potential Habitat Mapping to identify threatened species that have been modelled to have pre-clear potential habitat within the study area and surrounds (DES 2018-2020c).
- The Queensland Government's Environmentally Sensitive Area mapping to identify areas mapped as environmentally sensitive within the study area and surrounds (Queensland Government 2018-2020b).
- The DES Environmental Report: Biodiversity and Conservation Values, to identify known Biodiversity Planning Assessment areas and Aquatic Conservation Assessment areas within the study area and surrounds (DES 2018-2020d) (Appendix A).
- The BoM mapping of GDEs (study area and surrounds) (BoM 2021).

The database searches undertaken included:

- The DES Wildlife Online search and WildNet Wildlife Records results to identify Endangered, Vulnerable, Near Threatened (EVNT) and Special Least Concern (SLC) species records (searches based on central coordinate [-22.3503, 148.3908] with a 50 km buffer) (Queensland Government 2018-2020b, DES 2018-2020e). The results of the 10 km and 50 km searches are provided in Appendix A.
- The EPBC Act Protected Matters Search Tool to identify Matters of National Environmental Value (searches based on a central coordinate (-22.3503, 148.3908) with 10 km and 50 km buffers) (DAWE 2021) (the results of the 50 km search are provided in Appendix A).
- The Atlas of Living Australia Occurrence Records to identify EVNT and SLC species records (searches based on central coordinate [-22.3503, 148.3908] with a 50 km buffer) (ALA 2018-2020).

Several aquatic ecology surveys and assessments have been conducted for mining developments within proximity of the study area. Where available, these ecological surveys and assessments were reviewed to identify conservation significant flora and fauna.

5.2 Desktop assessment results

5.2.1 Previous aquatic ecology assessments

A literature review was conducted of studies that have investigated aquatic ecology values for adjacent and nearby projects. The review focused on aquatic habitat, aquatic flora and aquatic fauna values at these other projects and was used to help determine the aquatic values which could potentially occur within the study area, with a key focus being the occurrence of any aquatic species listed as threatened.

The key aquatic ecology studies considered were:

- Saraji East Project EIS located upstream Boomerang and One Mile Creek, west of the Project (frc environmental, 2018)
- Caval Ridge Coal Mine Project (BAAM 2009) located approximately 3.2 km west and north-west of the study area.
- Olive Downs Coking Coal Project EIS, located north of the Project (DPM Envirosciences, 2018)
- Isaac Downs Project located 22 km north north-west (frc environmental 2019) and the Isaac Plains East Extension, approximately 38 km north north-west of the study area C&R Consulting 2020).
- Lake Vermont Mine, which borders the southern and eastern boundaries of the study area (WBM Oceanics Australia 2003; Australasian Resource Consultants 2012; Australasian Resource Consultants 2016).
- A summary of the relevant information from the assessments is presented below. Comparison between the results of this aquatic ecology assessment and previous assessments in Section 8 where relevant.

Saraji East Project EIS

There were no threatened aquatic species identified within the study area for the Saraji East EIS which included One Mile Creek and Hughes Creek. Two sightings of eastern longnecked turtle (*Chelodina longicolis*) were presented in the EIS. Eleven native species of fish were caught during the baseline studies (frc environmental, 2018). All were common species that are tolerant of harsh environmental conditions (e.g. variable flow, fluctuating water quality) that are typical of ephemeral watercourses of the region.

Taxonomic richness of sampled macroinvertebrate communities ranged from 7 to 27 with four PET (Plecoptera, Ephemeroptera, Trichoptera) taxa recorded. SIGNAL-2 scores ranged from 2.14 to 3.5 demonstrating that macroinvertebrate communities are dominated by tolerant (i.e. not sensitive) taxa and are not sensitive to changes in environmental conditions.

As presented in the Saraji East EIS, macroinvertebrate sampling conducted at the operating Saraji Mine returned comparable results (SIGNAL-2 score of 3.3 and three PET taxa). The Saraji East EIS also presented evidence (Saraji Mine Trend Report 2011-2016, CQ University cited in frc environmental 2018) there were no adverse impacts on macroinvertebrate composition and indices between 2011 and 2016 from mining operations.

One pest species of aquatic plant was identified, water hyacinth *(Monochoria cyanea)* which is a listed biosecurity matter under the *Biosecurity Act 2014*.

Caval Ridge Project

Macroinvertebrate data was compared to the aquatic assessment for the nearby Daunia Coal Mine Project (also located within the Isaac River catchment) and indicated local waterways are 'significantly' or 'severely' impaired when analysed under the AusRivAS model (BAAM 2009).

Three fish species were caught, Western Carp Gudgeon (*Hypseleotris klunzingeri*), Spangled Perch (*Leiopotherapon unicolor*), and Eastern Rainbowfish (*Melanotaenia splendida*). All were typical of the Fitzroy drainage system. No aquatic fauna of special conservation significance was recorded during surveys for the Caval Ridge Project.

Olive Downs Coking Coal Project EIS

No conservation significant aquatic flora or fauna species listed under the NC At and/or EPBC Act were recorded. Nor was suitable habitat observed for EVNT turtle species or for Platypus (Ornithorhynchus anatinus). No MNES relevant to aquatic ecology were identified. The Project would remove seven High Ecological Significance (HES) wetlands (61 ha total) and subsequently, Pembroke has developed an offset strategy in accordance with State and Commonwealth requirements.

A total of 75 aquatic taxa representing 22 orders were contained within the samples from riverine and wetland ecosystems. Typically, the number of PET taxa, percentage of pollutant tolerant taxa and SIGNAL 2 scores fell within the DEHP (2011) 20:80 percentile guideline ranges derived for the Isaac River Sub-basin. This result indicates that aquatic macroinvertebrate community assemblages comprised the expected number of pollutant tolerant and pollutant sensitive taxa.

Isaac Downs Project

The three aquatic MNES species (White-throated snapping turtle, Fitzroy River turtle and Murray Cod) known to occur in the broader region were determined to be highly unlikely to occur in the waterways of the Isaac Downs Project study area. The nearest likely population is suggested to be 105 km downstream from the Isaac Downs Project study area. Five native fish species were detected within the study area as part of surveys; however, no Endangered species were recorded.

Isaac Plains Extension

None of the aquatic flora species known to occur within the region are listed under the EPBC Act or the NC Act, and none are declared Weeds of National Significance.

Past studies within neighbouring watercourses (and Smoky Creek downstream of the Project site) have identified 14 species of freshwater fish inhabiting the area, however, none of the fish species identified within Smoky Creek and/or neighbouring watercourses are listed under the EPBC Act or the NC Act.

Neither EPBC listed turtle species, the Fitzroy River turtle and White-throated snapping turtle were detected during the field surveys. The lack of preferred habitat, coupled with the highly ephemeral nature of the watercourses suggested there was no conducive habitats located across the Project site.

Lake Vermont Mine EIS

No rare or threatened flora species under the NC Act or EPBC Act were identified during aquatic ecology studies associated with the Project.

Six native fish species, all considered common throughout their ranges, have been recorded during surveys, namely; Spangled Perch *(Leiopotherapon unicolour*), Hyrtl's Tandan *(Neosilurus hyrtlii*), Midgley's Carp Gudgeon *(Hypseleotris species*), Flyspecked Hardyhead *(Craterocephalus stercusmuscarum),* Agassiz's Glassfish *(Ambassis agassizii*); and Southern Purple-spotted Gudgeon *(Mogurnda adspersa*). Most fish species recorded are capable of withstanding harsh environmental conditions. None are listed as threatened under Queensland or Commonwealth legislation.

Aquatic habitats within the Project site were utilised by two aquatic reptiles, the Keelback *(Tropidonophis mairii)* and Eastern Snake-neck turtle *(Chelodina longicollis*). These reptile species are both common and abundant in the region.

5.2.2 Matters of State Environmental Significance

5.2.2.1 Wetlands

Vegetation Management Wetlands

Under the VM Act a wetland is defined as an area of land that supports plants or is associated with plants that are adapted to and dependent on living in wet conditions for at least part of their life cycle (DEHP 2014a). The vegetation management wetlands map under section 20AA of the VM Act has been developed by the Queensland Government. The mapped vegetation management wetlands within the study area and surrounds are shown in Figure 10 as General Ecological Significance Wetlands (GES) or HES wetlands.

The majority of the mapped wetlands are towards the north of the study area (between One Mile Creek and Boomerang Creek) and in the west of the study area (along the Isaac River). Other palustrine wetlands are mapped along the Isaac River, both upstream and downstream of the confluence of the Isaac River with Boomerang Creek.

Vegetation Management Watercourses

The Queensland Government produces a vegetation management watercourse map, which shows watercourses defined under the VM Act and which is used to regulate vegetation clearing in proximity of watercourses. Boomerang Creek, Hughes Creek, One Mile Creek and Phillips Creek are defined watercourses under the VM Act (Figure 10).

Referable Wetlands

The Map of Queensland wetland environmental values is a statewide statutory map under the 'Environmental Protection (Water and Wetland Biodiversity) Policy 2019'. The map of referable wetlands includes:

- Wetland Protection Areas (WPAs), which comprise:
    - High Ecological Significance (HES) wetlands within the Great Barrier Reef Catchments; and
    - trigger areas that represent the area of hydrological influence of HES wetlands; and
- GES wetlands.

Wetland mapping indicates several WPAs associated with HES wetlands occur to the north and east of the Project (Figure 10). The closest HES wetland is located approximately 2.4 km east of the Project near the confluence of Boomerang Creek and Ripstone Creek. This HES wetland is within the aquatic ecology study area.

Although not a MSES, there is a lacustrine wetland of very low conservation value adjacent to One Mile Creek which has been mapped as part of the Aquatic Conservation Assessment (ACA) (DES 2018-2020d). The landform at this location has been modified to permanently hold water through the construction of a farm dam.

An additional HES wetland – Lake Vermont – is located approximately 7 km east of the Project and 700 m south of Phillips Creek. This waterbody is separated from the Project by the disturbance area approved for the existing Lake Vermont Mine.

5.2.2.2 Waterways providing fish passage

Waterways, as defined by the Fisheries Act, include rivers, creeks, streams, watercourses, and inlets of the sea. The 'Queensland waterways for waterway barrier works' mapping indicates the level of 'risk' associated with undertaking waterway barrier works within Queensland waterways. Waterways with higher stream orders, steeper slopes, higher flow rates, greater number of fish present and fish with stronger swimming abilities obtain a higher level of risk.

As Project activities will be undertaken within the ML under the conditions of an EA a waterway barrier works approval under the Planning Act is not required. However, the level of risk assigned to the mapped watercourses is useful for considering the potential value of watercourses and thus the potential impacts to aquatic ecology values from the Project.

Of the waterways providing fish passage within the study area:

- the Isaac River is classified as major risk (purple) of adverse impacts to fish movement;
- Philips Creek, Boomerang Creek and Hughes Creek are classified as major risk (purple) of adverse impacts to fish movement;
- One Mile Creek is classified as high (red) risk of adverse impacts to fish movement;
- One minor waterway classified as low (green) risk of adverse impacts to fish movement (located on ML 70477); and
- Ripstone Creek (to the north of the Project area) is classified a high (red) risk of adverse impacts to fish movement. A diversion of Ripstone Creek has been approved for the Olive Downs Coking Coal Project; the approved diversion can be seen as the relative straight section of Ripstone Creek to the east of the study area on Figure 11.

The proposed infrastructure corridor crosses Phillips Creek and One Mile Creek.

The risk rating of the waterways providing fish passage within the study area are shown in Figure 11.

5.2.2.3 Conservation significant species

No aquatic flora species listed as threatened under the NC Act were returned in the database searches.

Three listed fauna species (Table 2) were returned in the database searches as having records within 50 km of the study area (Appendix A). All three species were listed as threatened under both the NC Act and the EPBC Act, as such they are all considered MNES and discussed in section 5.2.3.1. Each fauna species, along with its protection status, habitat requirements, and an assessment of the likelihood of its occurrence, is provided in Appendix B.

5.2.3 Matters of National Environmental Significance

5.2.3.1 Threatened aquatic species

Four aquatic species listed as Critically Endangered, Endangered or Vulnerable under the EPBC Act were identified by the desktop assessment as having known records within the region (Table 2). A description of each flora and fauna species' distribution, habitat, ecology and likelihood of occurrence is provided in Appendix B. Terrestrial flora and fauna species identified in the database searches have been addressed in the Terrestrial Ecology Assessment Report (AARC, 2021) and are not considered in this report.

The likelihood of occurrence assessment for each species is described in Section 5.2.4.

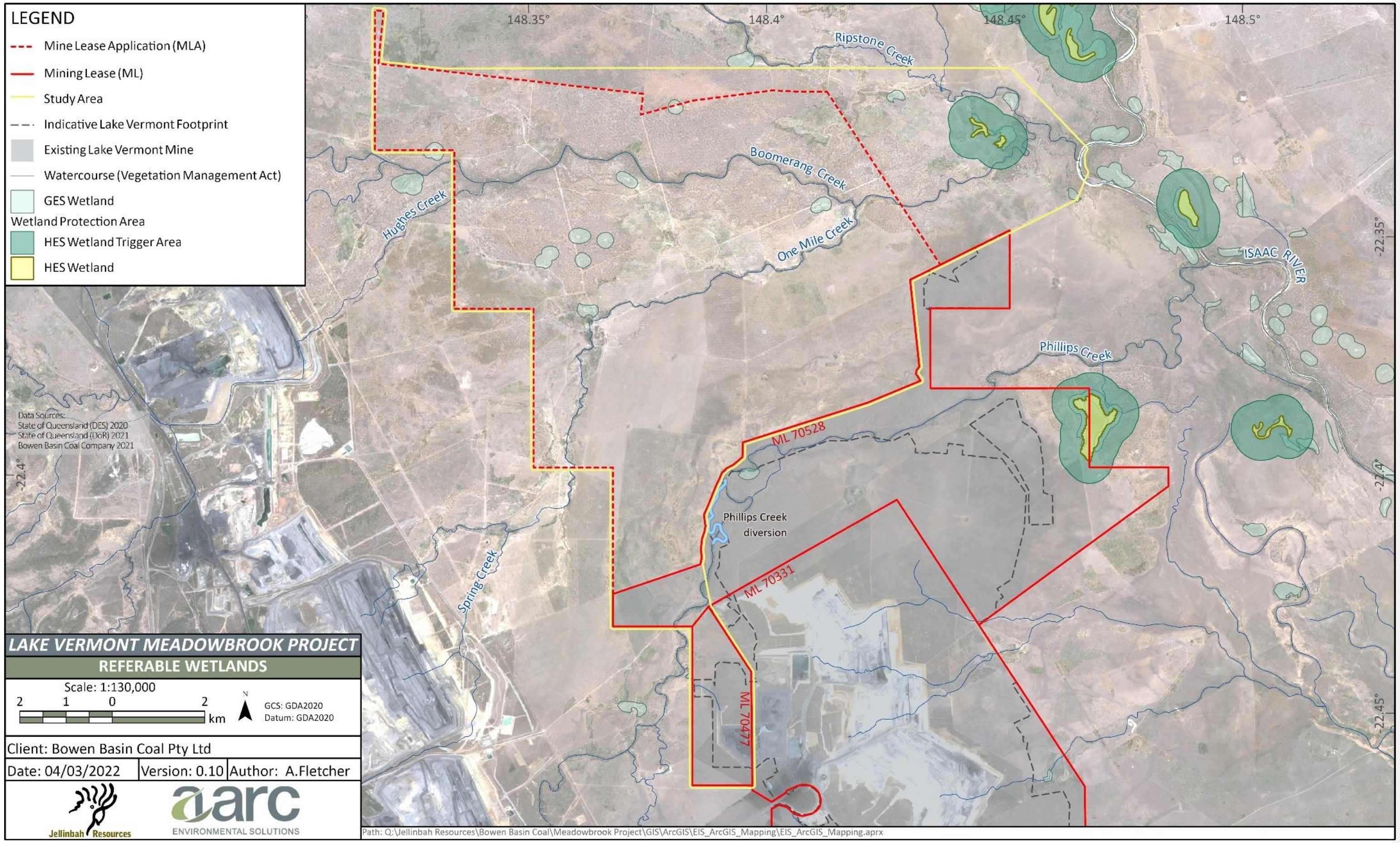


Figure 10: Map of referrable wetlands

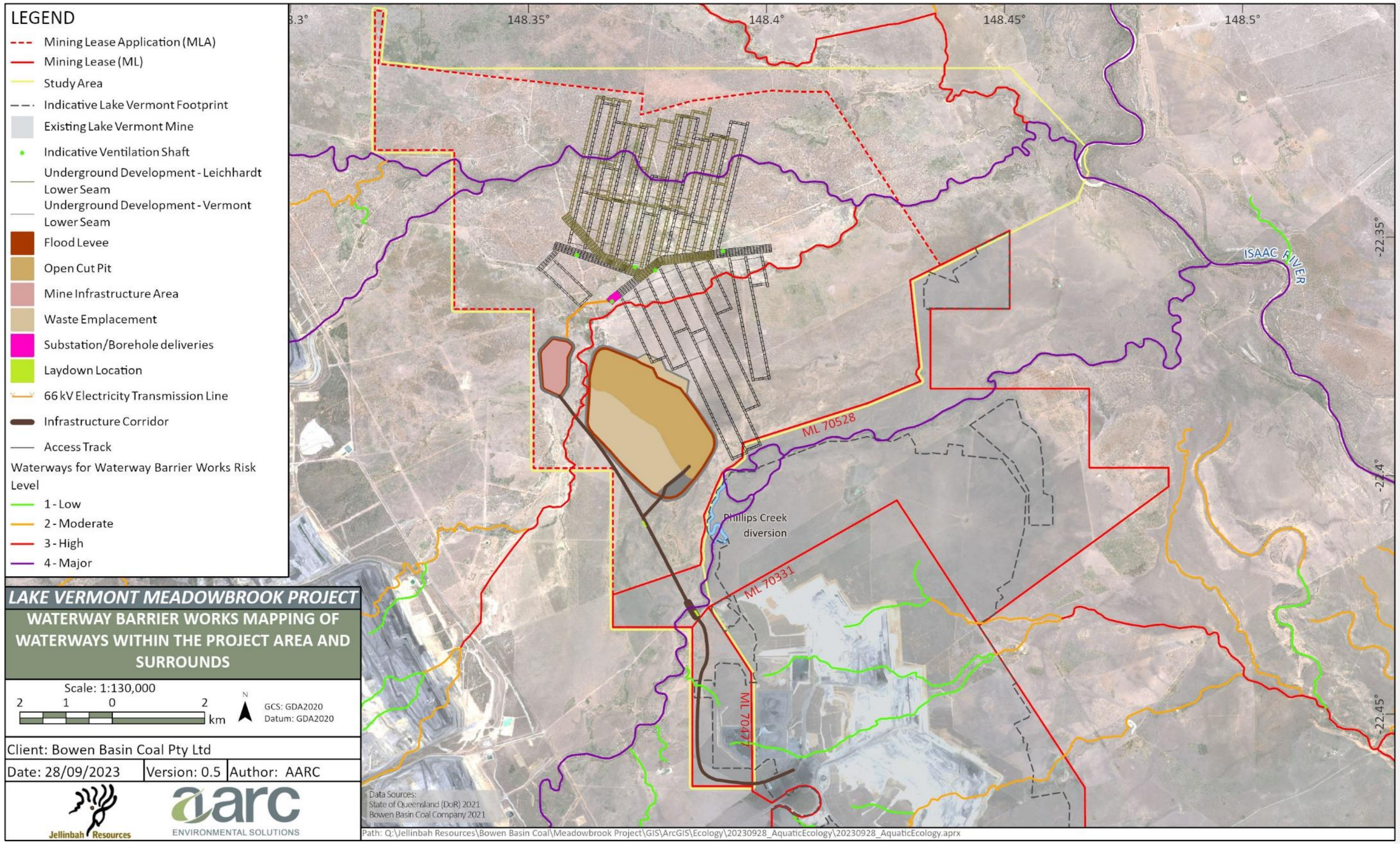


Figure 11: Waterway Barrier Works risk mapping of waterways within the study area

Table 2: EPBC Act listed Threatened flora and fauna species returned in database searches

Scientific name	Common name	EPBC status	NC Act status
Reptiles			
Elseya albagula	Southern Snapping Turtle	CE	E
Rheodytes leukops	Fitzroy River turtle	V	V
Fish			
Bidyanus bidyanus	Silver Perch	CE	-
Maccullochella peelii	Murray Cod	V	-

Key: CE - critically endangered; E – endangered; V – vulnerable; - not listed.

5.2.3.2 Migratory aquatic species

No migratory aquatic species were returned in the database searches (migratory wetland birds have been addressed in the Terrestrial Ecology Assessment Report [AARC 2022]).

5.2.4 Conservation significant species likelihood of occurrence

Species of conservation significance identified from the desktop assessment were assigned a likelihood of occurrence, based on the criteria identified in Table 3. This assessment was based on the knowledge of ecologists, habitat suitability, previous surveys conducted near the study area and scientific literature.

The results of the desktop assessment are described in Section 5.2.

Table 3: Criteria adopted for likelihood of occurrence determination

Likelihood of occurrence	Criteria
Unlikely	Species or species habitat may occur, is likely to occur, or is known to occur from the broader search area (based on database searches); and either; preferred habitat has not been identified within the study area; and there are no confirmed species records within 10 km of the study area; or preferred habitat occurs within the study area, but there are no confirmed species records within 50 km of the study area.
Potential	Species or species habitat may occur, is likely to occur, or is known to occur from the broader search area (based on database searches); and preferred habitat occurs within the study area; and there are confirmed species records within 50 km of the study area but there are no confirmed species records within 10 km of the study area.
Likely	Preferred habitat occurs within the study area; and there are confirmed species records within 10 km of the study area, however, the species is not yet confirmed as occurring within the study area.
Known	There are confirmed species records within the study area.

Through the likelihood of occurrence assessment is concluded that all four aquatic species of conservation significance identified by the database searches were unlikely to occur within the study area (Table 4). The full likelihood of occurrence assessment for each species is provided in Appendix B.

Table 4: Likelihood of occurrence assessment outcomes for conservation significant aquatic species.

Scientific Name	Common Name	Conservation status		Likelihood of occurrence
		EPBC status	NC Act status	
Reptiles				
Elseya albagula	Southern Snapping Turtle	CE	E	Unlikely
Rheodytes leukops	Fitzroy River turtle	V	V	Unlikely
Fish				
Bidyanus bidyanus	Silver Perch	CE	-	Unlikely
Maccullochella peelii	Murray Cod	V	-	Unlikely

Key: CE - critically endangered; E – endangered; V – vulnerable; - not listed.

5.2.5 Groundwater dependent ecosystems

The Commonwealth Bureau of Meteorology has developed the National Atlas of Groundwater Dependent Ecosystems (GDE Atlas) as an interactive tool, for assistance in the identification of potential GDEs (BoM 2021). The GDE Atlas provides ecological and hydrogeological information on potential GDEs and ecosystems that could potentially use groundwater. The GDE Atlas is a tool used for planning, management, and development, that incorporates a national dataset of GDEs. The GDE Atlas supplies information to support the identification of GDEs but does not provide a definitive map of GDEs.

The GDE Atlas mapping includes areas mapped as potential aquatic GDEs within the study area (Figure 12). The areas mapped correspond to the palustrine wetlands areas within the study area, the Isaac River, Phillips Creek and Boomerang Creek. The areas mapped along Phillips Creek and the Isaac River are predominately mapped as high potential GDEs with small areas of moderate potential GDE fringing the main river channel. Boomerang Creek is mapped as a moderate potential GDE along with the palustrine wetlands across the study area.

The DoR has also developed mapping of potential GDEs throughout much of Queensland; however, the DoR mapping has not mapped any GDEs for this region. A search of the Queensland Springs Database indicates no spring wetlands have been identified within the study area or surrounds.

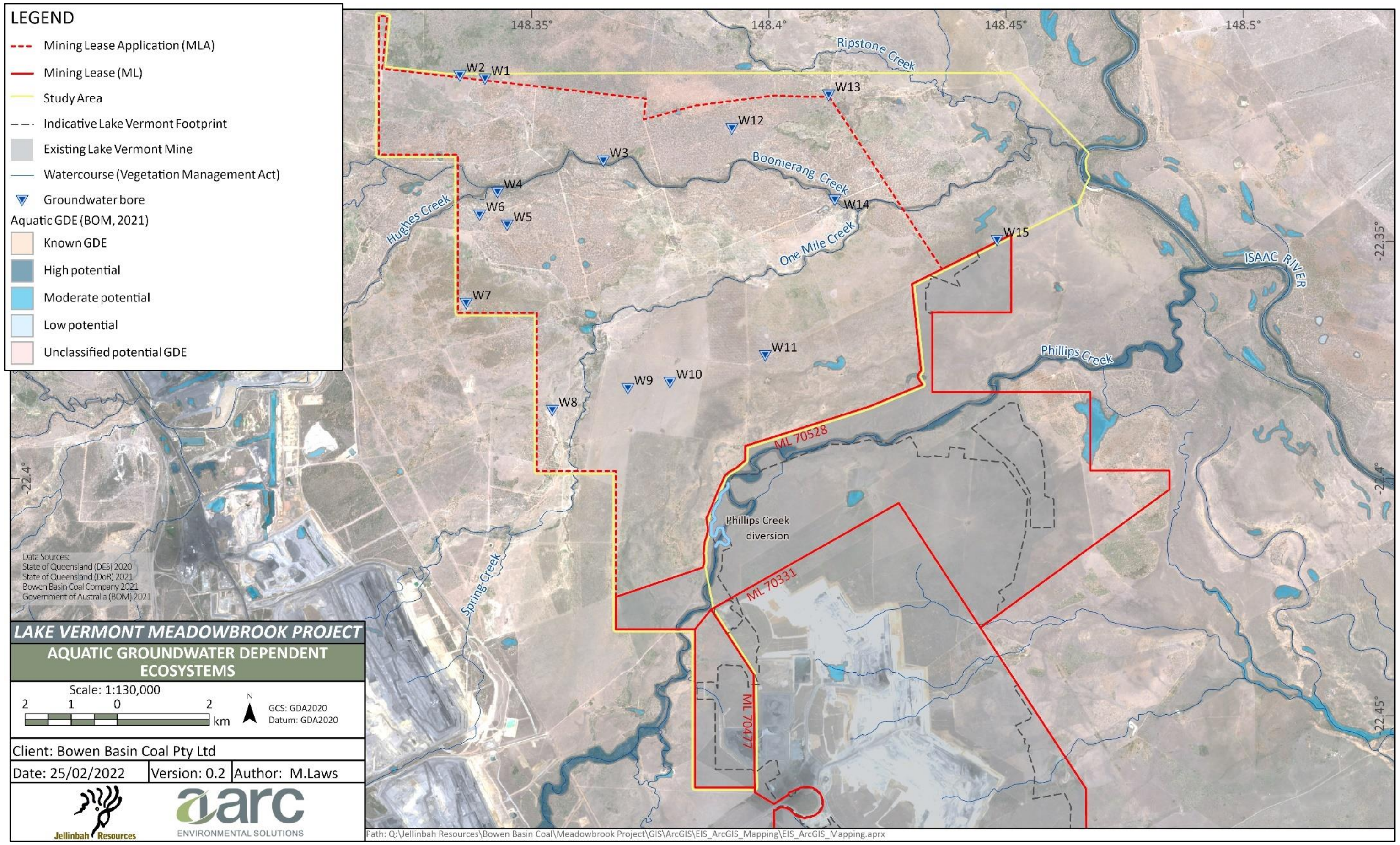


Figure 12: Groundwater dependent aquatic ecosystems mapped within the study area

5.3 Preliminary aquatic ecology survey

A preliminary aquatic ecology survey was undertaken in between 11 March 2019 and 20 March 2019. The purpose of the preliminary aquatic ecology assessment was to investigate conditions and aquatic EVs within the study area. The survey is described here to provide further context for the aquatic survey design and assessment. Although relevant results may be discussed in proceeding sections the preliminary aquatic ecology survey was limited in nature and was used for scoping purposes. The results have not been relied on when completing impact assessment. The preliminary aquatic survey included four survey sites within the study area, two sites on each of Boomerang Creek and One Mile Creek. The site locations are detailed in Table 5 and shown in Figure 14.

Table 5: Preliminary survey site locations

Site Code	Reference Location	Status	Latitude	Longitude
MAq01	One Mile Creek	Wet	148.363212	-22.371543
MAq02	Boomerang Creek	Dry	148.427996	-22.343053
MAq03	Boomerang Creek	Began flowing following rain at end of survey	148.377072	-22.338079
MAq04	One Mile Creek	Wet	148.387926	-22.356683

Figure 13: Photos of aquatic sites visited during preliminary aquatic ecology survey

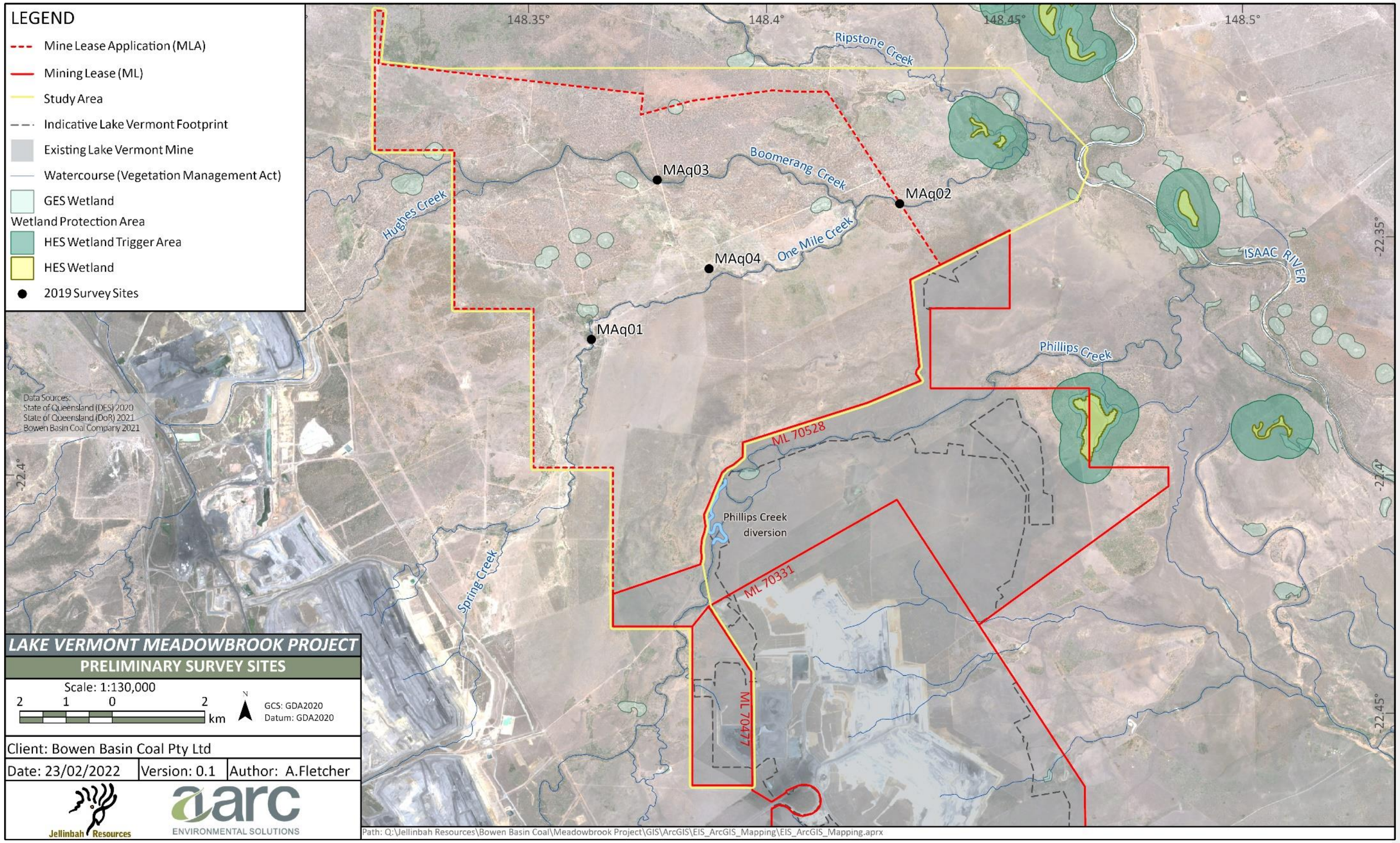


Figure 14: Preliminary aquatic ecology survey sites

Surface water quality sampling was undertaken at the three sites where water was present at some point during the survey period. Water quality sampling was carried out in accordance with the Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009 (DES, 2018b) methodology. Field readings of pH, Dissolved Oxygen, Turbidity, Electrical Conductivity (EC) and Temperature were also recorded. In situ measurements were collected using a multi-parameter water quality meter that is laboratory calibrated to the manufacturers' specifications. The results water sampling for physico-chemical parameters and dissolved metals are shown in Table 6 and Table 7, respectively.

Table 6: Physio-chemical water quality results from preliminary survey

Parameter	Unit	LOR	ANZECC 95% Protection	WQO	MAq01	Maq03	Maq04
pH Value	pH Unit	0.01	-	6.5-8.5	7.31	7.72	7.17
EC @ 25°C	µS/cm	1	-	<720	415	427	72
TDS (Calc.)	mg/L	1	-	n/a	270	278	47
TSS	mg/L	5	-	<55	114	21	29
Ammonia as N	mg/L	0.01	0.9	0.02	0.04	0.01	0.02
Turbidity	NTU			<50		100.3	95.8

Table 7: Dissolved metal concentrations from water sampling in preliminary survey

Dissolved Metals	LOR (mg/L)	ANZECC 95% Protection (mg/L)	WQO Livestock Drinking Water (mg/L)	MAq01	MAq03	MAq04
Aluminium	0.01	0.055	5	0.90	1.37	0.51
Arsenic	0.001	0.024	0.5	<0.001	<0.001	0.001
Barium	0.001	n/a	n/a	0.038	0.061	0.021
Beryllium	0.001	ID	ND	<0.001	<0.001	<0.001
Boron	0.05	0.37	5	<0.05	<0.05	<0.05
Cadmium	0.0001	0.002	0.01	<0.0001	<0.0001	<0.0001
Chromium	0.001	ID	1	<0.001	<0.001	0.002
Cobalt	0.001	ID	1	<0.001	<0.001	0.002
Copper	0.001	0.0014	1	0.002	0.002	0.004
Lead	0.001	0.0034	0.1	<0.001	<0.001	<0.001
Manganese	0.001	1.9	Not sufficiently toxic	0.003	0.019	0.021

Dissolved Metals	LOR (mg/L)	ANZECC 95% Protection (mg/L)	WQO Livestock Drinking Water (mg/L)	MAq01	MAq03	MAq04
Mercury	0.001	0.0006	0.002	<0.0001	<0.0001	<0.0001
Molybdenum	0.001	ID	0.15	<0.001	<0.001	<0.001
Nickel	0.001	0.011	1	0.004	0.002	0.002
Selenium	0.01	0.011	0.02	<0.01	<0.01	<0.01
Silver	0.001	0.00005	n/a	<0.001	0.002	0.001
Uranium	0.001	ID	0.2	<0.001	<0.001	<0.001
Vanadium	0.01	ID	ND	<0.01	<0.01	<0.01
Zinc	0.005	0.008	20	<0.005	<0.005	<0.005

Fauna surveys were undertaken at two of the four sites investigated as part of the preliminary aquatic ecology survey (MAq1 and MAq4). These sites were those with sufficient water to allow survey methods to be undertaken. Surveys included:

- Opera House trapping;
- box trapping; and
- cast netting.

The aquatic fauna species recorded at each of the two sites are detailed in Table 8.

Five fish species were recorded at MAq1 along with one turtle species (Krefft's river turtle Figure 15) and one crustacean. Two crustaceans were recorded at MAq4.

Table 8: Aquatic fauna recorded as part of preliminary aquatic ecology survey

Family	Scientific Name	NC Act Status	EPBC Act status	MAq1	MAq4
Parastacidae	Cherax destructor Blue claw crayfish	LC	NL	-	1
Parathelphusidae	Austrothelphusa transversa Freshwater crab	LC	NL	4	10
Chelidae	Emydura macquarii krefftii Krefft's river turtle	LC	NL	1	-
Ambassidae	Ambassis agassizii Agassiz's glassfish	LC	NL	1	-
Clupeidae	Nematalosa erebi Bony bream	LC	NL	3	-
Eleotridae	Oxyeleotris lineolata Sleepy cod	LC	NL	1	-
Eleotridae	Gudgeon sp	LC	NL	2	-
Melanotaeniidae	Melanotaenia splendida splendida Eastern rainbowfish	LC	NL	5	-

Figure 15: Photo of Krefft's river turtle captured at MAq1 during preliminary aquatic ecology survey

6 Environmental values and objectives

6.1 Environmental values

EVs are defined as the qualities of water that make it suitable for supporting aquatic ecosystems and human water use (DES 2018). The Project is within the western upland tributaries of the Isaac River Sub-basin. The Isaac River (and a small portion of the study area) is within the Isaac and lower Connors River main channel of the Isaac River Sub-basin.

The EPP (Water) for the Isaac River Sub-basin EVs and Water Quality Objectives (WQOs) Basin No. 130 (part) provides a list of EVs for all waters within the Isaac River Sub-basin (DES 2013), including:

protection of aquatic ecosystem values;

- suitability for irrigation;
- suitability for farm supply;
- suitability for stock watering;
- suitability for human consumers of wild or stocked fish, shellfish or crustaceans;
- suitability for primary contact recreation;
- suitability for secondary contact recreation;
- suitability for visual recreation;
- suitability for drinking water supplies;
- suitability for industrial use; and
- protection of cultural and spiritual values.

EVs deemed to be relevant to the Project's area of influence are aquatic ecosystem values and suitability for stock watering.

6.2 Water quality objectives

The EPP (Water) provides WQOs to support and protect the different EVs identified for waters within the western upland tributaries of the Isaac River Sub-basin. WQOs are provided in two main parts:

1) For the purposes of protecting the aquatic ecosystem EV; and
2) For EVs other than aquatic ecosystems (suitability for human uses such as stock watering).

Where more than one EV applies to receiving waters (e.g. aquatic ecosystem and stock watering), the most stringent WQO for each water quality indicator has been adopted to protect all identified EVs. Aquatic ecosystem WQOs are more stringent than objectives for stock watering and as such form the basis of this assessment. Table 9 provides the EPP (Water) guideline values for the protection of aquatic ecosystems, that have been adopted as WQOs for the Meadowbrook Project.

The WQOs for various toxicants are also detailed in the Australian and New Zealand Guidelines for Fresh and Marine Water (ANZECC & ARMCANZ 2000). Where applicable, the ANZECC guideline value for 95% ecosystem protection has been considered when interpreting the water quality results.

Table 9: EPP (Water) Guideline Values adopted for the Upper Isaac River catchment waters

Management intent (level of protection)	Parameter	Water Quality Objective
Aquatic ecosystem EV (moderately disturbed)	Ammonia N	<20 µg/L
	Oxidised N	<60 µg/L
	Organic N	<420 µg/L
	Total nitrogen	<500 µg/L
	Filterable reactive phosphorus (FRP)	<20 µg/L
	Total phosphorus	<50 µg/L
	Chlorophyll a	<5.0 µg/L
	Dissolved oxygen	85% – 110% saturation
	Turbidity	<50 NTU
	Suspended solids	<55 mg/L
	pH	6.5–8.5
	Conductivity (EC) baseflow	<720 µS/cm
	Conductivity (EC) high flow	<250 µS/cm
	Sulphate	<25 mg/L
Stock watering EV	Aluminium	5 mg/L
	Arsenic	0.5 (up to 53) mg/L
	Boron	5 mg/L
	Cadmium	0.01 mg/L
	Chromium	1 mg/L
	Cobalt	1 mg/L
	Copper	0.4 (sheep), 1 (cattle), 5 (pigs), 5 (poultry)
	Fluoride	2 mg/L
	Iron	not sufficiently toxic
	Lead	0.1 mg/L
	Manganese	not sufficiently toxic

Management intent (level of protection)	Parameter	Water Quality Objective
	Mercury	0.002 mg/L
	Molybdenum	0.15 mg/L
	Nickel	1 mg/L
	Selenium	0.02 mg/L
	Uranium	0.2 mg/L
	Vanadium	ND
	Zinc	20 mg/L

Note: Plans WQ1301, WQ1310 identify the Upper Isaac River Catchment Waters as the water area/type relevant to the Project.

6.3 Sediment quality objectives

Baseline levels of metals in sediments are important to investigate the accrual of any pollutants. Stream sediment quality objectives for the Project are adopted from the Interim Sediment Quality Guideline (ISQG) values (ANZECC & ARMCANZ, 2000) Table 10.

Table 10: ISQG Values adopted for the Meadowbrook Project

Contaminant	ISQG Value – Low (mg/kg)	ISQG Value – High (mg/kg)
Arsenic	20	70
Cadmium	1.5	10
Chromium	80	370
Copper	65	270
Lead	50	220
Nickel	21	52
Mercury	0.15	1
Zinc	200	410

6.4 Macroinvertebrate quality objectives

The WQOs for macroinvertebrates within the upland tributaries of the Isaac River Sub-basin as detailed in the EPP (Water) are shown in Table 11.

Table 11: Freshwater macroinvertebrate guidelines values for moderately disturbed waters in the Upper Isaac River catchment waters.

Index	Habitat	Guideline values
Taxa Richness	Composite	12–21
	Edge	23–33
PET Richness	Composite	2–5
	Edge	2–5
SIGNAL 2 Score	Composite	3.33–3.85
	Edge	3.31–4.20
% tolerant taxa	Composite	25–50 %
	Edge	44–56 %

7 Methodology

This section describes the aquatic ecology survey methodology, including survey timing and prevailing climatic conditions, the selection of survey sites and survey techniques utilised. The aquatic ecology surveys included:

- aquatic habitat survey (physical assessment, Habitat Bioassessment, and condition assessment);
- surface water quality (physicochemical water sampling);
- stream sediment quality (physicochemical sediment sampling);
- aquatic macroinvertebrates; and
- aquatic fauna (fish, turtles, and Platypus) survey.

The field surveys were conducted in accordance with the following guidelines:

- State Guidelines:
  - 'Monitoring and Sampling Manual: Environmental Protection (Water) Policy' (DES, 2018b); and
  - 'Queensland Australian River Assessment System (AusRivAS) Sampling and Processing Manual' (DNRM 2001).
- Commonwealth Guidelines:
  - 'Australian and New Zealand Guidelines for Fresh and Marine Water Quality' (ANZECC & ARMCANZ, 2000);
  - 'Survey guidelines for Australia's threatened reptiles' (DSEWPC 2011a);
  - 'Survey guidelines for Australia's threatened fish' (DSEWPC 2011b).

Although no species listed under the EPBC Act were considered likely or having the potential to occur within the study area (Table 4), surveys were designed and undertaken in consideration of the relevant species requirements outlined within the 'Species Profile and Threats Database' (SPRAT Database).

This report uses nationally accepted taxonomy for flora from the Australian Plant Census and the nomenclature for fauna follows the Australian Biological Resources Study Faunal Directory.

7.1 Survey timing and conditions

Aquatic ecology surveys were conducted within the study area in late wet season 2020 (20 March 2020 – 23 March 2020), and late wet season 2021 (14 April 2021 – 19 April 2021).

The survey timings are considered appropriate to maximise the likelihood of detecting aquatic species of significance within the study area. The late wet season survey timing generally aligns with the AusRivAS 'late wet' sampling season (May to July) but was conducted slightly early as the ephemeral watercourses within the study area are dry by May. Although the AusRivAS methodology suggests a sampling event be undertaken during the 'early wet' season (October to December), watercourses of the study area are generally dry during this time. As such sampling during this period would convey little value for the assessment, and a second survey during the 'late wet' was undertaken instead.

During the late wet 2020 survey, the weather conditions experienced were typical for the region. January 2020 and February 2020 both had significantly more than the long-term average rainfall (178.2 mm in fell in January 2020 and 138.2 fell in February 2020; median is 90.9 mm and 86.2 mm respectively). There was less rain during March 2020 than the long-term average (38.0 mm compared to a median 50.2 mm).

January 2021 had approximately average rainfall (95.7 mm compared to average of 90.9 mm), February 2021 was significantly drier than the long-term average (13.0 mm compared to median of 86.2 mm) and March was significantly wetter (194.4 compared to median of 50.2 mm).

Table 12: Temperatures and rainfall for the survey period

Survey Date	Temperature				Rainfall Recorded
	Minimum		Maximum		Boondarra Station3
	Moranbah Airport1	Clermont Airport2	Moranbah Airport1	Clermont Airport2	
Late wet 2020					
20-Mar-20	15.6°C	14.2°C	31.6°C	32.2°C	0.0 mm
21-Mar-20	17.1°C	14.7°C	32.1°C	33.4°C	0.0 mm
22-Mar-20	20.8°C	18.7°C	32°C	30.6°C	0.0 mm
23-Mar-20	18.7°C	17.4°C	33.4°C	34.9°C	0.0 mm
Late wet 2021					
14-Apr-21	16.1°C	14.1°C	30.7°C	29.2°C	0.0 mm
15-Apr-21	12.7°C	9.8°C	31.2°C	29.7°C	0.0 mm
16-Apr-21	16.1°C	11.2°C	32°C	31.3°C	0.0 mm
17-Apr-21	15.0°C	13.4°C	31.8°C	30.3°C	0.0 mm
18-Apr-21	18.7°C	16.7°C	30.8°C	28.8°C	0.0 mm
19-Apr-21	17.7°C	15.6°C	31.3°C	29.6°C	0.0 mm

1 Moranbah Airport Bureau of Meteorology Station 034035
2 Clermont Airport Bureau of Meteorology Station 035124
4 Booroondarra Bureau of Meteorology Station 035109

7.2 Site selection

Suitable aquatic survey sites were identified through review of the available mapping (Section 5) and aerial imagery and the results of the preliminary survey. Sites were selected to:

- target potential habitat for listed threatened species;
- achieve spatial distribution across the study area to capture aquatic values across the whole Project; and
- capture ‘entry’ and ‘exit’ points of waterways traversing the Project, to collect suitable baseline data for ‘reference’ and 'impact’ sites that can be utilised in any long-term monitoring programs.

A total of 16 aquatic survey sites were investigated as part of the aquatic study, including six during the 2020 survey and 10 during the 2021 survey. The location and survey methods used at each of the survey sites are detailed in Table 13. The location of each of the survey sites are shown in Figure 8.

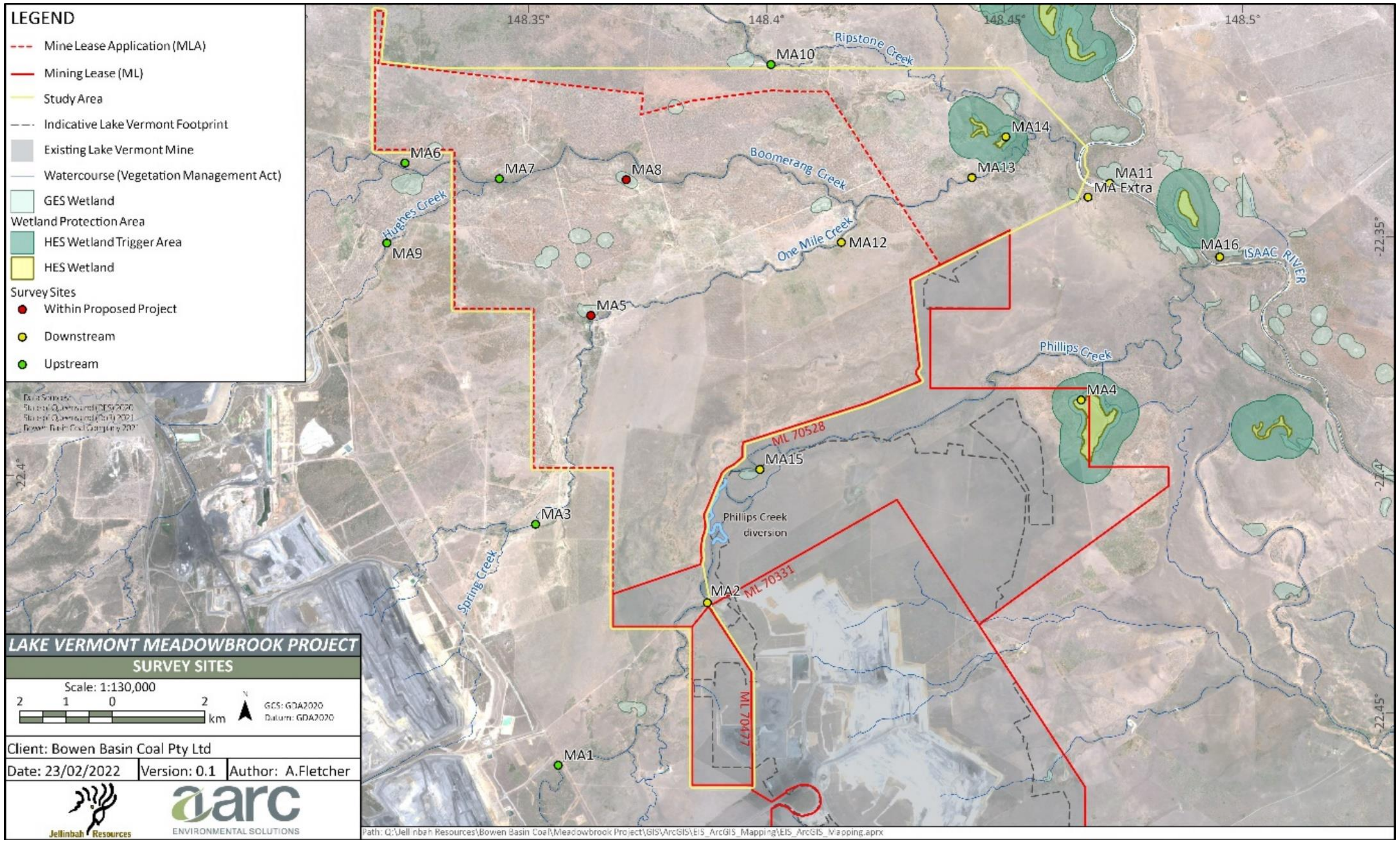


Figure 16: Map showing locations of aquatic ecology survey sites

Table 13: Aquatic ecology survey site locations and ecological indicators assessed during each survey

Site	Location	Latitude	Longitude	Year	Aquatic habitat	Water quality	Sediment quality	Aquatic and Riparian Flora	Aquatic Fauna	Macroinvertebrates
Upstream of Project area										
MA1	Phillips Creek	639430	7515341	2020	Yes	Yes	Yes	Yes	-	-
				2021	-	-	-	-	-	-
MA3	One Mile Creek	638992	7520948	2020	Yes	Yes	Yes	Yes	Yes	Yes
				2021	Yes	Yes	Yes	Yes	Yes	Yes
MA6	Boomerang Creek	636241	7529368	2020	Yes	Yes	Yes	Yes	-	Yes
				2021	Yes	Yes	Yes	Yes	-	Yes
MA7	Hughes Creek	638280	7528983	2020	Yes	Yes	Yes	Yes	Yes	Yes
				2021	Yes	Yes	Yes	Yes	-	-
MA9	Boomerang Creek	635833	7527511	2020	Yes	Yes	Yes	Yes	-	-
				2021	Yes	Yes	Yes	Yes	-	-
MA10	Ripstone Creek	644181	7531582	2020	Yes	Yes	Yes	Yes	-	-
				2021	Yes	Yes	Yes	Yes	-	-
Within Project area										
MA5	One Mile Creek	647053	752499	2020	Yes	Yes	Yes	Yes	Yes	Yes
				2021	Yes	Yes	Yes	Yes	-	-
MA8	GES Wetland	640234	7525787	2020	Yes	Yes	Yes	Yes	Yes	Yes
				2021	Yes	Yes	Yes	Yes	Yes	Yes

Site	Location	Latitude	Longitude	Year	Aquatic habitat	Water quality	Sediment quality	Aquatic and Riparian Flora	Aquatic Fauna	Macroinvertebrates
Downstream Project area										
MA2	Phillips Creek	651486	7528754	2020	Yes	Yes	Yes	Yes	Yes	Yes
				2021	Yes	Yes	Yes	Yes	-	-
MA4	Lake Vermont	650820	7523724	2020	Yes	Yes	-	-	-	-
				2021	Yes	Yes	-	-	-	-
MA11	Isaac River	645664	7527435	2020	Yes	Yes	Yes	Yes	Yes	Yes
				2021	Yes	Yes	Yes	Yes	Yes	Yes
MA12	One Mile Creek	648504	7528914	2020	Yes	Yes	Yes	Yes	Yes	Yes
				2021	Yes	Yes	Yes	Yes	Yes	Yes
MA13	Hughes Creek	649249	7529852	2020	Yes	Yes	Yes	Yes	-	Yes
				2021	Yes	Yes	Yes	Yes	-	-
MA14	HES Wetland	643852	7522178	2020	Yes	-	Yes	Yes	-	-
				2021	Yes	-	Yes	Yes	-	-
MA15	Phillips Creek			2020	Yes	-	-	-	-	-
				201	Yes	-	-	-	-	-
MA 17	~~One Mile Creek~~GES Wetland	650835	7528448	2020	-	-	-	-	-	-
				2021	-	-	-	-	Yes	-

7.3 Aquatic habitat

7.3.1 Physical assessment

This assessment method utilises monitoring techniques adapted from the following environmental sampling manuals:

- AusRivAS Physical Assessment Protocol (Parsons *et al.* 2001); and
- Queensland AusRivAS Sampling and Processing Manual (DNRM 2001).

The monitoring methodologies utilised in the aquatic ecology assessments are presented in Table 14. The physical assessment does not require the presence of water and was consequently undertaken at all sampling sites.

Table 14: Physical assessment methodology

Characteristic	Monitoring Methodology
Bank Shape	Categorise the predominant shape of the left and right banks along the length of the monitoring site in accordance with the AusRivAS physical assessment categories for bank shape (i.e. concave, convex, stepped, wide lower bench or undercut).
Bank Slope	Categorise the predominant slope of the left and right banks along the length of the monitoring site in accordance with the AusRivAS physical assessment categories for bank slope (i.e. vertical, steep, moderate, low or flat).
Factors Affecting Bank Stability	Identify disturbance factors present that may negatively influence bank stability of either the left or right bank.
Artificial Bank Stability Features	Note the presence of any artificial bank protection measures.
Large Woody Debris	Visually estimate the percent cover of large woody debris within the lower embankment and channel area, along a length of stream that is equal to the length of the monitoring site. Large woody debris includes logs and branches greater than 10 centimetre (cm) in diameter.
Turbidity, Water and Sediment Oils and Odours	Visually assess and categorise the presence of oily residues or odours in surface water and stream sediments at the aquatic sites.
Erosion Characteristics	Monitoring Methodology
Bare Ground	Note the extent of bare ground including eroded areas or those not supporting vegetation, due to some form of disturbance that would otherwise be expected to be vegetated.
Exposed Tree Roots	Note whether tree roots are exposed due to any disturbances.
Gully Erosion	Record any visible gully erosion adjacent to the watercourse.
Bank Slumping	Record any evidence of slumping banks along the watercourse.
Local Catchment Erosion	Note the erosion in the surrounding catchment on the approach to the site.

7.3.2 Habitat Bioassessment

A habitat assessment was performed at selected sites using a modified version of the AusRivAS protocols developed by the former Department of Natural Resources and Mines (DNRM 2001). AusRivAS is a nationally standardised method for undertaking an assessment of the biological health of inland rivers within Australia.

The assessment considers morphological characteristics of waterways only; including the broad habitat type, channel pattern, water level and flow, substrate character and cover, bed and bank stability, and riparian cover at each site. Each surveyed site was given a score out of 135, with higher numbers indicating favourable habitats normally associated with healthy waterways. Habitat assessments were completed at all sites in 2019. Table 15 provides a framework for interpreting habitat assessment scores.

Table 15: Key to AusRivAS Habitat Assessment Scores

Habitat Assessment Score	Interpretation
0–35	Habitat is poor. There is limited habitat availability for in-stream fauna. There is little variation in velocity and depth of water, and the creek bed consists of a single sediment type. The water body typically consists of a small, shallow pool. Streamside vegetation, if present, consists of grasses and sedges. There is moderate to significant erosion on the banks.
36–70	Habitat variety is fair. This could be due to leaf litter and other vegetation or detritus in the water, or the presence of boulders and rocks. The streamside vegetation consists mainly of grasses and sedges. There is moderate evidence of bank erosion, and the percentage of vegetative cover on the banks is less than 50%.
71–100	Habitat is relatively good. The bank is stable, there is variety in depth and velocity within the water body and substrate type is variable and tending towards boulders and rocks. Streamside vegetation is of trees and shrubs, adding to the bank stability. The percentage of streamside cover by vegetation is relatively high.
101–135	Indicates a pristine and favourable habitat. There is no bank erosion and the dominant vegetation is trees. There is great variety in depth and velocity, and the habitat is quite complex, offering many types of protection for fauna. This is usually afforded by logs and branches, leaf litter, variety in substrate type, variety in water depth, and presence of vegetation living within the water body.

7.3.3 Condition assessment

The condition assessment is an evaluation of the possible impacts to aquatic EVs caused by major disturbances within the waterway. Each category is scored from one to five, one indicating a 'very major' disturbance, and five indicating an 'indiscernible' disturbance. This assessment evaluated the influence of:

- agriculture upstream;
- major extractive industry (current or historical) upstream;
- major urban area upstream;
- major point source wastewater discharge upstream;
- dam or major weir;
- alteration to seasonal flow regime;
- alteration to the riparian zone;
- erosion and damage by stock on riparian zone and banks;

- major geomorphological change on stream channel; and
- alteration to in-stream conditions and habitats.

7.4 Surface water quality

Surface water quality data were collected at each of the aquatic ecology sample sites to aid in the interpretation of the biological survey results.

Water quality sampling was carried out in accordance with the Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009 (DES, 2018b) methodology. Field readings of pH, Dissolved Oxygen, Turbidity, EC and Temperature were also recorded. In situ measurements were collected using a multi-parameter water quality meter that is laboratory calibrated to the manufacturers' specifications. Grab samples were collected at a depth of 10 to 20 centimetres (cm) below the surface where sufficient water was available. The water quality meter was calibrated according to the manufacturer's instructions prior to field sampling.

All samples were held under the appropriate conditions (e.g. in eskies in the field and during transport) and delivered to ALS Environmental (a National Association of Testing Authorities [NATA] accredited laboratory) for analysis of the parameters included in the Model Water Conditions for Coal Mines in the Fitzroy Basin (ESR/2015/1561, formerly EM288).

The parameters analysed by ALS were:

- Total Suspended Solids (TSS);
- Nutrients (total nitrogen [N], nitrate, nitrite, oxides of nitrogen (NOx), ammonia, Total Kjeldahl Nitrogen, reactive phosphorus and total phosphorus);
- Total hardness ($CaCO_3$);
- Dissolved major cations (calcium, magnesium, sodium and potassium);
- Total and dissolved metals and metalloids (aluminium, arsenic, beryllium, barium, boron, cadmium, chromium, cobalt, copper, lead, iron, manganese, mercury, molybdenum, nickel, selenium, silver, uranium, vanadium and zinc);
- Total petroleum hydrocarbons and total recoverable hydrocarbons.

The results were compared to WQOs (Table 9) for Upper Isaac River catchment waters published for the Isaac River Sub-basin. Additionally, where applicable, results were compared to the ANZECC guidelines for Freshwater and Marine Water Quality for 95% protection.

7.5 Sediment quality

Similarly to water quality, sediment quality data were collected at each of the aquatic ecology sample sites to aid in the interpretation of the biological survey results. Sediment quality sampling was undertaken in accordance with the Queensland Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009 (DES, 2018b).

Five sub-samples (approximately 500 g each) of stream bed substrate were taken at each site along a 50 m transect in the riverbed. Samples were collected using a non-metallic shovel. Sub-samples were mixed in a plastic bucket to obtain a composite sample (approximately 500 g) then sealed in sterilised sample bags and sent to a NATA accredited laboratory for analysis.

All samples were held under the appropriate conditions (e.g. in eskies in the field and during transport) and delivered to ALS Environmental (a NATA accredited laboratory) for analysis of the parameters included in the Model Water Conditions for Coal Mines in the Fitzroy Basin (ESR/2015/1561, formerly EM288, DES 2018c).

Sediment samples were analysed for concentrations of total metals and metalloids including: arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, vanadium and zinc.

Where applicable, the results were compared to ISQG (ANZECC & ARMCANZ 2000a) (Table 10).

7.6 Aquatic Macroinvertebrates

Macroinvertebrate sampling was conducted in accordance with the AusRivAS sampling and assessment methodology as outlined by the Queensland Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009 (DES 2018b).

Along a ten-metre stretch of the waterbody, a 250 micrometre D-frame net was used to sample macroinvertebrates at each sampling site containing sufficient suitable aquatic habitat (refer Table 13). The nets were checked thoroughly for damage before use and washed between sites to ensure no cross contamination of samples. This procedure targets various micro-habitats where available, including riffles, runs, pools and edge/backwaters. Due to the ephemeral nature of the creeks and in the receiving environment, micro-habitats available for sampling were limited to pool and edge habitats. Ideally site sampling should include sampling in shallow and deep sections to target the various micro-habitats, however, this was not possible in any of the sites due to the limited water levels. Macroinvertebrates were live picked on-site, samples preserved, and sent for taxonomic identification to an AusRivAS accredited laboratory.

Data collected was assessed using a range of indices including:

- Total Abundance—the total number of animals collected from each site during each sampling event;
- Taxonomic Richness—a count of the number of different taxa collected from each site during each sampling event. Taxonomic richness considers common and abundant taxa equally.
- PET (taxa from the orders: Plecoptera, Ephemeroptera and Trichoptera) Richness. Taxa from these orders are considered to be particularly sensitive to changes in their environment and thus are good indicators of habitat degradation and poor water quality. Low PET scores generally indicate poor habitat condition, and high PET scores generally indicate good habitat condition. However, PET taxa are often naturally rare in ephemeral Queensland rivers and creeks (preferring clear, fast flowing streams), therefore low PET richness is not necessarily indicative of anthropogenic impacts; and
- SIGNAL 2 Biotic Index – weighted SIGNAL 2 scores were calculated following Chessman (2003) using the family version of the calculation method. Different macroinvertebrate taxa have been given a sensitivity grade number which reflects their sensitivity to various pollutants. This number is then weighted for abundance of the taxa. Taxa that do not have a sensitivity grade number, for example Copepoda, Cladocera and Ostracoda, were not used in the calculation of the SIGNAL Index as recommended in the Monitoring and Sampling Manual: Environmental Protection (Water) Policy (DES 2018a). A low SIGNAL score indicates that taxa are tolerant to a range of environmental conditions and a high score indicates that taxa are more sensitive to such conditions.
- Pollutant Tolerant Taxa - The percentage of pollution-tolerant taxa was calculated based on the SIGNAL2 indices. Tolerant taxa are classified as those with a SIGNAL2 score of 3 or less (DES 2018b). Macroinvertebrate families in this group are expected to be able to tolerate changes to their environment, including habitat degradation and some pollution. An absence of more sensitive taxa suggests environmental conditions may be too harsh for sensitive taxa (those with SIGNAL2 scores above 3) to tolerate.

Indices at each site sampled were compared to the water relevant WQO specified in the Isaac River Sub-basin EVs and Water Quality Objectives (DEHP 2011) (Table 11). The values specified in Table 11 are derived for streams (i.e. flowing waters) and as, the watercourses within the study area are ephemeral and were not flowing during sampling, comparisons of results with the biological objectives should be interpreted with caution.

A SIGNAL2 bi-plot was created for each survey period (i.e. one for 2020 and one for 2021) which plots the SIGNAL2 scores against the number of families found in the sample. The bi-plot demonstrates the level of pollution and suitability of the site for macroinvertebrate habitation. The bi-plot is divided into four quadrants, with each quadrant indicative of environmental conditions that may influence a community (Figure 17).

Quadrant boundaries for the SIGNAL 2 / Family bi-plot used for this assessment are based on the lower (20th percentile) WQO values for taxonomic richness and SIGNAL scores.

Sites that fall into quadrant 4 exhibit levels of pollutants that reflect urban, industrial, or agricultural pollution. Sites in quadrant 3 indicate the presence of harsh physical environments or toxic pollution. Sites in quadrant 2 reflect waters which are high in nutrients or salinity. Sites in quadrant 1 are indicative of favourable water quality and minimal levels of disturbance. All sites fell within quadrant 4 which is consistent with what the sites are exposed to, as the sites are exposed to anthropogenic pollutions (urban/industrial developments), agricultural pollution, and downstream effects of dams as all were open to human and livestock access.

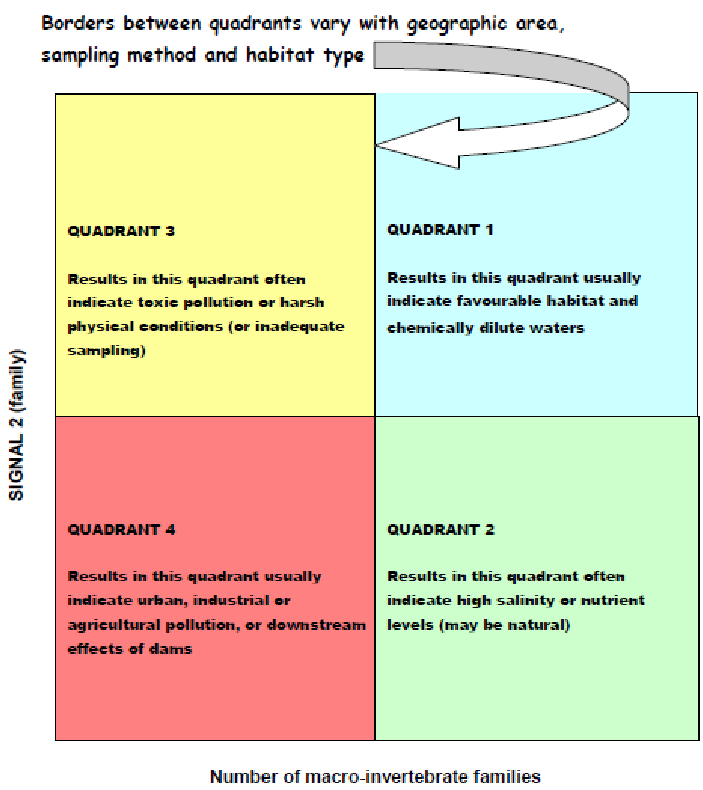


Figure 17: Example of SIGNAL2 bi-plot (source: Chessman 2003)

7.7 Aquatic flora

Any aquatic flora observed at each of the survey site was recorded.

7.8 Fauna

Several survey techniques were used to identify the aquatic fauna species present at the survey sites; these are described below. The survey effort undertaken during each aquatic fauna survey event is detailed in Table 16 for each sampling technique.

7.8.1 Opera House trapping

Opera house traps are a medium net and frame trap with funnel shaped openings. A small pouch inside the net can be equipped with bait. Aquatic animals enter through the large outside opening but find it difficult to exit from the small inside opening. The Opera House traps are designed for any aquatic animal that is small enough to fit through the trap entrance, but large enough that it cannot fit through the netting.

At each aquatic fauna site, three Opera House traps are deployed from the bank of the watercourse and left for a minimum of four nights. The traps are positioned in the water approximately 20 meters apart, so they are not fully submerged, and an air pocket remains. This ensures any animals trapped inside that need to surface for oxygen (i.e. turtles) can continue to do so. Traps are checked daily, and all captured animals identified and released. Traps are secured to the bank with rope, with the location marked with handheld GPS and flagging tape.

7.8.2 Box trapping

Box traps are small rectangular traps made of a fine mesh to capture aquatic fauna. The trap has an internal bait pouch, and circular openings which aquatic animals enter through, finding it difficult to exit. With the finer mesh, and smaller openings, the Box trap is designed to retain smaller animals than the Opera House traps.

At each aquatic fauna site, three box traps are deployed from the bank of the watercourse and left for a minimum of four nights. The traps are spaced approximately 20 meters from each other and are checked and re- baited every day. Aquatic animals caught in traps are identified at site and released.

7.8.3 Seine netting

Seine nets are long nets that are pulled by two people across the shallow water. The net hangs vertically with the bottom edge held down by weights. The net captures aquatic fauna as it is pulled through the waterbody. This method was only used during the 2021 survey at one site, MA 17.

Table 16: Survey effort

Site Name	Start Date	End Date	Opera Houses	Box Traps	Seine Net	Habitat Search
2020						
MA2	20/03/2020	22/03/2020	Yes	Yes	-	Yes
MA5	21/03/2020	22/03/2020	Yes	Yes	-	Yes
MA8	19/03/2020	22/03/2020	Yes	-	-	Yes
MA11	22/03/2020	22/03/2020	Yes	-	-	Yes
MA12	22/03/2020	22/03/2020	Yes	Yes	-	Yes
2021						
MA3	18/04/2021	20/04/2021	Yes	Yes	-	-
MA8	18/04/2021	20/04/2021	Yes	Yes	-	-
MA11	18/04/2021	20/04/2021	Yes	Yes	-	-
MA12	18/04/2021	20/04/2021	Yes	Yes	-	-
MA 17	18/04/2021	20/04/2021	Yes	Yes	Yes	-

8 Results

8.1 Aquatic habitat

8.1.1 Physical assessment

At each aquatic site the full AusRivAS Physical Assessment Protocol (Parsons *et al.*, 2002) was followed. This assessment identified the physical degradation of the banks for the receiving waterways (bank shape, bank slope, artificial bank stability features etc.), quality characteristics (e.g. sediment, water oils and odours, turbidity, etc.), and erosion characteristics. Table 17 provides the erosion specific observations at each site. Table 18 provides the AusRivAS physical assessment data collected at each aquatic site. Photos of sites are provided in Appendix C.

The effects of erosion on the banks of the receiving waters were minimal across all surveyed sites. The leading cause of local erosion appeared to be stock access, with runoff and the influence of edge effects from historic clearing also assisting the degradation.

Among other factors, bank degradation, runoff and stock access seem to be impacting the levels of erosion. High intensity rainfall events also cause increased runoff, potentially washing sediment from the bank and depositing it into the creeks. Cattle compact soil structures and trample vegetation; both leading to increased overland flow and deposition of sediments.

Table 17: Erosion Observations

Site	Bare Ground	Exposed Tree Roots	Gully Erosion	Bank Slumping	Local Catchment Erosion
MA1	Little	None	None	Little	Little
MA2	Some	Moderate	Moderate	Some	Moderate
MA3	Extensive	Extensive	Moderate	Little	Extensive
MA4	None	None	None	None	Little
MA5	Some	None	Little	None	Little
MA6	Little	None	Little	None	None
MA7	Some	Some	Some	Moderate	Some
MA8	Little	Little	None	None	None
MA9	Little	Little	Some	Little	Some
MA10	Little	Some	Little	Some	Some
MA11	Moderate	Extensive	Moderate	Extensive	Extensive
MA12	Moderate	Moderate	Extensive	Some	Extensive
MA13	Some	Extensive	Some	Little	Some
MA14	None	Little	None	None	None
MA15	Little	None	None	None	None

Table 18: AusRivAS physical assessment results

Site Name	Left bank land type and score	Right bank land type and score	Water flow	Water odour	Water oils	Water colour	Turbidity	Plume	Water surface condition
MA1	2	0	standing	none	none	Opaque	Clear	some	normal
MA2	3	3	standing	none	none	clear	slight	some	normal
MA3	1	1	slow flowing	none	none	Tannin	Turbid	lots	normal
MA4	2	2	standing	algal	none	Clear	Clear	some	normal
MA5	1	1	slow flowing	none	none	tannin	turbid	some	normal
MA6	3	3	standing	sulphide	none	opaque	turbid	some	normal
MA7	2	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a
MA8	2	2	standing	none	none	tannin	turbid	some	normal
MA9	2	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a
MA10	2	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a
MA11	2	2	standing	none	none	tannin	turbid	some	normal
MA12	2	2	slow flowing	none	none	tannin	turbid	some	normal
MA13	2	2	slow flowing	none	none	clear	clear	some	normal
MA14	2	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a
MA15	2	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a

8.1.2 Habitat Bioassessment

This assessment considered the morphological characteristics of waterways (as specified in Section 0), with 135 representing a perfect score for a healthy waterway. Habitat assessments were completed at all sites.

The Habitat Bioassessment scores from the aquatic sites within the sampling environment primarily fell into the fair and good categories (Figure 18), with the exception of one site MA15 which was classed as excellent. These results are indicative of the general health of the river and the surrounding systems, it does not consider the quality of the water present.

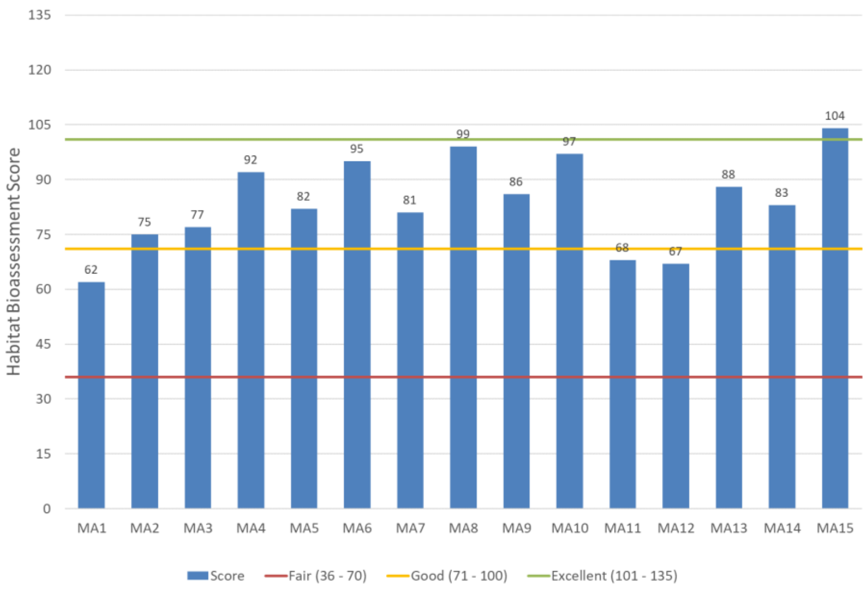


Figure 18: Habitat Bioassessment Scores

8.1.3 Condition assessment

The condition assessment considered the impact/influence of ten different upstream activities on the waterways (as outlined in Section 7.3.3) with 50 representing the maximum score (no impact) and 10 representing the minimum score (full impact). Impact assessments were completed at all sites and site assessment scores are presented in Figure 19.

Condition assessment scores ranged from 39 (MA3) to 49 (MA8) with a mean of 45.5. Of the sites surveyed, 14 of 15 sites received condition scores above 40 indicating that the influence of activities upstream has had minimal impact.

The most significant alteration to stream flow was identified as influence of major extractive industry upstream, followed by influence of agriculture upstream. The current land use of the study area is medium intensity cattle grazing and, in the absence of regular watering stations stock are reliant on natural waterways.

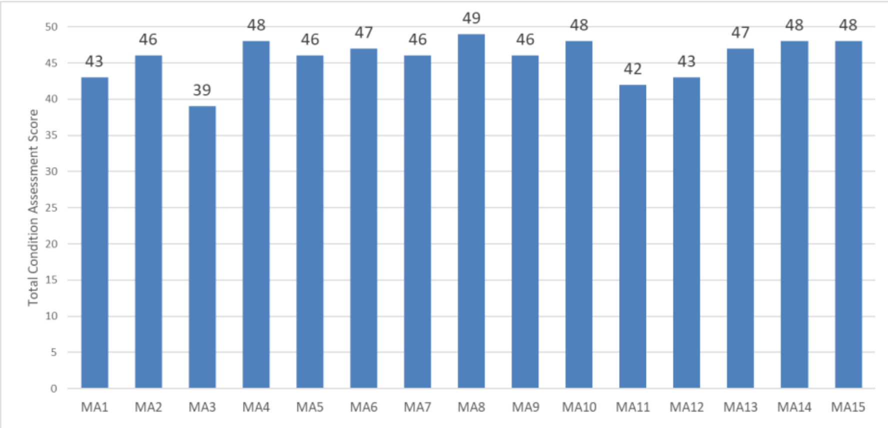


Figure 19: Condition Assessment Scores

8.2 Surface water quality

During the 2020 survey period, surface water was available and field data was collected from 10 of the 15 monitoring sites (MA1, MA2, MA3, MA4, MA5, MA6, MA8, MA11, MA12, and MA13). Samples for water analysis were collected from all but MA1 and MA4 monitoring sites. During the 2021 survey period, field data and surface water samples were collected at five sites (MA3, MA6, MA8, MA11, and MA12). All results from the 2020 and 2021 surveys are detailed in Table 19 and Table 20.

The results from the surface water quality analysis were compared to the regional WQOs to identify possible exceedances of the data. Data analysis and interpretation were referred to the EPP (Water) WQOs for the protection of aquatic ecosystems and livestock drinking water in the Isaac River Sub-basin. Additionally, where applicable, results were compared to the ANZECC Guidelines for Freshwater and Marine Water Quality for 95% protection.

Water quality exceedances of the relevant guideline values were identified for several parameters tested during the investigation. These are discussed as follows:

Physico-chemical parameters:

- Dissolved Oxygen (%) (DO) values were outside the WQOs (85-110%) at all sites except for MA1, MA5, MA8, and MA13 in 2020, and MA6 and MA11 in 2021.
- EC values exceeded WQO (720 µS/cm) at sites MA3, MA5, MA6, MA12, and MA13 in 2020, and at site MA3 in 2021.
- The water of the study area was neutral to alkaline, pH values were outside the WQO range (6.5-8.5) at sites MA3 and MA4 in 2020.
- Turbidity levels at each site exceeded the WQO for aquatic ecosystems (50 NTU) except for site MA6 and MA8 in 2021.
- Suspended solids (SS) exceed the WQO value (55 mg/L) at sites MA3, MA5 and MA6 in 2020, and sites MA3 and MA12 in 2021.
- Ammonia levels exceeded the WQO value (0.02 mg/L) at many sites, MA2, MA3, MA5, MA6, and MA12 in 2020, and sites MA6, and MA12 in 2021.
- Total nitrogen WQO values were not exceeded in 2020 however, it should be noted the 2021 samples were not analysed for total nitrogen.

- Total phosphorus exceeded the WQO value (0.05 mg/L) at all sites except MA13 in 2020. The 2021 samples were not analysed for total phosphorus.
- Sulphate exceeded the WQO value (25 mg/L) at all sites except MA8 in 2020, and sites MA6, MA8, and MA11 in 2021.

Dissolved metal exceedances were infrequent across all sites (Table 21). Only zinc exceeded the ANZECC value (0.008 mg/L) at sites MA6 and MA8 in 2020.

Total metal exceedances were recorded for several metals across multiple sites (Table 22). The exceedances are summarised below:

- Aluminium exceeded the ANZECC value (0.055 mg/L) across all sites.
- Cadmium exceeded the ANZECC value (0.002 mg/L) at site MA12 in 2021.
- Copper exceeded the ANZECC value (0.0014 mg/L) across all sites. The WQO value (1 mg/L, cattle) was exceeded at sites MA3, MA6, MA8, MA11, and MA12 in 2021.
- Lead exceeded the ANZECC value (0.0034 mg/L) at sites MA6 in 2020, and MA12 in 2021.
- Nickel exceeded the ANZECC value (0.011 mg/L) at site MA12 in 2021.
- Zinc exceeded the ANZECC value (0.008 mg/L) at sites MA3, MA5, MA6, and MA8 in 2020 and MA3, MA12, and MA13 in 2021.

Petroleum hydrocarbon exceedances were infrequent across monitored sites (Table 23). The exceedances are summarised below:

- C15-C28 Fraction exceeded the ANZECC value (100 µg/L) at site MA8 in 2020.
- C16-C34 Fraction exceeded the ANZECC value (100 µg/L) at site MA8 in 2020.

Several factors such as direct access of cattle to the watercourses and mining activities upstream of the Project (Saraji Mine and Saraji East Project) are likely to influence on the water results. Nevertheless, water quality in the Project is considered typical of a slightly to moderately disturbed aquatic ecosystem in this region.

Surface water quality results are detailed in Table 19, Table 20, Table 21, Table 22 and Table 23. Exceedances of the ANZECC guideline values protection for 95% of species are highlighted blue; while exceedances of the EPP (Water) WQO are highlighted orange.

Table 19: In situ physico-chemical data for all monitoring sites

Parameter	LOR	ANZECC 95% Protection	WQO	Year	MA1	MA2	MA3	MA4	MA5	MA6	MA8	MA11	MA12	MA13
Temperature (°C)	-	-	-	2020	28.8	22.1	28.3	26.9	23.9	24.7	25.4	31.6	22.6	23
				2021	-	-	27.1	-	n/a	25.8	25.7	19.6	24.8	-
Dissolved Oxygen (DO) (%)	-	-	85%-110%	2020	88.6	84.6	122	156.8	101.1	43.6	89.2	113.8	76.2	87.4
				2021	-	-	112.3	-	n/a	88.3	176.4	89.4	74.5	-
EC (µS/cm)	1	-	<720 µS/cm	2020	719	359.5	1262	235.4	783	1186	142.4	637	756	781
				2021	-	-	4002	-	n/a	569	208.8	244.2	433.7	-
Total Dissolved Solids	1	-	-	2020	-	-	-	-	-	-	-	-	-	-
				2021	-	-	2502	-	n/a	365	134	177	283	
pH	0.01	-	6.5-8.5	2020	7.73	7.87	8.83	9.75	7.38	6.9	6.88	7.78	7.62	7.78
				2021	-	-	7.34	-	n/a	7.24	7.8	7.27	7.06	-
Turbidity (NTU)	-	-	<50 NTU	2020	140.9	371.9	204.5	65.4	384	2010	-	262.5	244.8	194.5
				2021	-	-	88.6	-	n/a	25.91	14	56.2	574.66	-

Table 20: Physico-chemical laboratory results from survey sites

Parameter	LOR	ANZECC 95% protection	WQO	Year	MA2	MA3	MA5	MA6	MA8	MA11	MA12	MA13
Suspended Solids (SS)	5		< 55 mg/L	2020	44	56	74	113	36	24	32	30
				2021	-	68	-	22	14	23	79	-
Ammonia N	0.01	0.9	< 0.02 mg/L	2020	0.15	0.04	0.03	0.08	< 0.01	0.02	0.1	0.02
				2021	-	0.02	-	0.03	< 0.01	< 0.01	0.05	-
Oxidised N:	-	-	< 0.06 mg/L	2020	0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01
				2021	-	< 0.01	-	< 0.01	< 0.01	< 0.01	0.02	-
Organic N	-	-	< 0.42 mg/L	2020	0.04	0.04	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
				2021	-	< 0.01	-	< 0.01	< 0.01	< 0.01	0.06	-
Total nitrogen	-	-	< 0.5 mg/L	2020	0.05	0.04	< 0.01	0.01	< 0.01	< 0.01	0.01	< 0.01
				2021	-	-	-	-	-	-	-	-
Filterable reactive phosphorus (FRP)	-	-	< 0.02 mg/L	2020	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01
				2021	-	< 0.01	-	< 0.01	< 0.01	< 0.01	< 0.01	-
Total phosphorus	-	-	< 0.05 mg/L	2020	0.16	0.12	0.56	0.14	0.31	0.08	0.07	0.05
				2021	-	-	-	-	-	-	-	-
Sulphate	-	-	< 25 mg/L	2020	26	158	92	129	< 1	61	95	92
				2021	-	1080	-	11	4	21	48	-

Table 21: Dissolved metals concentrations in water quality samples

Parameter	Units	LOR	ANZECC 95% Protection	WQO	Year	MA2	MA3	MA5	MA6	MA8	MA11	MA12	MA13
Aluminium		0.01	0.055	5 mg/L	2020	0.01	< 0.01	< 0.01	< 0.01	0.11	< 0.01	0.02	< 0.01
					2021		< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	
Arsenic		0.001	0.013	0.5 mg/L	2020	0.001	< 0.001	0.001	0.003	< 0.001	< 0.001	< 0.001	
					2021		0.002		0.002	0.002	< 0.001	< 0.001	
Barium		0.001	n/a	n/a	2020	0.063	0.064	0.052	0.089	0.041	0.077	0.074	0.081
					2021		0.179		0.152	0.042	0.077	0.067	
Beryllium		0.001	ID	ND	2020	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
					2021		< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	
Boron		0.05	0.37 mg/L	5 mg/L	2020	< 0.05	< 0.05	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
					2021		0.11		0.09	0.05	0.05	0.07	
Cadmium		0.0001	0.0002 mg/L	0.01 mg/L	2020	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
					2021		5E-04		< 0.0001	< 0.0001	< 0.0001	< 0.0001	
Chromium		0.001	1	1 mg/L	2020	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
					2021		< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	
Cobalt		0.001	ID	1 mg/L	2020	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001
					2021		< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	

Parameter	Units	LOR	ANZECC 95% Protection	WQO	Year	MA2	MA3	MA5	MA6	MA8	MA11	MA12	MA13
Copper		0.001	0.0014	1 mg/L (cattle)	2020	0.002	0.002	< 0.001	0.001	0.001	0.001	0.001	0.001
					2021		0.002		< 0.001	0.001	0.001	0.003	
Lead		0.001	0.0034	0.1 mg/L	2020	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
					2021		< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	
Manganese		0.001	1.9	not sufficiently toxic	2020	0.013	< 0.001	< 0.001	0.317	0.049	0.001	0.01	< 0.001
					2021		0.033		0.19	0.009	0.005	0.027	
Molybdenum		0.001	ID	0.15 mg/L	2020	0.001	0.002	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001
					2021		< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	
Nickel		0.001	0.011	1 mg/L	2020	0.004	0.003	0.002	0.004	0.004	0.002	0.003	0.003
					2021		0.005		0.003	0.002	0.001	0.005	
Selenium		0.01	0.011	0.02 mg/L	2020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
					2021		< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	
Silver		0.001	0.00005	ND	2020	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
					2021		< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	
Uranium		0.001	ID	0.2 mg/L	2020	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
					2021		0.002		< 0.001	< 0.001	< 0.001	< 0.001	

Parameter	Units	LOR	ANZECC 95% Protection	WQO	Year	MA2	MA3	MA5	MA6	MA8	MA11	MA12	MA13
Vanadium		0.01	ID	ND	2020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
					2021		< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	
Zinc		0.005	0.008	20 mg/L	2020	0.014	< 0.005	0.005	0.044	0.024	< 0.005	< 0.005	< 0.005
					2021		< 0.005		< 0.005	< 0.005	< 0.005	< 0.005	
Mercury		0.001	0.0006	0.002 mg/L	2020	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
					2021		< 0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001	
Ferrous Iron				not sufficiently toxic	2020	< 0.05	0.26	0.07	0.1	0.68	< 0.05	0.33	0.34
					2021		< 0.05		< 0.05	0.22	< 0.05	< 0.05	

Table 22: Total metals concentrations in water quality samples

Parameter	LOR	ANZECC 95% Protection	WQO	Year	MA2	MA3	MA5	MA6	MA8	MA11	MA12	MA13
Aluminium	0.01	0.055	5 mg/L	2020	2.79	3.23	2.76	3.78	0.69	1.7	2.35	1.5
				2021		1.47		0.51	0.2	1.95	14.4	
Arsenic	0.001	0.024	0.5 mg/L	2020	0.001	0.002	0.002	0.005	0.005	0.001	0.002	0.002
				2021		0.002		0.002	0.002	< 0.001	0.004	
Barium	0.001	n/a	n/a	2020	0.081	0.085	0.073	0.124	0.054	0.092	0.086	0.094
				2021		< 0.001		< 0.001	< 0.001	< 0.001	0.002	
Beryllium	0.001	ID	ND	2020	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
				2021		0.08		0.06	< 0.05	< 0.05	< 0.05	
Boron	0.05	0.37	5 mg/L	2020	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
				2021		< 0.0001		< 0.0001	< 0.0001	< 0.0001	2E-04	
Cadmium	0.0001	0.002	0.01 mg/L	2020	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
				2021		0.001		< 0.001	< 0.001	0.002	0.025	
Chromium	0.001	ID	1 mg/L	2020	0.005	0.004	0.004	0.005	0.001	0.002	0.003	0.002
				2021		0.003		0.001	< 0.001	0.001	0.009	
Cobalt	0.001	ID	1 mg/L	2020	0.002	0.002	0.002	0.004	0.001	< 0.001	0.001	0.001
				2021		0.003		< 0.001	0.001	0.002	0.013	
Copper	0.001	0.0014	1 mg/L (cattle)	2020	0.004	0.004	0.004	0.007	0.002	0.002	0.002	0.002
				2021		2.36		1.83	2.29	1.82	18.5	
Lead	0.001	0.0034	0.1 mg/L	2020	0.001	0.003	0.003	0.005	0.002	0.001	0.002	0.001

Parameter	LOR	ANZECC 95% Protection	WQO	Year	MA2	MA3	MA5	MA6	MA8	MA11	MA12	MA13
				2021		0.003		< 0.001	< 0.001	0.001	0.01	
Manganese	0.001	1.9	not sufficiently toxic	2020	0.075	0.124	0.144	0.402	0.074	0.061	0.056	0.107
				2021		0.698		0.214	0.036	0.112	0.202	
Molybdenum	0.001	ID	0.15 mg/L	2020	0.002	0.002	0.001	0.001	< 0.001	< 0.001	0.001	0.001
				2021		0.006		0.001	< 0.001	< 0.001	0.001	
Nickel	0.001	0.011	1 mg/L	2020	0.009	0.007	0.006	0.008	0.005	0.004	0.005	0.005
				2021		0.008		0.004	0.002	0.003	0.022	
Selenium	0.01	0.011	0.02 mg/L	2020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
				2021		< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	
Silver	0.001	0.00005	ND	2020	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
				2021		< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	
Uranium	0.001	ID	0.2 mg/L	2020	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
				2021		0.002		< 0.001	< 0.001	< 0.001	< 0.001	
Vanadium	0.01	ID	ND	2020	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
				2021		< 0.01		< 0.01	< 0.01	< 0.01	0.03	
Zinc	0.005	0.008	20 mg/L	2020	0.008	0.017	0.084	0.009	0.019	0.006	0.006	0.006
				2021		0.009		0.006	< 0.005	0.009	0.037	
Mercury	0.001	0.0006	0.002 mg/L	2020	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
				2021		< 0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001	

Table 23: Petroleum hydrocarbons concentrations in water quality samples

Petroleum Hydrocarbon	ANZECC 95% Protection	Year	MA2	MA3	MA5	MA6	MA8	MA11	MA12	MA13
C6- C9 Fraction	20 µg/L	2020	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
		2021		< 20		< 20	< 20	< 20	< 20	
C10 - C14 Fraction	100 µg/L	2020	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
		2021		< 50		< 50	< 50	< 50	< 50	
C15-C28 Fraction	100 µg/L	2020	< 100	< 100	< 100	< 100	160	< 100	< 100	< 100
		2021		< 100		< 100	< 100	< 100	< 100	
C29-C36 Fraction	100 µg/L	2020	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
		2021		< 50		< 50	< 50	< 50	< 50	
C10-C36 Fraction (sum)	100 µg/L	2020	< 50	< 50	< 50	< 50	160	< 50	< 50	< 50
		2021		< 50		< 50	< 50	< 50	< 50	
C6-C10 Fraction	20 µg/L	2020	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
		2021		< 20		< 20	< 20	< 20	< 20	
C6-C10 Fraction minus BTEX (F1)	100 µg/L	2020	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
		2021		< 20		< 20	< 20	< 20	< 20	
>C10-C16 Fraction	100 µg/L	2020	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100
		2021		< 100		< 100	< 100	< 100	< 100	
>C16-C34 Fraction	100 µg/L	2020	< 100	< 100	< 100	< 100	160	< 100	< 100	< 100
		2021		< 100		< 100	< 100	< 100	< 100	
>C34-C40 Fraction	100 µg/L	2020	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100

Petroleum Hydrocarbon	ANZECC 95% Protection	Year	MA2	MA3	MA5	MA6	MA8	MA11	MA12	MA13
		2021		< 100		< 100	< 100	< 100	< 100	
>C10-C40 Fraction (sum)	100 µg/L	2020	< 100	< 100	< 100	< 100	160	< 100	< 100	< 100
		2021		< 100		< 100	< 100	< 100	< 100	
>C10-C16 Fraction minus Napthalene (F2)	100 µg/L	2020	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100
		2021		< 100		< 100	< 100	< 100	< 100	

8.3 Stream sediment quality

The results from the sediment quality analysis are displayed below in Figure 20, Table 24,Table 25 and Table 26, along with the relevant low and high Sediment Quality Guidelines (SQGs).

No exceedance of SQG high or low trigger values were identified during the sediment quality assessment, with the results at all sites well below the SQG low trigger values.

Sediment particle size distribution is shown from samples collected is shown in Table 26. There was no difference between the particle size distribution of sediment samples collected in 2020 and 2021, as such the results from 2021 sediment particle size analysis are presented in Figure 20. In general sediment particles predominately fell within the sand and fine classification classes. Sediment from One Mile Creek (MA3, MA5, MA12), comprised a higher percentage of fines particles than the other watercourses (apart from one site on Boomerang Creek). The site on Boomerang Creek with a high percentage of fine particles was the furthest upstream of the sampling sites and located outside the potential impact area. The sediment particle size from the site located on the HES wetland (MA14) was small with more than 95% of the particles being classified as fines. This is typical of a wetland located on a floodplain.

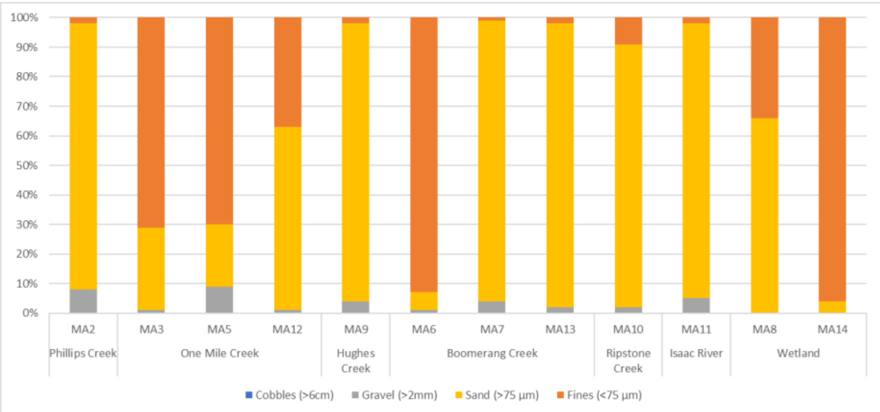


Figure 20: Sediment particle size classification

Table 24: Soil moisture and pH

Parameter	LOR	Year	MA2	MA3	MA5	MA6	MA7	MA8	MA9	MA10	MA11	MA12	MA13	MA14
pH	0.1	2020	8.6	8	6.5	6.2	7.4	5.5	8.8	6.7	7.2	6.9	8.7	4.9
		2021	-	-	-	-	-	-	-	-	-	-	-	-
Moisture content (%)	1.0	2020	26.9	17.8	38.0	39.4	24.2	54.3	2.0	23.4	20.3	24.2	18.2	7.6
		2021	< 1.0	23.9	32.0	29.9	< 1.0	31.0	22.2	< 1.0	18.6	21.4	20.4	9.2

Table 25: Sediment total metals analysis

Parameter	ISQG Value – Low (mg/kg)	ISQG Value – High (mg/kg)	Year	MA2	MA3	MA5	MA6	MA7	MA8	MA9	MA10	MA11	MA12	MA13	MA14
Arsenic	20	70	2020	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
			2021	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Barium			2020	40	100	80	60	10	50	30	20	< 50	60	< 50	80
			2021	50	80	80	90	20	40	30	10	< 10	40	< 10	110
Beryllium			2020	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	1
			2021	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1
Boron			2020	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
			2021	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Cadmium	1.5	10	2020	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
			2021	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Chromium	80	370	2020	12	10	13	6	7	8	10	4	4	11	3	12

Parameter	ISQG Value – Low (mg/kg)	ISQG Value – High (mg/kg)	Year	MA2	MA3	MA5	MA6	MA7	MA8	MA9	MA10	MA11	MA12	MA13	MA14
			2021	13	8	14	11	7	6	10	7	4	12	3	12
Cobalt			2020	5	9	8	5	2	< 2	3	< 2	< 2	6	< 2	6
			2021	6	8	5	8	3	< 2	2	< 2	< 2	5	< 2	5
Copper	65	270	2020	< 5	8	11	7	< 5	6	< 5	< 5	< 5	6	< 5	14
			2021	< 5	11	12	12	< 5	< 5	< 5	< 5	< 5	< 5	< 5	15
Lead	50	220	2020	< 5	12	9	7	< 5	7	< 5	< 5	< 5	6	< 5	14
			2021	< 5	9	12	12	< 5	5	< 5	< 5	< 5	< 5	< 5	15
Manganese			2020	133	482	271	135	38	52	71	59	18	208	16	91
			2021	215	276	196	231	74	63	75	58	18	162	23	82
Nickel	21	52	2020	12	11	10	8	4	4	5	< 2	< 2	8	< 2	11
			2021	11	13	9	11	4	3	4	2	< 2	6	< 2	10
Selenium			2020	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
			2021	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Vanadium			2020	13	17	22	16	12	10	21	7	5	20	< 5	25
			2021	10	13	27	28	12	8	21	9	6	18	< 5	25
Zinc	200	410	2020	11	13	14	20	< 5	14	< 5	< 5	< 5	8	< 5	24
			2021	6	20	16	25	< 5	12	< 5	< 5	< 5	6	< 5	23
Mercury	0.15	1	2020	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
			2021	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

Table 26: Sediment particle size analysis

Particle	Year	MA2	MA3	MA5	MA6	MA7	MA8	MA9	MA10	MA11	MA12	MA13	MA14
+75µm	2020	86	27	49	9	98	67	97	89	99	61	99	5
	2021	98	29	30	7	99	66	98	91	98	63	98	4
+150µm	2020	79	13	35	7	96	52	97	83	98	34	99	3
	2021	98	17	22	5	98	40	98	88	97	45	98	3
+300µm	2020	55	5	24	5	86	22	89	73	87	6	95	2
	2021	96	7	16	4	93	17	86	78	90	21	88	2
+425µm	2020	35	3	20	4	66	14	68	58	53	3	79	2
	2021	91	4	14	3	75	8	54	58	65	11	60	2
+600µm	2020	18	2	17	4	34	10	45	37	30	2	47	1
	2021	69	3	13	3	46	4	28	34	40	5	30	< 1
+1180µm	2020	2	1	13	2	6	7	20	8	7	< 1	7	< 1
	2021	18	2	11	2	10	2	8	5	10	1	4	< 1
+2.36mm	2020	< 1	< 1	11	1	1	5	7	1	< 1	< 1	< 1	< 1
	2021	4	< 1	8	< 1	2	1	2	< 1	2	< 1	1	< 1
+4.75mm	2020	< 1	< 1	11	1	1	5	7	1	< 1	< 1	< 1	< 1
	2021	< 1	< 1	4	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1
+9.5mm	2020	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2021	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
+19.0mm	2020	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Particle	Year	MA2	MA3	MA5	MA6	MA7	MA8	MA9	MA10	MA11	MA12	MA13	MA14
	2021	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
+37.5mm	2020	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2021	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
+75.0mm	2020	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
	2021	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

8.4 Aquatic macroinvertebrates

8.4.1 Abundance

Total abundance of macroinvertebrates across the sites ranged between 42 and 509 individuals in 2020, and between 136 and 311 in 2011 (Figure 21). Results illustrated that abundance was generally higher in 2020. The lowest total abundance was recorded at site MA13 in 2020, with 42 individuals. The highest number of macroinvertebrates was recorded at impact site MA3 in 2020 with 509 individuals, and at site MA12 in 2021 with 311 individuals. A complete list of all identified macroinvertebrates is available in Appendix D.

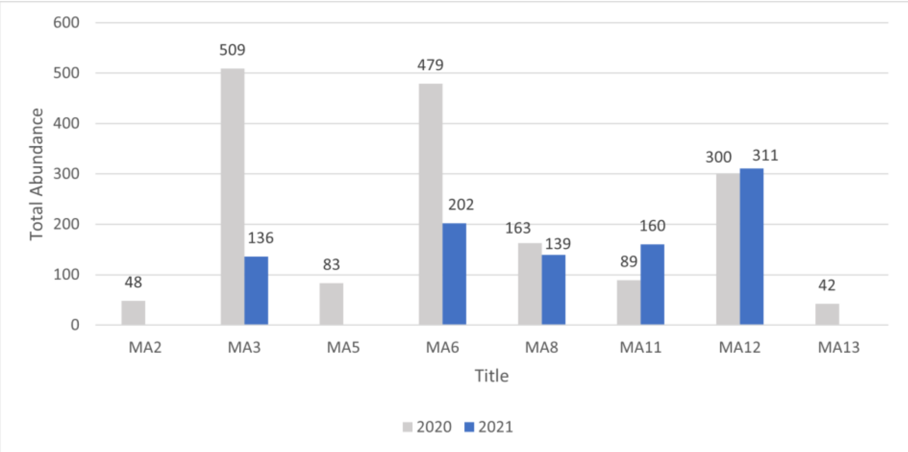


Figure 21: Macroinvertebrate abundance

8.4.2 Taxonomic richness

A total of 37 and 24 taxa were identified in the 2020 and 2021 surveys respectively across all sites for all macroinvertebrates.

Taxonomic richness of the samples is generally low to moderate (Figure 22) ranging from 11 to 17 during the 2020 survey and 10 to 15 during the 2021 survey. None of the sites sampled during either survey exhibited a taxonomic richness which met the upper WQO for taxonomic richness. Samples from five sites (MA3, MA5, MA6, MA8 and MA12) met the lower WQO during the 2020 survey; samples from four site (MA6, MA8, MA11 and MA12) met or exceeded the lower WQO during the 2021 survey. The taxonomic richness was higher at most sites during the 2020 survey than the 2021 survey.

The taxonomic richness is reflective of the ephemeral nature of the watercourses within the study area and may be an indication of unfavourable physicochemical conditions or reduced habitat quality within the study area compared to aquatic habitats outside the study area in the Lower Isaac River Sub-basin.

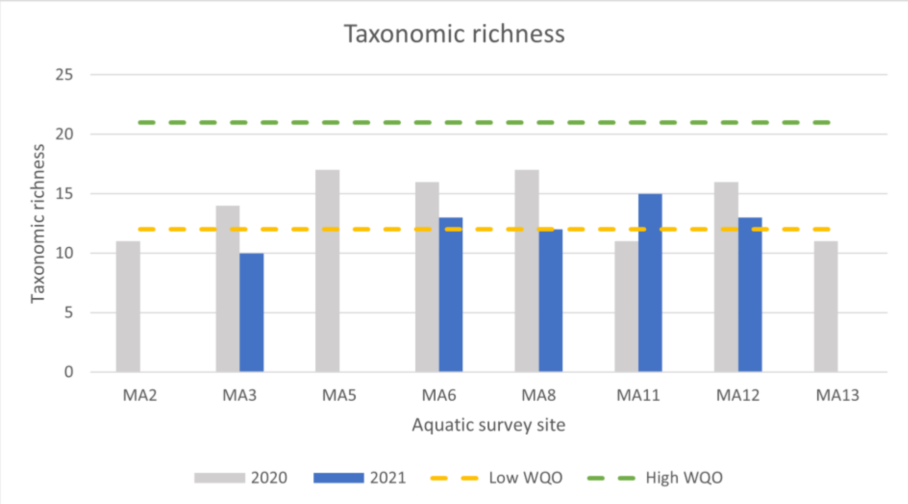


Figure 22: Macroinvertebrate taxonomic richness at aquatic ecology survey sites

8.4.2.1 PET Taxa

The PET taxa are three orders of macroinvertebrate (Ephemeroptera, Trichoptera, Plecoptera) that are particularly sensitive to disturbance. They require favourable water quality conditions and diverse habitat to survive. PET taxa richness in ephemeral waterbodies tends to be low, due to the naturally harsh conditions in these waterways (i.e. poor water quality and low habitat diversity). However, trending declines in the number of PET taxa at a site may be an indication of pollution or poor water quality.

A total of four PET taxa were identified across all sites during both surveys, *Ephemeroptera Baetidae, Ephemeroptera Caenidae, Tricoptera Ecomidae,* and *Trichoptera Leptoceridae* (Figure 23).

Samples from five sites collected during the 2020 survey contained PET taxa *(Ephemeroptera Baetidae, Ephemeroptera Caenidae and Trichoptera Leptoceridae*), while samples from only two sites collected during the 2021 survey contained PET taxa *(Ephemeroptera Baetidae, Ephemeroptera Caenidae, Tricoptera Ecomidae,* and *Trichoptera Leptoceridae)*. Notably samples collected during both surveys from MA11 and MA12 contained PET taxa. These sites also supported the more PET taxa than other sites.

Samples collected during the 2021 survey from MA11 contained the greatest number of PET taxa (three), followed by samples collected during the 2020 survey from MA12 (two). All other samples contained one or less PET taxa. PET taxa were collected from the Trichoptera and Ephemeroptera orders; no taxa from the Plecoptera order were collected.

PET taxa richness was below the high WQO in samples from all sites collected in both surveys. PET taxa richness was above the low WQO in the sample from MA11 collected during 2021 and met the low WQO in the sample collected from MA12 in the 2020 survey.

The low levels of PET taxa sampled is likely due to the lack of available habitats presents at the sample sites at the time of sampling and the ephemeral nature of the watercourses within the study area.

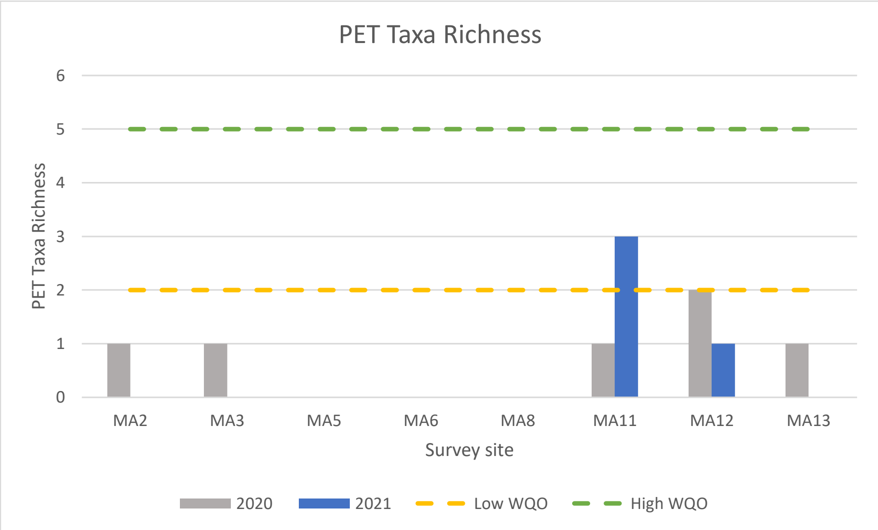


Figure 23: *PET taxa richness for each aquatic survey site*

8.4.3 SIGNAL2 scores

The weighted SIGNAL 2 scores recorded (Figure 24) from the samples collected were generally low ranging from 2.6 to 4.2. The SIGNAL2 scores at one site (MA11) were above the low WQO during the 2020 survey and above the high WQO for the 2021 survey. However, the SIGNAL2 scores were below the low WQO for all other sites from samples collected during both surveys. The SIGNAL2 scores were consistent at each site across the two surveys.

The SIGNAL2 scores for most sites fell within Quadrant 4 in both surveys (site conditions are likely influenced by urban industrial or agricultural pollution)[2]. The SIGNAL2 score from the sample taken during the 2021 survey for one site (MA11) fell within Quadrant 3 (Toxic pollution or harsh physical environments).

Overall, the SIGNAL2 scores indicate poor habitat availability and environmental conditions. The ephemeral nature of the watercourses within the study area is a key factor behind the low SIGNAL 2 scores and classification of results on bi-plot.

The SGINAL2 score results are consistent with the results from the aquatic survey conducted for the adjacent Saraji East Project (frc environmental 2018) where SIGNAL2 scores ranged from 2.14 to 3.5 and Olive Downs Project (DPM Envirosciences 2018) where SIGNAL2 scores ranged from 2.63 to 4.43. These results reinforce the conclusion that the macroinvertebrate communities which are dominated by tolerant taxa that are not sensitive to environmental conditions and that the existing habitat is exhibits the effects of agricultural pollution.

2 Note quadrat boundaries were set at the high WQO specified for macroinvertebrates within the upland tributaries of the Isaac River Sub-basin as detailed in the EPP (Water).

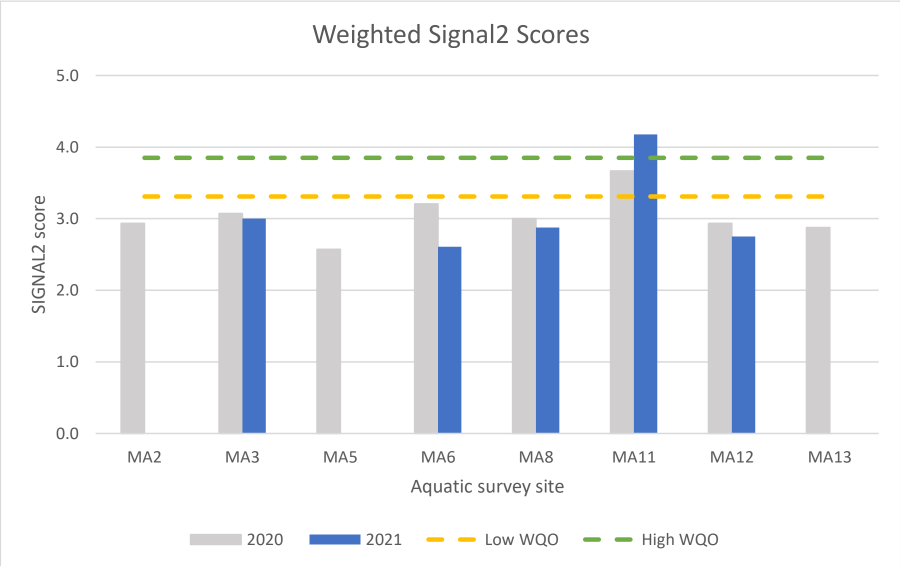


Figure 24: SIGNAL2 scores for samples collected from aquatic survey sites

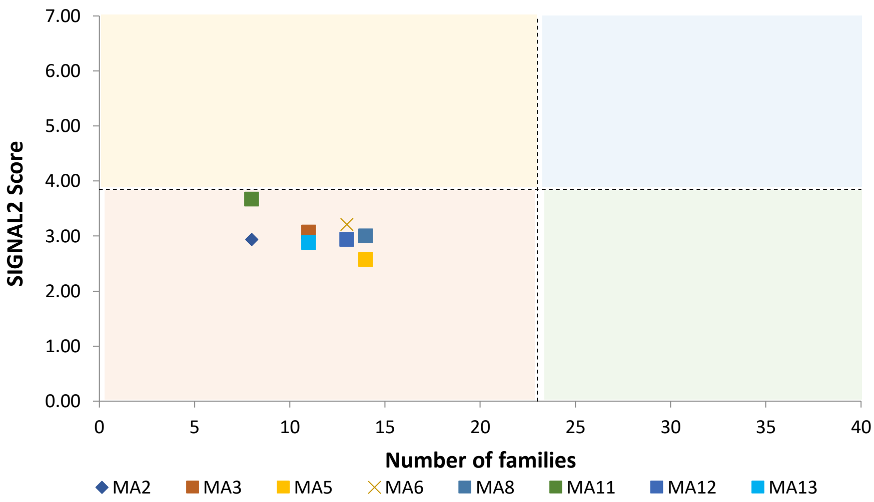


Figure 25: Macroinvertebrate SIGNAL2 bi-plot for samples collected in 2020

8.4.4 Tolerant taxa index

It is expected that a site experiencing adverse impacts will see a change in the proportion of tolerant taxa abundance. The Percent Tolerant Taxa index is based on the proportion of total taxa that are rated as having a "tolerant" sensitivity grade (SIGNAL grades 1, 2 and 3). The lower the SIGNAL grade, the more tolerant to impacts the taxa are, and subsequently, a higher proportion of tolerant taxa indicates poorer water quality and/or a more disturbed ecosystem.

The percentage of pollutant tolerant taxa ranged from 13% to 81% in 2020, and from 46% to 97% in 2021 Figure 26 Data is presented against the DEHP (2011) WQOs for the 'Upper Isaac River catchment waters' derived for composite habitats tolerant taxa percentage range 25% to 50%. Typically, the percentage of pollutant taxa within samples exceeded the 25% to 50% guideline range. This indicates macroinvertebrate communities within the study area generally lacked taxa more sensitive to pollutants. The samples taken in 2021 contained a notably higher composition of tolerant taxa. The largest contrast between the years is seen in the data from site MA6 which in 2020 had the lowest percentage of tolerant taxa (13%), to having the highest amount in 2021 (97%). Of the sites sampled both years, all except site MA11, had an increase in the percentage of tolerant taxa. An increase in the percentage of pollutant tolerant taxa at these locations may indicate unfavourable physical conditions and / or reduced habitat quality and are likely to reflect a temporary state due to conditions encountered at the time of sampling.

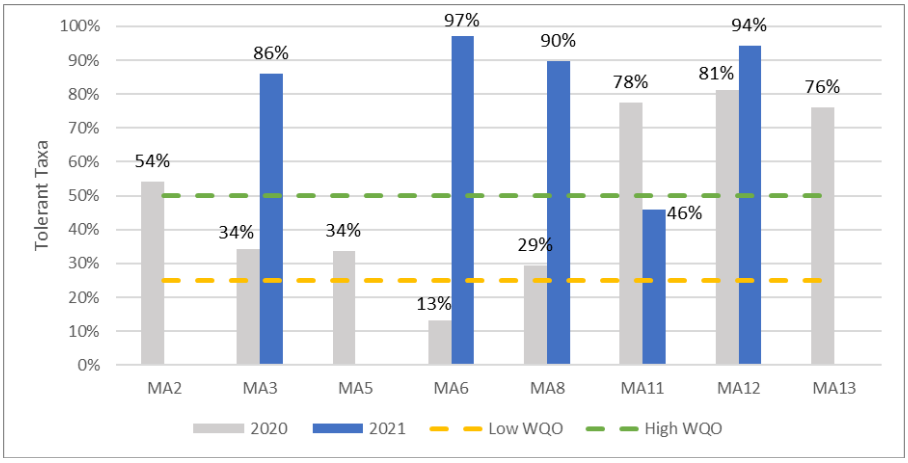


Figure 26: Percentage of tolerant taxa

8.5 Aquatic flora

The aquatic flora species encountered were common emergent species, two semi-aquatic sedges, *Cyperus difformis* (site MA4), and *Cyperus iria* (site MA8). *Cyperus iria* considered Least Concern under the NC Act and *Cyperus difformis* is not listed. The lack of both diversity and abundance of aquatic plants at some sites is likely indicative of harsh physical conditions, cattle grazing and trampling, or a combination of these factors.

8.6 Aquatic fauna

8.6.1 Fish

Australia yields a low diversity of fish species predominantly due to its large areas of arid and semi-arid land, as well as the ephemeral nature of large areas of catchments (Allen *et al.* 2002). Due to the ephemeral nature of the waterways present within the study area the overall habitat available to freshwater species is relatively low. For most of the year, the waterways on-site are vastly unconnected with other aquatic habitats. Resulting in shallow still pools of water with limited refuge, breeding or feeding areas.

A total of 638 fish were captured across all sites during both survey periods representing nine species from five families. There was markedly more fish captured during the 2021 survey (633 individuals from nine species) and the previous 2020 survey (5 individuals from 2 species). Table 27 gives the number of each species recorded during the 2020 survey and Table 28 gives the species recorded in 2021. A total of 344 crustaceans were captured across all sites during both survey periods representing five species from four families. Similarly, there were more crustaceans captured during the 2021 survey (306 individuals from five families) than the 2020 survey (38 individuals from two families).

The taxonomic richness was relatively even across the survey sites sampled in 2021 ranging between four and seven different species recorded per site.

No listed (EVNT) species were recorded at any of the survey sites during any of the surveys. All fish species recorded in the study area are considered common or widespread species in the Isaac River Sub-basin. No pest fish species were recorded during any of the surveys.

Table 27: Fish and crustacean species abundance and richness at sites during 2020 survey

Species	MA2	MA5	MA8	MA11	MA12
Fish species					
Melanotaenia splendida splendida Eastern Rainbowfish	1	-	-	-	-
Leiopotherapon unicolor Spangled Perch	2	-	-	1	1
Total abundance	**3**	**-**	**-**	**1**	**1**
Species richness	**2**	**-**	**-**	**1**	**1**
Crustacean species					
Paratya australiensis Freshwater shrimp	1	-	-	-	-
Austrothelphusa transversa Freshwater crab	5	1	14	17	-
Total abundance	**6**	**1**	**14**	**17**	**-**
Species richness	**2**	**1**	**1**	**1**	**-**

Table 28: Fish and crustacean species abundance and richness at sites during 2021 survey

Species	MA3	MA8	MA10	MA11	MA12	MA 17
Fish species						
Ambassis agassizii Agassiz's glassfish	135	150	-	1	1	-
Craterocephalus stercusmuscarum Flyspecked Hardyhead	10	-	-	-	-	-
Hypseleotris klunzingeri Western Carp Gudgeon	-	44	-	2	7	64
Hypseleotris sp. A Midgley's Carp Gudgeon	1	40	-	-	2	26
Oxyeleotris lineolate Sleepy cod	-	-	-	-	1	-
Philypnodon grandiceps Flathead Gudgeon	1	-	-	-	1	-
Melanotaenia splendida splendida Eastern rainbowfish	27	9	-	56	-	11
Amniataba percoides Barred Grunter	3	-	-	-	-	-
Leiopotherapon unicolor Spangled perch	3	12	-	7	3	16
Total abundance	**180**	**255**	**-**	**66**	**15**	**117**
Species richness	**7**	**5**	**-**	**4**	**6**	**4**
Crustacean species						
Paratya australiensis Freshwater shrimp	32	-	-	-	27	-
Caridina sp. Freshwater shrimp	18	-	-	-	12	-
Cherax destructor Blue claw crayfish	17	-	-	-	6	1
Austrothelphusa transversa Freshwater crab	4	1	-	19	68	-
Macrobrachium australiense Common Australian River Prawn	85	-	-	1	15	-
Total abundance	**156**	**1**	**-**	**20**	**128**	**1**
Species richness	**5**	**1**	**-**	**2**	**5**	**1**

8.6.2 Turtles

No turtle species listed under the EPBC Act or NC Act were recorded during the surveys. No Least Concern turtle species were recorded during the 2020 or 2021 surveys. A single Krefft's River Turtle (*Emydura macquarii krefftii*) was recorded during the preliminary survey in 2019 from MAq1.

The ephemeral nature of the watercourses limits the suitable habitat for turtle species listed under the EPBC Act. Discussion of suitable habitat for EPBC Act listed species is provided in section 10.1.

8.6.3 Platypus

The Platypus (*Ornithorhynchus anatinus*) is listed as SLC under the NC Act and has been recorded from the Isaac River drainage sub-basin (DES 2021). Platypus was not detected during the aquatic ecology surveys. Preferred habitat for the species includes areas with clear, flowing water with coarse bed substrates (e.g. cobble and gravel), riffle zones and dense coverage of submerged aquatic vegetation. The ephemeral watercourse in the study area do not contain the specific habitat required by the species. For the short periods when the water watercourses are in flow, the water is turbid and lack the typical coarse bed substrates (Figure 20), riffle zones and submerged aquatic vegetation preferred by the species.

The Isaac River is the watercourse within the study area that has the greatest potential to contain habitat for and support the Platypus, however, no suitable habitat for the species was observed at the survey sites along the Isaac River. There would not be any direct impacts at the Isaac River, and any potential impacts would be indirect impacts associated with changes in hydrological processes or water quality. Although there are several small farms dams within the study area

The assessment of lack of habitat for the Platypus in the Isaac River corresponds to the findings of assessments for other projects approved in the broader region. Particularly the aquatic ecology assessment for the Olive Downs Project included surveys and habitat assessments for Platypus along the Isaac River near the confluence of the Isaac River and Boomerang Creek (i.e. downstream of the Project).

There are no records of the species within 50 km of the Project (Appendix A), and there are no records from within the Isaac River Sub-catchment of the Fitzroy River Basin (there are records from the Connors River sub-catchment).

8.7 Groundwater dependent ecosystems

Groundwater Dependent Ecosystems (or GDEs) are ecosystems that rely upon groundwater for their continued existence. Aquatic GDEs are surface water ecosystems which may have a groundwater component (i.e. a surface expression of groundwater) and can include rivers, wetlands and springs (BoM 2020).

Section 5.2.5 details the areas which are potential GDEs based on the BoM mapping. As the BoM mapping is not completed at a suitable spatial scale at which impact assessment from a Project can be determined, a field based GDE assessment was completed (Appendix 1 of the EIS); a summary of the results of the assessment is provided here (details of the assessment are used in part to support the impact assessment in this report).

Multiple lines of evidence including measurement of Leaf Water Potential, Soil Moisture Potential (SMP), stable isotopes and physical observation were applied to assess for the presence of and characterise the ecological function of GDEs within areas potentially subject to mining influence. Based on the results of the field survey and associated data analysis, it was concluded that two types of GDEs are present within aquatic ecology study area, namely:

1) Type 1 GDEs: Includes drainage features with developed alluvial landforms that host variable groundwater volumes and are seasonally recharged via surface flows and flooding. This includes Phillips Creek, Boomerang Creek, and the Isaac River.
2) Type 2 GDEs: This represents a conceptualised perched groundwater lens that lies below the HES wetland in the east of the study area (GDE Assessment Site 3 in the GDE assessment report). Percolation of

groundwater through the alluvial soils occurs when surface water is recharged, and the infiltrating surface water is captured above an aquitard at the alluvial unconformity. Tree roots of River Red Gum and Coolibah are utilising this freshwater lens, which possibly only remains viable for several months following rainfall. The perched freshwater lens is inferred to be >6 m below the base of the wetland.

9 Potential impacts

9.1 Direct impacts

The Project would remove and/or directly modify a small area of aquatic habitat, however, the watercourses in the area to be disturbed are of low to moderate ecological value. The Project will not cause any direct disturbance to wetlands. Specifically, the following activities have the potential to have direct impacts on aquatic ecology values within the study area:

- loss of watercourses and wetlands due to direct disturbance; and
- creation of barriers to fish passage at infrastructure corridor watercourse crossings.

9.1.1 Loss of waterways and wetlands

Construction of the infrastructure corridor (specifically the access/haul road) will require stream crossings of Phillips Creek and One Mile Creek. These are the only two watercourses defined by the Water Act that will be directly impacted by the Project.

The infrastructure corridor will include:

- access/coal haulage roads for personnel, materials and coal haulage;
- an overhead 66kV electricity transmission line;
- a raw water supply pipeline; and
- telecommunications infrastructure.

Where the infrastructure corridor crosses these watercourses there will be small areas of loss or modification of the watercourse. The stream crossings will be constructed as causeways with appropriately sized culverts to pass low flows but will be inundated approximately 5 days per annum. The causeway length for the One Mile Creek crossing will be approximately 164 m. This causeway will be of concrete construction, with an underlying box culvert sized at 750 mm wide x 600 mm high (Figure 27). The causeway length for the Phillips Creek crossing will be approximately 17.5 m. This causeway will again be of concrete construction, with two underlying box culverts sized at 3600 mm wide x 1800 mm high (Figure 27). The sizing differences of these two causeways is representative of the different channel and bed structures of the two watercourses, as well as the respective flow regimes.

~~T~~The culverts are not subject to the Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works (DAF 2018) ~~for new culvert crossings~~ because they will be within a ML~~,~~ and therefore ~~not subject to the~~exempt from assessment under the Planning Act~~, which is the legislation under which culverts deemed assessable development would be assessed~~. Notwithstanding, to minimise impacts to fish habitats and fish passage culverts will be configured according to the accepted development requirements by adopting the following design configuration:

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- all instream works will commence and finish within 180 calendar days;
- the culvert aperture will span a minimum of 100% of the low flow channel width;
- the culvert will be installed at no steeper gradient than the waterway bed gradient;
- outermost culvert cells will incorporate roughening elements on the bank side walls and upstream wingwalls to the height of the upstream obvert;
- the culvert cells will be aligned parallel to the direction of water flow;
- the width of the culvert aperture will span a minimum of 75% of the main channel width for Phillips Creek and approximately 40% for One Mile Creek where the channel width is approximately 3 m; and

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- the internal roof of the culvert must be 600 mm above the waterway bed level.~~; and~~

It is noted that the disturbance required to support construction of the Phillips Creek crossing will be approximately 100 m wide. This width is primarily required to facilitate excavation and grading of the channel bed, to maintain existing flow velocities through this section of stream (including the proposed culverts). Revegetation works will be undertaken as part of culvert construction activity, with causeways and culverts to remain post mine closure. Construction activities will be undertaken during the dry season, to minimise erosion and sediment mobilisation, while also facilitating time to generate stability prior to wet season flows.

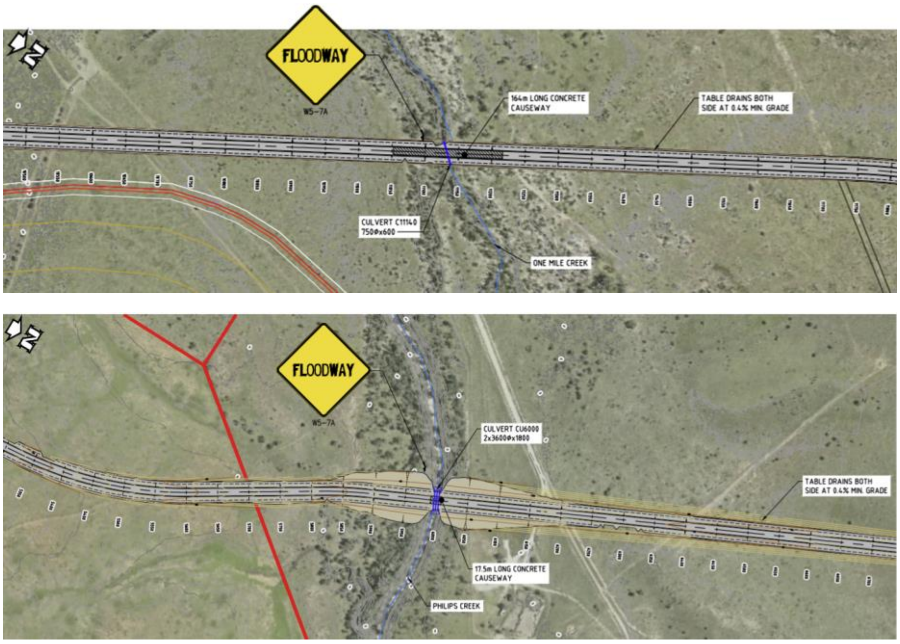

Figure 27: Conceptual designs of One Mile Creek (top) and Phillips Creek (bottom) crossings

A small area of a GES wetland will be disturbed by the electricity transmission line (ETL) and light vehicle access road running from the MIA to the substation/borehole deliveries area (Figure 3). This wetland is a lacustrine wetland of very low conservation value adjacent to One Mile Creek the landform at this location has been modified to permanently hold water through the construction of a farm dam. The ETL and vehicle access road would result in 0.01 ha of disturbance to the GES wetland. The disturbance area to the GES wetland was calculated using the State's Vegetation management wetlands map – version 7.05 (DES 2019). This mapping deviated slightly from the field verified wetland vegetation mapping. Although the wetland was classified as good in the Habitat Bioassessment, total macroinvertebrate abundance and PET richness were very low.

Overall, the aquatic habitats of these waterways and wetlands are common and typical of the region, and while their removal will mean a loss of available aquatic habitat for aquatic communities, this is not expected to impact aquatic ecology on a regional scale.

The construction of watercourse crossings associated with the infrastructure corridor could directly clear aquatic flora species; however, few aquatic flora species were detected during the surveys, and all species detected are classified as Least Concern under the NC Act.

There will also be a reduction in habitat available to aquatic fauna as a result of the removal of habitat within the disturbance area. The small area of direct disturbance and ephemeral nature of the watercourses indicates that there will be minimal impact to aquatic fauna species. Given that direct disturbance will occur when watercourses are not flowing the likelihood of aquatic fauna becoming stranded or experiencing direct mortality is low. The potential adverse impacts on all aquatic species and their habitats will be avoided and minimised through proposed management measures. All aquatic fauna species (including fish, turtles and macroinvertebrates) detected within the disturbance area during the field surveys are Least Concern under the NC Act and are not protected under the EPBC Act. ~~No endemic species is expected to be present within the disturbance area.~~ As such, the Project may result in the loss of individuals of species that are considered common and have a broad distribution in the region but is unlikely to result in the loss of any individuals of listed ~~or endemic~~ species. ~~The potential adverse impacts on all aquatic species and their habitats will be avoided, minimised, or mitigated through the proposed management measures.~~

The small area of direct disturbance to watercourses and wetlands is unlikely to impact aquatic flora on a regional scale. Impacts from direct disturbance to riparian and wetland vegetation communities is discussed in the Terrestrial Ecology Impact Assessment (Appendix G of the EIS).

9.1.2 Barriers to fish passage at waterway crossings

The construction of waterway crossings along the infrastructure corridor has the potential to create barriers to fish movement along the waterways. Barriers to fish movement which could be created by the Project include waterway crossings of Phillips Creek (purple), One Mile Creek (red) and the minor waterway (green) by the infrastructure corridor.

The minor waterway (green) is a shallow drainage line of stream order one and is highly ephemeral, only flowing for short periods of the year. It is crossed by the infrastructure corridor close to existing disturbance associated with the Lake Vermont Mine at which point the waterway terminates indicating fish are unlikely to utilise the areas upstream of the waterway crossing. The waterway is not expected to currently provide fish passage and the disturbance associated with the infrastructure corridor will not create an impediment to fish passage.

Both One Mile Creek and Phillips Creek are highly ephemeral waterways that do not flow for long stretches of the year, limiting the connectivity of waterways and wetlands within, upstream and downstream of the Project. It is considered that both waterways are likely to provide some localised fish passage for periods during which they sustain flow. Upstream of the Project, both waterways pass through the existing BMA Mine site, where they are both crossed by and existing road network (culverts are located at crossing locations). Additionally, the proposed Saraji East development will include a 'transport and infrastructure corridor' which will cross both One Mile Creek and Phillips Creek upstream of the Meadowbrook Project.

The watercourse crossings of Phillips Creek, One Mile Creek associated with the Meadowbrook Project's infrastructure corridor would be constructed in consideration of fish passage and water flow. Both crossings will consist of causeway crossings with appropriately sized culverts to allow low flows to pass (see section 9.1.1). It is anticipated that the appropriately sized culverts will maintain fish passage. If there was any impact to fish passage, this would be localised, and due to the poor-quality fish habitat and fish passage values of the waterways, there is unlikely to be a measurable impact to fisheries resources beyond the Project area.

9.2 Indirect impacts

The Project has the potential to have indirect impacts on aquatic ecology values through changes to water quality and hydrology. The following activities have been assessed for their potential to have indirect impacts on aquatic ecology values:

- changes in timing and magnitude of flow, caused by loss of catchment area;
- subsidence of the stream bed level caused by underground mining operations;
- subsidence induced changes in ponding caused by underground mining operations;
- changes to flood regimes due to surface infrastructure and subsidence;
- erosion and sedimentation due to Project activities;

- water quality changes due to water releases;
- water quality changes due to releases from final rehabilitated pit landform;
- impacts to water quality from litter, wastes and spills; and
- impacts to aquatic ecosystems utilising groundwater due to groundwater drawdown.

Aquatic ecosystems have the potential to be impacted through changes in hydrology by:

- affecting the life cycles of aquatic species that have adapted to existing hydrological conditions (i.e. affecting cues for movement, migration and breeding);
- changing the diversity and structure of in-stream aquatic habitat in turn influencing the composition of aquatic communities;
- affecting water quality through changes in the volume and timing of flows (especially flushing);
- increasing erosion of watercourses which further affects water quality and habitat conditions; and
- altering the connectivity between aquatic habitats through changes in flows.

9.2.1 Impacts to downstream channel flows

The Project will result in a loss of catchment area due to the construction of the open pit and waste rock dump, and MIA both of which will be surrounded by flood protection levees for the duration of the operations. The MIA flood protection levee will be removed at mine closure and the open pit flood protection levee will be required until the final overburden profile is achieved and associated permanent landform is established. Additionally, the subsidence induced changes to the floodplain morphology will retain additional water during flood events. The retained water would pond and either seep into the underlying sediments or evaporate, effectively reducing the catchment area and thus the downstream flows.

Where practical, minor drainage channels are proposed to drain the subsidence panels (Figure 3), minimising the volume of water captured in the subsided panels. This is not possible in all areas and ponding of runoff captured in the floodplain between Boomerang and One Mile Creeks would effectively reduce the local catchment draining to One Mile Creek by approximately 9 km^2 (6.9%). This catchment loss would impact the downstream 4 km reach of One Mile Creek before the confluence with Boomerang Creek in minor runoff events. The stretch of One Mile Creek where flows are modelled to be reduced during regular flow events has moderate aquatic ecological values and the reduction in flows will have a minor ecological impact to aquatic values.

The impacts to stream flows would be minimal downstream of the confluence, where loss of catchment would make up 1.8% of the 489 km^2 total catchment area. The modelled flood hydrographs downstream of the Boomerang Creek/One Mile Creek confluence for the 50% and 2% AEP events show that loss of catchment would attenuate the flood hydrograph for the 50% AEP event, reducing and delaying the flood peak compared to existing conditions (Figure 28). This reduction in flow would reduce the 50% AEP flood depths in the Boomerang Creek by about 0.3 m to 0.5 m.

In larger floods, the effect of storage on flood flows and downstream flood levels is minimal (Figure 29).

There is not predicted to be any changes to downstream flow in Phillips Creek due to loss of catchment area.

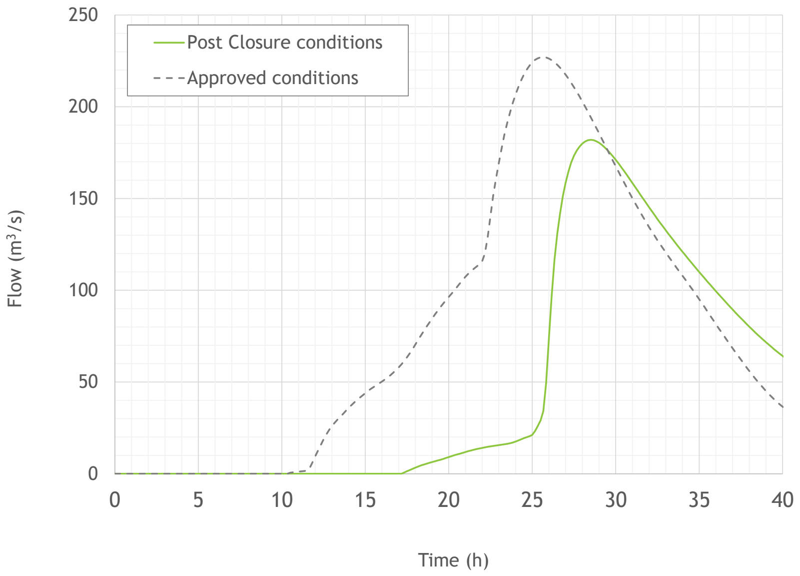

Figure 28: Downstream flood hydrograph - Boomerang/One Mile Creek - 50% AEP (WRM 2022)

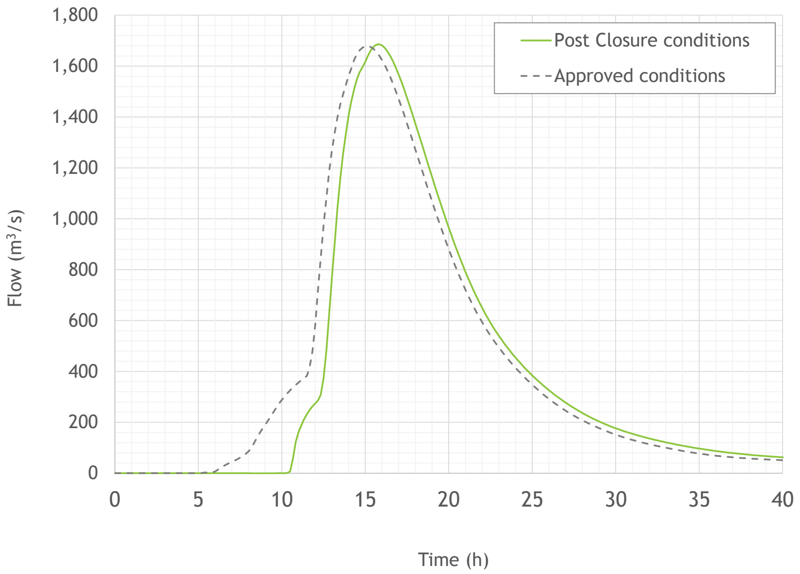

Figure 29: Downstream flood hydrograph - Boomerang/One Mile Creek - 2% AEP (WRM 2022)

9.2.2 Subsidence of streambed

Underground mining operations are proposed beneath Boomerang and One Mile Creeks, and within 50 m Phillips Creek. A subsidence assessment (Gordon Geotechniques 2021) has been prepared to model the predicted subsidence effects of the Project on the surrounding landform, including the watercourses. The assessment predicted that both One Mile Creek and Boomerang Creek would experience subsidence of the creek bed where the creeks traversed the northern longwall panels. The maximum subsidence of the Boomerang Creek is predicted to be 4.0 m (Figure 30), while maximum subsidence on One Mile Creek is predicted to the be 3.0 m (Figure 31). The channel of Phillips Creek would not be directly affected by subsidence.

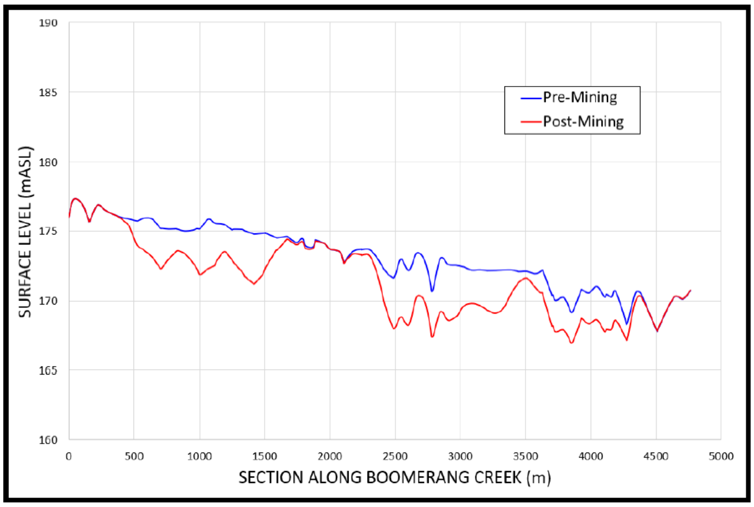

Figure 30: Subsidence—cross-section along Boomerang Creek (source: Gordon Geotechniques 2021)

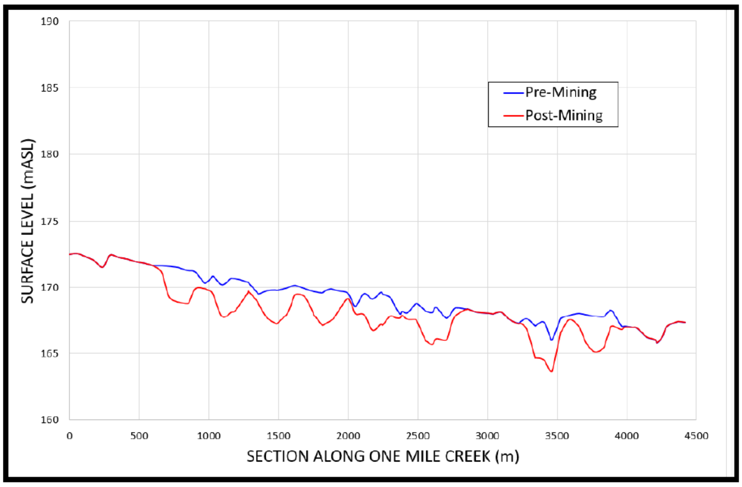

Figure 31: Subsidence—cross-section along One Mile Creek (source: Gordon Geotechniques 2021)

The subsidence assessment has been used by WRM (WRM 2021) to assess changes in sediment transport characteristics in Boomerang Creek and One Mile Creek. A summary of the results and how they relate to potential impacts to aquatic ecology values is discussed here.

9.2.2.1 Boomerang Creek

The proposed subsidence would result in a series of six main troughs in the channel bed where there would be a decrease in channel velocity, bed shear and stream power, causing reductions in sediment transport capacity in each trough, and promoting aggradation of the bed (relative to the top of bank level) in these areas. Channel velocity, bed shear and stream power are greater across each of the pillars when compared to the mine subsidence troughs. However, this increase in-stream flow characteristics is different to the current conditions at four locations where the Creek crosses the underlying pillar.

The bed sediments at the downstream side of the relative elevated sections (i.e. the point where the stream flows from panel to trough) are expected scour and the elevated section may erode to match the downstream bed profile. There may be marginal increases in bank erosion at these locations

During initial flows, local incision and bank erosion can be expected over the pillars between subsidence troughs. However, given the abundant sediment supplies in Boomerang Creek, the sand bedload will infill the troughs such that the bed grade should revert to approaching the pre-mining grade over time. The expected aggradation relative to the bank levels could accelerate the potential abandonment of the existing Boomerang Creek channel. It should be emphasised that given the number of remnant channels and abundant sediment supplies in the catchment, a new Boomerang Creek channel could form in the absence of the proposed subsidence.

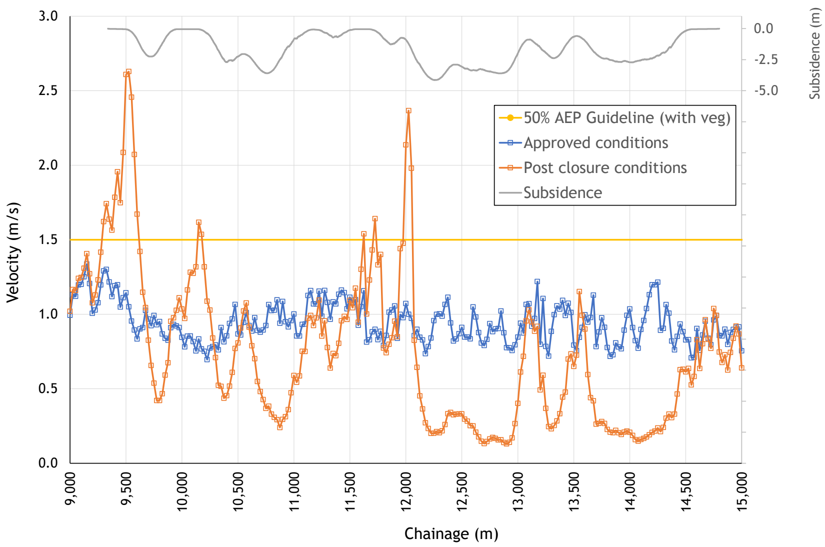

Figure 32: Changes in Boomerang Creek flow velocity due to subsidence profile (50% AEP flow)

The erosion and scouring of the watercourse could cause localised loss of in-stream habitat at the point where erosion and scouring occurs. This could have a localised impact on habitat availability for macroinvertebrate species and aquatic flora. However, as the erosion is predicted to be localised, it is not expected that this impact will extend off-lease. Nor will it impact habitat availability for other aquatic species such as fish and turtles given there is currently limited in-stream habitat for these species. As there is plentiful sediment supply within Boomerang Creek and the turbidity of the water typically exceeds the water quality guidelines, it is not expected that the increased sediment load associated with the localised erosion and transport of bed sediments will impact water quality to the extend the aquatic ecology values and negatively impacted.

Although the subsided depth profile would follow the existing stream bed profile the post mining subsided landform would create significantly deeper sections of the watercourse which may form pools for significantly longer periods of the year than currently occurs. Given the ephemeral nature of the watercourse, the creation of subsided areas of the streambed are not expected that the changes in-stream bed morphology will create a barrier for fish or turtle that may migrate along the watercourses.

9.2.2.2 One Mile Creek

The proposed subsidence would result in a series of eight main troughs in the channel bed due to the differential settlement across the longwall panels and the intervening unmined pillars in the one overlying coal seam which are aligned approximately perpendicular to the channel.

The channel velocity, bed shear and stream power in sections where the channel flows over the subsided panels. This will cause a reduction in sediment transport capacity in each trough promoting further aggradation of the bed (relative to the top of bank level) in these areas.

Channel velocity, bed shear and stream power are expected to increase at four locations where the watercourse drains from the underlying pillar sections into the relatively lower subsided panel sections. Although velocities would remain below AEP guideline values (‘Guideline: Works that interfere with water in a watercourse for a resource activity—watercourse diversions authorised under the Water Act 2000’) the relatively fine sediment in this area and the apparent limitation in sediment supply, these reaches are expected to erode as the channel morphology changes to reflect the higher bed grade. This may also lead to increases in bank erosion as the channel capacity increases.

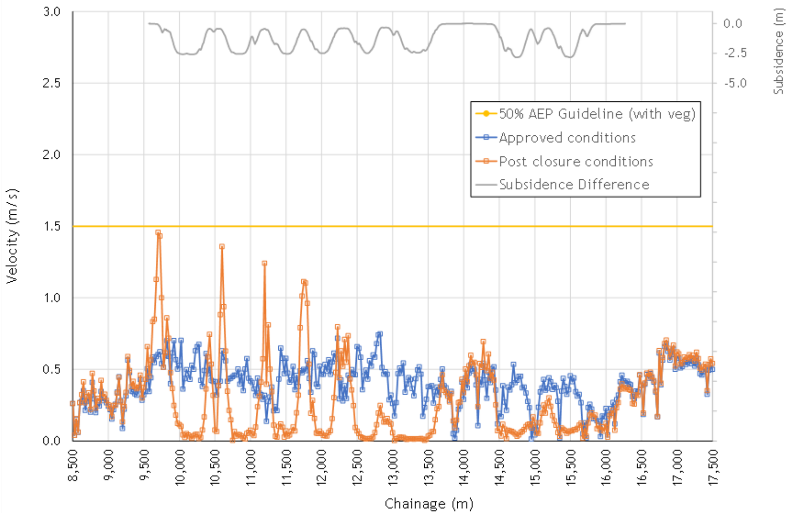

Figure 33: Changes in One Mile Creek flow velocity due to subsidence profile (50% AEP flow)

The erosion and scouring of the watercourse could cause localised loss of in-stream habitat at the point where erosion and scouring occurs. This could have a localised impact on habitat availability for macroinvertebrate species and aquatic flora. However, as the erosion is predicted to be localised, it is not expected that this impact will extend off-lease. Nor will it impact habitat availability for other aquatic species such as fish and turtles given there is currently limited in-stream habitat for these species.

If there was sufficient sediment supply, the post subsidence channel velocity, bed shear and stream power would revert towards pre-mining conditions. However, as it appears sediment supply is limited, this may take a long time, and the ponds formed by the sediment may persist for a comparatively long time (WRM 2022).

~~The erosion and scouring of the watercourse could cause localised loss of in-stream habitat at the point where erosion and scouring occurs. This could have a localised impact on habitat availability for macroinvertebrate species and aquatic flora. However, as the erosion is predicted to be localised, it is not expected that this impact will extend off-lease. Nor will it impact habitat availability for other aquatic species such as fish and turtles given there is currently limited in-stream habitat for these species.~~ Given that turbidity at sites on One Mile Creek (MA5 384 NTU (2020), MA12 (262.5 NTU (2020) and 574.66 NTU (2021)) was recorded as well above WQO value (<50 NTU) under pre-mining conditions, it is unlikely that an increase in turbidity due to localised erosion will impact aquatic flora or fauna communities.

Although the subsided depth profile would follow the existing stream bed profile the post mining subsided landform would create significantly deeper sections of the watercourse which may form pools for significantly longer periods of the year than currently occurs. Given the ephemeral nature of the watercourse, the creation of subsided areas of the streambed are not expected that the changes in-stream bed morphology will create a barrier for fish or turtle that may migrate along the watercourses.

9.2.3 Subsidence induced changes to ponding

Subsidence of the landform due to longwall mining will create a series of depressions aligned with the underground mining panel array and orientated in a largely north-south direction. How the local hydrological regimes will be affected by these depressions has been modelled as part of the hydrological assessment of the Project (WRM 2022) and summarised below.

To minimise the extent of ponding caused by the subsided landform, BBC is proposing to establish two drainage channels would be cut through the pillars separating the subsidence troughs to allow free drainage of catchment runoff through the subsidence zone (Figure 34). Additionally, small embankments are proposed across the subsidence panels to restrict the flow of water from Phillips Creek to One Mile Creek. The drainage channels and embankments would significantly reduce the extent of ponding due to subsidence, however, post-mitigation ponding would still occur.

In relation to the potential impact to aquatic ecology values, the post-mitigation ponding has been considered in two categories, namely ponding connected to the One Mile Creek channel and ponding on the floodplain. It should be noted that the ponding associated with One Mile Creek is related to the impacts of subsidence to the One Mile Creek streambed (Section 9.2.2).

Subsidence of panels along One Mile Creek would create eight ponds which would be connected, and perpendicular, to the existing stream channel. During flood flows, water would flow laterally into the subsidence areas and even during regularly occurring flood events (50% AEP) would persist for several months post filling. As the sediment load in One Mile Creek is considered to be limited (see previous section) it is anticipated that these ponds will persist for multiple years. The creation of these stream connected ponds have the potential to create additional aquatic habitat locally, as water is constrained within them rather than flowing further downstream (impacts due to changes to hydrological flows downstream are addressed elsewhere). Particularly, the persistence of water in the local landscape for an extended period (i.e. longer than is currently occurring) potentially creates additional habitat for macroinvertebrate assemblages and other aquatic fauna. The sustained inundation of these areas (up to 1 m in depth) may provide seasonal refugial habitat for aquatic fauna between flow events, and at times across the dry season. Impacts to vegetation through the establishment of these ponds is discussed in the terrestrial ecology assessment (AARC 2022).

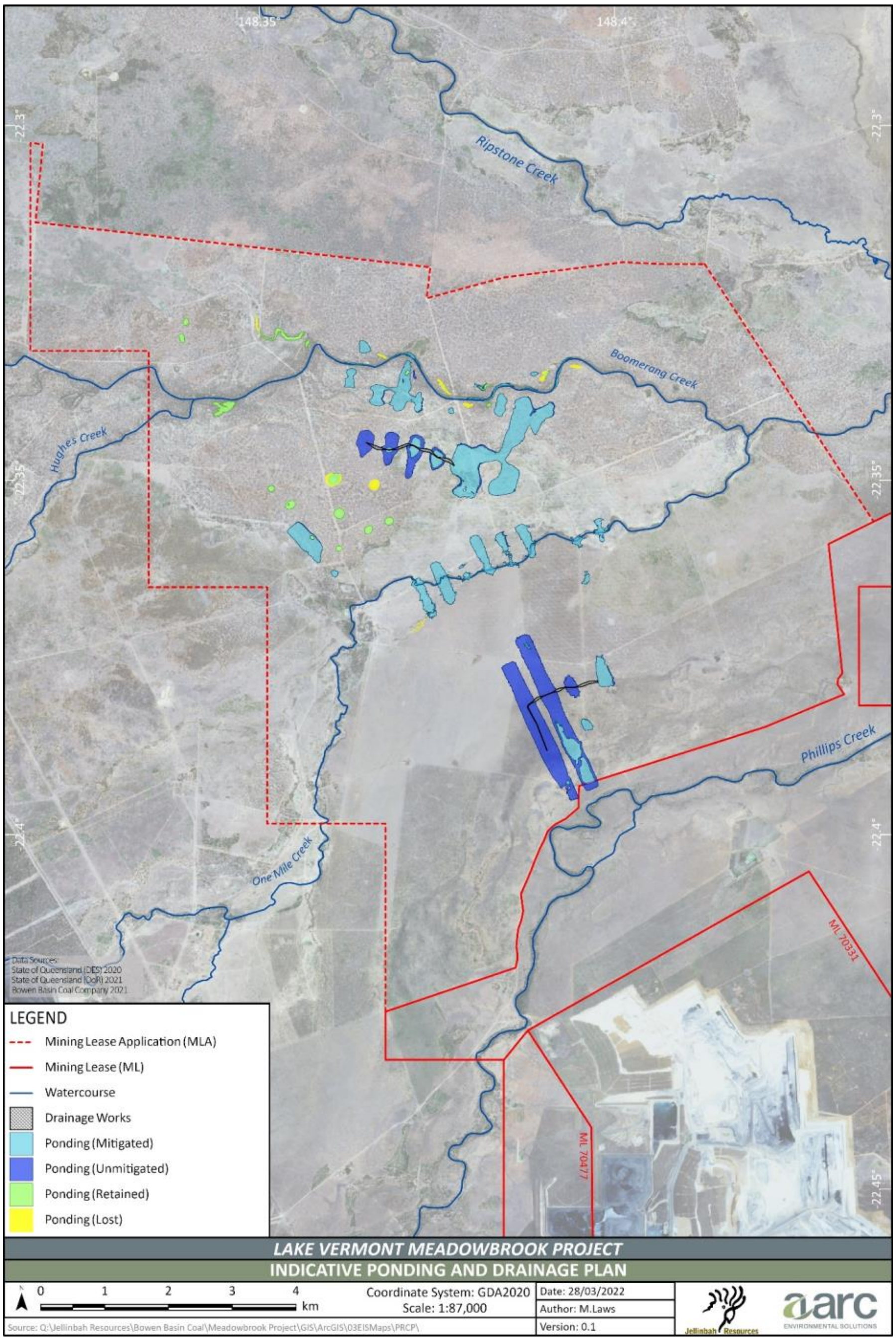

Figure 34: Map showing mitigated subsidence induced ponding and location of mitigation measures

Similarly, the areas of post mitigation ponding on the floodplains (Boomerang Creek, Phillips Creek and One Mile Creek) are anticipated to hold water for extended periods to a similar depth. The depressions would partially fill with local rainfall and runoff and slowly evaporate or seep into the local soils. The duration of ponding in these depressions would depend on the depth and duration of rainfall, but based on water balance modelling, they would be unlikely to fill completely, and would be expected to store more than 1 m of water less than 10% of the time. However, based on modelling of the 50% AEP flood, the depressions would be expected to fill with Boomerang Creek floodwater at least every few years. The ponded water would then persist until it evaporated or seeped into the underlying soil. In the absence of seepage, depending on their depth, the ponds could then be expected to persist for several months post filling. These ponded areas are likely to have an ecological function similar to the ephemeral wetlands which occur within the surrounding landscape and provide habitat for invertebrates and small amphibians and reptiles, especially during periods of inundation. Given that inundation of the ponding areas will persist for several months at times, this additional water within the local landscape could provide habitat and foraging resources for both aquatic and terrestrial fauna species.

The changes in surface ponding due to mine induced subsidence are also predicted to change the extent of surface water availability at three VM Act wetlands, namely subsidence would result in:

- seasonal inundation being completely absent from one of the VM Act wetlands (i.e. water available pre-mining would not be available post mining);
- the extent of inundation at one wetland being reduced by approximately one-quarter; and
- a significant increase in the extent (and likely duration) of inundation of one wetland.

The VM Act wetland where subsidence will cause complete loss of surface water availability should be considered as removed. The loss of this wetland will have an impact on a local scale as it is likely to support flora and fauna species which are common within the surrounding landscape. The VM Act wetland is unlikely to support habitat for any threatened aquatic species.

Where the subsidence will cause a reduction in the extent of inundation at a VM Act wetland, the composition and ecological function of the wetland may be negatively impacted. The change in inundation could cause a change in vegetation structure, soil moisture properties and aquatic flora and fauna species composition. However, given the common nature of species and communities which inhabit the study areas, it is unlikely that the change in inundation at the VM Act wetland will have a significant impact on any threatened species, but rather would reduce a small area of available habitat for common species within the local area.

The aquatic ecological characteristics of the one VM Act wetland which will be further inundated due to the changes in ponding will likely change. However, the nature of this change is at this stage unclear. The large area of inundation due to subsidence at this location will, over time, likely have similar ecological function in terms of aquatic ecological values as the existing wetland, however, over a larger area. Although the greater area of inundation will likely result in the vegetation community which currently fringes the wetland being lost, the ability of macroinvertebrate communities found within the local environment to tolerate harsh environmental conditions indicate that the inundation area will support assemblages of such species. As the existing VM Act wetland is unlikely to support any threatened aquatic flora or fauna, there is no anticipated to threatened species at this location due to the changes in ponding.

Impacts to regulated vegetation associated with the VM Act wetlands are discussed in the Terrestrial Ecology Assessment (AARC 2022).

9.2.4 Changes to flood regimes

Ripstone, One Mile, and Boomerang Creeks all have relatively shallow channels that experience flow breakouts even in relatively frequent floods. Through much of the Project area, the catchment boundary of One Mile Creek extends to a natural levee along the southern bank of Boomerang Creek. Minor indistinct floodplain flow paths direct runoff from the catchment boundary southeast across the proposed mining area towards One Mile Creek.

Phillips Creek has a much greater channel capacity than the northern streams, and flow is relatively frequent flood events (50% AEP). In larger flows (1% AEP) floodwater covers the majority of the Phillips Creek northern floodplain, begins to form flow paths to One Mile Creek across the proposed underground mining area and joins to the One Mile Creek flood plain in the east of the aquatic ecology study area and before the confluence of the Isaac River.

The Project is predicted to have three mechanisms to change the flood regimes (depth and velocity), namely:

- Construction of flood protection levees around the open cut pit and MIA
- Construction of the haul road; and
- Subsidence caused by underground mining.

The construction of the flood protection levees around the open cut pit would increase flood depth under the 1% AEP scenario by between 1 m and 3 m at the southern extent of the bund where it was closest to the Phillips Creek channel. Despite the increase in depth the flood flow velocities under the same scenario are more constrained - localised to the south-eastern corner of the flood protection levee where the velocity would increase by up to 1.5 m/s.

The flood protection levee around the MIA would increase flood depth around the southern and eastern section by up to 1.0 m, with some of the change in flood depth being attributed to the embankment created by the establishment of the haul road. There would also be a small area over which flood depth increased at the northern extent of this flood protection levee. Despite the increase in flood depth around the MIA flood protection levee, flood flow velocities are only predicted to be marginally higher than currently experienced along the eastern section of the flood protection levee.

The increase in flood velocities close to the open cut bund could cause erosion and sediment transport into the surrounding aquatic environments. It is unlikely the increase in flood velocities and depths associated with the MIA flood protection levee would cause any significant increase in erosion and sediment transport. Both of the proposed levees would be designed to ensure they could withstand the predicted velocities during operations and would be removed on decommissioning and closure at which time the flood velocities would return to pre mining conditions (WRM 2022).

The construction of the haul road would cause changes in flood regime on both the Phillips Creek and One Mile floodplains. The stream crossings will be constructed as causeways with appropriately sized culverts to pass low flows but will be inundated approximately 5 days per annum. The vertical alignment has been designed for a maximum of 300 mm overtopping in a minor flow of 50% AEP – Q2. In the 10%, 2% and 1% AEP events, the low-level crossing of Phillips Creek becomes drowned, and the afflux is reduced so that off-lease flood levels upstream of the haul road are not increased by the Project. The 1 in 1,000 (0.1%) AEP and PMF flood events show no afflux in Phillips Creek upstream of the haul road crossing. In small flows, when the proposed low flow crossing is not drowned, the afflux created by the haul road is sufficient to extend off the mine lease area. In the 50% AEP design event, the afflux is confined to areas within the channel, with a maximum of 60 mm at the lease boundary. Velocities associated with the changed flood patterns due to the establishment of the haul road would be minimal and not expected to cause significant erosion or scouring provided cross-drainage structures were appropriately designed.

The establishment of the flood protection levees, and mining-induced landform subsidence will locally reduce the flood level but will increase the depth and extent of flooding. Floodplain conveyance and storage would also be reduced – this would have the effect of locally increasing upstream flood levels and redistributing downstream flow to the opposite floodplains until the levees were decommissioned and the floodplain landform returned to pre-mining levels. The effect of the change of flood regimes on aquatic ecology values is not anticipated to be significant given the adaptation of the aquatic flora and fauna to the relatively harsh environmental conditions which are currently experienced within the study area. Despite the change in the flood regime, the wetland areas within the study area are all expected to receive water from flood events.

Changes in flood depths are not expected to extend far outside the Project area, with the regional model demonstrating that flood height at the Isaac River would be comparable to current conditions. Similarly, predicted changes in flood depths, there would be minimal changes to velocity outside the proposed ML area.

9.2.5 Groundwater drawdown

The aquatic habitats associated with Boomerang Creek, Phillips Creek and the Isaac River along with the GES wetland and HES wetlands within the study area may comprise aquatic GDEs. As watercourses and wetlands are ephemeral, any groundwater dependence of the aquatic environments would be for short periods of the year and given the ephemerality of the aquatic environments the aquatic species that inhabit them are adapted to wetting and drying cycles.

The groundwater model and groundwater impact assessment (JBT 2022) concluded that the only location where the alluvium is permanently saturated is the Isaac River alluvium (JBT 2022), and that this is consistent with available data from landowner groundwater bores. The modelled drawdown of the alluvium sediments does not extend to the Isaac River; drawdown in the alluvium is confined to a relatively small area along Boomerang Creek which the groundwater model predicted to contain some water (JBT 2022).

Although the alluvium is dry for much of the year the groundwater impact assessment concluded that the groundwater drawdown contours assigned to the Tertiary sediments can be used to indicate the zone within which any water that does occur within the alluvium would have an enhanced potential for downward seepage. The Tertiary sediment drawdown contours do not extend to the Isaac River, and thus any dependence aquatic ecosystems had on groundwater would not be impacted by the Project.

The HES wetland to the east of the Project area, but within the aquatic ecology study area was determined to be partial groundwater dependent (3D Environmental 2022). However, the conceptualisation of this potential GDE noted that it was likely a perched alluvial groundwater aquifer inferred to be more than six metres below the base of the HES wetland but separated from the underlying Tertiary sediments and groundwater environment. This perched aquifer may provide seasonally accessed water to the riparian vegetation of the HES wetland which in turn contributes to the aquatic environment of the HES wetland through provision of shade and habitat structure etc. The perched alluvial system is conceptualised as dry for extended periods of the year and through extended drought periods and as such the terrestrial vegetation which may seasonally rely on the alluvial groundwater in the perched system will be adapted dry long periods. The groundwater modelling conducted for the Project predicted drawdown would not interact with the mapped HES wetland and the surface water flows which both recharge the alluvial groundwater lens and provide a water source for terrestrial vegetation at the HES will not be affected. As such, it is not predicted that there will be impacts to aquatic environment at the HES wetland as a result of the Project.

The Tertiary sediment groundwater drawdown contours do extend under Phillips Creek which is mapped as a high potential aquatic GDE. However, the alluvium under Phillips Creek is unsaturated for most of the year (apart from small pockets which may occur in the alluvium following recharge by rainfall or stream flow), and the creek is ephemeral indicating aquatic species and communities are not reliant groundwater. Further, as the groundwater quality is poor (EC 10,000 µS/cm), groundwater is considered unsuitable for aquatic ecosystem support and is unlikely to be supporting the aquatic environments within the study area.

It is unlikely that groundwater drawdown associated within the Project will impact aquatic ecology values.

9.2.6 Water quality impacts

Surface water quality downstream waterways can be impacted through a number of mechanisms including increased sedimentation and turbidity, increased concentrations of nutrients and contaminants (namely metals and hydrocarbons) and saline and acid drainage.

Increases in sediment can potentially impact the health, composition and resilience of aquatic fauna and flora by affecting respiration, breeding and feeding (e.g. clogging fish gills) or by burying benthic communities. High levels of turbidity as a result of sedimentation can impact growth and diversity of aquatic plants and algae as light required for photosynthesis is reduced (although there are few aquatic plants in the receiving environment). In addition, the deposition of fine sediments can decrease in-stream bed roughness and habitat diversity and may result in the filling of existing pools. The resulting decrease in habitat available for aquatic fauna could lead to a decline in the abundance and diversity of both macroinvertebrate and fish communities in the creeks and a reduction in the number of pools available as refuge habitat in the dry season.

Increased nutrients from nutrient laden runoff can lead to aquatic plant and algal blooms, potentially resulting in high dissolved oxygen concentrations during the day (during net photosynthesis), but very low dissolved oxygen concentrations during the night and early morning (when there is a net consumption of oxygen as during respiration). In extreme cases, this can lead to eutrophication and fish kills.

Hydrocarbons and other contaminants (such as heavy metals) can impact growth, morphology, reproduction and development of aquatic flora and fauna. Acute and chronic toxic effects can also occur. The type, volume and concentration of hydrocarbons and other contaminants, along with environmental factors (e.g. dilution, mixing, existing exposure levels), determines the severity of impact.

Where saline or acid drainage finds a path to enter surface water, impacts to aquatic ecology can include:

- Contamination of water and/or sediment;
- Poor health and possible death of fish and other aquatic organisms;
- Reduction of in-stream and riparian vegetation;
- Promotion of noxious plant growth; and
- Visual changes to waterways.

The potential drivers and impacts to water quality due to the Project are discussed below.

9.2.6.1 Erosion and sedimentation

Excavation within a watercourse and the development of a crossing can have impacts on aquatic ecosystems downstream. Similarly, changes in flow velocities within streams or the creation of flood protection structures against which flood water flows can increase erosion which in turn increase sediment load within water.

Construction of the watercourse crossings will be undertaken in the dry season, thus minimising the release of sediment into the receiving waters.

The flood protection structures levee would be designed to ensure it could withstand the predicted velocities during operations.

Measures such as rock bank protection will be considered if monitoring indicates that the increase in erosion is having a demonstrable impact on the channel form.

Increases in sediment loads within aquatic environmental increases turbidity and changes water conditions. This change in water conditions can in turn affect aquatic organisms – for instance making it more difficult for aquatic fauna to locate and capture prey items and /or decreasing light penetration which impacts aquatic flora. Pollutants and nutrients which may have been trapped in the sediment can also be transported with the sediment and can cause contamination or eutrophication of waterways.

However, the watercourses within the study area experience high levels of sediment transport and deposition during the wet season. Watercourses are typically highly turbid to which the aquatic organisms of the study area are adapted. The erosion and sediment impacts associated with the Project are not expected to significantly impact the aquatic ecological values on a regional scale.

9.2.6.2 Water releases

There is no controlled water release proposed as part of the Project.

Runoff from the open cut waste rock dumps will be managed under an erosion and sediment control plan which is to be implemented throughout the Project, such that sediment generated and transported by runoff will be settled in a sediment dam. During open cut mining operations, catchment runoff from overburden dumps will be captured in in three sediment dams (referred to as the Southern Sediment Dam, Northern Sediment Dam 1 and Northern Sediment Dam 2). Sediment dams will be designed and operated in accordance with the Department of Environment and Heritage Protection Guideline - Stormwater and environmentally relevant activities (DEHP, 2021). However, significantly more sediment dam capacity will be provided at the Meadowbrook open cut operations (more than double the above requirement) such that in conjunction with pumping back to the MIA dam, no offsite discharges would occur under modelled historical conditions (WRM 2022).

As the sediment dam capacities adopted for the Project are relatively large, and as a result, the likelihood of uncontrolled releases from the sediment dams to One Mile and Phillips Creek is very low. The model results (WRM 2022) show releases would only be expected in the wettest 1% of historical climate periods. The largest modelled spill event would see a total of 360 ML released from the north and south sediment dams combined at a total dissolved salts (TDS) of less than 800 mg/L. Dilution by flows in the receiving waters would likely result in indiscernible impact to the downstream environment (WRM 2022).

9.2.7 Mine drainage from waste rock emplacements

The open cut mining activities would see overburden material placed in out-of-pit and in-pit waste rock emplacements adjacent to the proposed open cut pit. The largest waste rock emplacements will be located within the flood protection levee surrounding the open pit, with the smaller waste rock emplacement located to the north-west of the open pit and outside the flood protection levee.

Weathering processes in the waste rock areas result in; the dissolution of soluble minerals, partial dissolution of lower solubility minerals (mineral weathering), cation exchange, and reaction. Mining activities increase the hydraulic conductivity and surface area of naturally occurring materials, resulting in a body of waste rock more prone to leaching.

The 'Geochemical Assessment of Mining Waste Materials Project' (RGS 2021) indicates waste rock at the Meadowbrook Project would have:

- low sulphur content, excess acid neutralising capacity, negligible risk of acid generation and a high factor of safety with respect to potential for the generation of acidity;
- no significant metal/metalloid enrichment compared to median crustal abundance in unmineralised soils;
- slightly alkaline to alkaline surface runoff and seepage with relatively low salinity; and
- low dissolved metal/metalloid concentrations in surface runoff and leachate.

The water extract solutions were generally dominated by ions of sodium, chloride and sulphate with lesser concentrations of other major ions.

Runoff from the open cut waste rock dumps will be managed under an erosion and sediment control plan which is to be implemented throughout the Project, such that sediment generated and transported by runoff will be settled in a sediment dam. During operations a perimeter drain will be constructed to divert runoff from the waste rock emplacement outside the open cut pit flood protection levee to the southern sediment dam. Material from this waste rock dump will be put back into the pit and the area rehabilitated on mine closure. The management of water captured within the sediment dams is discussed in Section 9.2.6.2) and further details of the water management system are outlined in (WRM 2022).

9.2.8 Final rehabilitated pit landform seepage and overflow

In any pit void which does not have a mechanism for salts to flow out (e.g. by flushing through flood inflows and discharges, or by fresh groundwater inflows), salinity will tend to increase over time.

The water balance model developed to assess the behaviour of the final rehabilitated pit landform under various climate scenarios is provided in (WRM 2022). Water levels in the final rehabilitated pit landform are expected to rapidly reach an equilibrium level approximately 1 m above the floor and fluctuate within a 2.2 m range. However, due to the size of the catchment area, and fluctuations in modelled water level, it is likely the final rehabilitated pit landform will be subject to intermittent periods of ponding but is not expected to be a permanent water body. Under all climate change scenarios modelled, the long-term water levels would remain more than 25 m below the spill level and would not overflow.

The results of groundwater modelling undertaken for the Project groundwater impact assessment (JBT 2022) concluded that (including allowance for seepage from the catchment and water ponded in the final landform depression) post-mining recovery of groundwater to equilibrium levels (approximately 2.6 m below the adopted base level of the final rehabilitated pit landform) would take about 350 years (approximately 150 years to reach the level of the base of open cut mining and a further 200 years to reach the regional groundwater level).

During this period, water would seep from the landform to the rising groundwater table, minimising the accumulation of salts within any intermittent ponding in the final rehabilitated pit landform. The equilibrium groundwater flow potential would be towards the final landform at very shallow gradients. Once the groundwater reaches an equilibrium level, seepage from the final landform depression would result in mounding of groundwater below the landform, with the groundwater flow potential being away from the depression.

While catchment runoff is likely to provide a diminishing source of dissolved salts, and long-term groundwater inflows are expected to be minimal. The salinity of any water intermittently ponded within the final rehabilitated pit landform will fluctuate significantly and increase over time. Under high and low seepage rate scenarios, the median TDS of the stored water ranged between 295 mg/L and 913 mg/L (WRM 2022). The maximum TDS values of this intermittent water body are expected to remain well below the 'low risk' trigger value (4,000 mg/L) of the applied livestock drinking water quality guideline (ANZG 2018).

9.2.9 Litter, waste and spills

If litter and waste from construction and operations was to enter aquatic ecosystems, it could potentially entangle aquatic fauna and contribute to the degradation of water and sediment quality. As a Waste Management Plan is in place for the Lake Vermont Project which would apply to the Meadowbrook Project, the risk of litter and waste entering aquatic ecosystems and subsequent impact on aquatic ecology values is very low.

Provided the appropriate management of chemicals is maintained, the Project is unlikely to result in leaks or spills that would eventuate in serious environmental harm to aquatic species or their habitat. Appropriate storage of chemicals and hydrocarbons will be required as part of ongoing operations as well as a dedicated fuel and lube facility, which will be constructed to provide adequate containment and spill response. An existing Chemical and Fuel Management Plan is in place for the Lake Vermont Project which would apply to the Meadowbrook Project, as such risk of stored chemicals entering the aquatic ecosystems and subsequent impact on aquatic ecology values is very low.

9.3 Cumulative impacts

The cumulative impacts to water resources have been assessed based on the predicted impacts of the Project along with the existing or approved impacts of other activities in the region. Cumulative impacts have considered cumulative changes in hydrological characteristics and quality of surface water and groundwater. The cumulative impact assessments included all current and known future coal mining operations, as well as the operation of the Arrow Energy CSG borefield.

The cumulative impact assessment conducted as part of the groundwater impact assessment concluded that there would be:

- no cumulative drawdown in the alluvium;
- drawdown in the Tertiary sediments from Olive Downs South and Eagle Downs extends southward to coalesce with the drawdown from the Meadowbrook operation, resulting in an additional 2 to 10 m of drawdown beneath Boomerang Creek and an additional 2 to 15 m of drawdown beneath Ripstone Creek;

In terms of cumulative impacts from surrounding projects on regional flooding, the assessment (WRM 2022) noted the Willunga and Olive Downs South domains of the proposed Olive Downs Project which extend onto the Isaac River floodplain downstream and upstream of the Meadowbrook Project, and the flood impacts of the two projects would potentially interact.

Both the end of life (2051) conditions of the Project with mitigation measures and other projects, and the post closure conditions of the Project with other projects were modelled in the cumulative impact assessment, with the maximum disturbance of all projects modelled to occur simultaneously (conservative assessment). The cumulative impact modelling was undertaken for the 1 in 1,000 (0.1%) AEP regional flood event.

The cumulative flood impact outside of the Project area is dominated by the relatively large impacts of the disturbance on the Isaac River floodplains approved for other projects. The impacts, of the Meadowbrook Project are relatively minor and there is minimal interaction with the impacts of the other projects.

Although there will be some direct disturbance to aquatic habitat values within the Project area, the direct disturbance is a small area of regional aquatic habitat and when compared to other approved projects in the region.

9.4 Facilitated impacts

Facilitated impacts relate to impacts from other projects (including by third parties) which are made possible (facilitated) by the Project being assessed (this Project). Facilitated impacts may be expected to occur through the development of an infrastructure project (e.g. a dam, road or rail line), where that development would enable the development of other projects which otherwise may not have been viable (e.g. the development of a road leads to urban development in an undeveloped area).

The Project will not develop any infrastructure that will facilitate the development of any other projects. Mining operations will not facilitate the development of any other projects which could not already be developed. Proposed electrical, water supply and telecommunications infrastructure will link to existing infrastructure at the Lake Vermont Mine and does not facilitate the development of other future projects. Any proposed infrastructure, including electrical, water supply and telecommunications, will avoid waterways where possible, and any that do not have a functional requirement to be in a waterway will not be placed within them.

Post mining it is expected that where possible the Project area will be reinstated to grazing lands at a similar suitability to that existing prior to mining or, where this cannot be achieved, used for alternative use that provides a similar value to that pre-mining or able to provide long-term ecological value to the region. It is not considered that the return of lands to an agricultural land use or alternative use that provides similar value will facilitate the development of projects which would cause additional (facilitated) impacts to those identified for the Project.

As such there is not expected to be any facilitated impacts from the Project on any aquatic ecology values.

10 Impact assessments

10.1 Impacts to matters of national significance (MNES)

This section provides an assessment of the significance of impacts of the Project on threatened aquatic species in accordance with the Project Terms of Reference and EPBC Act Significant Impact Guidelines (DoE 2013).

There were no aquatic flora or fauna that are MNES recorded within, or considered likely to occur, within the study area. Although neither the Fitzroy River turtle or Southern Snapping Turtle are expected to occur within the Project area based on results of surveys and habitat assessment, an assessment of the potential impacts to the Fitzroy River turtle and, in accordance with the required impact assessment hierarchy for MNES, is provided below.

10.1.1 Fitzroy River turtle

10.1.1.1 Description

The Fitzroy River turtle is a medium to dark brown freshwater turtle with an oval shell, growing up to 25 cm in length with scattered darker spots on the upper shell surface (DoE 2021). It has a pale yellow or cream underside, dull olive-grey exposed fleshy parts and a distinct narrow white ring around the eye in adults, or a silvery-blue iris in hatchlings (Cogger 2000, Hamann *et al.* 2007, DoE 2021). The Fitzroy River turtle has relatively long forelimbs with five long claws and large cloacal bursae which has a respiratory function (Cogger 2000, Wilson & Swan 2003).

This species is a benthic omnivore, with a diet consisting of insects, macroinvertebrates (principally larvae and pupae of Trichoptera and Lepidoptera), crustaceans, gastropods, worms, freshwater sponges, algae and aquatic plants including ribbonweed *(Vallisneria sp.)* (DEWHA 2008b).

The Fitzroy River turtle is only found in the drainage system of the Fitzroy River, Queensland. It is estimated that this species occurs in a total area of less than 10 000 km² (DoE 2021). Known sites include Boolburra, Gainsford, Glenroy Crossing, Theodore, Baralaba, the Mackenzie River, the Connors River, Duaringa, Marlborough Creek, and Gogango (DoE 2021). The species is largely sedentary with relatively small home ranges and its movements have been shown to be restricted between riffle zones and adjacent pools, although large scale movements for dispersal, courtship, nesting migrations and repositioning following flood displacement may occur (Tucker *et al*. 2001).

The Fitzroy River turtle is found in rivers with large deep pools with rocky, gravelly or sandy substrates, connected by shallow riffles. Preferred areas have high water clarity and are often associated with Ribbonweed (Vallisneria sp.) beds (Cogger *et al.* 1993). Common riparian vegetation associated with the Fitzroy River turtle includes Blue Gums *(Eucalyptus tereticornis*), River Oaks *(Casuarina cunninghamiana),* Weeping Bottlebrushes *(Callistemon viminalis)* and Paperbarks *(Melaleuca linariifolia)* (Tucker *et al*. 2001).

Preferred in-stream habitat for the species is clear fast flowing watercourses that have (Cogger *et al.* 1993; Tucker *et al.* 2001; DoE 2020):

- Rocky, gravelly or sandy substrates;
- Large deep pools (between 1 and 5 m deep) that provide refuge areas and are associated with shallow riffles zones that provide favourable foraging habitat for macroinvertebrates;
- In-stream features such as undercut banks, submerged boulders, tree roots and logs, which provide rest and refuge spots; and
- In-stream vegetation, in particular ribbonweed *(Vallisneria sp.)* which is a preferred food source and provides favourable foraging habitat for macroinvertebrates.

The Fitzroy River turtle is thought to prefer well oxygenated riffle zones and moves into deeper pools as the riffle zones cease to flow (Tucker *et al.* 2001). However, studies have captured several turtles from deep pools (Gordos *et al.* 2007) where they may associate with surface or sub-surface logs (Tucker *et al.* 2001).

Nesting habitat is restricted to areas with alluvial sand/loam banks 1–4 m above water level, however, nesting sites have been found 15 m from the water on flat sandbanks (DEWHA 2008b). Preferred banks include that which have a relatively steep slope, low density of ground/understorey vegetation and partial shade cover. Females have an annual reproductive potential of 46 to 59 eggs laid within three clutches which are deposited in nesting chambers 170 mm deep (DEWHA 2008b). Nesting occurs from September to November, with hatching occurring between November and March (DoE 2021).

10.1.1.2 Desktop analysis

There are no records of the Fitzroy River turtle close to the study area or from the Isaac River. The closest published records of the Fitzroy River turtle from the Qld Wildnet and Atlas of Living Australia are shown in Figure 35. There are no records from the Isaac River Sub-catchment and only three records from the Connors River sub-catchment of the Fitzroy River Basin. Any other records are located a considerable distance downstream (i.e. greater than 100 km), and as such will not be impacted by the Project.

None of the other studies conducted for surrounding projects detailed in Section 5.2.1, recorded the species as part of survey program. Of note, the aquatic ecology study completed for the Olive Downs Project which included assessment sites on Risptone Creek and the Isaac River (downstream of the Meadowbrook aquatic study area), did not record the species nor habitat for the species as part of the assessment.

10.1.1.3 Survey effort

Survey effort for the Fitzroy River turtle is detailed in Table 16. The Fitzroy River turtle can be difficult to survey as they rarely enter traps, however, the highly turbid waters and ephemeral nature of the watercourses of the study area prevented the use of snorkelling (preferred survey technique). As such a combination of trapping and habitat assessment were relied on for the survey of the species.

10.1.1.4 Survey outcomes

No Fitzroy River turtles were recorded in the surveys.

10.1.1.5 Habitat assessment

There is no suitable habitat for the Fitzroy River turtle within the study area.

The habitat within the study area is characterised by ephemeral watercourses which flow for relatively short periods following the cessation of considerable rainfall in the catchment. The preferred habitat of the species (rivers with large deep pools with rocky, gravelly or sandy substrates, connected by shallow riffles with high water clarity) is not found in the study area and the ephemeral nature, high turbidity and sandy to fine sediment substrate do not constitute habitat for the species. The Isaac River is the largest watercourse within the study area, however, ephemeral and does not constitute and does not support year-round habitat for the species.

The Project area will not directly disturb any potential habitat for the species.

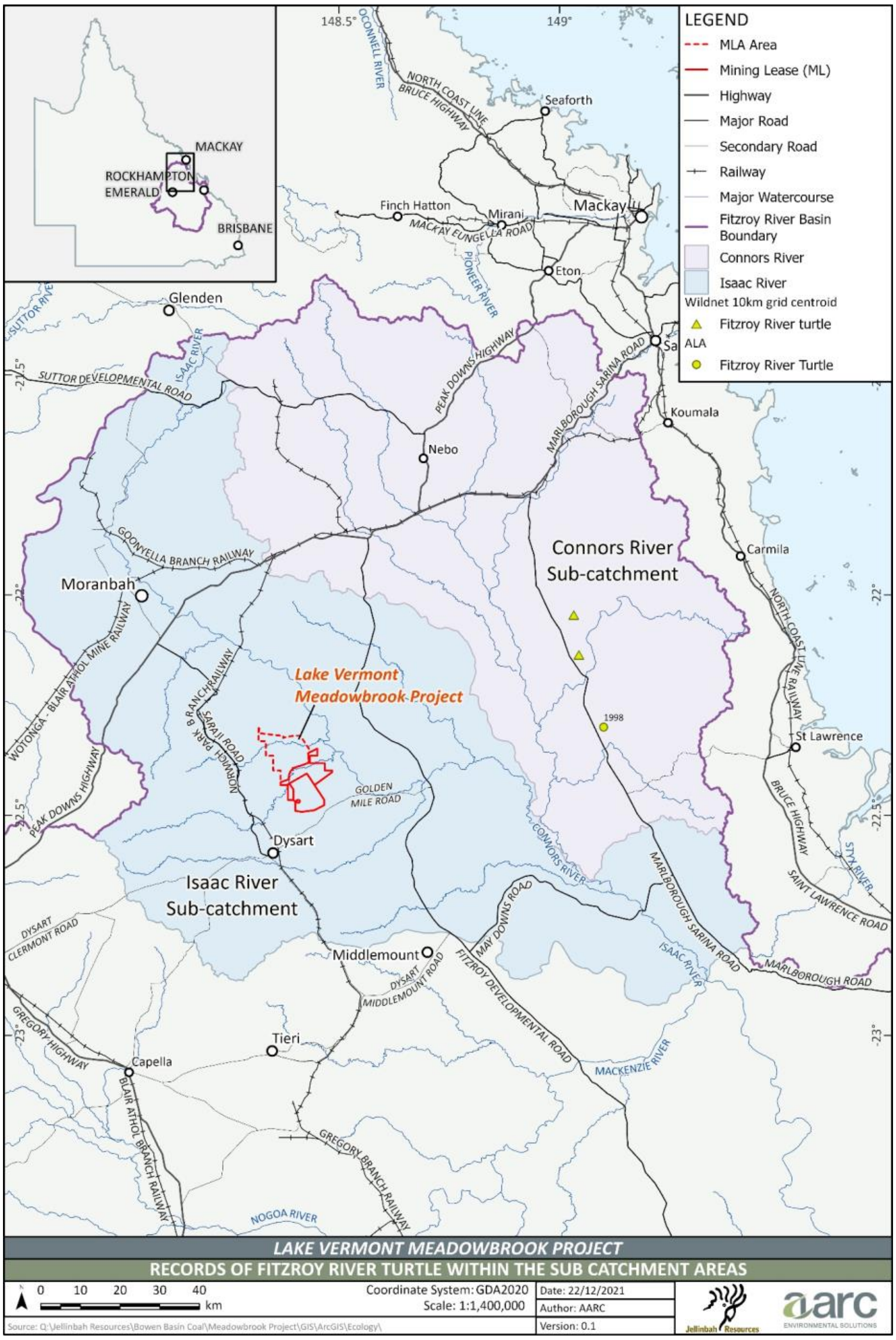

Figure 35: Map showing records of Fitzroy River turtle within the Fitzroy River Basin

10.1.1.6 Direct impacts

There is no potential habitat for the Fitzroy River turtle within the study area, and thus there will not be any direct impacts to the species from the Project.

10.1.1.7 Indirect impacts

The species could be indirectly impacted through changes in watercourse profile through subsidence which change that availability of pool and riffle habitat for the species or through changes in watercourse flow timings or volume. The subsidence profile from underground mining does not extend to areas that are considered suitable habitat for the species. The surface water modelling and flood modelling (WRM 2022) demonstrated there would not be significant changes to regional flooding or volume or timing of flows on a regional scale. The modelled changes in flooding and surface water flows do not extend to the Isaac River, and thus do not extend to the likely nearest population of the species.

As discussed in Section 9.2, the potential impacts to water quality through either sediment chemical release are expected to be minor. Given that any habitat for the Fitzroy River turtle is only likely to be found a significant distance downstream of the Isaac River, any minor changes in water quality due to the Project are unlikely to impact habitat for the Fitzroy River turtle.

The Project is not expected to result in the introduction of any new aquatic pest species to the watercourses which support habitat for the Fitzroy River turtle, and as such, no indirect impacts to the habitat of the Fitzroy River turtle are expected.

As such it is unlikely there will be any indirect impacts to individuals or habitat of the Fitzroy River turtle.

10.1.1.8 Facilitated impacts

The Project will not result in any other actions that have the potential to impact on the Fitzroy River turtle or their habitats. As such, no facilitated impacts to the Fitzroy River turtle are predicted.

10.1.1.9 Cumulative impacts

The Project will not result in any impacts to the species and is not expected to contribute to any cumulative impacts to the species.

10.1.1.10 Avoidance, mitigation and management measures

There is no potential habitat for the Fitzroy River turtle within the study area, and thus direct impacts to the species will be avoided. Given that there is no habitat for the species that is likely to be indirectly impacted, no species-specific management measures are proposed. However, general management measures will be implemented to both minimise disturbance to aquatic habitats and minimise changes to water quality, namely:

- Design of watercourse crossings to consider fish passage;
- Flood levees are designed to withstand increase in flood velocities;
- Limit the extent of direct impact to the identified disturbance area;
- Locate areas of disturbance outside of watercourses and wetlands where possible; and
- Development of environmental management plans, including:
    - Erosion and sediment control plan;
    - Water management plan;
    - Chemical and fuel management plan; and
    - Waste management plan

10.1.1.11 Significant impact assessment

The significance of the impacts from the Project on the Fitzroy River turtle, after the avoidance, mitigation and management measures have been implemented, has been assessed against the significant impact criteria for vulnerable species (DoE 2013) in Table 29.

Table 29: Significant impact assessment for the Fitzroy River turtle

Significant Impact Criteria (DoE 2013)	Significant Impact Assessment for the Project
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that is will:	
lead to a long-term decrease in the size of an important population of a species	An important population of the Fitzroy River turtle has not been identified within the waters of the study area nor downstream of the study area. It is not expected that the Project will result in mortality of the species, nor impacts to breeding success or movement of the species. The Project will not cause any impacts to water quality or hydrological flows in an area where the species is known to occur.
reduce the area of occupancy of an important population	An important population of the Fitzroy River turtle has not been identified within the water bodies within the study area. Studies completed for nearby Project have also failed to detect the species within water upstream and downstream of the Meadowbrook Project. The hydrological regime of the Isaac River will not be impacted by the Project.
fragment an existing important population into two or more populations	An important population of the Fitzroy River turtle has not been identified within the study area nor has a population been detected upstream or for a significant distance downstream of the study area. The Project is no expected to have any direct or indirect impact on habitat used by the Fitzroy River turtle which would result in the fragmentation of an existing population.
adversely affect habitat critical to the survival of the species	The waters within the study area have not been determined to provide habitat critical to the survival of the species. It is not expected that the waters provide suitable habitat.
disrupt the breeding cycle of an important population	The waters within the study area do not provide suitable breeding habitat for the species.
modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The Project will not adversely impact habitat for the Fitzroy River turtle habitat and thus will not cause the species to decline.
result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The Project will not result in the establishment of an invasive species within the Fitzroy River turtle's habitat.
introduce disease that may cause the species to decline	The construction and operation of the Project is not expected to introduce diseases that may cause the species to decline.
interfere substantially with the recovery of the species	The Project will not interfere with the recovery of the Fitzroy River turtle, as it will not directly or indirectly impact this species or its habitat.

10.1.2 Southern snapping turtle

The Southern Snapping Turtle is listed as critically endangered under the EPBC Act.

10.1.2.1 Description

The Southern Snapping Turtle is one of the largest short-necked freshwater turtles in Australia with females (which are larger than males) reaching up to 42 cm in length (DES 2017). Adults of the species are heavily built, and females have white markings on their face and neck (Limpus *et al*. 2011).

The White-throated snapping turtle is a habitat specialist and has a small home range but is thought to migrate kilometres along rivers to regular nesting sites (Limpus *et al.* 2011). It is only found in in the Fitzroy, Mary and Burnett Rivers and associated smaller drainages. The species only inhabits permanent flowing streams and is does not occur within farm dams, ephemeral swamplands or brackish waters (Hamann *et al.* 2007). Within the Fitzroy catchment, this species occurs throughout the permanent freshwater reaches from the Fitzroy Barrage to the uppermost spring fed pool in the McKenzie and Dawson sub catchments. It may also occur in permanent water impoundments (Limpus *et al.* 2011).

The species prefer permanent, clear, well oxygenated water that is flowing and contains in-stream habitat features and shelter such as large woody debris and undercut banks (Todd *et al.* 2013). During the day, the species inhabit areas of high shade (i.e. submerged logs, overhanging riparian vegetation), and at night they inhabit shallow riffles. The species' preferred habitat is clear, flowing and well oxygenated watercourses that have (Limpus *et al.* 2011):

- Sandy gravel substrates;
- Large deep pools (between 1 and 10m deep) that provide refuge areas and are associated with glides;
- Runs or riffle zones that provide favourable foraging habitat;
- In-stream features such as undercut banks, submerged boulders, tree roots and logs, which provide rest and refuge spots;
- In-stream vegetation which provides a food source and favourable foraging habitat; and
- Healthy riparian vegetation fringing the waterway.

Within the permanent water bodies, the Southern Snapping Turtle is typically found in deep pools (>6 m) bordering a riffle zone (Gordos *et al.* 2007; Hamann *et al.* 2007). During the dry season, the White-throated snapping turtle is found in remnant pools with slow flowing water.

Suitable turtle and nesting habitat that is preferred by these species includes:

- general habitat features such as:
  - clear, flowing and well oxygenated water with riffle zones and deep pools;
  - sandy gravel substrate; a diversity of in-stream features for shelter and to refuge among (e.g. submerged aquatic vegetation, submerged rock crevices, undercut banks and/or submerged logs and fallen trees); and
- nesting habitat features, including sandy or loam banks (Limpus *et al.* 2011).

10.1.2.2 Threats

The species is estimated to have lost more than 70% of its hatchling production and more than 70% of juveniles and sub-adults in the last 20 years (Limpus *et al.* 2011). This loss of juveniles can be attributed to loss of eggs and nest through trampling (particularly by cattle) and failure to recruit immature age classes. Additionally, direct impacts associated with the construction of barrages, dams and weirs have led to a decline in the population across its range (DAWE 2020b).

Current threats to the species are outlined in the adopted recovery plan (DAWE 2020b), and include:

- Predation and trampling at nest sites;
- Installation of in-stream barriers which obstruct movement;
- Degradation of habitat and water quality;
- Climate change resulting in impacts from increased temperatures and changed rainfall patterns; and
- Fishing and boating activities.

10.1.2.3 Desktop analysis

There are no records of the Southern Snapping Turtle close to the aquatic ecology study area or from the Isaac River catchment. The closest published record of the Southern Snapping Turtle from the Queensland Wildnet and Atlas of Living Australia are a single record from the Connors River, with an additional record from the Mackenzie River – well downstream of the Project. Neither of the location where the species has been previously recorded will be impacted by the Project.

None of the other studies conducted for surrounding projects detailed in Section 5.2.1, recorded the species as part of survey program. Of note, the aquatic ecology study completed for the Olive Downs Project which included assessment sites on Risptone Creek and the Isaac River (downstream of the Meadowbrook aquatic study area), did not record the species nor habitat for the species as part of the assessment.

The absence of records from within and around the study area are reflective of the lack of habitat for the species (i.e. permanent flowing water). It is considered likely that the nearest population of the species is at or near the confluence of the Isaac River and Connors River approximately 60 km downstream of the Project footprint, a well outside the area of any expected change in surface water flows or water quality due to the Project.

10.1.2.4 Survey effort

Survey effort for the Southern Snapping Turtle is detailed in Table 16. The Southern Snapping Turtle can be difficult to survey as they rarely enter traps, however, the highly turbid waters and ephemeral nature of the watercourses of the study area prevented the use of snorkelling (preferred survey technique). As such a combination of trapping and habitat assessment were relied on for the survey of the species.

10.1.2.5 Survey outcomes

No southern snapping turtles were recorded in the surveys.

10.1.2.6 Habitat assessment

There is no suitable habitat for the Southern Snapping Turtle within the study area.

The habitat within the study area is characterised by ephemeral watercourses which flow for relatively short periods following the cessation of considerable rainfall in the catchment. These ephemeral watercourses are not considered to be suitable habitat for the sites The remnant pools retained in Phillips Creek, One Mile Creek and Boomerang Creek following flow events are comparable to the small non-flowing waterbodies in which the species is unlikely to be found (10.1.2.1).

The Isaac River is the largest watercourse within the study area; however, this watercourse is still ephemeral and does not constitute preferential habitat for the species.

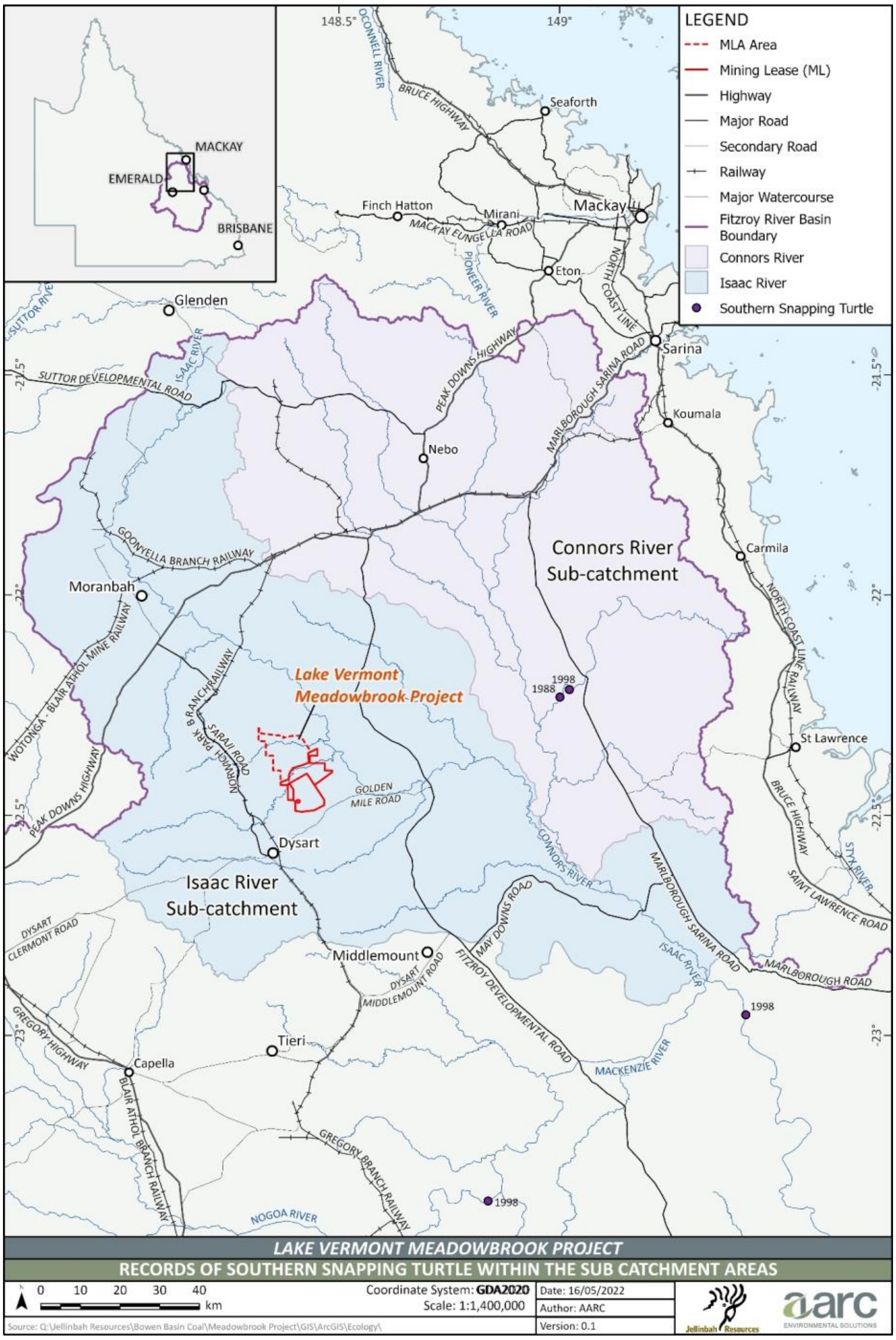

Figure 36: Map showing records of Southern Snapping Turtle within the Fitzroy River Basin

10.1.2.7 Direct impacts

There is no potential habitat for the Fitzroy River turtle within the study area, and thus there will not be any direct impacts to the species from the Project.

10.1.2.8 Indirect impacts

The species could be indirectly impacted through changes in watercourse profile through subsidence which change that availability of pool and riffle habitat for the species or through changes in watercourse flow timings or volume. The subsidence profile from underground mining does not extend to areas that are considered suitable habitat for the species. The surface water modelling and flood modelling (WRM 2022) demonstrated there would not be significant changes to regional flooding or volume or timing of flows on a regional scale. The modelled changes in flooding and surface water flows do not extend to the Isaac River, and thus do not extend to the likely nearest population of the species.

As discussed in Section 9.2, the potential impacts to water quality through either sediment chemical release are expected to be minor. Given that any habitat for the Southern Snapping Turtle is only likely to be found a significant distance downstream of the Isaac River, any minor changes in water quality due to the Project are unlikely to impact habitat for the Southern Snapping Turtle.

The Project is not expected to result in the introduction of any new aquatic pest species to the watercourses which support habitat for the Southern Snapping Turtle, and as such, no indirect impacts to the habitat of the Southern Snapping Turtle are expected. As such it is unlikely there will be any indirect impacts to individuals or habitat of the Southern Snapping Turtle.

10.1.2.9 Facilitated impacts

The Project will not result in any other actions that have the potential to impact on southern snapping turtles or their habitats. As such, no facilitated impacts to the Southern Snapping Turtle are predicted.

10.1.2.10 Cumulative impacts

The Project will not result in any impacts to the species and is not expected to contribute to any cumulative impacts to the species.

10.1.2.11 Avoidance, mitigation and management measures

There is no potential habitat for the Southern Snapping Turtle within the study area, and thus direct impacts to the species will be avoided. Given that there is no habitat for the species that is likely to be indirectly impacted, no species-specific management measures are proposed. However, general management measures should be considered to both minimise disturbance to aquatic habitats and minimise changes to water quality, namely:

- design of watercourse crossings to consider fish passage;
- flood levees are designed to withstand increase in flood velocities;
- limit the extent of direct impact to the identified disturbance area;
- locate areas of disturbance outside of watercourses and wetlands where possible; and
- development of environmental management plans, including:
    - an Erosion and Sediment Control Plan;
    - a Water Management Plan;
    - a Chemical and Fuel Management Plan; and
    - a Waste Management Plan

10.1.2.12 Significant impact assessment

The significance of the impacts from the Project on the Southern Snapping Turtle, after the avoidance, mitigation and management measures have been implemented, has been assessed against the significant impact criteria for critically endangered species (DoE 2013) in Table 30.

Table 30: Significant impact assessment for the Southern Snapping Turtle

Significant Impact Criteria (DoE 2013)	Significant Impact Assessment for the Project
An action is likely to have a significant impact on a critically endangered species if there is a real chance or possibility that is will:	
lead to a long-term decrease in the size of a population	A population of the Southern Snapping Turtle has not been identified within the waters of the study area nor downstream of the study area. It is not expected that the Project will result in mortality of the species, nor impacts to breeding success or movement of the species. The Project will not cause any impacts to water quality or hydrological flows in an area where the species is known to occur.
reduce the area of occupancy of the species	The Southern Snapping Turtle has not been found to occupy the area within the study area not any area affected by an altered hydrological regime, as such the Project will impact habitat such that the area of occupancy of the species is reduced.
fragment an existing population into two or more populations	No populations of Southern Snapping Turtle within the study area, and no populations of the species have been detected upstream of the Project. The Project is not expected to have any direct or indirect impact on habitat used by the Southern Snapping Turtle. The Project would not result in modifications to the aquatic environment such that the passage of the Southern Snapping Turtle would be restricted through the Project area (if the aquatic environment was used for such purpose).
adversely affect habitat critical to the survival of the species	The waters within the study area have not been determined to provide habitat critical to the survival of the species. It is not expected that the waters provide suitable habitat.
disrupt the breeding cycle of an important population	The waters within the study area do not provide suitable breeding habitat for the species.
modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The Project will not adversely impact habitat for the Southern Snapping Turtle and thus will not cause the species to decline.
result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The Project will not result in the establishment of an invasive species within the Southern Snapping Turtle's habitat.
introduce disease that may cause the species to decline	There are no diseases known to impact the species. Disease is not identified as a threat to the species. The construction and operation of the Project is not expected to introduce diseases that may cause the species to decline.

Significant Impact Criteria (DoE 2013)	Significant Impact Assessment for the Project
interfere substantially with the recovery of the species	A recovery plan has been adopted for the species. The Project will not interfere with the recovery of the Southern Snapping Turtle, as it will not directly or indirectly impact this species or its habitat.

10.2 Impacts to matters of State Environmental Significance

10.2.1 Wetlands and watercourses

Offsets are required under the EO Act for significant residual impacts on High Ecological Significance (HES) wetlands, wetlands occurring within a wetland protection area, and any wetland or watercourse in high ecological value waters. No wetland or watercourse in high ecological value waters are located within the study area or surrounds.

The Project will not result in any direct disturbance to the HES wetlands or HES WPAs; however, HES wetlands could be impacted by indirect impacts through changes to hydrogeological or hydrological flows.

There are two HES wetlands and associated wetland protection area mapped within the study area (referred to as HES wetland 8 and HES wetland 9 in the GDE assessment (3d Environmental 2022) and groundwater impact assessment (JBT 2022)). Theses HES wetlands are located east of the Project footprint near the confluence of Ripstone and Boomerang Creeks (Figure 10). HES wetland 9 has been assessed to be surface feature perched on a clay aquitard that will not be influenced by groundwater drawdown related impacts. A conceptual model has been developed for HES wetland 8 which indicates the presence of a perched lens of fresh groundwater lying at depth below the wetland pan.

Although the two HES wetlands are utilising freshwater held in a perched groundwater lens below the wetland, the majority of the alluvium within the study area is dry. The groundwater modelling determined the HES wetland is outside the predicted groundwater drawdown in the alluvial sediments. However, groundwater drawdown in the Tertiary sediments has been used to infer the extent where water level impacts on the Quaternary alluvium could occur via an enhanced potential for downward drainage from the Quaternary alluvium to the underlying Tertiary sediments (i.e. water from the perched groundwater lens could be drawn to the underlying Tertiary sediments). The HES wetland is within the modelled groundwater drawdown of the Tertiary sediments.

The HES wetlands would be reliant on surface water flows to recharge and support the associated aquatic environment. Changes to the surface water flows due to the Project could thus impact the HES wetlands. The surface water modelling (WRM 2022) has assessed the changes in both flood regime and channel flows which can be used to determine changes in water availability at the HES wetlands. The results show that the increased flood storage introduced by the subsidence would attenuate the flood hydrograph for the 50% AEP event, reducing and delaying the flood peak compared to existing conditions. This reduction in flow would reduce the 50% AEP flood depths in the Boomerang Creek by about 0.3 m to 0.5 m. In larger floods, the effect of storage on flood flows and downstream flood levels is minimal.

There are no other HES wetlands or WPAs within the study area. There is a wetland protection area and HES wetlands to the north of Ripstone Creek (Figure 10) which is within the footprint of the Olive Downs Project. The Olive Downs Coking Coal Project will remove this wetland to develop the Olive Downs South Domain (DPM Envirosciences 2018), as such the HES wetland cannot be impacted by the Meadowbrook Project. Lake Vermont (located to the south-east of the Project and within the existing Lake Vermont ML) is also mapped as a HES wetland with associated wetland protection area.

Table 31 provides an assessment of the likelihood of significant impacts on prescribed wetlands in accordance with the Significant Residual Impact Guideline.

Table 31 Prescribed wetlands significant impact assessment

Significance criteria	Assessment of significance
An action is likely to have a significant residual impact on prescribed wetlands or watercourses if it is likely that the action will result in EVs being affected in any of the following ways:	
areas of the wetland or watercourse being destroyed or artificially modified;	The HES wetlands that occur to the east of the study area will not be directly impacted by the Project. No areas of the wetlands will be destroyed or artificially modified.
a measurable change in water quality of the wetland or watercourse—for example a change in the level of the physical and/or chemical characteristics of the water, including salinity, pollutants, or nutrients in the wetland or watercourse, to a level that exceeds the water quality guidelines for the waters; or	There will not be any releases of mine affected water from the Project. The subsidence may cause some changes to sediment transport across sections of Boomerang and One Mile Creeks upstream of the HES wetland. The majority of any eroded sediments are likely to be trapped in the subsided sections of the watercourses due to reduced flow velocity. If eroded stream bed sediments from the subsided section of the watercourses do reach the HES wetland, there is no indication from the sediment quality analysis that these sediments would negatively affect the water or sediment quality at the HES wetland.
the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent upon the wetland being seriously affected; or	The wetland will not be directly impacted by the Project, and as such, no habitat for aquatic species will be seriously affected. The wetland is ephemeral and provides only moderate aquatic ecological value and minimal aquatic habitat to fauna except during wet periods. The hydrological regime (see below) is not expected to significantly change, and thus the habitat and lifecycle of aquatic fauna species in not expected to be impacted.
a substantial and measurable change in the hydrological regime or recharge zones of the wetland, e.g. a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland; or	The flood hydrograph for the confluence of Boomerang and One Mile Creek indicated there would be a delay and attenuation of the flood peak at this location during a 50% AEP flow event, but no significant change in timing or volume of flow during a 1% AEP flow event (WRM 2022). The delay an attenuation of the flow event is attributed to the additional volume of flood storage due to the subsidence in the landform. However, the location of hydrograph assessment is well upstream of the HES wetland at which location the attenuation of the flood event would be expected to be reduced. The flood modelling for 50% AEP flow events indicates there will be a reduction in flood height at the HES wetland (between 0.25 m and 0.1 m), with no reduction in flood height during 1% AEP flow events. The hydrological modelling indicates that although there may be changes to the hydrological regime at the HES wetland, the wetland will still be inundated (1.0 m to 1.5 m) during regular flood events (50% AEP), and as such, the changes in hydrological regime are not expected to be significant. The HES wetland was determined to be a Type 2 GDE, which periodically utilised a perched freshwater alluvial aquifer. The alluvial groundwater drawdown due to mining activities will not impact this perched aquifer. HES wetland 9 has been assessed to be surface feature perched on a clay aquitard that will not be influenced by groundwater drawdown related impacts. A conceptual model has been developed for HES wetland 8 which indicates the presence of a perched lens of fresh groundwater lying at depth below the wetland pan. Drawdown of the underlying Tertiary sediments, which could increase infiltration from the alluvium, would only just reach the edge of the HES wetland, which is likely to cause minimal to no loss of groundwater in the perched system. Although the large Eucalypt at the wetland may utilise this groundwater (all other species are obligatory reliant on surface water) their adaptation to wet/dry

Significance criteria	Assessment of significance
	periods including frequent periods of extended dry indicates their use of the groundwater at the HES wetland is minimal.
an invasive species that is harmful to the EVs of the wetland being established (or an existing invasive species being spread) in the wetland.	The study area is located within a modified rural landscape used for cattle grazing, where introduced species such as Buffel Grass and Feral Pigs are present. The Project is unlikely to increase the spread of established invasive species or result in an invasive species becoming established. A Weed and Pest Management Plan will be implemented for the Project to manage weeds and pests.
Conclusion	The Project will not result in a significant impact to prescribed wetlands.

10.2.2 Waterways providing fish passage

An environmental offset may be required for a part of a waterway that provides for fish passage if the Project includes the construction, installation and/or modification of a waterway barrier that will limit fish passage along that waterway. Waterway barriers to fish passage can:

- fragment populations of fish;
- decrease habitat availability for fish populations by preventing movement to habitat areas;
- cause direct mortality of fish through entrapment in areas of unsuitable water volume, flow and/or quality;
- decrease habitat quality of areas necessary for fish survival and/or breeding; and
- increase predation due to entrapment of fish at watercourse barrier.

Within the study area the Isaac River, Philips Creek, Boomerang Creek and Hughes Creek are classified as major risk (purple) of adverse impacts to fish movement, One Mile Creek is classified as high (red) risk of adverse impacts to fish movement, and a minor waterway classified as low (green) risk of adverse impacts to fish movement (located on ML 70477).

Barriers to fish movement which could be created by the Project include waterway crossings of Phillips Creek, One Mile Creek and the minor waterway (green) on ML70477 by the infrastructure corridor. Additionally, the subsidence of the watercourses providing fish passage could change the ability of fish to navigate passage upstream, this would in effect act as a dam or other barrier to fish passage if the subsidence sufficiently changed the watercourse profile.

The watercourse crossings of Phillips Creek, One Mile Creek and the minor waterway would be constructed in consideration of the *Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works* (DAF 2018) using box culverts to permit navigation of fish during low flow events and maintaining fish passage across the Project area.

The subsidence profile of both Boomerang Creek and One Mile Creek will result in a series of deeper sections of the channel. These sections will experience reduce flow velocity and will hold water for extended periods, while the adjacent reaches of the watercourse may be dry. This is not expected to change the ability of fish or other aquatic species to navigate that watercourse and may provide refugial aquatic habitat for species to utilise during extended dry periods.

During the development of the Project, areas subject to subsidence will be monitored to identify where the potential impacts occur. An adaptive management approach will be pursued with proactive measures to predict, mitigate, report, and improve areas affected by subsidence. A Subsidence Management Plan (SMP) will be prepared for the Project. The SMP will include monitoring, management, and mitigation measures for potential subsidence impacts of the Project, and relevant for fish passage, will include mitigation measures to reprofile subsided channels.

A significant residual impact assessment on the waterways providing fish passage in accordance with the Queensland Environmental Offset Policy Significant Residual Impact Guideline (DEHP 2014) is detailed in Table 32.

It is concluded that the Project is unlikely to have a significant impact on waterways providing fish passage

Table 32: significant residual impact assessment for waterways providing fish passage

Criteria	Assessment
An action is likely to have a significant impact on a waterway providing for fish passage if there is a real possibility that it will:	
Result in the mortality or injury of fish; or	The Project is unlikely to create barriers which result in the mortality of fish, as: Waterway crossings would be constructed in consideration of the Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works. Subsidence is unlikely to sufficiently impact the watercourses such that barriers to fish passage are created.
result in conditions that substantially increase risks to the health, wellbeing and productivity of fish seeking passage such as through the depletion of fish's energy reserves, stranding, increased predation risks, entrapment or confined schooling behaviour in fish; or	The Project is unlikely to create conditions that substantially increase risks to the health, wellbeing and productivity of fish seeking passage because: waterways are ephemeral and provide limited fish passage foremost of the year. ~~Remnant ponds are small and create environments for entrapment and predation;~~ The hydraulic models indicate that the remnant ponds associated with waterways are not predicted to hold less water as a result of subsidence. They also indicate that more remnant ponds would be created (Section 8.3.7). waterway crossings for the infrastructure corridor would be constructed so as not to impede fish movement and thus not impact that health or wellbeing of fish; and although subsidence will cause subsidence of the streambed, the remnant pools resulting from this will be larger than those currently experienced and are not expected to create additional barriers to fish passage. As aggradation occurs stream bed profile is expected to equalise.
reduce the extent, frequency or duration of fish passage previously found at a site; or	The Project is unlikely to create conditions that reduce the extent, frequency or duration of fish passage, as: waterways are ephemeral and provide limited fish passage foremost of the year; and waterway crossings for the infrastructure corridor would be constructed so as not to impede fish movement and thus not impact that health or wellbeing of fish.

Criteria	Assessment
substantially modify, destroy or fragment areas of fish habitat (including, but not limited to in-stream vegetation, snags and woody debris, substrate, bank or riffle formations) necessary for the breeding and/or survival of fish; or	The Project is unlikely to create conditions that substantially modify, destroy or fragment areas of fish habitat, as: aquatic habitat within the study area predominately consists of discrete isolated pools separated by significant length of dry stream bed for most of the year. All the species within the study area are common in the region and adapted to ephemeral systems and poor habitat quality; only small areas of aquatic habitat will be disturbed as a result of the infrastructure corridor waterway crossings; subsidence of watercourses is not expected to significant alter in-stream habitat characteristics, however, subsidence is predicted to create additional areas of intermittent ponding connected to watercourses. erosion is likely to occur as watercourses enter subsided panel areas, this erosion may reduce in-stream habitat for fish locally, however, the minimal in-stream fish habitat that exists indicates this is unlikely to be a significant impact to fish migration or habitat availability.
result in a substantial and measurable change in the hydrological regime of the waterway, for example, a substantial change to the volume, depth, timing, duration and frequency of flows; or	The Project is unlikely to create conditions that result in a substantial and measurable change in the hydrological regime of the waterway, as: all aquatic species recorded in the study area are tolerant of ephemeral flows; The volume, timing, duration, frequency and depth of flows are not predicted to change such that it would significantly impact fish habitat. The conditions would still reflect the current ephemeral conditions; Subsidence induced ponding would intermittently and temporarily increase ponded water within the study area and thus water availability; there are no planned water releases as part of the Project.
lead to significant changes in water quality parameters such as temperature, dissolved oxygen, pH and conductivity that provide cues for movement in local fish species; or	The Project is unlikely to create conditions that lead to significant changes in water quality parameters, as: all aquatic species recorded in the study area are tolerant of variable water quality; there are no planned water releases as part of the Project; and water quality is not expected to suddenly or significantly change that would act as cues for fish species.

10.2.3 Threatened turtles

The potential for significant impacts to the two turtle species returned through the database searches are discussed in Section 10.1 as both are listed under the EPBC Act. No significant impacts to either the Fitzroy River turtle or Southern Snapping Turtle are expected to occur from the Project.

11 Risk assessment mitigation measurement and offsets

Risks of potential impacts were assessed according to the criteria outlined in Table 33, Table 34 and Table 35. The unmitigated risks were assessed as well as the mitigated risks. The outcomes of the assessment, including suggested mitigation measures, is presented in Table 36.

Table 33: Risk matrix applied to the categorisation of risk to aquatic ecology values from the Project

Likelihood of Consequence	Severity of Consequence				
	Insignificant	Minor	Moderate	Major	Severe
Almost Certain	Low	Medium	High	Very High	Very High
Likely	Low	Medium	High	High	Very High
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium

Table 34: Definitions of likelihood for the risk assessment

Likelihood	Definitions
Almost certain	The event is expected to occur in most circumstances (expected to occur multiple times a year or is clearly imminent).
Likely	The event will probably occur in most circumstances (expected to occur approximately once per year).
Possible	The event may occur at some time (the event is likely to occur approximately once every 5 years).
Unlikely	The event is not expected to occur (the event is likely to occur approximately once every 5 - 10 years).
Rare	The event may occur in exceptional circumstances (expected to occur less than once every 10 years).

Table 35: Definitions of consequence for the risk assessment

Severity of Consequence	Definitions
Severe	Extensive long-term environment harm and/or harm that is extremely widespread. Impacts considered to be permanent.
Major	Major or widespread, moderate to long-term effect. Significant resources required to respond and rehabilitate, and damage caused may take more than 10 years to recover with long-term evidence of the incident resulting.
Moderate	Localised, short-term to moderate unplanned environmental impact. Moderate but repairable damage that may take up to 10 years to recover.
Minor	Localised short-term effect. Minor environmental impact that is contained on-site. It will take less than two years for the asset to fully recover, or it will only require minor repair.
Insignificant	No impact or no lasting effect. Negligible damage that is contained on-site and is fully recoverable with no permanent effects, taking less than six months to fully recover.

The Project is not expected to have a significant impact on any aquatic EVs and, as such, no offsets for these matters are proposed.

Table 36: Risk assessment outcomes

Potential impact from Project	Potential impact to aquatic ecology values	Unmitigated risk	Proposed mitigation measures	Mitigated risk
Direct disturbance of watercourses	Direct loss of small areas of watercourse aquatic habitat common within the region with low to moderate aquatic ecological value.	Likelihood: Almost certain Consequence: Minor **Risk: Medium**	Limit area of direct impact to the disturbance area. Use disturbance area for any temporary construction and storage.	Likelihood: Almost certain Consequence: Minor **Risk: Medium**
Construction of waterway crossings along the infrastructure corridor	Waterway crossing creates a barrier to fish passage along either Phillips Creek and/or One Mile Creek. Fish passage along bother waterways may occur during periods of flow, however, the utilisation of the waterways for fish passage is considered low based on field surveys. Impacts are expected to be restricted to the Project area and would be minor on a regional scale.	Likelihood: Possible Consequence: Minor **Risk: Medium**	Waterway crossings will be designed and constructed in consideration of Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works. Construction to be undertaken during periods of no-flow when fish passage is not possible due to natural environmental conditions.	Likelihood: Unlikely Consequence: Insignificant **Risk: Low**
Direct loss of aquatic flora	The ephemeral nature of the watercourses means patchy and infrequent occurrence of aquatic flora, however, the small area of direct disturbance within aquatic environments may result in disturbance to aquatic flora. Any aquatic plants to be lost are all considered common with a broad distribution in the region. The impacts are expected to be minor on a regional scale.	Likelihood: Likely Consequence: Insignificant **Risk: Low**	Limit area of direct impact to the disturbance area. Use disturbance area for any temporary construction and storage.	Likelihood: Likely Consequence: Insignificant **Risk: Low**
Direct loss of aquatic fauna	The direct disturbance of aquatic environments associated with the Project may result in localised loss of habitat for aquatic fauna and loss of aquatic fauna within the disturbance footprint. Aquatic fauna to be lost are individuals of species common with a broad distribution in the region. The impacts are expected to be minor on a regional scale.	Likelihood: Almost certain Consequence: Insignificant **Risk: Low**	Limit area of direct impact to the disturbance area. Use disturbance area for any temporary construction and storage.	Likelihood: Almost certain Consequence: Insignificant **Risk: Low**

Potential impact from Project	Potential impact to aquatic ecology values	Unmitigated risk	Proposed mitigation measures	Mitigated risk
Change in watercourse morphology through subsidence	Localised change in habitat availability for aquatic fauna and fauna within the subsidence area. Aquatic fauna to be lost are individuals of species common with a broad distribution in the region. The impacts are expected to be minor on a regional scale. Induced changes to stream flow characteristics including erosion and sediment transport with associate downstream impacts to aquatic flora and fauna.	Likelihood: Almost certain Consequence: Minor **Risk: Medium**	To promote the movement of water and sediment through this reach, Bowen Basin Coal will consider decommissioning the existing farm dam on One Mile Creek prior to the commencement of mining. A subsidence monitoring plan will be developed to assess the changes in bed levels and the impact of increased localised sedimentation. Measures such as rock bank protection will be considered if monitoring indicates that the increase in erosion is having a demonstrable impact on the channel form.	Likelihood: Almost certain Consequence: Minor **Risk: Medium**
Changes in flood regimes (flow and velocity) and subsidence induced ponding	Localised impacts, as a result of loss of available aquatic habitat due to areas no longer inundated (lost due to development of the mine) and a gain of aquatic habitat in other areas that will be more frequently inundated.	Likelihood: Almost certain Consequence: Moderate **Risk: High**	The flood levees are designed to the minimal extent necessary for the Project such that there is minimal capture of natural flows by the Project. Drainage channels will be installed to minimise inundation of areas of the flood plain which are currently dry.	Likelihood: Almost certain Consequence: Minor **Risk: Medium**
Changes in flow in watercourses due to loss of catchment	Decreased water availability along downstream reaches of One Mile Creek due to loss of catchment. Impacts downstream of confluence with Boomerang Creek and during larger flood events are predicted to be minimal. Reduction in flow could lead to localised loss of habitat for aquatic fauna and loss of aquatic flora within the impacted reach. Aquatic fauna to be lost are individuals of species common with a broad distribution in the region. The impacts are expected to be minor on a regional scale.	Likelihood: Almost certain Consequence: Minor **Risk: Medium**	None	Likelihood: Almost certain Consequence: Minor **Risk: Medium**

Potential impact from Project	Potential impact to aquatic ecology values	Unmitigated risk	Proposed mitigation measures	Mitigated risk
Changes in water availability at GES wetlands due to subsidence induced changes to landform	There will be impacts at three GES wetlands due to changes in the hydrological regime because of subsidence. The hydrological changes will cause the loss of one GES wetland, reduction in the extent of a second and inundation of a third. The impacts will likely cause localised loss of habitat for aquatic fauna and loss of aquatic fauna within the disturbance footprint. Aquatic fauna to be lost are individuals of species common with a broad distribution in the region. The impacts are expected to be minor on a regional scale.	Likelihood: Almost certain Consequence: Minor **Risk: Medium**	Drainage channels to be installed to minimise subsidence induced ponding, however, impacts to GES wetlands remain.	Likelihood: Almost certain Consequence: Minor **Risk: Medium**
Impacts to water quality from surface runoff	Surface water runoff that has contact disturbed areas is limited to roads and flood protection levees. Reduced water quality, including high suspended sediments, sedimentation and turbidity from disturbed areas. Potential impacts to health, composition and resilience of flora and fauna; respiration and feeding of fauna; reduce growth and diversity in aquatic plants and algae; and/or bury benthic communities.	Likelihood: Almost certain Consequence: Major **Risk: Very High**	Sediment basins designed to contain sediment affected runoff from disturbed areas including rehabilitated areas until they are suitably established. Localised erosion protection works ~~such as rock armouring~~ will be implemented if required, to prevent scouring of the areas identified with increases in peak flood velocities around flood protection levees. Management measures may include fencing (for stock exclusion), revegetation of beds and banks and the use of natural logs, jute matting, coir logs etc. Sediment and erosion control structures designed in accordance with the IECA guidelines to minimise water quality impacts from disturbed land on the receiving waterways.	Likelihood: Rare Consequence: Moderate **Risk: Low**
Impacts to water quality from uncontrolled releases of mine affected water	Uncontrolled releases of mine affected water cause negative impact to water quality and indirect impacts to aquatic ecology in the receiving environment (e.g. toxicity to flora and fauna).	Likelihood: Almost certain Consequence: Major **Risk: Very High**	Mine water system has been designed to prevent uncontrolled releases from the sediment dams in all but the wettest 1% of historical climate periods. The largest modelled spill event would see a total of 360 ML released from the north and south sediment dams combined at a TDS of less than 800 mg/L. Dilution by flows in the receiving waters would likely result in minimal to the downstream environment.	Likelihood: Rare Consequence: Minor **Risk: Low**

Potential impact from Project	Potential impact to aquatic ecology values	Unmitigated risk	Proposed mitigation measures	Mitigated risk
Leaks and/or spills of hydrocarbons and other contaminants	Leaks and/or spills cause impact to water quality and indirect impacts to aquatic ecology in the receiving environment (e.g. toxicity to flora and fauna).	Likelihood: Likely Consequence: Major **Risk: Very High**	Update and adoption of Chemical and Fuel Management Plan that is in place for the existing Lake Vermont Mine. Implementation of appropriate fuel and chemical storage and management procedures. Storage of fuels and chemicals to be located within the MIA flood protection levee. Storage designs to ensure there is effective means of secondary containment to prevent releases to the environment from any fuel and oil storage on-site.	Likelihood: Unlikely Consequence: Minor **Risk: Low**
Saline and acid mine drainage	Seepage is expected to be of low salinity and neutral to alkaline pH. It is not expected that seepage from waste rock dumps will cause any additional impacts to water quality in the receiving waterways.	Likelihood: Possible Consequence: Moderate **Risk: Medium**	Waste material to be predominately placed within the flood protection levee. Seepage to be managed through the mine water system.	Likelihood: Rare Consequence: Minor **Risk: Low**
Litter and waste created by the Project is released to the aquatic environment	Potentially be ingested by fauna; entangle or entrap aquatic fauna and / or negatively impact water quality.	Likelihood: Almost Certain Consequence: Minor **Risk: Medium**	Update and adoption of the Waste Management Plan that is in place for the existing Lake Vermont Mine to minimise the production of litter and waste.	Likelihood: Unlikely Consequence: Minor **Risk: Low**
Introduction of invasive aquatic species	Introduction of invasive aquatic species causes changes in community structure and general health of aquatic fauna and flora.	Likelihood: Possible Consequence: Major **Risk: High**	Update and adoption of the Pest (and Weed) Management Plan that is in place for the existing Lake Vermont Mine which incorporates standard and industry recognised controls for weed and pest animal management (e.g. use of wash-down facilities by all vehicles and plant prior to entering existing the site, if they have been operating off graded roads).	Likelihood: Unlikely Consequence: Minor **Risk: Low**

12 Summary

The Project is located within the Isaac River Sub-basin of the wider Fitzroy River Basin. The Isaac River is the main waterways downstream of the Project with the study area being intersected by three ephemeral watercourses: Phillips Creek, One Mile Creek and Boomerang Creek. Agricultural activities and existing mining projects dominate surrounding land uses. These activities impact the catchment through contributing to contaminated runoff and erosion associated with land clearing.

Aquatic habitat conditions of the waterways within the study area are poor as they consist of ephemeral drainage lines that had minimal in-stream habitat features (or were dry) and were highly disturbed by activities associated with the adjacent land use.

The Project has the potential to directly and indirectly impact aquatic ecosystems through:

- loss of aquatic habitat, flora and fauna within the study area;
- creation of barriers to fish passage through establishment of watercourse crossings;
- changes to flow and flood regimes within and adjacent to the study area;
- changes in water and sediment quality associated with surface water runoff; changed hydrological conditions of watercourses due to subsidence, and seepage and or drainage;
- creation of littler and waste; and
- introduction and/or proliferation of weeds and pests.

The potential impacts to aquatic ecosystems will be minimised and mitigated by:

- limiting the area of direct disturbance to the proposed disturbance footprint;
- design and construction of watercourse crossings in consideration of fish passage requirements;
- implementing effective erosion and sediment control strategies;
- implementation of an effective water management system; and
- implementation of high-quality management plans for the management of waste, hydrocarbons and contaminants and weeds and pest animals.

Despite the mitigation measures, there are likely to be impacts to aquatic ecosystem values through:

- direct disturbance of watercourses and wetlands
- subsidence of the streambed
- subsidence induced changes in ponding; and
- changes to flood regimes

However, considering the existing impacts in the catchment and provided the appropriate mitigation measures are put in place, it is considered unlikely that the Project will result in significant impacts to aquatic ecosystems of the Isaac River Sub-basin, including to aquatic MNES and MSES. Based on the results of modelling of the impacts to flows, the Project is not expected to make any significant contribution to cumulative impacts to aquatic ecosystems in the Isaac River Sub-basin or wider Fitzroy Basin.

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Appendix A. Database search results

Appendix B. Aquatic species likelihood of occurrence

Species	Status		Description	Desktop Likelihood of Occurrence
	EPBC Act[1]	NC Act[3]		
Reptiles				
Southern snapping turtle *Elseya albagula*	CE	E	**Distribution** The White-throated snapping turtle is endemic to the Fitzroy, Mary and Burnett Rivers and associated smaller drainages in south-eastern Queensland. It occurs across approximately 3300 km of riverine habitat: Fitzroy Catchment (~2,150 km), Burnett Catchment (~700 km) and Mary Catchment (<500 km) (Hamann *et al.* 2007). Its area of occupancy is estimated to be less than 500 km^2 (DAWE 2020). Adults are widespread and abundant within all three of these catchments, but immature turtles are poorly represented within populations. **Habitat** It mostly inhabits sections of stream with permanent water and habitat features that provide shelter, such as undercut banks, overhanging riparian vegetation, moderate to high densities of submerged boulders and/or log jams, and macrophyte beds. The species is considered by some to be a habitat specialist (Todd *et al.* 2013) and to prefer clear, flowing, well oxygenated waters (Hamann *et al.* 2007) but has been observed in both clear and turbid waters. **Ecology** The White-throated snapping turtle is a benthic foraging species with a broad diet. When young, the species will feed on benthic invertebrates and as adults change to primarily herbivorous, with a diet comprised of the fruit and buds of riparian vegetation that fall on the water (Rogers, 2000; Armstrong & Booth, 2005; Thomson *et al.*, 2006; Limpus *et al.* 2011b). Breeding occurs during the dry season, with nesting occurring on alluvial sand-loam banks deposited by floodwaters. The species has relatively small home ranges, commonly utilising stream lengths of less than 1 km (Hamann *et al.*, 2007; Micheli-Campbell *et al.* 2017)	Unlikely This species or species habitat was returned in the 10 km PMST search as likely to occur. However, no confirmed records of this species are within 50 km of the Project were returned from Wildlife Online or ALA. Wildlife Online did return with four records of the species within 100 km of the Project. The study area contains highly ephemeral systems with permanent flowing water is unlikely to be found within the study area.

Species	Status		Description	Desktop Likelihood of Occurrence
	EPBC Act[1]	NC Act[3]		
Fitzroy River turtle *Rheodytes leukops*	V	V	**Distribution** The Fitzroy River turtle is only found in the drainage system of the Fitzroy River within Queensland (DoE 2020f). Known sites within this area include Boolburra, Gainsford, Glenroy Crossing, Theodore, Baralba, the Mackenzie River, the Connors River, Duaringa, Marlborough Ck, and Gogango (DEWHA 2008d). **Habitat** Found in rivers with large deep pools with rocky, gravelly, or sandy substrates, connected by shallow riffles, the Fitzroy River turtle prefers areas have high water clarity, often associated with Ribbonweed (Vallisneria sp.) beds (DoE 2020f, DEWHA 2008d). Common riparian vegetation associated this species include Paperbarks (Melaleuca linariifolia), Weeping Bottlebrushes (Callistemon viminalis), Blue Gums (Eucalyptus tereticornis) and River Oaks (Casuarina cunninghamiana) (DoE 2020f). **Ecology** This species is a benthic feeder, and is known to consume a variety of foods, including aquatic plants like Ribbonweed (Vallisneria sp.), freshwater sponges, insects, and terrestrial plant material such as leaves and bark (DoE 2020f, DEWHA 2008d). Nesting occurs between September and October, located on river sandbanks 1–4 m above water level (DoE 2020f). This turtle is sedentary, often remaining in the same location for days (DoE 2020f). It has been observed being active in the day and at night (DoE 2020f) and is not known to have specific dispersal habitat requirements.	Unlikely This species or species habitat was returned in the 10 km PMST search as likely to occur. No confirmed records of this species are within 50 km of the Project were returned from Wildlife Online or ALA. However, Wildlife Online returned with 11 records of the species within 100 km of the Project.

Species	Status		Description	Desktop Likelihood of Occurrence
	EPBC Act[1]	NC Act[3]		
Fish				
Silver Perch *Bidyanus bidyanus*	CE	-	**Distribution** Silver perch are endemic to the Murray–Darling system (including all states and sub-basins) (Allen *et al.* 2002; Lintermans 2007). Currently there is only one strong, viable natural population in the middle Murray region. **Habitat** Silver perch are consistently reported by anglers and researchers to show a general preference for faster-flowing water, including rapids and races, and more open sections of river, throughout the Murray–Darling Basin (Clunie and Koehn 2001). **Ecology** Adult silver perch are omnivorous, taking a variety of small prey including zooplankton, aquatic insects, molluscs, small crustaceans and worms as well as algae (Clunie and Koehn, 2001; NSW DPI, 2006). Silver perch breed in spring or summer at sites where water flows over gravel or rock rubble substrate (Merrick & Schmida 1984). Silver perch are a highly migratory freshwater fish. Juveniles and adults and have been recorded moving over 200 km (Mallan Cooper *et al.* 1995)	Unlikely Wildlife Online returned with one record of the species within 50 km of the Project and a second within 100 km. The study area contains highly ephemeral systems with permanent flowing water is unlikely to be found within the study area.

Species	Status		Description	Desktop Likelihood of Occurrence
	EPBC Act[1]	NC Act[3]		
Murray Cod *Macculochella peelii*	V	-	**Distribution** The Murray Cod was historically distributed throughout the Murray–Darling Basin (the Basin). The species still occurs in most parts of this natural distribution (the species' distribution) up to approximately 1000 m above sea level (Kaminskas pers. comm. 2015). The Basin contains approximately 13 245 km of waterways that may encompass areas of suitable habitat for the Murray Cod. The species' estimated extent of occurrence, based on areas with an average river width of 50m, is 660 km² (TSSC 2003). **Habitat** Murray Cod are frequently found in the main channels of rivers and larger tributaries. Preferred microhabitat consists of complex structural features in streams such as large rocks, snags (pieces of large submerged woody debris), overhanging stream banks and vegetation, tree stumps, logs, branches and other woody structures. The species has been found to be strongly associated with structural woody habitat (>68% cover), deeper (>2.4 m), slower water (<0.2 m s-1) closer to the riverbank (Koehn & Nicol 2014). **Ecology** The species' diet changes with age with the typical adult diet consisting of spiny crayfish, yabbies and shrimps (National Murray Cod Recovery Team 2010). It is considered to be an apex predator of the Murray–Darling Basin. Murray Cod are generally sedentary (Reynolds 1983 cited in Koehn *et al.* 2009) outside the spawning season from mid-summer to late winter. The species has been shown to undertake substantial long-distance movements prior to spawning (Koehn 1996, 2006, Koehn & Nicol 1998 cited in National Murray Cod Recovery Team 2010). Some adult Murray Cod have been tracked up to several hundred kilometres upstream (National Murray Cod Recovery Team 2010).	Unlikely No records of the species within 100 km.

1 EPBC Act Conservation status: CE – Critically Endangered; E - Endangered; V – Vulnerable.

3 NC Act Conservation status: E - Endangered; V – Vulnerable.

Appendix C. Site descriptions

Photographs	Site description
Site: MA1 – Phillips Creek	
  	This site was located on Phillips Creek upstream of the Project area. Phillips Creek is identified as a watercourse under the Water Act and is classified as a stream order four waterway. The site was characterised by small pools of standing water in 2020. The site was dry during the 2021 survey. No in-stream aquatic habitat features were present. Bank was moderately stable with infrequent eroded areas. Riparian habitat consisted of RE 11.3.25 and non-remnant vegetation. Dominant vegetation consisted of grass and sedges. Parthenium and prickly pear were identified in the riparian zone. Surrounding land use is 'grazing'. Overall, MA1 scored 'fair' in the Habitat Bioassessment. The aquatic ecological value of the site was considered low. It is unlikely to provide consistently available habitat for refuge or breeding. It is ephemeral and has poor connectivity to other areas for aquatic fauna, including listed species.

<table>
<tr><th>Photographs</th><th>Site description</th></tr>
<tr><td colspan="2">Site: MA2 – Phillips Creek</td></tr>
<tr><td>

</td><td>This site was located on Phillips Creek downstream of the proposed infrastructure corridor.

The site was characterised by small pools of standing water in both survey years.

No in-stream aquatic habitat features were present. Bank stability was considered poor with many eroded areas.

Riparian habitat consisted of RE 11.3.25 and non-remnant vegetation. The dominant vegetation consisted of trees. Parthenium was identified in the riparian zone.

Surrounding land use is 'grazing'.

Overall, MA2 scored 'good', in the Habitat Bioassessment. The site lacked diversity in the absence of a variety of flow regimes and substrate types, and the channel morphology was modified due to the deposition of fine sediments in-stream and around bends.</td></tr>
</table>

Photographs	Site description
Site: MA3 - One Mile Creek	
2020   	This site was located on One Mile Creek upstream of the Project area. One Mile Creek is identified as a watercourse under the Water Act and is classified as a stream order three waterway. The site is characterised by slow flowing water. In-stream habitat comprised of: • shallow pools • large and small woody debris, logs, and branches • brown clay sediments No in-stream aquatic habitat features were present. Bank stability was considered poor with many eroded areas. Riparian habitat of RE 11.3.25 and non-remnant vegetation. The dominant vegetation consisted of trees. Surrounding land use is 'grazing'. Overall, MA3 scored 'good', in the Habitat Bioassessment.

<table>
<tr><th>Photographs</th><th>Site description</th></tr>
<tr><td colspan="2">Site: MA4 - Lake Vermont</td></tr>
<tr><td>

</td><td>This site was located at Lake Vermont, a palustrine wetland characterised by RE 11.3.27 and 11.5.3. Lake Vermont is adjacent to an unnamed tributary of Phillips Creek. The confluence of the tributary and Phillips Creek is downstream of the Project area.

The site is characterised by standing water.

Riparian habitat RE 11.3.2, 11.3.7, 11.5.3 and non-remnant vegetation. Trees made up the dominant vegetation.

Surrounding land use is ‘grazing’.

Overall, MA4 scored ‘good’, in the Habitat Bioassessment.</td></tr>
</table>

Photographs	Site description
Site: MA5 - One Mile Creek/Open Cut Pit	
  	This site was located on One Mile Creek within the footprint of mine layout of the Project. The site was characterised by slow flowing water. Bank were stable with no evidence of erosion or bank failure. Riparian habitat consisted of RE 11.3.25, 11.4.9, 11.5.17, 11.5.3 and non-remnant vegetation. Grasses and sedges make up the dominant vegetation. Surrounding land use is 'grazing'. Overall, MA5 scored 'good', in the Habitat Bioassessment.

Photographs	Site description
Site: MA6 - Boomerang Creek	
2020   	This site was located on Boomerang Creek upstream of the Project area. Boomerang Creek is identified as a watercourse under the Water Act and is classified as a stream order four waterway. The site is characterised by standing water with a sulphide odour. The dominant vegetation consisted of trees and consequentially, in-stream habitat included large and small woody debris. Riparian habitat comprised of RE 11.3.2. It was noted that there was a high level of weeds present including Parthenium and Noogoora Burr.

<table>
<tr><th>Photographs</th><th>Site description</th></tr>
<tr><td colspan="2">Site: MA7 - Hughes Creek</td></tr>
<tr><td>2020


</td><td>This site was located on Hughes Creek upstream of the Project area. Hughes Creek is identified as a watercourse under the Water Act and is classified as a stream order five waterway.

The site is characterised by RE 11.3.2 and 11.3.25. No in-stream aquatic habitat features were present.

Riparian habitat consisted of RE 11.3.25. The dominant vegetation cover was trees. Parthenium and Noogoora Burr were identified in the riparian zone.</td></tr>
</table>

<table>
<tr><th>Photographs</th><th>Site description</th></tr>
<tr><td colspan="2">Site: MA8 - Wetland RE 11.3.27/Underground Mine Footprint</td></tr>
<tr><td>2021


</td><td>This site was located at an unnamed palustrine wetland approximately 300 m from Hughes Creek. It is located within the footprint of the underground mine layout of the Project.

The site was characterised by standing water. No in-stream aquatic habitat features were present. Bank was moderately stable with infrequent eroded areas.

Riparian habitat consisted of 11.3.27 and was dominated by grasses. Parthenium was identified in the riparian zone.

Surrounding land use is 'grazing'.

Overall, MA8 scored 'good' in the Habitat Bioassessment.</td></tr>
</table>

Photographs	Site description
Site: MA9 - Boomerang Creek	
No photos available	This site was located on Hughes Creek upstream of the Project area. Hughes Creek is classified as a stream order four waterway at this site location as it is upstream of the Hughes/Boomerang Creek confluence. The site was dry during the 2020 and 2021 surveys. The was no in-stream habitat. Riparian habitat consisted of RE 11.3.25 with trees accounting for the dominant cover. Parthenium and Noogoora Burr was identified in the riparian zone. Surrounding land use is 'grazing'. Overall, MA9 scored 'good' in the Habitat Bioassessment.
Site: MA10 - Ripstone Creek	
No photos available	This site was located on Ripstone Creek upstream of the Project area. Ripstone Creek is identified as a watercourse under the Water Act and is classified as a stream order three waterway. The site was dry during both surveys. No in-stream aquatic habitat features were present. In-stream habitat comprised… Riparian habitat consisted of RE 11.3.25 with trees being the dominant vegetation. Parthenium and Noogoora Burr were identified in the riparian zone.
Site: MA11 - Isaac River	
	This site was located on Isaac River downstream of the Project area. Isaac River is identified as a watercourse under the Water Act and is classified as a stream order six waterway. The site is characterised by standing water. No in-stream aquatic habitat features were present. Riparian habitat consisted of RE 11.3.25 with trees being the dominant vegetation. Noogoora Burr was identified in the riparian zone. Overall, MA11 scored 'fair' in the Habitat Bioassessment.

Photographs	Site description
 	
Site: MA12 - One Mile Creek	
2021 	This site was located on One Mile Creek downstream of the Project area. The site is characterised by slow flowing water. No in-stream aquatic habitat features were present. Bank was unstable with many eroded areas. Riparian habitat consisted of RE 11.3.25, 11.3.25, and non-remnant vegetation. Trees were the dominant vegetation cover. Parthenium was identified in the riparian zone. Surrounding land use is 'grazing'. Overall, MA12 scored 'fair' in the Habitat Bioassessment.

<table>
<tr><th>Photographs</th><th>Site description</th></tr>
<tr><td>
</td><td></td></tr>
<tr><td colspan="2">Site: MA13 - Hughes Creek</td></tr>
<tr><td>2020
</td><td>This site was located on Hughes Creek downstream of the Project area.
The site is characterised by slow flowing water. No in-stream aquatic habitat features were present. Bank was unstable with many eroded areas.
Riparian habitat consisted of RE 11.3.2 and 11.3.2. Trees were the dominant vegetation cover.
Surrounding land use is ‘grazing’.
Overall, MA13 scored ‘good’ in the Habitat Bioassessment.</td></tr>
</table>

Photographs	Site description
 	
Site: MA14 - HES Wetland	
2020 	This site was located within the HES wetland downstream of Project, 900 m from the confluence of Phillips Creek and Isaac River. The site is characterised was dry during both the 2020 and 2021 surveys. Riparian habitat consisted of RE 11.3.27 and 11.3.3. Grasses were the dominant vegetation cover. Surrounding land use is 'grazing'. Overall, MA143 scored 'good' in the Habitat Bioassessment.

Photographs	Site description
	
Site: MA ~~Extra~~ 17 - One Mile Creek	
 	This site was located within an unnamed palustrine wetland, approximately 460 m from the Isaac River. The site is predominately characterised by slow flowing water. In-stream habitat comprised… Riparian habitat was characterised by non-remnant vegetation with a patch of RE 11.3.27 and 11.3.7 in the northern end (closest to the Isaac River). Parthenium was identified in the riparian zone.

Photographs	Site description
	

Appendix D. Macroinvertebrate species list

Class/Order	Family/Sub-family	2021								2020							
		MA2	MA3	MA5	MA6	MA8	MA11	MA12	MA13	MA2	MA3	MA5	MA6	MA8	MA11	MA12	MA13
Acarina	sp.						8			5			22	24	3	2	
Amphipoda	Talitridae																
Amphipoda	Ceinidae																
Amphipoda	Eusiridae																
Amphipoda	Paracalliopidae																
Amphipoda	Paramelitidae																
Amphipoda	Neoniphargidae																
Amphipoda	Perthiidae																
Amphipoda	Melitidae																
Amphipoda	sp.																
Anaspididae	sp.																
Anisoptera	sp.																
Anostraca	Branchiopodidae																
Anostraca	sp.																
Bivalvia	Cyrenidae																
Bivalvia	Sphaeriidae																
Bivalvia	sp.																

Class/Order	Family/Sub-family	2021								2020							
Branchiura	sp.																
Bryozoa	sp.																
Cladocera	sp.		3		17	6	5	85		3	100	23	110	32	1	15	
Coleoptera	Microsporidae																
Coleoptera	Carabidae																
Coleoptera	Haliplidae												1				
Coleoptera	Hygrobiidae																
Coleoptera	Noteridae									2	1						
Coleoptera	Dytiscidae				2						2	8	2	9		5	
Coleoptera	Gyrinidae												5				
Coleoptera	Hydrophilidae									1		1					
Coleoptera	Spercheidae																
Coleoptera	Georissidae																
Coleoptera	Hydraenidae		1				1	2			6			1		1	1
Coleoptera	Staphylinidae																
Coleoptera	Scirtidae																
Coleoptera	Elmidae																
Coleoptera	Limnichidae																
Coleoptera	Heteroceridae																
Coleoptera	Psephenidae																

Class/Order	Family/Sub-family	2021								2020							
Coleoptera	Ptilodactylidae																
Coleoptera	Chrysomelidae																
Coleoptera	Nanophyidae													1			
Coleoptera	Curculionidae											1					
Coleoptera	Hydrochidae																
Coleoptera	sp.																
Collembola	sp.																
Conchostraca	sp.													1			
Copepoda	sp.		15		9	1	6	85		8	75	10	34	17	2	14	
Corophiidae	sp.																
Crustacea	sp.																
Decapoda	Atyidae																
Decapoda	Palaemonidae																1
Decapoda	Parastacidae																
Decapoda	Hymenosomatidae																
Decapoda	Gecarcinucidae																
Decapoda	Grapsidae																
Decapoda	sp.																
Diplopoda	sp.																
Diptera	Tipulidae																

Class/Order	Family/Sub-family	2021								2020							
Diptera	Tanyderidae																
Diptera	Blephariceridae																
Diptera	Chaoboridae																
Diptera	Dixidae																
Diptera	Culicidae		2					6		3	5	1				18	27
Diptera	Ceratopogonidae		5		1	2	1	1			4	1		1	1	3	1
Diptera	Simuliidae																2
Diptera	Thaumaleidae																
Diptera	Psychodidae																
Diptera	Pelecorhynchidae																
Diptera	Athericidae																
Diptera	Tabanidae																
Diptera	Stratiomyidae																
Diptera	Empididae																
Diptera	Dolichopodidae																
Diptera	Syrphidae									1							
Diptera	Sciomyzidae																
Diptera	Ephydridae																
Diptera	Muscidae																
Diptera	sp.																

Class/Order	Family/Sub-family	2021								2020							
Diptera	Aphroteniinae																
Diptera	Diamesinae																
Diptera	Podonominae																
Diptera	Tanypodinae		10		4	3	42	3			25	6	10		4	14	1
Diptera	Orthocladiinae						1								5	1	3
Diptera	Chironominae		85		110	25	64	90		7	125	3	28	8	66	185	1
Diptera	Cecidomyidae																
Diptera	Scatopsidae																
Diptera	Sciaridae																
Ephemeroptera	Siphlonuridae																
Ephemeroptera	Baetidae							1		1						3	2
Ephemeroptera	Oniscigastridae																
Ephemeroptera	Ameletopsidae																
Ephemeroptera	Coloburiscidae																
Ephemeroptera	Leptophlebiidae																
Ephemeroptera	Vietnamellidae																
Ephemeroptera	Caenidae						13								2	1	
Ephemeroptera	Prosopistomatidae																
Ephemeroptera	sp.																
Gastropoda	Viviparidae							2									

Class/Order	Family/Sub-family	2021								2020							
Gastropoda	Tateidae																
Gastropoda	Bithyniidae											3					
Gastropoda	Thiaridae																
Gastropoda	Lymnaeidae																
Gastropoda	Ancylidae																
Gastropoda	Planorbidae											5	4	5			
Gastropoda	Physidae																
Gastropoda	sp.																
Gastropoda	Glacidorbidae																
Gastropoda	Pomatiopsidae																
Hemiptera	Mesoveliidae																
Hemiptera	Hebridae																
Hemiptera	Hydrometridae																
Hemiptera	Veliidae												1				2
Hemiptera	Gerridae																
Hemiptera	Leptopodidae																
Hemiptera	Saldidae																
Hemiptera	Nepidae																
Hemiptera	Belostomatidae											2					
Hemiptera	Ochteridae																

Class/Order	Family/Sub-family	2021								2020							
Hemiptera	Gelastocoridae																
Hemiptera	Corixidae												2				
Hemiptera	Micronectidae		2		6	7	1	18		14	34	1	21	9	2	33	
Hemiptera	Naucoridae																
Hemiptera	Notonectidae												1				
Hemiptera	Pleidae													2		1	
Hemiptera	sp.																
Hirudinea	Glossiphoniidae																
Hirudinea	Hirudinidae																
Hirudinea	Ornithobdellidae																
Hirudinea	Erpobdellidae																
Hirudinea	sp.																
Hydrazoa	Hydridae				39	75									1		
Hydrazoa	Clavidae																
Hymenoptera	sp.																
Hyriidae	sp.																
Isopoda	Amphisopidae																
Isopoda	Mesamphisopidae																
Isopoda	Phreatoicopsidae																
Isopoda	Phreatoicidae																

Class/Order	Family/Sub-family	2021								2020							
Isopoda	Corallanidae																
Isopoda	Sphaeromatidae																
Isopoda	Janiridae																
Isopoda	Oniscidae																
Isopoda	sp.																
Lepidoptera	Crambidae																
Lepidoptera	sp.																
Mecoptera	Nannochoristidae																
Mecoptera	sp.																
Megaloptera	Corydalidae																
Megaloptera	Sialidae																
Megaloptera	sp.																
Mytilidae	sp.																
Nematoda	sp.				2			1									
Nematomorpha	Gordiidae																
Nematomorpha	sp.																
Nemertea	Tetrastemmatidae																
Nemertea	sp.				3												
Neritidae	sp.																
Neuroptera	Osmylidae																

Class/Order	Family/Sub-family	2021								2020							
Neuroptera	Neurorthidae																
Neuroptera	sp.																
Notostraca	sp.																
Odonata	Hemiphlebiidae																
Odonata	Coenagrionidae											2		2			
Odonata	Isostictidae																
Odonata	Platycnemididae																
Odonata	Lestidae																
Odonata	Hypolestidae																
Odonata	Megapodagrionidae																
Odonata	Synlestidae																
Odonata	Lestoideidae																
Odonata	Aeshnidae																
Odonata	Gomphidae																
Odonata	Corduliidae					4	1										
Odonata	Libellulidae					4						1		1			
Odonata	Chorismagrionidae																
Odonata	Telephlebiidae																
Odonata	Lindeniidae																
Odonata	Synthemistidae																

Class/Order	Family/Sub-family	2021								2020							
Odonata	Gomphomacromiidae																
Odonata	Macromiidae																
Odonata	Austrocorduliidae																
Odonata	Cordulephyidae																
Odonata	Hemicorduliidae																
Odonata	Urothemistidae																
Odonata	Zygoptera																
Odonata	Epiproctophora																
Odonata	sp.																
Oligochaeta	sp.		3		2	4	1	1			1		1	7			1
Ostracoda	sp.		10		4	5	3	16		3	125	14	235	40	2	3	
Ozobranchidae	sp.																
Petaluridae	sp.																
Plecoptera	Eustheniidae																
Plecoptera	Gripopterygidae																
Plecoptera	Notonemouridae																
Plecoptera	sp.																
Polychaeta	sp.																
Porifera	Spongillidae																
Porifera	sp.																

Class/Order	Family/Sub-family	2021								2020							
Pyralidae	sp.																
Rotifera	sp.																
Sisyridae	sp.																
Syncarida	Koonungidae																
Tardigrada	sp.																
Telmatogetoninae	sp.																
Trichoptera	Hydrobiosidae																
Trichoptera	Glossosomatidae																
Trichoptera	Hydroptilidae																
Trichoptera	Philopotamidae																
Trichoptera	Hydropsychidae																
Trichoptera	Polycentropodidae																
Trichoptera	Ecnomidae						1										
Trichoptera	Psychomyiidae																
Trichoptera	Limnephilidae																
Trichoptera	Oeconesidae																
Trichoptera	Tasimiidae																
Trichoptera	Conoesucidae																
Trichoptera	Antipodoeciidae																
Trichoptera	Helicopsychidae																

Class/Order	Family/Sub-family	2021								2020							
Trichoptera	Calocidae																
Trichoptera	Helicophidae																
Trichoptera	Kokiriidae																
Trichoptera	Philorheithridae																
Trichoptera	Odontoceridae																
Trichoptera	Atriplectididae																
Trichoptera	Calamoceratidae																
Trichoptera	Leptoceridae						12				5						
Trichoptera	Dipseudopsidae																
Trichoptera	sp.																
Turbellaria	Temnocephalidae																
Turbellaria	Dugesiidae										1	1	2	3		1	
Turbellaria	sp.				3	3											
Unidentified	sp.																