AQUATIC ECOLOGY ASSESSMENT

VECCO CRITICAL MINERALS PROJECT

PREPARED FOR
VECCO GROUP PTY LTD

26 April 2023

ENVIRONMENTAL SOLUTIONS

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Project Manager:	Gareth Bramston

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1 Introduction

1.1 Background

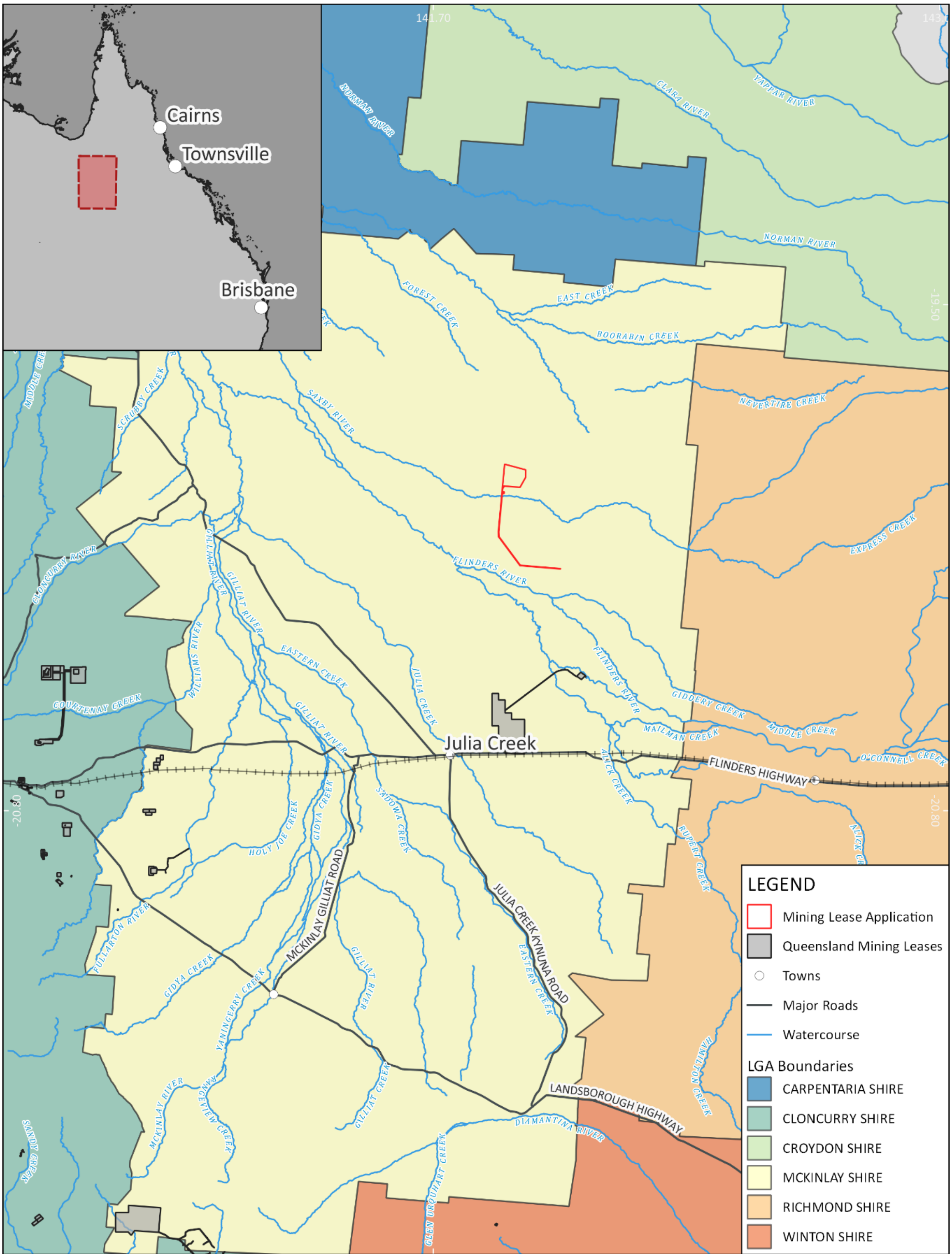
AARC Environmental Solutions Pty Ltd (AARC) was commissioned by Vecco Group (the Proponent) to prepare an Aquatic Ecology Assessment for the Vecco Critical Minerals Project (the Project).

The Project is located approximately 70 km north of Julia Creek township and approximately 515 km west of Townsville in northwest Queensland (Figure 1). The townships of Cloncurry and Richmond are located approximately 125 km west and 145 km east of the Project respectively.

An assessment of terrestrial ecological values was conducted within the aquatic ecology study area of the three proposed Mining Lease Applications (MLA) that cover the Project area, including the Production ML, Transport ML, and Infrastructure ML. This assessment forms part of the supporting studies required for Project's approval processes.

Key components of the Project include:

- open cut mining of up to 1.9 Mtpa ROM ore over a period of approximately 26 years, with all waste progressively backfilled behind the mining pit. All mined land will be returned to natural topography (or above) resulting in no final void. Rehabilitation of mined land will occur progressively over the LOM;
- development of a mine infrastructure area (MIA) including, administration buildings, bathhouse, crib rooms, storage warehouse, workshop, fuel storage, refuelling facilities, wash bay, laydown area, and a helipad;
- development of waste rock emplacement areas;
- construction and operation of a Mineral Processing Plant (MPP) and ore handling facilities adjacent to the MIA (including ROM ore and product stockpiles and rejects);
- construction of an access road from Punchbowl Road to the MIA;
- construction of an airstrip to provide access for the Royal Flying Doctors Service;
- construction of a 10 MW solar farm and associated energy storage system;
- installation of a raw water supply pumping system and pipeline to connect the MIA to the Saxby River for water harvesting;
- construction of an on-site workers village and associated facilities, including an adjacent sewage treatment plant (STP);
- other associated minor infrastructure, plant, equipment and activities;
- progressive establishment of soil stockpiles, laydown area and borrow pits (for road base and civil works). Material will be sourced from local quarries where required;
- open-cut mining operations using conventional surface mining equipment (excavators, front end loaders, rear dump trucks, dozers);
- strategic disposal of neutralised process rejects within the backfilled mining void;
- continued exploration and resource definition drilling on the MLAs;
- progressive development of internal roads and haul roads including a causeway over the Saxby River (designed for minimum impact on flow events) to enable access and product haulage;
- development of water storage dams and sediment dams, and the installation of pumps, pipelines, and other water management equipment and structures including temporary levees, diversions and drains; and
- progressive rehabilitation occurring at defined milestones through the operational life. All voids will be backfilled to natural surface, ensuring all rehabilitated landforms achieve a sustainable post-mining land use on closure.



Project Locality

Vecco Critical Minerals Project

Client	Vecco Industrial Pty Ltd
Date	31-08-2023
Author	L.Morgan
Projection	GDA2020 / MGA zone 54
Scale	1:1300000

0 10 20 30 40 km

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Figure 1: Regional location

1.2 Study objectives

This report assesses the aquatic ecological values of the Project area 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 aquatic species of conservation significance known or with potential to occur in the region (Section 4.1);
- describes surface water quality, stream sediment sampling, macroinvertebrate sampling and results, prepared in accordance with the Australian River Assessment System (AusRivAS) Physical Assessment Protocol (Parsons et al. 2002), the Queensland AusRivAS Sampling and Processing Manual (DNRM 2001) and the Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009 (DES 2018);
- provides an assessment of the aquatic ecological values identified on site, potential impacts of the Project on these values; and
- recommends management strategies to minimise the impacts associated with the proposed mining activities.

1.3 Regional setting

The Project is located within the Flinders Drainage Basin, which encompasses an area of 109,298.1 km^2 and contains the Cloncurry River, Flinders River and Saxby River sub-catchment areas (DES 2022a). The Project is located within the Saxby River sub-catchment, which covers a total area of 10,147 km^2 and comprises the catchment of the ephemeral Saxby River. The Saxby River (characterised by a braided channel) is situated approximately 1 km south of the Project footprint. The Saxby River is approximately 1,030 km in length and begins at the Norman River and flows south-west for 108 km before turning north-west converging with the Flinders River eventually discharging into the Gulf of Carpentaria. The catchments of the Project area are within the Gulf Drainage Basin, declared under the EPP (Water and Wetland Biodiversity Policy) (Figure 2).

The Project is located within the Gulf Plains Bioregion, which is located in the Gulf of Carpentaria of northern Queensland. The bioregion encompasses approximately 211,000 km^2 of low-lying country and offshore islands of north-west Queensland and is characterised by extensive alluvial plains and coastal areas. The Project is located inland approximately 20 km north-west of the Mitchell Grass Downs and Gulf Plains bioregion border. The inland vegetation of the Gulf Plains bioregion is dominated by grasslands, eucalypt woodlands, melaleuca and acacia which cover the landscape of plains and river channels comprising clay and alluvial soils (EHP 2015).

Land use within the Gulf Plains Bioregion is primarily cattle grazing on native grassland pastures and infrastructure support for mines and Gulf of Carpentaria fisheries (EHP 2015).

There are no World Heritage areas, national protected areas, or state protected areas (established under the Queensland Nature Conservation Act 1992) within the Project area or within 150 km of the project footprint. There is a Queensland riparian biodiversity corridor mapped along the main channel of the Saxby River.

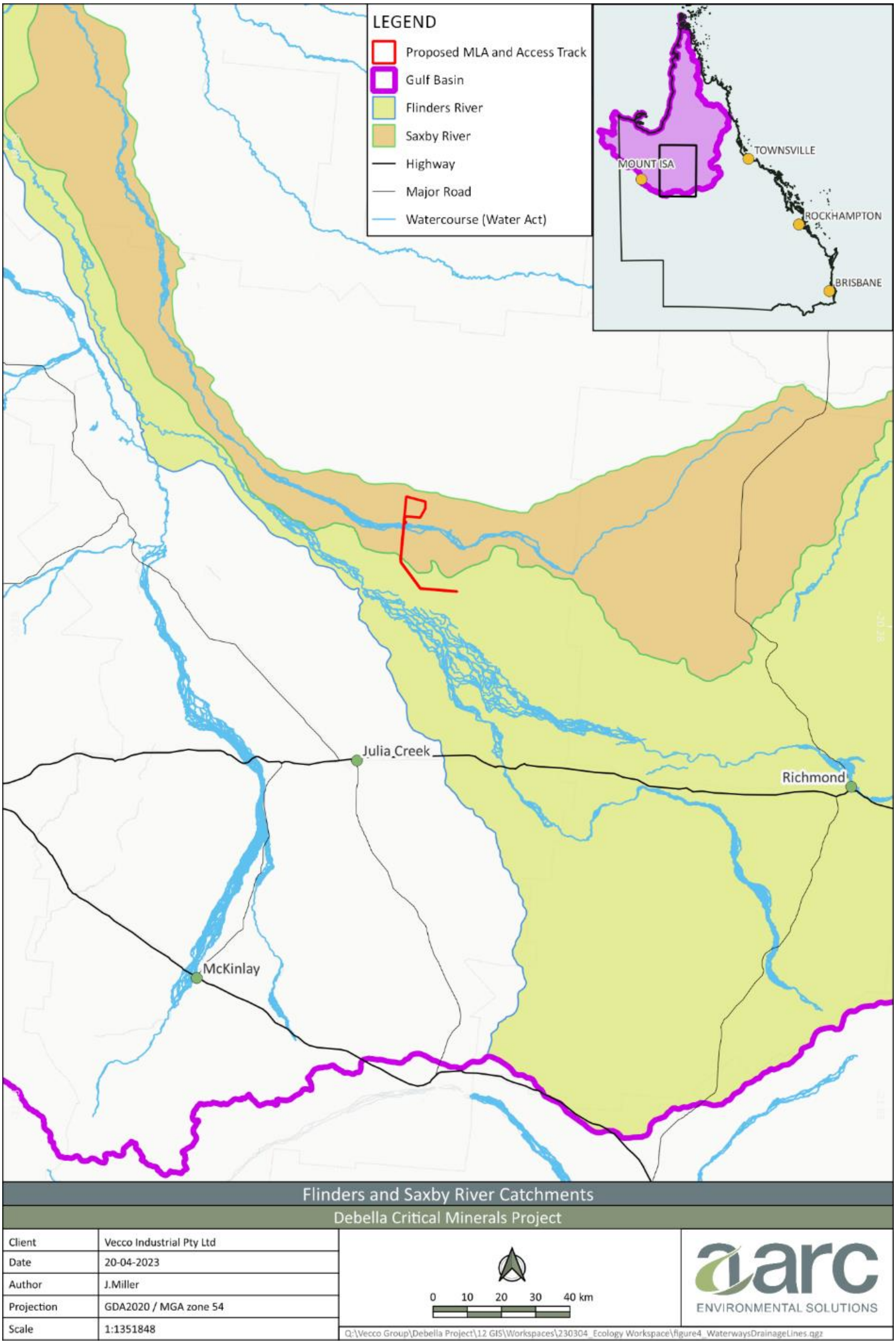

Figure 2: Gulf Basin catchments

1.4 Climate

The region's climate is described as sub-tropical with monsoonal influence, with a winter dry season and summer wet season that can result in alternating periods of inundation over much of the region during the summer. Long-term climate data (2013 to current) were retrieved from SILO/LongPaddock for 141.90 °E, -19.95 °S (Queensland Government n.d.), presented in Figure 3.

Rainfall records indicate annual rainfall is 480.9 mm/year. The majority of rainfall occurs during rainfall events in the wet season (November to March), with dry conditions persisting for the majority of the year. The mean annual evaporation within the Study Area is 2784.4 mm, approximately six times higher than average rainfall, meaning there is a constant potentially high soil water deficit.

The mean monthly maximum temperature is highest in December (39.3°C), dropping to 28.3°C in June before rising in subsequent months. The mean monthly minimum temperature ranges between 11.4°C to 25.0°C throughout the year, with an annual mean minimum temperature of 19.1°C.

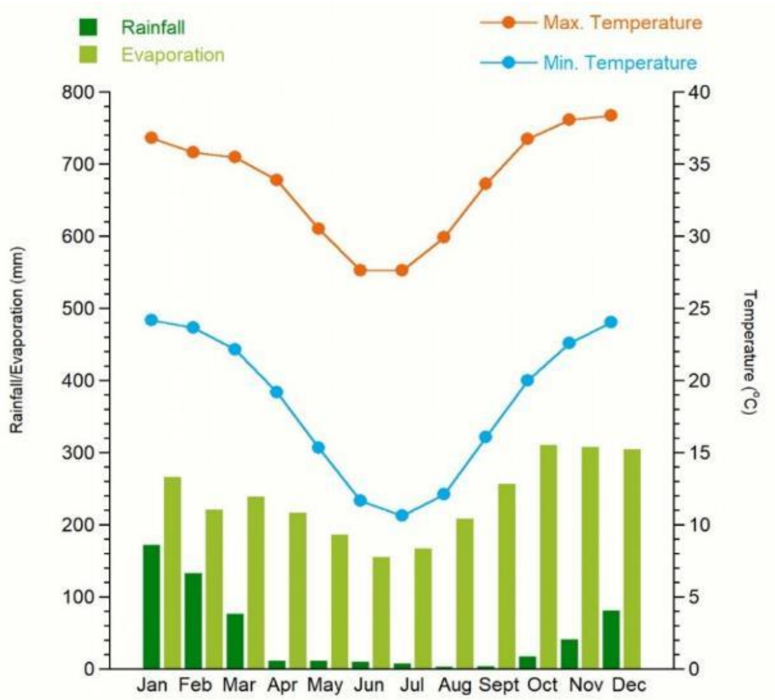

Figure 3: Climate data (2013 to 2023) from SILO/LongPaddock (Queensland Government n.d.)

2 Description of study area

2.1 Aquatic ecology study area

The proposed Production ML including upstream and downstream areas of the Saxby River formed the key study area for this assessment. The study area shown on Figure 4 includes one focus area, to assess whether Project features have the potential for significant impact on natural aquatic ecology values:

- A 6 km length of the Saxby River, south of the mining area, including the access road crossing and water harvesting location.

Aquatic survey techniques targeted this area as the receiving environment for the mining operation.

The assessment also included an area along the southern extent of the Transport ML and access road, where a number of wetlands are located in proximity to the ML. One of these small palustrine wetlands intersects the access ML to a minor extent (0.45 ha). The aquatic survey assessed the values of this wetland group through a combination of field observations from a helicopter and ground observations (including flora species composition) during the dry season.

There are no other mapped watercourses, wetlands, or other aquatic features of environmental value within the ML. There is, however, a series of artificial bore drains used by underlying landholders to distribute water from uncapped (open) artesian bores. The drain network provides cattle drinking water for the local landholders, with much of the water lost to evaporation and seepage. The artificial bore drains do not provide aquatic ecology values.

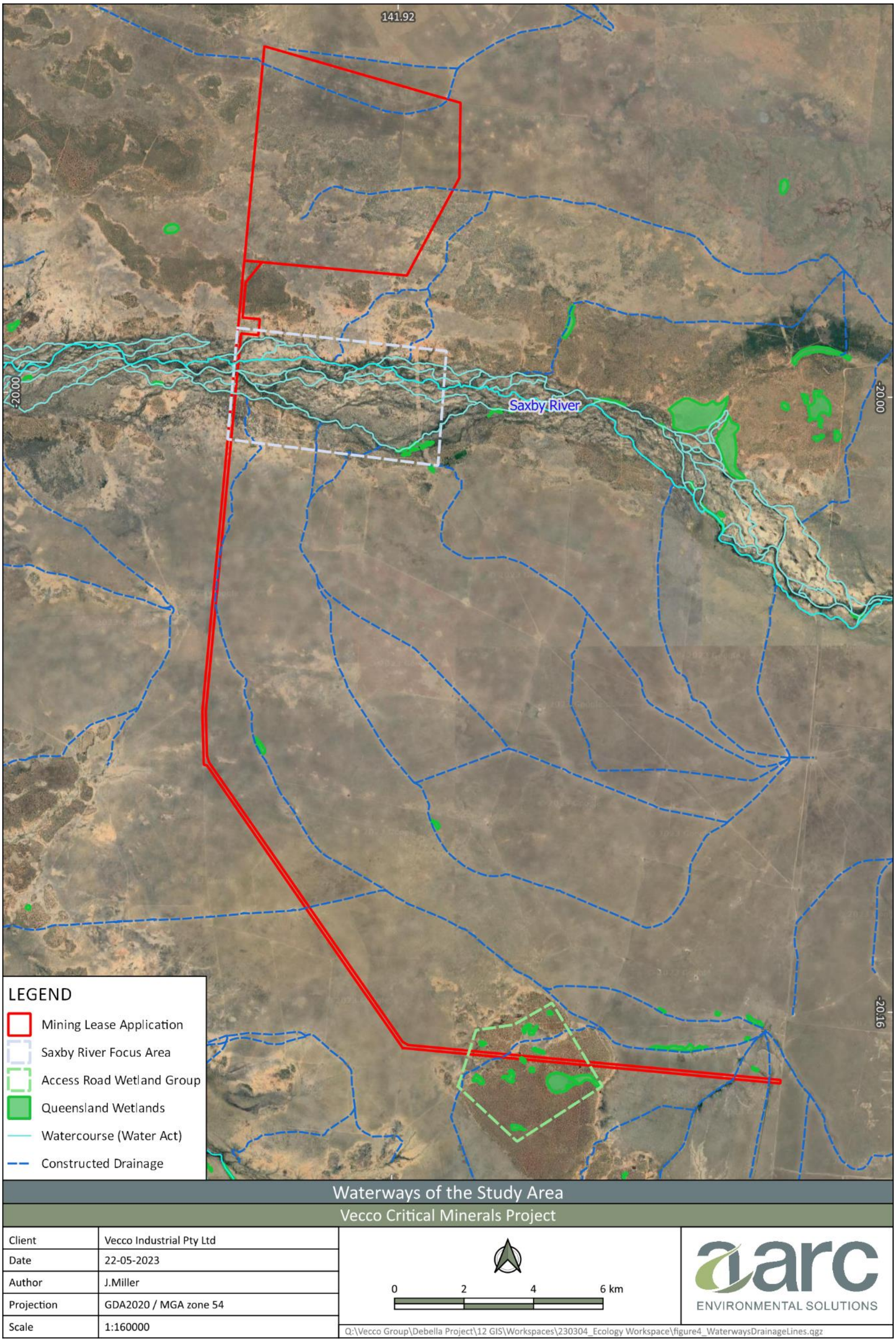

Figure 4: Aquatic ecology study and focus areas, watercourses and constructed drains

2.2 Waterways

2.2.1 Flinders River

As the longest river in Queensland, the Flinders River flows through the townships of Hughenden, Richmond, Julia Creek and Cloncurry before its outlet to the Gulf of Carpentaria. The Flinders River flows in a generally north-westerly direction with the headwaters originating on the western slopes of the Great Dividing Range around Mt Emu Plains, Strathay, and Reedy Springs. As stated above, the Flinders River joins with the Saxby River around 220 km downstream of the Project. The confluence between the Flinders and Cloncurry Rivers, is located around 30 km upstream of the Saxby/Flinders River confluence.

In comparison with other rivers in the Gulf Drainage Region, the Flinders River is fed by relatively high groundwater flows from underlying shallow alluvial aquifers as well as the Gilbert River Formation. These help maintain streamflow and connectivity along the river well into the dry season, as reflected in recorded dry season baseflow volume of 0.5 GL at the Flinders River at the Richmond stream gauge in comparison with a dry season baseflow volume of 0.1 GL at the Cloncurry River at the Damsite stream gauge, which is a similar distance inland in the adjacent sub catchment

2.2.2 Saxby River

The Saxby River is an ephemeral watercourse typically subject to periods of low flows during the dry season (April – October) and high flow/flooding events during the wet season (November – March). There are multiple channels of the Saxby River at the Project location, covering a width of 3 km. The Saxby River floodplain is restricted on the northern side of the river at the Production ML boundary, with the topography rising by around 5 m over 800 m to where the Project site is located. The southern bank floodplain extends out around 10 km from the Saxby River channel to the border of the Flinders River sub-catchment with water during significant floods flowing from the Saxby River into the Flinders River.

Since records began in 2014, the Saxby River at Punchbowl Rd stream gauge station (Station Number 915017A) has recorded mean monthly flow volumes of between 0 ML and 195 ML during the dry season, with no flow recorded for the months of May, June, September, and November. In comparison, the mean monthly flow volume in the wet season ranges from 1.7 GL (December) to 55.3 GL (February). However, it should be noted that the high value for the February monthly mean flow volume is likely due to the prolonged intense flood event in early February 2019 caused by a near-stationary monsoonal trough.

The stream flow recorded at the Saxby River gauge station, approximately 15 km upstream of the Project, between January 2021 and June 2022 is presented in Figure 5.

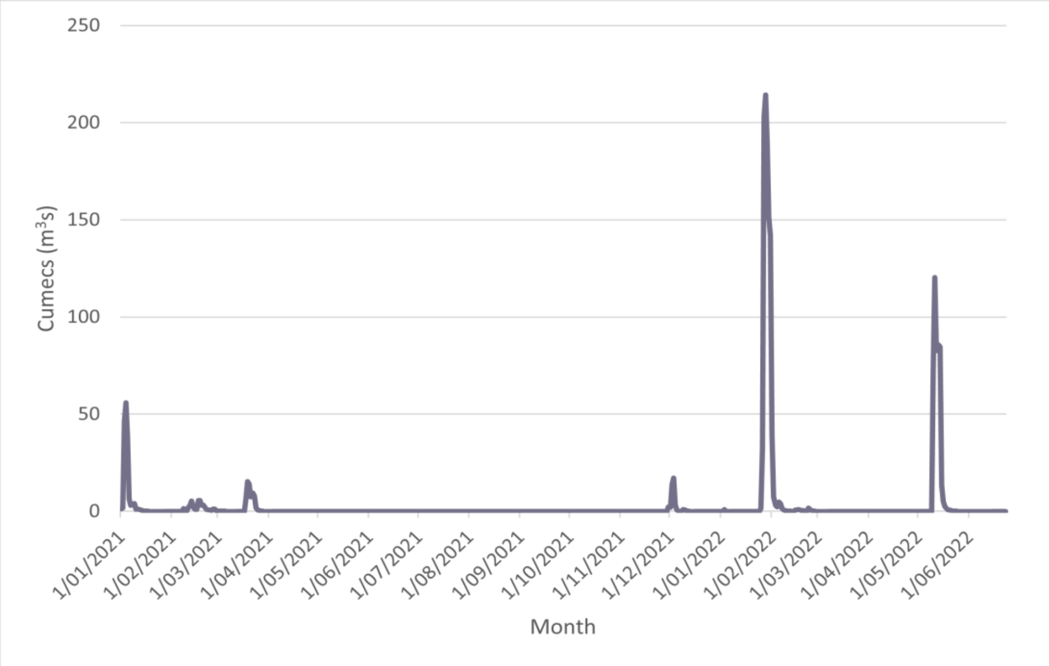

Figure 5: Flow regime 2021-2022 recorded at Saxby River gauge station

2.3 Topography, Land Zones and soils

The topography of the study area is generally flat to gently undulating, with elevations ranging between 140 m and 150 m Australian Height Datum (AHD). The topography of the study area is representative of the surrounding region. The study area topography therefore most accurately meets the ANZECC (2000) lowland aquatic ecosystem category.

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

- Land Zone 3 – Quaternary alluvial systems; and
- Land Zone 5 – Tertiary-early Quaternary loamy and sandy plains and plateaus.

2.4 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'.

3 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.

3.1 Commonwealth

3.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (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:

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

Of these MNES, nationally listed threatened species and ecological communities are most relevant to the aquatic values of the Project.

3.2 Queensland

3.2.1 Environmental Protection Act 1994

The objective of the *Environmental Protection Act 1994* (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 ERA including a resource activity, and which will include conditions that will regulate the Project activities; and
- duties of care associated with environmental harm.

3.2.2 Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP (Water and Wetland Biodiversity) 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 identification and protection of EVs within the Flinders Drainage Basin and associated tributaries.

There are no specific guidelines available under the EPP (Water and Wetland Biodiversity) for the Saxby River.

3.2.3 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:

- extinct;
- extinct in the wild;
- critically endangered;
- endangered;
- vulnerable;
- near threatened; and
- least concern.

3.2.4 Biosecurity Act 2014

The Queensland *Biosecurity Act 2014* (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.

3.2.5 Fisheries Act 1994

The main purpose of the Queensland *Fisheries Act 1994* (Fisheries Act) 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 the principles of (and promote) Ecologically Sustainable Development (ESD). 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.

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

The Fisheries Act also regulates waterway barrier works where waterway crossings are constructed or upgraded. However, this provision of the Fisheries Act is not applicable for mining developments which occur within the boundaries of the relevant mining lease.

3.2.6 Water Act 2000

The Queensland *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 caused by the exercise of underground water rights by the resource sector.

Under the Water Act, a person must not take or interfere with water unless authorised under the Water Act, or another Act. The Saxby River, which intersects the Transport ML, is a declared watercourse and is subject to the provisions of the Water Act.

4 Desktop assessment

4.1 Desktop assessment methods

A desktop assessment was conducted to collate information on aquatic ecological values identified in the region. These searches include previous surveys, community records and other sources. A review of databases was conducted to inform the specific field survey techniques to target certain aquatic flora and fauna species known from the region.

All database searches were based on either the Lot/Plan, the study area, or a central coordinate point, depending on the database search undertaken. The following database searches were undertaken:

- **The DES Environmental Report:** Matters of State Environmental Significance, to identify known MSES within the study area and surrounds (DES 2021-2022a).
- **The Queensland Government's Wetlands Maps Report**, to identify wetland waterbodies and protected areas within the study area and surrounds (Queensland Wetlands Program 2021-2022).
- **The DES Modelled Potential Habitat Mapping** to identify threatened flora and fauna species that have been modelled to have pre-clear potential habitat within the study area and surrounds (DES 2021-2022d).
- **The Queensland Government's Environmentally Sensitive Area mapping** to identify areas mapped as environmentally sensitive within the study area and surrounds (Queensland Government 2021-2022a).
- **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 2021-2022e).

The EPBC Act Protected Matters Search Tool was used to identify MNES with the potential for species or species habitat to occur in the study area or surrounds (searches based on 10 km and 60 km buffers) (DCCEEW 2021-2022).

Searches of databases were also conducted to identify known records. These searches 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 10 and 50 km buffer) (Queensland Government 2021-2022b, DES 2021-2022f).
- **The Atlas of Living Australia Occurrence Records** to further verify EVNT and SLC species records (searches based on 10 and 50 km buffer) (ALA 2021-2022).

A literature review of other available aquatic ecology assessments was undertaken to identify ecological values within proximity of the Project. One aquatic ecology survey and assessment, the Saint Elmo Vanadium Project (Epic Environmental 2020), has been conducted for a mining development located 60 km south of the study area.

Additional resources that provide species records and related information such as the Atlas of Living Australia (ALA) and Queensland Museum were consulted where appropriate to support likelihood desktop study.

The following sections address items of nature conservation relevant to the study area identified within the desktop assessment.

4.2 Desktop assessment results

4.2.1 Previous aquatic ecology assessments

The nearby Saint Elmo Vanadium Aquatic Ecology Assessment and Stygofauna Pilot Study (Epic Environmental 2020) was conducted to investigate aquatic ecology values within proximity of the Project.

The Saint Elmo Aquatic Ecology Assessment methodology was a desktop approach of aquatic matters in and surrounding the study area. No threatened aquatic MNES species under the EPBC Act or MSES species under the NC Act were identified. No threatened aquatic plant species were recorded under the EPBC Act or MSES species under the NC Act.

Preliminary water quality and macroinvertebrate data was collected from watercourses Julia Creek, Alick Creek, Spellary Creek and the Flinders River. No data was collected from major watercourses or tributaries which are assessed by the Project.

Pre-mining water quality results exceeded Water Quality Objective (WQO) for pH, ammonia, turbidity, total nitrogen and total phosphorus.

Taxonomic richness of sampled macroinvertebrate communities ranged from 20 to 29 with two PET (*Ephemeroptera*, *Trichoptera*) taxa recorded. SIGNAL-2 scores ranged from 2.96 to 3.31 indicating that all are dominated by tolerant (i.e. not sensitive) taxa and are not sensitive to changes in environmental conditions. Records of Freshwater Mussels (*Velesunio spp*.) and Redclaw Crayfish (*Cherax quadricarinatus*) were recorded from Julia Creek at Julia Creek Township.

4.2.2 Matters of National Environmental Significance

One aquatic species listed as Critically Endangered, Endangered or Vulnerable under the EPBC Act was identified by the desktop assessment. This species was the Freshwater Sawfish (*Pristis pristis*) listed as vulnerable, which was identified as having habitat potentially occurring within 50 km of the Project site using the Protected Matters Search Tool.

WildNet and ALA species records identified that the nearest known record was approximately 245 km from the study area.

The likelihood of occurrence for the Freshwater Sawfish at the Project study area was considered unlikely. Potential habitat for the species is unlikely to occur within the study area due to the ephemeral nature of the waterways within and surrounding the study area, and there are no known records within 50 km of the site. Furthermore, no aquatic species listed as Critically Endangered, Endangered or Vulnerable under the EPBC Act were identified during the site surveys. As such, the Project is not expected to pose any risk to aquatic species listed as Critically Endangered, Endangered or Vulnerable under the EPBC Act.

Terrestrial flora and fauna species have been addressed in the Terrestrial Ecology Assessment (AARC 2023) and are not considered in this report.

4.2.3 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 wetlands located within the southern focus area were identified as VM Act wetlands. Small ponding areas within the Saxby River focus area were also identified as VM Act wetlands. No VM Act wetlands were identified within the proposed mining areas within the Production ML.

Queensland Wetlands Maps

The Queensland Wetland Maps (WetlandInfo 2023) identified both palustrine and riverine wetlands within the two focus areas. Palustrine Wetlands are primarily vegetated non-channel environments of less than 8 hectares. They include billabongs, swamps, bogs, springs, soaks etc, and have more than 30% emergent vegetation. Riverine wetlands are all wetlands and deepwater habitats within a channel. The channels are naturally or artificially created, periodically or continuously contain moving water, or connecting two bodies of standing water.

Referable Wetlands

The map of Queensland wetland environmental values is a state-wide statutory map under the 'Environmental Protection (Water and Wetland Biodiversity) Policy 2019'. The map of referable wetlands defines:

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

General Ecological Significance (GES) wetlands are identified in the map of Queensland wetland environmental values, however, do not constitute referrable wetlands.

Figure 6 shows all features under the Map of Queensland wetland environmental values (Wetland data version 5) within the Production ML and focus areas. No WPAs or HES wetlands are mapped within or surrounding the Production ML or focus areas. The closest HES wetland is located approximately 250 km northeast of the Project.

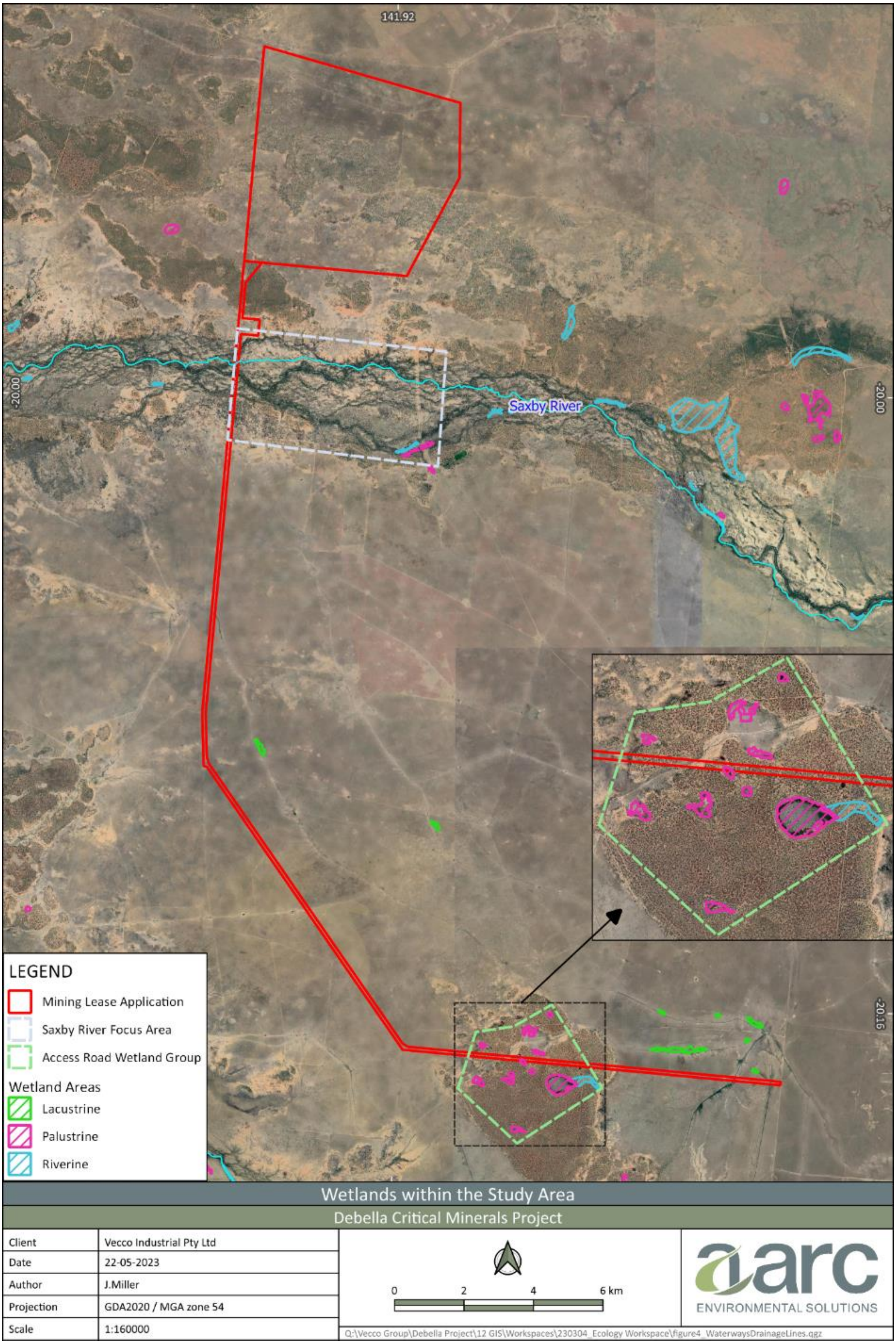

Figure 6: *Wetlands Map*

4.2.3.1 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.

The proposed access road crosses the Saxby River to the south-west of the Production ML, this reach of the Saxby River is classified as major risk of adverse impacts to fish movement (mapped as category 4, purple) (Figure 7). The river is ephemeral at this location and existing disturbance exists at the location of the proposed crossing.

An assessment of Project impacts to waterways providing fish passage is provided in Section 10.1.

4.2.3.2 Conservation significant species

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

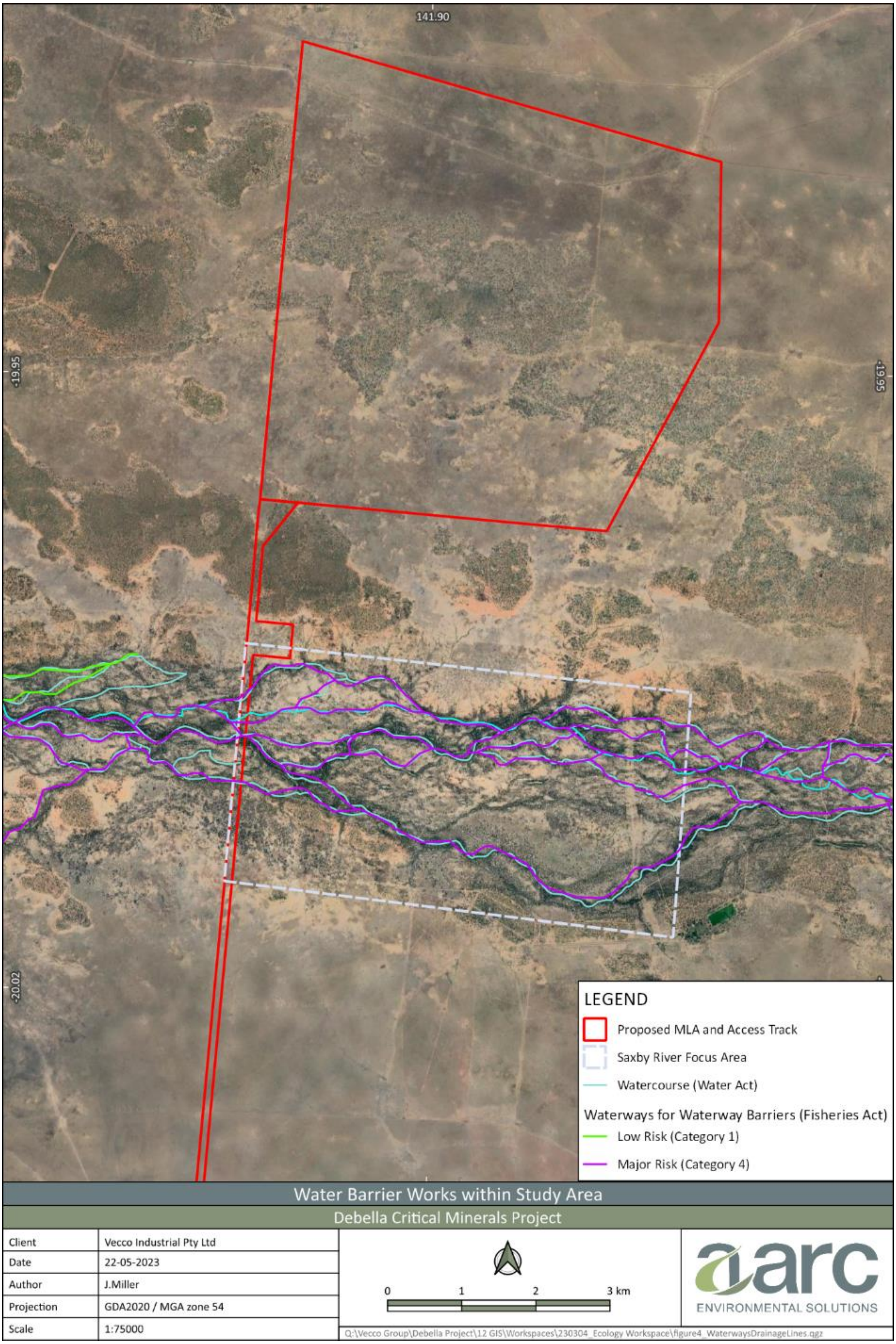

Figure 7: *Waterway Barrier Works within the Study Area*

5 Environmental values and objectives

5.1 Environmental values

Environmental Values (EVs) are defined as the qualities of water that make it suitable for supporting aquatic ecosystems and human water use (ANZECC 2000). The waterways of the Project fall within the Flinders Drainage Basin and the tributary of the Saxby River.

There are no prescribed EVs under the EPP (Water and Wetland Biodiversity) for the Flinders River Basin or Saxby River drainage sub-basin in which the Project is located. The perceived environmental values (Engeny 2023) for the Project surface waters based on all available information and legislative requirements include:

- aquatic ecosystems;
- aquaculture and human consumption
- crop irrigation
- agriculture
- recreational uses;
- drinking water;
- industrial use; and
- visual recreation and cultural and spiritual values.

5.2 Water quality objectives

In the absence of scheduled Water Quality Objectives (WQO), the EPP (Water and Wetland Biodiversity) requires WQOs to be a set of water quality guidelines for all indicators that will protect all environmental values for the water. The ANZECC (ANZECC & ARMCANZ, 2000) and QWQG (DEHP, 2009) provide broad-scale thresholds for water quality parameters for varying levels of ecosystem protection.

Relevant physical and chemical stressors and toxicants in the default guidelines, for lowland rivers with slightly to moderately disturbed waters, were the source of water quality objectives (ANZECC 2000 and ANZG 2018). For electrical conductivity, the 80th percentile of value for the relevant salinity zone was applied from the Queensland Water Quality Guidelines (DEHP 2009).

Table 1 and

Table 2 provides the guideline values for the protection of aquatic ecosystems, that have been adopted as WQOs for the assessment.

Table 1: EPP (Water) Guideline Values adopted for the Project

Management Intent (level of protection)	Parameter	Unit	Water Quality Objective
Aquatic ecosystem (for application for slightly to moderately disturbed ecosystems) for comparison against dissolved concentrations	pH	pH units	6.0 – 7.5
	EC (QWQG derived)	µS/cm	550
	Dissolved oxygen	%	85 – 120
	Turbidity	NTU	15
	Total nitrogen	µg/L	300
	Total phosphorus	µg/L	10
	Aluminium	µg/L	55
	Arsenic	µg/L	13
	Boron	µg/L	370
	Cadmium	µg/L	0.2
	Chromium	µg/L	1
	Copper	µg/L	1.4
	Lead	µg/L	3.4
	Manganese	µg/L	1,900
	Nickel	µg/L	11
	Zinc	µg/L	8
Stock watering – for comparison against the total concentration	Aluminium	mg/L	5
	Arsenic	mg/L	0.5 (up to 53)
	Boron	mg/L	5
	Cadmium	mg/L	0.01
	Chromium	mg/L	1
	Cobalt	mg/L	1
	Copper	mg/L	0.4 (sheep), 1 (cattle), 5 (pigs), 5 (poultry)
	Fluoride	mg/L	2
	Iron	mg/L	not sufficiently toxic
	Lead	mg/L	0.1
	Manganese	mg/L	not sufficiently toxic
	Mercury	mg/L	0.002

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

Table 2: Petroleum hydrocarbons (Water) Guideline Values adopted for the Project

Parameter	ANZECC (2000) Trigger Value	Units
C6- C9 Fraction	20	mg/L
C10 - C14 Fraction	100	mg/L
C15-C28 Fraction	100	mg/L
C29-C36 Fraction	100	mg/L
C10-C36 Fraction (sum)	100	mg/L
C6-C10 Fraction	20	mg/L
C6-C10 Fraction minus BTEX (F1)	100	mg/L
>C10-C16 Fraction	100	mg/L
>C16-C34 Fraction	100	mg/L
>C34-C40 Fraction	100	mg/L
>C10-C40 Fraction (sum)	100	mg/L
>C10-C16 Fraction minus Napthalene (F2)	100	mg/L

5.3 Sediment quality objectives

Default guideline values for toxicants in sediment are provided by ANZG (2018) and ANZECC & ARMCANZ (2000). Stream sediment quality objectives as per ANZG (2018) relevant to the Project are adopted as presented in Table 3.

Table 3: Sediment Quality Default Guideline values adopted for the Project

Contaminant	Sediment Quality Value – Low (mg/kg)	Sediment Quality 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
Total petroleum hydrocarbons	280	550

6 Methodology

This section describes the aquatic ecology survey methods employed, including survey timing and prevailing climatic conditions, the selection of survey sites and survey techniques utilised.

The survey design was tailored to address the level of risk presented by proposed Project activities. As such, the aquatic ecology survey effort focussed on the receiving environment for the mining areas, being the Saxby River focus area. Aquatic ecology survey techniques carried out at this location included:

- aquatic habitat survey (physical assessment, habitat bioassessment, and condition assessment);
- surface water quality (physio-chemical water sampling);
- stream sediment quality (physio-chemical sediment sampling); and
- aquatic macroinvertebrates.

Methods employed were developed in accordance with the following guidelines:

- 'Monitoring and Sampling Manual: Environmental Protection (Water) Policy' (DES 2018);
- 'Queensland Australian River Assessment System (AusRivAS) Sampling and Processing Manual' (DNRM 2001);
- 'Background to aquatic macroinvertebrates sampling and index calculation' (DES 2018); and
- 'Aquatic macroinvertebrate sampling, processing and index calculation' (DES 2018).
- 'Australian and New Zealand Guidelines for Fresh and Marine Water Quality' (ANZG 2018).

The aquatic survey of the group of wetlands along the access road included the following techniques:

- Visual observations during wet and dry periods, both on the ground and from a helicopter;
- Vegetation surveys to identify species composition and species of conservation significance; and
- Fauna observations, targeting wetland reliant species, and habitat observations.

The series of artificial bore drains used by underlying landholders to distribute water from uncapped (open) artesian bores were not considered to provide significant aquatic value warranting further assessment. Water quality samples were collected from open drains to assist in understanding contributing factors to the baseline condition of the natural receiving environment.

6.1 Survey timing and conditions

Two aquatic ecology surveys were conducted within the study area. One was undertaken during the wet season on 14th February 2022. The second survey was undertaken following an unseasonal post wet season rain event on 16th May 2022.

During the February 2022 survey, the weather conditions experienced were typical for the region. The weather data was obtained from Bunda Bunda weather station (029036), located approximately 30 km East of the study area (BoM 2022). Rainfall recorded in the three months prior to the first survey (November to January) (254.8 mm) was similar to the long-term average rainfall (259.6 mm) for these months recorded at the Bunda Bunda weather station. In contrast, rainfall recorded in the three months prior to the second survey (February to April), (37 mm) was considerably lower than the long-term average rainfall (198.2) for these months.

A total of 108.5 mm was recorded during the last week of January, three weeks preceding the February 2022 survey. Field conditions during the February 2022 survey were dry with localised pools in the Saxby River channels and slow flowing conditions at one of the sites.

A total of 186mm was recorded during one rainfall event six days prior to the second survey in May. Field conditions during the second survey were dry, with standing water and localised pools, but with more locations presenting flowing conditions, likely related to the high rainfall event.

6.2 Survey site selection

Suitable aquatic survey sites were identified in the Saxby River focus area through review of the available mapping (Section 4) and aerial imagery. Sites were selected to:

- achieve sufficient spatial distribution across the focus areas; and
- capture ‘entry’ and ‘exit’ points of waterways traversing the focus area, enabling collection of suitable baseline data for ‘reference’ and 'impact’ sites that can be utilised in any long-term monitoring programs.

A total of seven aquatic survey sites that were investigated as part of the assessment, including three upstream reference sites and four downstream impact sites. The location and survey methods used at each of the survey sites are detailed in Table 4 and Figure 8.

At each Saxby River survey site, water quality, sediment quality and macroinvertebrate sampling were conducted according to methodologies presented in Sections 6.4, 6.5, and 6.6. The aquatic habitat was assessed at sites US1, DS1, and DS2 according to the methodology presented in Section 6.3.

Additional surface water monitoring was also conducted at two sites established in excavated bore channels, located outside of the focus areas (Channel 01 and Channel 02).

Table 4: Aquatic ecology and water quality survey sites

Site	Location	Latitude	Longitude
Upstream of Project area			
US1	Saxby River	-19.99670	141.92519
US2	Saxby River	-19.99115	141.92282
US3	Saxby River	-20.0051	141.9403
Downstream Project area			
DS1	Saxby River	-19.98663	141.87852
DS2	Saxby River	-19.99407	141.87575
DS3	Saxby River	-19.9944	141.8993
DS4	Saxby River	-20.0005	141.8875
Bore Channels			
Channel01	Excavated channel north of the proposed ML	-19.91544	141.88623
Channel02	Excavated channel east of the proposed ML	-19.947460	141.94426

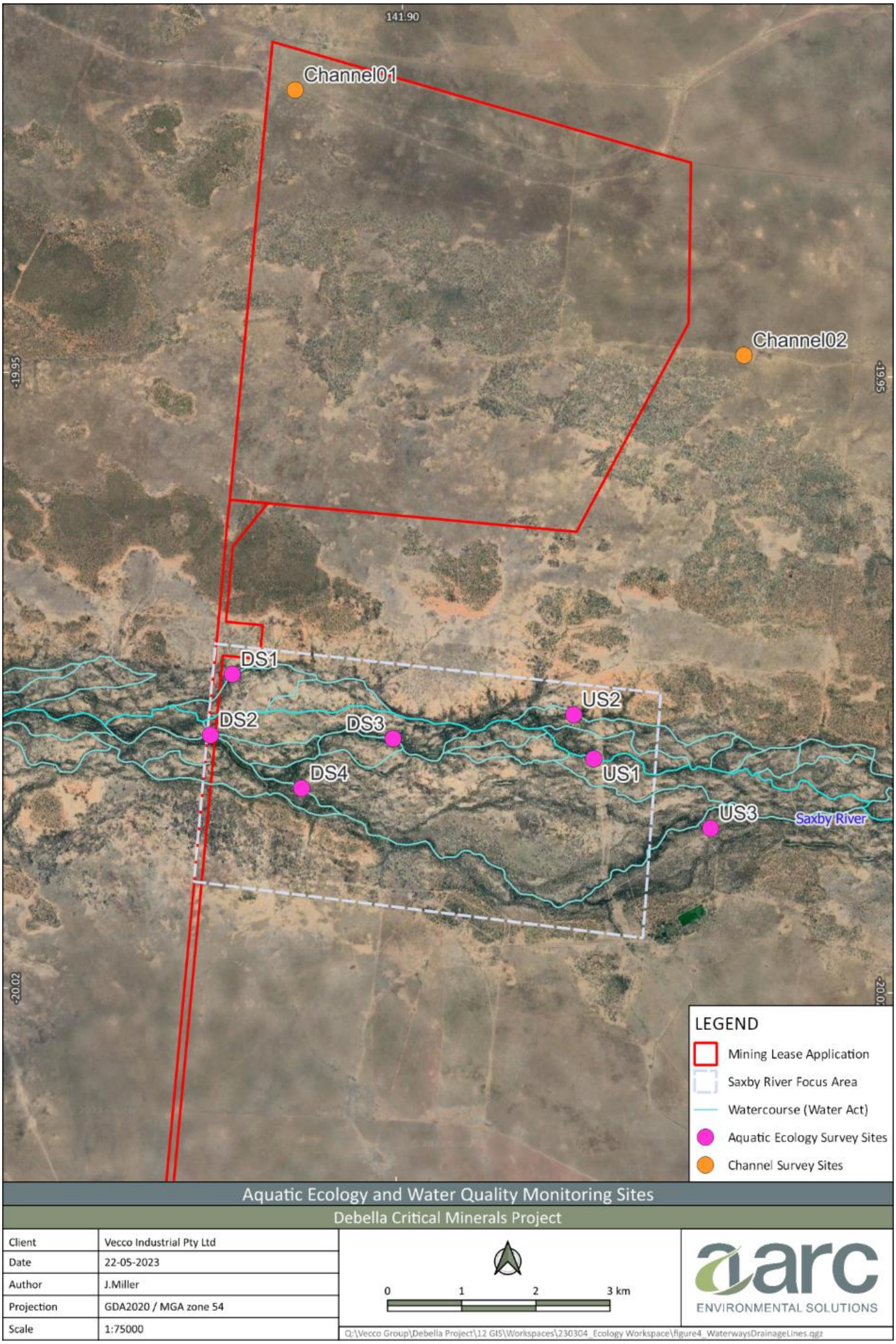

Figure 8: Aquatic Survey Locations and channel water sampling sites

6.3 Aquatic habitat

6.3.1 Physical assessment

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

- AusRivAS Physical Assessment Protocol (Parsons et al. 2002, p.5); and
- Queensland AusRivAS Sampling and Processing Manual (DNRM 2001).

The specific techniques utilised in the aquatic habitat physical assessments are presented in Table 5. The survey technique was deployed at aquatic sample sites within the Saxby River focus area. Assessments were undertaken at three sites (DS1, DS2 and US1) during the first aquatic survey conducted in February 2022 which are representative of the Saxby River channels.

Table 5: Physical assessment methodology

Characteristic	Monitoring Methodology
Bank Characteristic	
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	
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.

6.3.2 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. Table 6 provides a framework for interpreting habitat assessment scores.

The survey technique was deployed at aquatic sample sites within the Saxby River focus area. Habitat assessments were completed at three (DS1, DS2 and US1) sites considered representative of the Saxby River channels during the first aquatic survey undertaken in February 2022.

Table 6: Key to AusRivAS habitat assessment scores

Habitat Assessment Score	Rating	Interpretation
0 – 35	Poor	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	Fair	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	Good	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	Pristine	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.

6.3.3 Condition assessment

The condition assessment is an evaluation of the possible impacts to aquatic environmental values caused by major disturbances within the waterway. The survey technique was deployed at all aquatic sample sites within the Saxby River focus area.

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 instream conditions and habitats.

6.4 Surface water quality

Surface water quality samples were collected at each of the aquatic ecology sample sites within the Saxby River focus area and at two bore drain locations.

Water quality sampling was carried out in accordance with the Monitoring and Sampling Manual (DES, 2018) methodology. Field readings of pH, dissolved oxygen (DO), turbidity, electrical conductivity (EC) and temperature (°C) were 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.

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 identified in Section 5.2. Petroleum hydrocarbon data was also identified from the samples (Table 12). The results were compared to the guideline values adopted as per (Table 1).

Piper trilinear plots were created using data from laboratory analysis of samples collected within the study area. Piper trilinear diagrams are used to categorize the water facies on the basis of dominant ions (Piper 1944). Categorizing facies aids in understanding whether the water type is safe for use across different purposes whether that be for irrigation or industrial use.

6.5 Sediment quality

Similarly, to water quality, sediment quality data was collected at each of the aquatic ecology sample sites within the Saxby River focus area. Sediment quality sampling was undertaken in accordance with the Queensland Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009 (DES 2018).

Five sub-samples (approximately 500 grams (g) each) of stream–bed substrate was 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 National Association of Testing Authorities [NATA] accredited laboratory). Results were compared to Sediment Quality Default Guideline Values (Table 3).

6.6 Aquatic macroinvertebrates

Macroinvertebrate sampling was conducted at Saxby River focus area sites, in accordance with the AusRivAS sampling and assessment methodology as outlined by the Queensland Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009 (DES 2018).

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 4). 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 2018). 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 (Marshall *et al*. 2001). 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.

The watercourses within the study area are ephemeral, however the survey sites had contained water for a period sufficient for the assemblage of macroinvertebrates to develop as representative of the water quality and environment, and not limited by a lack of water. At the time of sampling sites DS1, DS3, US1 and US2 were not flowing which has been given consideration in the interpretation of results.

A SIGNAL2 bi-plot was created for the survey 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 9).

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.

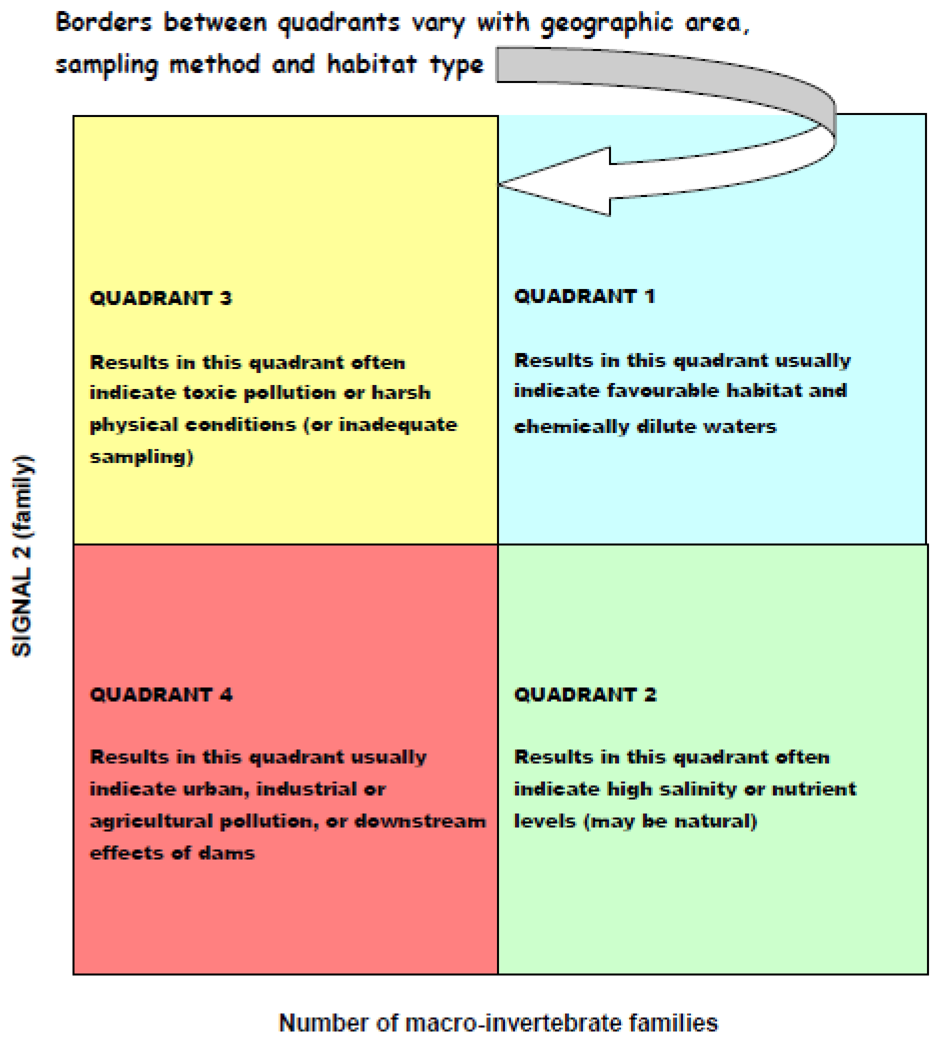

Figure 9: Example of SIGNAL2 bi-plot (source: Chessman 2003)

6.7 Wetland assessment

The assessment also included an area along the southern extent of the access road, where a number of wetlands are located in proximity to the Transport ML. One of these small palustrine wetlands intersects the ML to a minor extent (0.45 ha). The aquatic survey assessed the values of this wetland group through a combination of field observations from a helicopter and ground observations (including flora species composition) during the dry season.

7 Results and Discussion

7.1 Aquatic habitat

7.1.1 Physical assessment

Table 7 provides the erosion specific observations at each site. Table 8 provides the AusRivAS Physical Assessment data collected at each aquatic site. Site descriptions and photos are provided in Appendix Appendix C.

The effects of erosion on the banks of the receiving waters were minimal across surveyed sites DS1 and DS2. The leading cause of local erosion at site US1 appeared to be stock access, with edge effects from historic clearing and an access road crossing the watercourse 50 m upstream. Overall bank stability was determined to be sound.

Table 7: Erosion observations

Site	Bare Ground	Exposed Tree Roots	Gully Erosion	Bank Slumping	Local Catchment Erosion
DS1	Little	Some	None	None	None
DS2	Little	Some	None	None	None
US1	Some	Some	None	None	Some

Table 8: AusRivAs physical assessment results

Site Name	Water Flow	Water Odour	Water Oils	Water Colour	Turbidity	Plume	Water Surface Condition
DS1	Standing	None	None	Opaque	Turbid	Moderate	Normal
DS2	Flowing	None	None	Opaque in stream clear in pools	Slight	Little	Normal
US1	Standing	None	None	Tannin	Turbid	Some	Normal

7.1.2 Habitat bioassessment

This assessment considered the morphological characteristics of waterways (as specified in Section 6.3.2), with 135 representing a perfect score for a healthy waterway.

The habitat bioassessment scores from the aquatic sites within the sampling environment fell into the fair and good categories described in Table 6 (Figure 10). 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 10: Habitat Bioassessment Scores

7.1.3 Condition assessment

The condition assessment considered the impact/influence of ten different upstream activities on the waterways (as outlined in Section 6.3.3) 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 11.

Condition assessment scores ranged from 44 (US1) to 48 (DS2) with a mean of 46. Of the sites surveyed, all three sites had 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 agriculture upstream. The current land use of the study area is low intensity cattle grazing and, in the absence of regular watering stations stock are reliant on natural waterways.

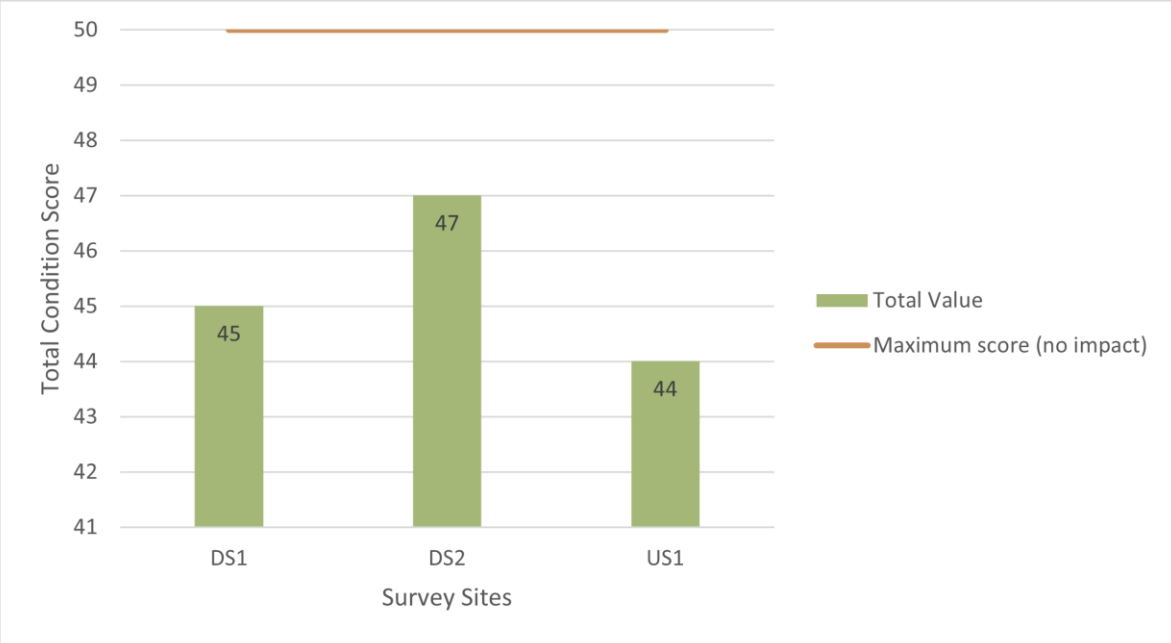

Figure 11: Condition assessment scores of survey sites

7.2 Surface water quality

Water was collected during the 2022 aquatic sampling surveys and supplemented with data from early 2023. Data was collected from all monitoring sites over the period.

The results from the surface water quality analysis were compared to the ANZECC (2020) Water Quality Objectives (WQOs) to identify possible baseline exceedances of the water quality objectives (Table 9 and Table 10). The physcio-chemical results were compared against relevant objectives (Table 11) and the petroleum hydrocarbons were compared to relevant objectives (Table 12).

Water quality in the Saxby River showed consistent elevation of some parameters including aluminium, chromium, copper, manganese and hydrocarbons when compared to the aquatic ecosystem objectives for slightly to moderately disturbed waters. These elevated parameters are assumed to be linked to natural mineralisation in the sub-soils of the area. Other potential contributing sources to water include grazing and agricultural land practices. In addition, contributions from uncapped groundwater bores, accessing underlying artesian waters and overtopping to land and waters via constructed bores drains may be contributing to water quality in the Saxby River.

Despite elevated concentrations of some parameters, baseline water quality results were considered typical of a slightly to moderately disturbed aquatic ecosystem in this region.

Table 9: Dissolved metals results and comparison to aquatic ecosystem protection guideline values

Parameter	Water quality objective	Units	DS1	DS2	US1	US2	US1	US2	US3	DS4	DS2	DS3	Channel01	Channel02	DS1	DS2	DS3	DS4	US1	US2	US3
			14/02/22	14/02/22	14/02/22	14/02/22	16/05/22	16/05/22	16/05/22	16/05/22	16/05/22	16/05/22	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23
Aluminium	0.055	mg/L	0.011	0.089	0.263	<5	0.966	0.334	1.01	0.743	1.25	1.44	<0.01	<0.01	0.11	0.26	0.15	0.04	0.07	0.06	0.10
Arsenic	0.013	mg/L	0.001	0.001	0.002	0.004	0.001	0.001	<0.001	0.001	<0.001	<0.001	0.003	0.004	<0.001	0.001	0.001	<0.001	0.002	0.002	0.001
Boron	0.370	mg/L	<0.05	<0.05	<0.05	0.16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Cadmium	0.0002	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	0.001	mg/L	<0.001	<0.001	<0.001	0.002	<0.001	0.002	<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	0.0014	mg/L	0.002	0.001	0.002	0.001	0.002	<0.001	0.002	0.002	0.002	0.002	<0.001	<0.001	0.001	0.002	0.001	0.001	0.002	<0.001	0.002
Lead	0.0034	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.001	0.001	0.002	<0.001	0.002
Manganese	1.9	mg/L	0.007	0.02	0.066	0.263	0.003	0.022	0.009	0.006	0.002	0.002	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	0.011	mg/L	0.002	0.001	0.002	0.010	0.002	<0.001	0.002	0.002	0.002	0.002	0.001	0.001	<0.001	0.002	0.002	0.001	0.002	0.002	0.002
Zinc	0.008	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Notes: Cells shaded orange indicate exceedance of objective.

Table 10: Total metals results and comparison to stock watering objectives

Parameter	WQO	Units	DS1	DS2	US1	US2	US1	US2	US3	DS4	DS2	DS3	Channel01	Channel02	DS1	DS2	DS3	DS4	US1	US2	US3
			14/02/22	14/02/22	14/02/22	14/02/22	16/05/22	16/05/22	16/05/22	16/05/22	16/05/22	16/05/22	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23
Aluminium	5	mg/L	25.4	4.44	5.62	33.6	6.4	1.02	7.83	4.34	9.82	9.67	0.08	0.22	4.47	6.10	3.12	5.34	1.29	2.19	3.57
Arsenic	0.5	mg/L	0.004	0.002	0.003	0.009	0.002	0.001	0.002	0.002	0.002	0.002	0.004	0.006	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Boron	5	mg/L	0.05	<0.05	<0.05	0.18	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.001	0.005	0.004	0.005	0.003	0.005	0.001	0.002	0.003
Cadmium	0.01	mg/L	0.0002	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	0.002	0.005	0.001	0.002	0.002	0.002	0.001	0.001	0.002
Chromium	1	mg/L	0.025	0.004	0.006	0.034	0.007	0.001	0.009	0.003	0.012	0.012	0.002	0.001	0.004	0.004	0.003	0.004	0.002	0.003	0.003
Cobalt	1	mg/L	0.008	0.002	0.003	0.025	0.003	0.001	0.004	0.002	0.007	0.005	<0.001	<0.001	0.001	0.002	<0.001	0.002	<0.001	<0.001	0.002
Copper	1 (cattle)	mg/L	0.017	0.003	0.004	0.02	0.006	0.002	0.006	0.003	0.009	0.008	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Lead	0.1	mg/L	0.01	0.002	0.003	0.019	0.002	<0.001	0.003	0.002	0.006	0.005	0.001	0.002	0.003	0.004	0.003	0.004	0.003	0.002	0.003
Mercury	0.002	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.004	0.006	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Molybdenum	0.15	mg/L	0.003	0.001	0.002	0.004	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel	1	mg/L	0.013	<0.001	0.002	0.024	0.007	0.002	0.008	0.004	0.01	0.009	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Selenium	0.02	mg/L	0.00007	<0.2	0.0003	0.0017	0.0003	<0.0002	0.0004	<0.0002	0.0006	0.0005	<0.001	0.005	0.004	0.005	0.003	0.005	0.001	0.002	0.003
Uranium	0.2	mg/L	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.005	0.001	0.002	0.002	0.002	0.001	0.001	0.002
Zinc	20	mg/L	0.05	0.01	0.014	0.058	0.015	0.008	0.018	0.008	0.026	0.021	<0.001	<0.001	0.001	0.002	<0.001	0.002	<0.001	<0.001	0.002
Fluoride	2	mg/L	-	-	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Notes: Cells shaded orange indicate exceedance of objective.

Table 11: Physico-chemical results and comparison to water quality objectives

Parameter	WQO	Units	DS1	DS2	US1	US2	US1	US2	US3	DS4	DS2	DS3	Channel01	Channel02	DS1	DS2	DS3	DS4	US1	US2	US3
			14/02/22	14/02/22	14/02/22	14/02/22	16/05/22	16/05/22	16/05/22	16/05/22	16/05/22	16/05/22	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23
pH	6 to 8	-	7.37	7.8	7.93	8.13	7.28	7.3	7.27	7.32	7.41	7.5	7.50	7.60	7.53	7.42	7.78	7.93	7.86	7.68	7.93
EC	550	µS/cm	216	153	153	1170	104	46	101	69	99	99	150	136	73	56	141	145	164	103	147
Total Hardness	n/a	CaCO3 mg/L	-	-	-	67	33	12	33	23	31	31	45	57	22	18	54	47	61	33	54
Sulphate as SO4	n/a	mg/L	40	5	6	11	7	2	7	5	8	8	<1	<1	3	2	2	3	3	2	2
Ammonia as N	n/a	mg/L	-	-	-	0.1	<0.01	0.08	0.04	0.28	0.06	0.09	0.09	0.05	0.04	0.03	0.10	0.39	0.10	0.04	4.01
Nitrite as N	n/a	mg/L	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	n/a	mg/L	-	-	-	<0.01	0.01	<0.01	<0.01	<0.01	0.06	0.06	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.02	<0.01	<0.01
Chloride	n/a	mg/L	<1	3	<1	2	2	4	4	3	<1	2	7	4	3	2	7	9	7	5	9
TSS	n/a	mg/L	-	-	-	141	46	9	92	31	263	149	28	22	49	32	41	78	34	16	54
Turbidity	15	ntu	1040	152	181	1400	220	19.9	287	133	424	371	13.6	11.7	96.1	121	65.5	113	44.4	37.2	88.5

Notes: Cells shaded orange indicate exceedance of objective.

Table 12: Petroleum hydrocarbon data and comparison to water quality objectives

Parameter	ANZECC (2000) Trigger Value	Units	US2	US1	US3	DS4	DS2	DS3	Channel01	Channel02	DS1	DS2	DS3	DS4	US1	US2	US3
			16/05/22	16/05/22	16/05/22	16/05/22	16/05/22	16/05/22	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23	02/03/23
C6- C9 Fraction	20	mg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C10 – C14 Fraction	100	mg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C15-C28 Fraction	100	mg/L	<100	<100	<100	<100	<100	<100	<100	140	<100	<100	<100	130	380	<100	<100
C29-C36 Fraction	100	mg/L	<50	<50	<50	<50	<50	<50	<50	60	<50	<50	<50	<50	80	<50	<50
C10-C36 Fraction (sum)	100	mg/L	<50	<50	<50	<50	<50	<50	<50	200	<50	<50	<50	130	460	<50	<50
C6-C10 Fraction	20	mg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C6-C10 Fraction minus BTEX (F1)	100	mg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
>C10-C16 Fraction	100	mg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C16-C34 Fraction	100	mg/L	<100	<100	<100	<100	<100	<100	<100	170	<100	<100	<100	<100	430	<100	<100
>C34-C40 Fraction	100	mg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C10-C40 Fraction (sum)	100	mg/L	<100	<100	<100	<100	<100	<100	<100	170	<100	<100	<100	<100	430	<100	<100
>C10-C16 Fraction minus Napthalene (F2)	100	mg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100

Notes: Cells shaded orange indicate exceedance of objective.

7.3 Stream sediment quality

The results from the sediment quality analysis are displayed below in Figure 12, Table 13, Table 14, and Table 15 along with the relevant sediment quality objective.

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

The particle size analysis is shown in Figure 12. Saxby River stream sediment is characterised by high percentages of sand (up to 88 %) at the majority of sites with variable levels of clay and silt. Two sites US3 and DS3 had higher concentrations of clay and silt 62 % and 43 % respectively. Minor gravel presence was recorded at all sites with site DS3 recording the highest percentage at 21 %. Only minor large cobble was present recorded at less than 1 % for all sites.

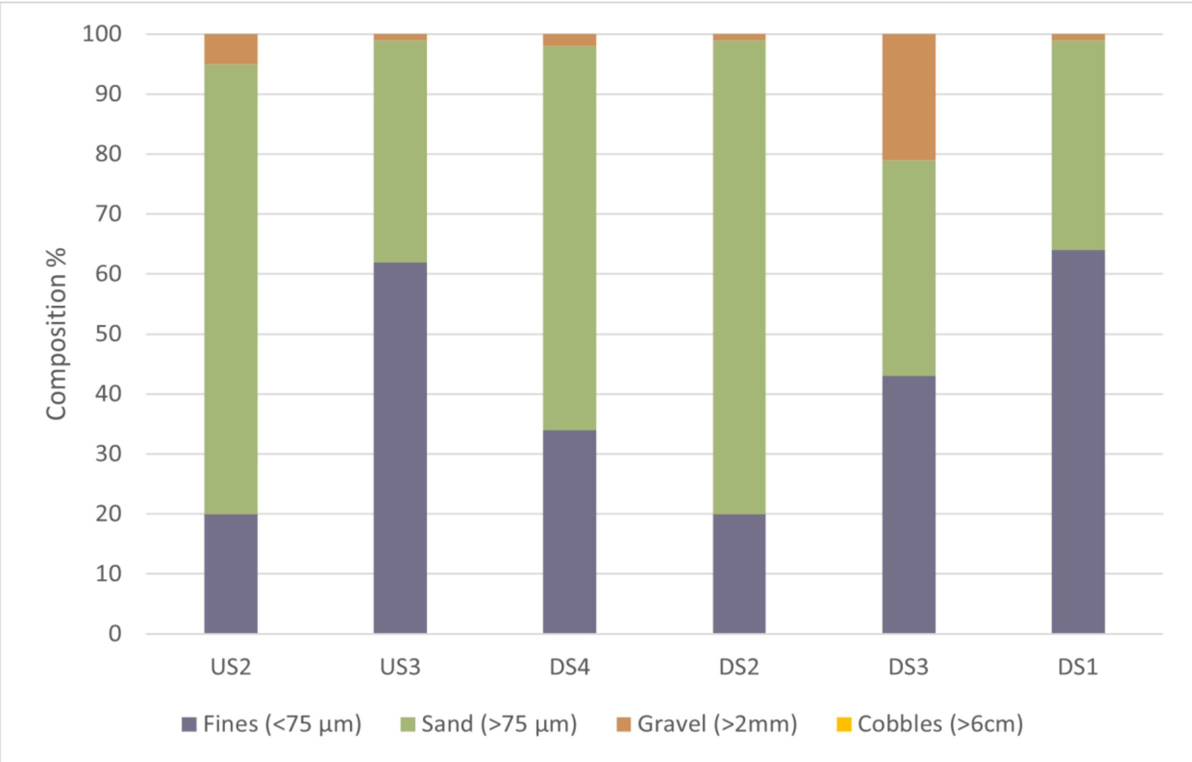

Figure 12: Particle size distribution results

Table 13: Soil moisture and pH

Parameter	DS1	DS2	US1	US2	US1	US2	US3	DS4	DS2	DS3
	14/02/2022	14/02/2022	14/02/2022	12/04/2022	16/05/2022	16/05/2022	16/05/2022	16/05/2022	16/05/2022	16/05/2022
Moisture Content (%)	27.5	14.8	21.9	33.6	21	17.5	33.2	23.2	19.7	22.3
pH (pH units)	-	-	-	-	6.9	6.6	6.7	7.2	7.4	7.9

Table 14: Sediment total metals analysis results

Parameter	DGV Low (mg/kg)	DGV High (mg/kg)	DS1	DS2	US1	US2	US1	US2	US3	DS4	DS2	DS3
			14/02/22	14/02/22	14/02/22	12/04/22	16/05/22	16/05/22	16/05/22	16/05/22	16/05/22	16/05/22
Arsenic	-	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cadmium	1.5	10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chromium	80	370	7	3	4	8	3	4	7	4	4	6
Copper	65	270	7	<5	<5	7	<5	<5	6	<5	<5	8
Lead	50	220	7	<5	<5	6	<5	<5	6	<5	<5	<5
Nickel	21	52	6	<2	<2	10	<2	<2	6	3	2	9
Zinc	200	410	13	<5	<5	12	<5	<5	11	6	<5	16
Mercury	0.15	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Table 15: Sediment particle size analysis results

Particle size fraction	**US1**	**US2**	**US3**	**DS4**	**DS2**	**DS3**
	16/05/2022	16/05/2022	16/05/2022	16/05/2022	16/05/2022	16/05/2022
Fines (<75 µm)	11	20	62	34	20	43
Sand (>75 µm)	88	75	37	64	79	36
Gravel (>2mm)	1	5	1	2	1	21
Cobbles (>6cm)	<1	<1	<1	<1	<1	<1

7.4 Aquatic macro-invertebrates

7.4.1 Abundance

Total abundance of macroinvertebrates across the sites in the Saxby River ranged between 23 and 116 individuals in the 2022 survey (Figure 13). The lowest total abundance was recorded at impact site DS3 with 23 individuals. The highest number of macroinvertebrates was recorded at reference site US1 with 116 individuals. A complete list of all identified macroinvertebrates is available in Appendix A.

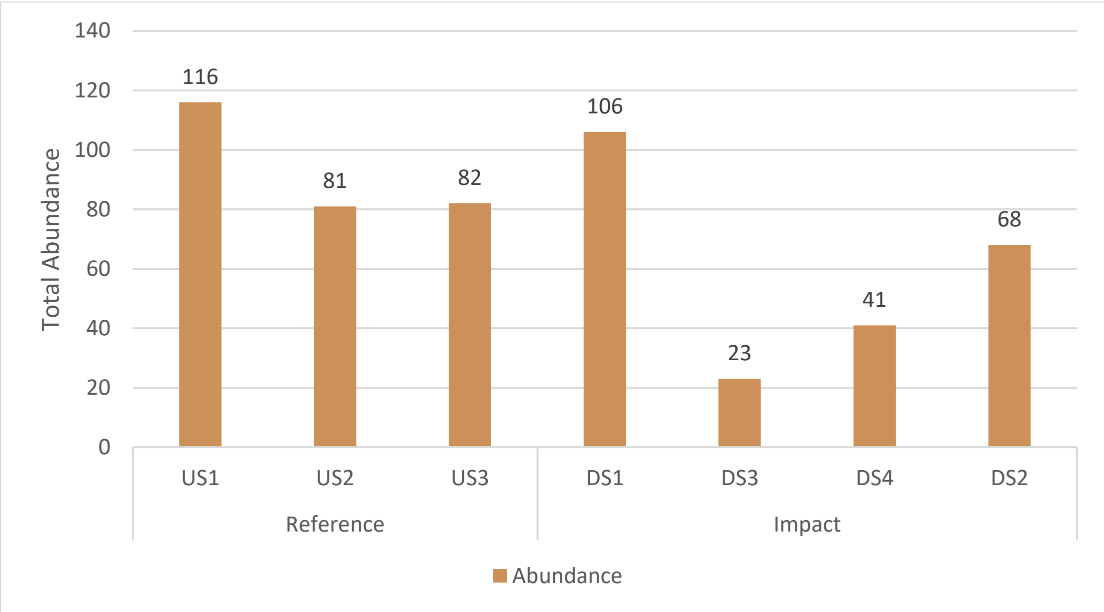

Figure 13: Total macroinvertebrate abundance at aquatic ecology survey sites

7.4.2 Taxonomic richness

A total of 45 macroinvertebrate taxa were identified in the 2022 survey across all Saxby River sites.

Taxonomic richness of the samples (Figure 14) ranges from 8 to 16 total taxa. No WQOs exist for macroinvertebrates in the Flinders River Basin or Saxby River drainage sub-basin in which the Project is located. The taxonomic richness is reflective of the ephemeral nature of the watercourses within the study area and likely to be representative of aquatic ecosystems in the Saxby River sub-basin.

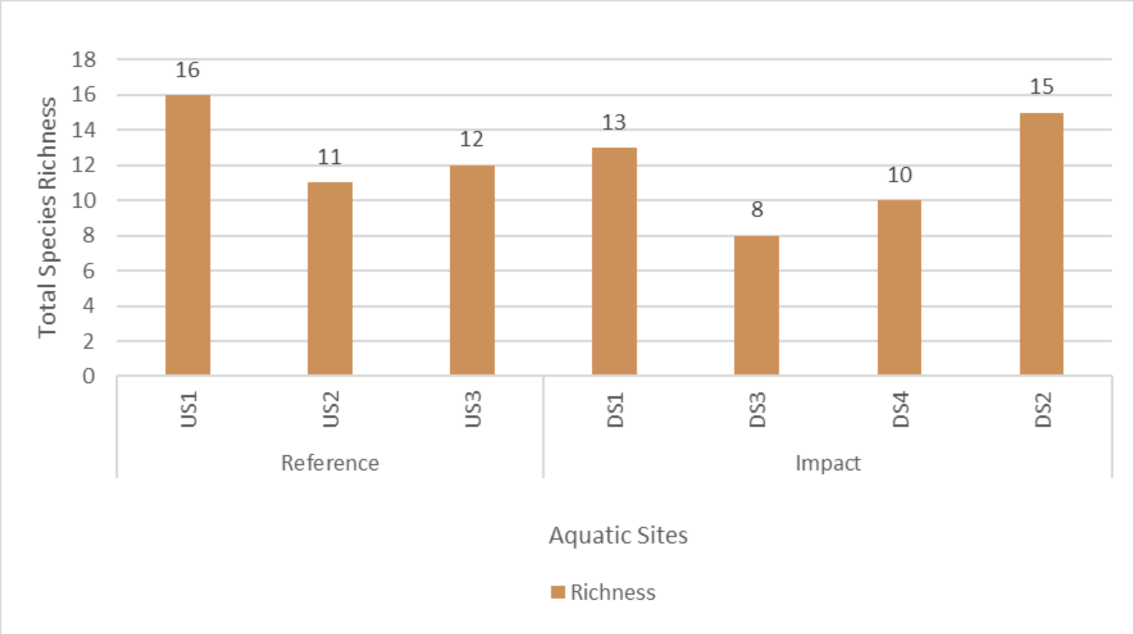

Figure 14: Macroinvertebrate taxonomic richness at aquatic ecology survey sites

7.4.2.1 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, *Trichoptera Hydropsychidae*, *Ephemeroptera Leptophlebiidae*, *Ephemeroptera Caenidae*, and *Trichoptera Leptoceridae*.

Samples from two sites (DS1 and DS2) collected during the survey contained PET taxa (Table 16).

The low levels of PET taxa sampled is likely due to the ephemeral nature of the waterway and the lack of available habitats present at the sample sites at the time of sampling, this includes the rapid flow of water at site DS4 during the May 2022 survey.

Table 16: Total PET taxa at aquatic ecology survey sites

Taxa	DS1	DS2	US1	DS3	DS4	US2	US3
Ephemeroptera	0	2	0	0	0	0	0
Plecoptera	0	0	0	0	0	0	0
Trichoptera	1	2	0	0	0	0	0
Total	1	4	0	0	0	0	0

7.4.3 SIGNAL2 scores

The weighted SIGNAL 2 scores recorded from the samples collected were generally low ranging from 2 to 3.8.

The SIGNAL2 scores for all sites fell within Quadrant 4 (Figure 15) on the Bi-Plot. Sites that fall into quadrant 4 exhibit levels of pollutants that reflect urban, industrial, or agricultural pollution. The SIGNAL2 scores correspond with polluted or poor habitat availability and environmental conditions. Given the aquatic habitat condition assessment results (Section 7.1.3) show that the study site is not subject to substantial upstream activity impacts, the SIGNAL2 scores recorded are likely reflective of typical environmental conditions for the catchment.

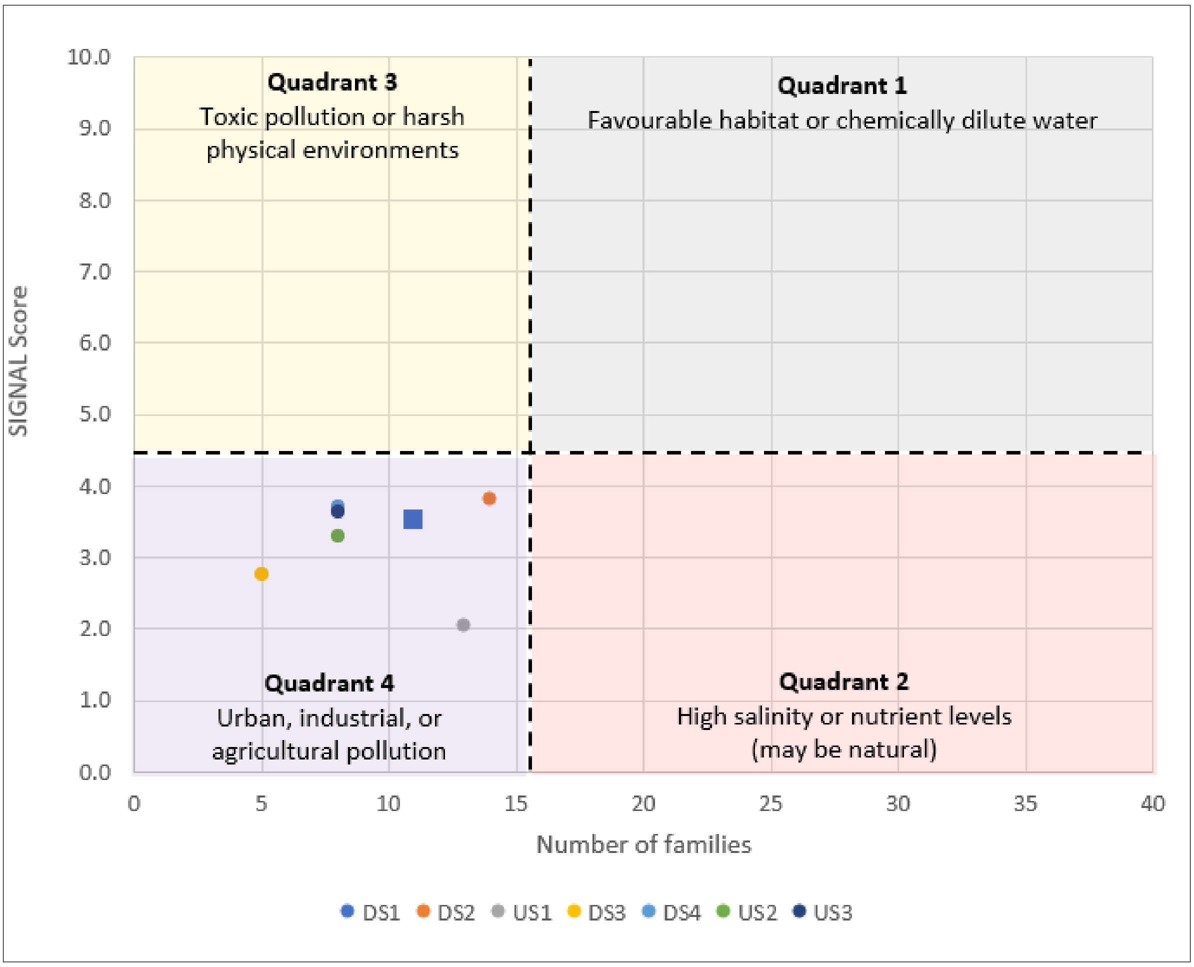

Figure 15: Bi-Plot of Signal2 scores for all sites

7.4.4 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 50 % to 90.9 % during the 2022 survey (Figure 16). Reference site US2 presented the highest percentage of tolerant taxa (90.9 %), reference site US1 recorded the lowest percentage (50 %).

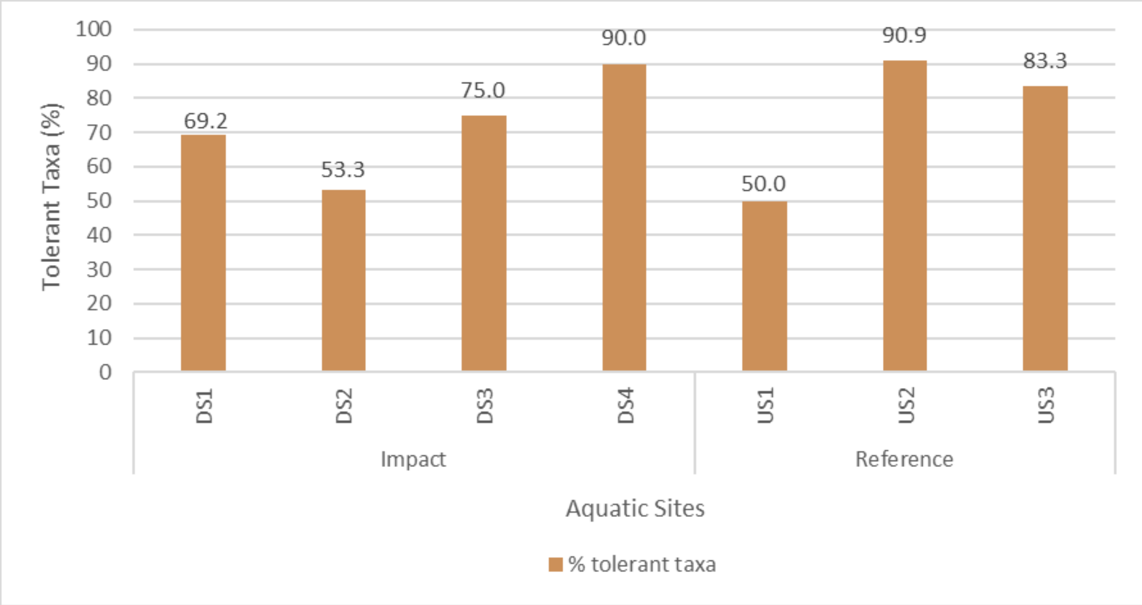

Figure 16: Percentage of tolerant taxa

7.5 Aquatic fauna

Aquatic Fauna were not targeted during the 2022 Aquatic survey due to the ephemeral nature of the watercourses and limited availability of safe and ethical trapping conditions. However, aquatic fauna observations were made where possible during data collection at survey locations.

One species of freshwater crab (*Austrothelphusa spp*.) and one fish species, Spangled Perch (*Leiopotherapon unicolor*) was observed at sites DS1 and DS2 (Table 17).

No conservation significant or EPBC Act or NC Act listed Endangered, Vulnerable or Near Threatened (EVNT) species were observed at any of the survey sites during the survey. All aquatic species recorded in the study area are native and are considered common or widespread species in the Flinders Drainage Basin. No pest fish species were observed during the survey.

Table 17: Fish and crustacean species observed during survey

Fish Species	**DS1**	**DS2**
Leiopotherapon unicolor Spangled perch	1	1
Austrothelphusa transversa Freshwater crab	1	1

7.6 Riparian zone fauna

Riparian fauna was not targeted during this survey, however, observations were taken while completing the survey. Two native, Least Concern status (NC Act), amphibian species were observed during the survey at site DS1, these included the Eastern Snapping Frog (*Litoria novaehollandiae*) (Photo Plate 1) and the Ornate Burrowing Frog (*Opisthodon ornatus*) (Photo Plate 2). No fauna species of conservation significance were observed during surveys.

Photo Plate 1: Eastern Snapping Frog

Photo Plate 2: Ornate Burrowing Frog

7.7 Wetland assessment

A group of small palustrine wetlands, located along a stretch of the Transport ML, were surveyed by ecologists and characterised as:

- topographical depressions forming ephemeral wetlands and waterbodies that fill irregularly following local rainfall and overland flow;
- trees are typically absent or sparse, with occasional Gutta-percha (*Excoecaria parvifolia*);
- shrubs are also spares and represented by scattered Currant Bush (*Carissa spinarum*) only; and
- the ground layer is dominated by Native Couch (*Brachyachne convergens*).

Cattle grazing was evident within the wetland areas. The availability of standing water, when present, thought to provide a source of drinking water, attracting cattle to the location.

Historic satellite image analysis shows the wetlands are rarely inundated in the dry season and only occasionally inundated in the wet season, following local rainfall. For example, the wetland that is partially located within the Transport ML was found to contain water in 1 in 25 dry seasons and 2 out of 9 wet seasons.

The ephemeral wetland features are not fed by any groundwater source or open bore drain.

Photo Plate 3: Circular depression wetland areas

7.8 Summary of Aquatic Values

The aquatic values of the study area have been described based on the combined results of the aquatic ecology assessment. Two features of aquatic ecology value were associated with the Project:

- The Saxby River located to the south of the Project mining area and intersected by the Transport ML; and
- A group of small ephemeral wetlands located along a section of the Transport ML.

The artificial bore drains located within the proposed mining areas provided no aquatic ecology value of significance.

The aquatic ecology assessment focussed on the ephemeral Saxby River ecosystem, which forms the foremost receiving environment for the Project, located approximately 2 km south of the mining area and intersected by the proposed Transport ML.

The Saxby River comprises a series of shallow braided channels, over a width of up to 2.5 km in proximity to the Project. The river system was assessed to be stable with only minor localised erosion recorded. Influences of existing agricultural land uses were present on site and in the data collected. Water quality in the Saxby River, collected from three sampling events, showed consistent elevation of some parameters including aluminium, chromium, copper, manganese and hydrocarbons when compared to the aquatic ecosystem objectives for slightly to moderately disturbed waters. These elevated parameters are assumed to be linked to natural mineralisation in the sub-soils of the area. Other potential contributing sources to water include grazing and agricultural land practices, in addition to contributions from uncapped groundwater bores, accessing underlying artesian waters and overtopping to land and waters via constructed bores drains.

Macroinvertebrate communities were representative of an ephemeral system with influences from agricultural land practices evident. The presence of freshwater fish, crustaceans and amphibians were also recorded, confirming suitable habitat in the Saxby River ecosystem. No species of conservation significance were recorded.

The group of small palustrine wetlands located along the southern extent of the access road are formed by topographical depressions that occasionally fill with water in response to local rainfall. The mapped wetlands represent a modified ecosystem dominated by common couch grasses, occasional shrubs and trees only. The location forms a natural watering hole for cattle. The wetlands hold water irregularly providing some limited aquatic value.

8 Potential impacts

The proposed Project will have potential to impact aquatic ecosystems over the construction, operation and decommissioning stages through the following:

- direct impacts to riverine and palustrine wetland ecosystems via land disturbance for roads;
- potential for the release of mine affected water or runoff containing sediments to the receiving waterway and associated impacts to ecosystem health;
- potential for spills and/or leaks from the mining equipment or activities causing contamination in the receiving waterways;
- erosion from cleared lands or mine infrastructure such as spoil dumps, resulting in increased sediment loads entering the aquatic ecosystems;
- potential for the introduction and spread of weed and pest species through increased people, vehicle and equipment movements;
- potential for the take of water from the Saxby River to reduce water flows in the downstream receiving environment, with flow on effects to aquatic values possible; and
- possible creation of fish barriers from the construction of access road or other infrastructure crossing of Saxby River.

Recommended strategies for the avoidance and mitigation of these potential impacts are presented in Section 9. The assessment of impacts which may constitute MNES or MSES is detailed in Section 10.

9 Mitigation and management strategies

Mitigation strategies are recommended to avoid and minimise risk of potential impacts to aquatic ecosystems, including the Saxby River and palustrine wetlands directly south of the Production ML. The following mitigation measures are recommended:

- sediment and erosion control structures be installed and maintained near all at risk areas to prevent sediment release to riverine areas and wetlands;
- release of Mine Affected Water only under controlled conditions, during existing flow events, and at a quality and quantity that will not compromise aquatic ecosystem values in the downstream receiving environment;
- fuel and hazardous liquids should be stored in a bunded facility, design and maintained in accordance with relevant Australian Standards;
- a Spill and Emergency Management plan should be implemented during construction and operation to minimise the risk of contaminant release to aquatic ecosystems;
- all water holding structures should be designed and managed in accordance with a water management plan prepared by a suitably qualified expert. The plan should include provision for regular inspection of all structures;
- a Receiving Environment Monitoring Program (REMP) should be implemented and should include monitoring of water, sediments, riparian / riverine vegetation health and biological indicators in aquatic environments including;
    - monitoring at a suitable suite of sites upstream and downstream in the Saxby River;
    - comparison to baseline water quality and reference sites in order to detect changes potentially linked to the proposed mining activity; and
    - monitoring of streamflow including at suitable gauging stations located on or near to the Project site; and
- Any take of water from the Saxby River should be in accordance with the conditions of a water licence or allocation under the Water Act 2000, thereby ensuring that any allocation does not exceed environmental or other flow objective for the system.

Recommended mitigations to impacts from stream crossing construction and impacts of barriers to fish passage at waterway crossings include:

- crossing design should provide for the fish passage during low and high flow events. This is expected to be achieved through the implementation of typical bed level and culvert crossing design prepared by TMM (2023), in accordance with Department of Transport and Main Roads recommendations for fish passage; and
- construction activities within watercourses or wetland areas should be undertaken during dry periods, to minimise erosion and sediment mobilisation, while also facilitating time to generate stability prior to wet season flows.

10 Offset Assessment

10.1 Impacts to Matters of State Environmental Significance (MSES)

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 QEOP Significant Residual Impact Guideline (DEHP 2014) is used to determine whether residual impacts are considered significant.

Prescribed environmental matters (MSES) are listed in Schedule 2 of the Environmental Offsets Regulation. One prescribed matter was mapped or identified within the Project area by the aquatic ecology survey:

- Fish habitat areas and waterways providing for fish passage (under the *Fisheries Act 1994*).

An assessment of the significance of impacts of the Project on Matters of State Environmental Significance is outlined in section 10.1.1 below.

10.1.1 Wetlands and watercourses

The Significant Residual Impact Guide (DEHP 2014) provides the significant impact criteria for impacts to MSES wetlands and watercourses. The significant impact criteria apply where an impact is likely to occur to:

- WPAs;
- HES wetlands; and
- high ecological value waters identified under the Environmental Protection (Water) Policy 2009, schedule 2.

No MSES wetlands or watercourses are present within the Production ML or potential Project impact area and no significant impact to MSES wetlands is likely to occur as a result of the Project.

10.1.2 Waterways providing fish passage

The Saxby River is mapped as being at major risk of adverse impact from waterway barrier works on fish movement (refer Section 4.2.3.1). The Project will require the construction of a low-level crossing of the Saxby River across several channels (mapped as major risk), where a set of culverts will result in low impact on flow events and fish passage. This river is an ephemeral waterway that does not flow for long stretches of the year, limiting the connectivity of waterways and wetlands near the Project. It is considered the Saxby River is likely to provide some fish passage for periods during which it sustains flow.

An assessment of the potential impacts to the Saxby River as a waterway providing fish passage according to the Significant Residual Impact Guide (DEHP 2014) is presented in Table 18.

When assessed against the MSES residual impact guidelines, the Project is considered unlikely to result in a significant residual impact on the waterways providing for fish passage. Based on the assessment, no offsets under the *Environmental Offset Regulation 2014* for waterways providing for fish passage are required for the Project.

Table 18: MSES Significant residual impact criteria for waterways providing for 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.	No, the Project will not result in the mortality or injury of fish. Construction of the access road will occur during dry period where flow in the Saxby River is not occurring. All waterway crossing over the Saxby River will be constructed to minimise or avoid impact on fish passage.
Result in conditions that substantially increase risks to the health, wellbeing and productivity of fish seeking passage such as through the depletion of fishes energy reserves, stranding, increased predation risks, entrapment or confined schooling behaviour in fish.	No, the Project is unlikely to result in the depletion of fishes' energy reserves, stranding fish, increase the risk of predation, entrapment or confined schooling behaviour in fish. The access road crossing has been designed to minimise changes to fish passage or river flow.
Reduce the extent, frequency or duration of fish passage previously found at a site.	No, the waterway crossing over the Saxby River has been designed and will be constructed to minimise or avoid impact on fish passage. The extent, duration and frequency of fish passage in the ephemeral river system is not expected to change.
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.	No, the Project will not substantially modify, destroy or fragment areas of fish habitat necessary for breeding and/or the survival of fish. The access road crossing has been designed to minimise changes to fish passage, habitat and river flow.
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.	No, the Project is unlikely to result in substantial and measurable changes in the hydrological regime of the waterways within and around the study area. The volume, depth, timing, duration and frequency of flows are anticipated continue to reflect the ephemeral and variable flow nature of the waterways around the study area. The access road crossing has been designed to minimise changes river flow.
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.	No, given the mitigation measures recommended in this report, the Project is unlikely to lead to a significant change in water quality within the Saxby River. Monitoring programs are proposed to ensure protection of aquatic values.

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Appendix A. Macroinvertebrate species results

Class/Order	Family/Sub-family	DS1	DS2	DS3	DS4	US1	US2	US3
Acarina	sp.	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.				1		2	
Bivalvia	Cyrenidae (fornerly Corbiculiidae)							
Bivalvia	Sphaeriidae							
Bivalvia	sp.							
Branchiura	sp.							
Bryozoa	sp.							
Cladocera	sp.	18				14		
Coleoptera	Microsporidae				1			4
Coleoptera	Carabidae							
Coleoptera	Haliplidae							
Coleoptera	Hygrobiidae							
Coleoptera	Noteridae							
Coleoptera	Dytiscidae	2				19		
Coleoptera	Gyrinidae				5		8	
Coleoptera	Hydrophilidae	1				3		
Coleoptera	Spercheidae (formerly within Hydrophillidae)						2	
Coleoptera	Georissidae (formerly within Hydrophillidae)							

Class/Order	Family/Sub-family	DS1	DS2	DS3	DS4	US1	US2	US3
Coleoptera	Hydraenidae		1					
Coleoptera	Staphylinidae							4
Coleoptera	Scirtidae							
Coleoptera	Elmidae							
Coleoptera	Limnichidae							
Coleoptera	Heteroceridae							
Coleoptera	Psephenidae							
Coleoptera	Ptilodactylidae							
Coleoptera	Chrysomelidae							
Coleoptera	Brentidae							
Coleoptera	Curculionidae							
Coleoptera	Hydrochidae							
Coleoptera	sp.							
Collembola	sp.							
Conchostraca	sp.	4						
Copepoda	sp.	6		3	3	4	34	29
Corophiidae	sp.			1				3
Crustacea	sp.							
Decapoda	Atyidae							
Decapoda	Palaemonidae							
Decapoda	Parastacidae			1				
Decapoda	Hymenosomatidae							
Decapoda	Gecarcinucidae (formerly Parathelphusidae and Sundathelphusidae)							
Decapoda	Grapsidae							
Decapoda	sp.							
Diplopoda	sp.							
Diptera	Tipulidae							
Diptera	Tanyderidae							
Diptera	Blephariceridae							
Diptera	Chaoboridae							
Diptera	Dixidae							

Class/Order	Family/Sub-family	DS1	DS2	DS3	DS4	US1	US2	US3
Diptera	Culicidae		1			22		
Diptera	Ceratopogonidae			2	16		7	16
Diptera	Simuliidae							2
Diptera	Thaumaleidae			2				
Diptera	Psychodidae							
Diptera	Pelecorhynchidae							
Diptera	Athericidae							
Diptera	Tabanidae							
Diptera	Stratiomyidae							
Diptera	Empididae							
Diptera	Dolichopodidae							
Diptera	Syrphidae							
Diptera	Sciomyzidae							
Diptera	Ephydridae							
Diptera	Muscidae							
Diptera	sp.							
Diptera	Aphroteniinae							
Diptera	Diamesinae							
Diptera	Podonominae							
Diptera	Tanypodinae	15	6					
Diptera	Orthocladiinae							11
Diptera	Chironominae	13	17			1		
Diptera	Cecidomyidae			10	1		6	7
Diptera	Scatopsidae							
Diptera	Sciaridae							
Ephemeroptera	Siphlonuridae							
Ephemeroptera	Baetidae							
Ephemeroptera	Oniscigastridae							
Ephemeroptera	Ameletopsidae							
Ephemeroptera	Coloburiscidae							
Ephemeroptera	Leptophlebiidae		1					
Ephemeroptera	Vietnamellidae (formerly Teloganodidae)							

Class/Order	Family/Sub-family	DS1	DS2	DS3	DS4	US1	US2	US3
Ephemeroptera	Caenidae		13					
Ephemeroptera	Prosopistomatidae							
Ephemeroptera	sp.							
Gastropoda	Viviparidae					1		
Gastropoda	Tateidae (formerly Hydrobiidae)				7		7	
Gastropoda	Bithyniidae					1		
Gastropoda	Thiaridae							
Gastropoda	Lymnaeidae							
Gastropoda	Ancylidae							
Gastropoda	Planorbidae							
Gastropoda	Physidae							
Gastropoda	sp.							
Gastropoda	Glacidorbidae							
Gastropoda	Pomatiopsidae							
Hemiptera	Mesoveliidae							
Hemiptera	Hebridae							
Hemiptera	Hydrometridae							
Hemiptera	Veliidae	4	4					
Hemiptera	Gerridae						2	
Hemiptera	Leptopodidae							
Hemiptera	Saldidae							
Hemiptera	Nepidae							
Hemiptera	Belostomatidae							
Hemiptera	Ochteridae							
Hemiptera	Gelastocoridae							1
Hemiptera	Corixidae							
Hemiptera	Micronectidae (split from Corixidae)	27	4			20		
Hemiptera	Naucoridae			3				3
Hemiptera	Notonectidae					15		
Hemiptera	Pleidae				1			
Hemiptera	sp.							
Hirudinea	Glossiphoniidae							

Class/Order	Family/Sub-family	DS1	DS2	DS3	DS4	US1	US2	US3
Hirudinea	Richardsonianidae							
Hirudinea	Ornithobdellidae							
Hirudinea	Erpobdellidae							
Hirudinea	sp.							
Hydrazoa	Hydridae							
Hydrazoa	Clavidae							
Hymenoptera	sp.							
Hyriidae	sp.							
Isopoda	Amphisopidae							
Isopoda	Mesamphisopidae							
Isopoda	Phreatoicopsidae							
Isopoda	Phreatoicidae							
Isopoda	Corallanidae (formerly Cirolanidae)							
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.							
Nematomorpha	Gordiidae				2		4	
Nematomorpha	sp.							
Nemertea	Tetrastemmatidae							
Nemertea	sp.							
Neritidae	sp.							
Neuroptera	Osmylidae							

Class/Order	Family/Sub-family	DS1	DS2	DS3	DS4	US1	US2	US3
Neuroptera	Neurorthidae							
Neuroptera	sp.							
Notostraca	sp.							
Odonata	Hemiphlebiidae				4		5	1
Odonata	Coenagrionidae		2			4		
Odonata	Isostictidae		2			1		
Odonata	Platycnemididae (formerly Protoneuridae)							
Odonata	Lestidae							
Odonata	Hypolestidae							
Odonata	Megapodagrionidae (also known as Argiolestidae)							
Odonata	Synlestidae							
Odonata	Lestoideidae (formerly Diphlebiidae)							
Odonata	Aeshnidae							
Odonata	Gomphidae							
Odonata	Corduliidae	3	4			1		
Odonata	Libellulidae	4				1		
Odonata	Chorismagrionidae							
Odonata	Telephlebiidae							
Odonata	Lindeniidae							
Odonata	Synthemistidae							
Odonata	Gomphomacromiidae							
Odonata	Macromiidae							
Odonata	Austrocorduliidae							
Odonata	Cordulephyidae							
Odonata	Hemicorduliidae							
Odonata	Urothemistidae							
Odonata	Zygoptera							
Odonata	Epiproctophora							
Odonata	sp.							
Oligochaeta	sp.					2		
Ostracoda	sp.		8			7		1

Class/Order	Family/Sub-family	DS1	DS2	DS3	DS4	US1	US2	US3
Ozobranchidae	sp.			1			4	
Petaluridae	sp.							
Plecoptera	Eustheniidae							
Plecoptera	Gripopterygidae							
Plecoptera	Notonemouridae							
Plecoptera	sp.							
Polychaeta	sp.							
Porifera	Spongillidae							
Porifera	sp.							
Pyralidae	sp.							
Rotifera	sp.							
Sisyridae	sp.							
Syncarida	Koonungidae							
Tardigrada	sp.							
Telmatogetoninae	sp.							
Trichoptera	Hydrobiosidae							
Trichoptera	Glossosomatidae							
Trichoptera	Hydroptilidae							
Trichoptera	Philopotamidae							
Trichoptera	Hydropsychidae		2					
Trichoptera	Polycentropodidae							
Trichoptera	Ecnomidae							
Trichoptera	Psychomyiidae							
Trichoptera	Limnephilidae							
Trichoptera	Oeconesidae							
Trichoptera	Tasimiidae							
Trichoptera	Conoesucidae							
Trichoptera	Antipodoeciidae							
Trichoptera	Helicopsychidae							
Trichoptera	Calocidae							
Trichoptera	Helicophidae							
Trichoptera	Kokiriidae							

Class/Order	Family/Sub-family	DS1	DS2	DS3	DS4	US1	US2	US3
Trichoptera	Philorheithridae							
Trichoptera	Odontoceridae							
Trichoptera	Atriplectididae							
Trichoptera	Calamoceratidae							
Trichoptera	Leptoceridae	6	1					
Trichoptera	Dipseudopsidae							
Trichoptera	sp.							
Turbellaria	Temnocephalidae							
Turbellaria	Dugesiidae							
Turbellaria	sp.							
Unidentified	sp.							

Appendix B. Laboratory analysis soil and water

Appendix C. Site descriptions

Photographs	Site Description
Site DS1  	Site DS1 was located on the Saxby River downstream of the Project area. The Saxby River is identified as a watercourse under the Water Act. During the February survey, this site was characterised by small pools of standing water with a damp waterlogged stream bed where pools were absent. The stream bed comprised of fine silts and clay. The bank was moderately stable and, in some sections, absent, comprising of small flat flood plain zones. Surrounding land use is grazing. Overall, DS1 scored 'fair' in the Habitat Bioassessment.

Photographs	Site Description
Site DS2  	Site DS2 was located on the Saxby River downstream of the Project area. The Saxby River is identified as a watercourse under the Water Act. During the February survey, this site was characterised by a slow moving watercourse of opaque water on a sandy stream bed. The stream bed comprised of mostly sand with some fine silt. The bank was stable and heavily vegetated with grasses and large riparian tree species. Surrounding land use is grazing. Overall, DS2 scored ‘good’ in the Habitat Bioassessment.

<table>
<tr><th>Photographs</th><th>Site Description</th></tr>
<tr><td>Site DS3

</td><td>Site DS3 is located on the Saxby River downstream of the Project area. The Saxby River is identified as a watercourse under the Water Act. During the May survey, this site was characterised by a long pool of highly turbid water.

The stream bed comprised of fine silts, sand and gravel. The bank was somewhat stable with cattle access surrounding the sample location causing some erosion.

Surrounding land use is grazing.</td></tr>
</table>

<table>
<tr><th>Photographs</th><th>Site Description</th></tr>
<tr><td>Site DS4

</td><td>Site DS4 was located on the Saxby River downstream of the Project area. The Saxby River is identified as a watercourse under the Water Act. During the May survey, this site was characterised by a deep and wide channel of flowing turbid water.

The stream bed comprised of fine silts and sand. The bank was somewhat stable with cattle access surrounding the sample location causing some erosion. The banks were lightly vegetated though overall bare.

Surrounding land use is grazing.</td></tr>
</table>

Photographs	Site Description
Site US1  	Site US1 was located on the Saxby River upstream of the Project area. The Saxby River is identified as a watercourse under the Water Act. During the February survey, this site was characterised by a large standing pool of highly turbid water with several fallen logs and branch debris. The stream bed comprised of fine silts, sand and clay. The bank was somewhat stable with cattle access and an access road upstream of the sample location causing some erosion. Surrounding land use is grazing. Overall, US1 scored 'good' in the Habitat Bioassessment.

Photographs	Site Description
Site US2  	Site US2 was located on the Saxby River upstream of the Project area. The Saxby River is identified as a watercourse under the Water Act. During the May survey, this site was characterised by a wide pool of opaque to clear standing water. The stream bed comprised of fine silts and sand. The bank was stable with cattle access surrounding the sample location causing some erosion. The banks were vegetated with grasses and riparian shrubs and trees. Surrounding land use is grazing.

<table>
<tr><th>Photographs</th><th>Site Description</th></tr>
<tr><td>Site US3

</td><td>Site US3 was located on the Saxby River upstream of the Project area. The Saxby River is identified as a watercourse under the Water Act. During the May survey, this site was characterised by a shallow standing pool of highly turbid water.

The stream bed comprised of fine silts, sand and gravel. The bank was level to the ground at many points and somewhat stable with cattle access surrounding the sample location causing some erosion.

Surrounding land use is grazing.</td></tr>
</table>