Vecco Group

Surface Water Assessment

Vecco Critical Minerals Project

23 October 2023

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0	27/06/2023	Client Issue	Aaron Baldwin	Andrew Vitale	Aaron Baldwin	Samantha Breslin
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Signatures						

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1 INTRODUCTION

This document has been prepared for Vecco Industrial Pty Ltd ACN 158 805 497 (Vecco), to support the application for an Environmental Authority for the Vecco Critical Minerals Project (the Project). This report summarises the assessment of surface water interactions and potential impacts associated with the proposed mining activity to support an application for an Environmental Authority for the Project.

1.1 BACKGROUND

The Vecco Critical Minerals Project (Project) is being developed to meet the growing demand for vanadium, High Purity Alumina (HPA) and Rare Earth Elements (REE).

Vanadium is recognised as a 'critical mineral' by both the Queensland Government and the Commonwealth Government. In addition to its traditional uses, vanadium is used in the manufacture of vanadium redox flow batteries, which will be critical to the development of renewable energy generation and the global shift to decarbonisation. These large-scale batteries can store energy from solar panels and wind turbines to use at night-time or when the wind is not blowing. Vanadium does not degrade over a 25-year battery life making it a truly green energy storage solution and part of the circular economy. As a result, vanadium demand is growing rapidly. Queensland's vanadium deposits, including the Debella deposit that is planned to be mined through the Project, offering an in-demand product in the decarbonising movement.

HPA and REE are also recognised as 'critical minerals' by both the Queensland Government and the Commonwealth Government. Their uses include batteries and other renewable energy technology, such as wind turbines and solar panels.

The development of these resources in Queensland provides a unique regional employment opportunity with significant economic benefits for local communities such as Julia Creek and Townsville. The Project will also provide significant benefits to the State, in respect of both royalties payable and contributions toward Queensland's renewable energy target. In addition to supporting local demand, the Project will contribute to Queensland's growing vanadium export industry.

1.2 PROPONENT

The proponent of the Vecco Critical Minerals Project (Project) is Vecco Industrial Pty Ltd ACN 158 805 497 (Vecco), a wholly owned subsidiary of Vecco Group Pty Ltd ACN 162 084 424.

Vecco is a private Australian based company developing local vanadium, HPA and REE resources and manufacturing downstream products, such as vanadium electrolyte, for use in batteries and renewable energy generation. Vecco is currently developing Australia's first vanadium electrolyte manufacturing facility in Townsville which will integrate with the production of vanadium from the Vecco Critical Minerals Project to provide a secure supply chain for batteries in Australia.

The Executive Team and Board of Vecco Group have over 100 years' experience in the development and operation of mining assets in Queensland.

1.3 LOCATION

The Project is located approximately 70 km north of Julia Creek township and approximately 515 km west of Townsville in north-west Queensland (refer Figure 1.1:). The townships of Cloncurry and Richmond are located approximately 125 km west and 145 km east of the Project, respectively.

The land within and surrounding the Project area is designated as 'Rural' zone under the McKinlay Shire Planning Scheme 2019. Existing land use of the project area is low intensity cattle grazing.

The Project will comprise three mining lease applications (MLA) including:

- The main Production Mining Lease (ML) - Contains the mine pit and mine infrastructure area to the north of the Saxby River.

- A Transport Mining Lease (ML) - Runs from Punchbowl Road to the Production ML, over the Saxby River.
- An Infrastructure Mining Lease (ML) - Contains pump infrastructure along the access road, to the north of the Saxby River.

The location of the project is shown in Figure 1.3.

1.4 PROJECT DESCRIPTION

Vecco is seeking to develop the Project to mine and process the world class Debella vanadium deposit. The Project will primarily target vanadium pentoxide (V2O5) and HPA, with minor quantities of other REEs also produced. The life of mine (LOM) is expected to be approximately 36 years, including construction, operation, and rehabilitation.

A conceptual Project layout is provided in Figure 1.2. The Project is a proposed greenfield operation that will consist of a shallow, open-cut mine that will process up to 1.9 Mtpa ROM feed to produce up to approximately 5,500tpa V2O5 and 4,000tpa HPA over an operational life of approximately 26 years. Minor quantities of other REE may present opportunities for saleable bi-products of the process. Ore will be mined to an approximate depth of up to 35m. Processing will occur following on site crushing and screening of the ore. Mineral products will be packed in containers and transported by truck or rail to Townsville, for secondary processing into battery electrolyte or export from the Port of Townsville to international markets.

Key components of the Project include:

- Open cut mining of up to 1.9 Mtpa ROM ore over a period of approximately 26 years.
- 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 mine areas (open cut pits) and out-of-pit waste rock emplacements. This includes vegetation and soil stripping.
- Development of out-of-pit waste rock emplacements.
- 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.

Existing regional infrastructure, facilities and services may be used to support Project activities. These include the Townsville Port, the rail networks, electricity networks, local roads and the Flinders Highway.

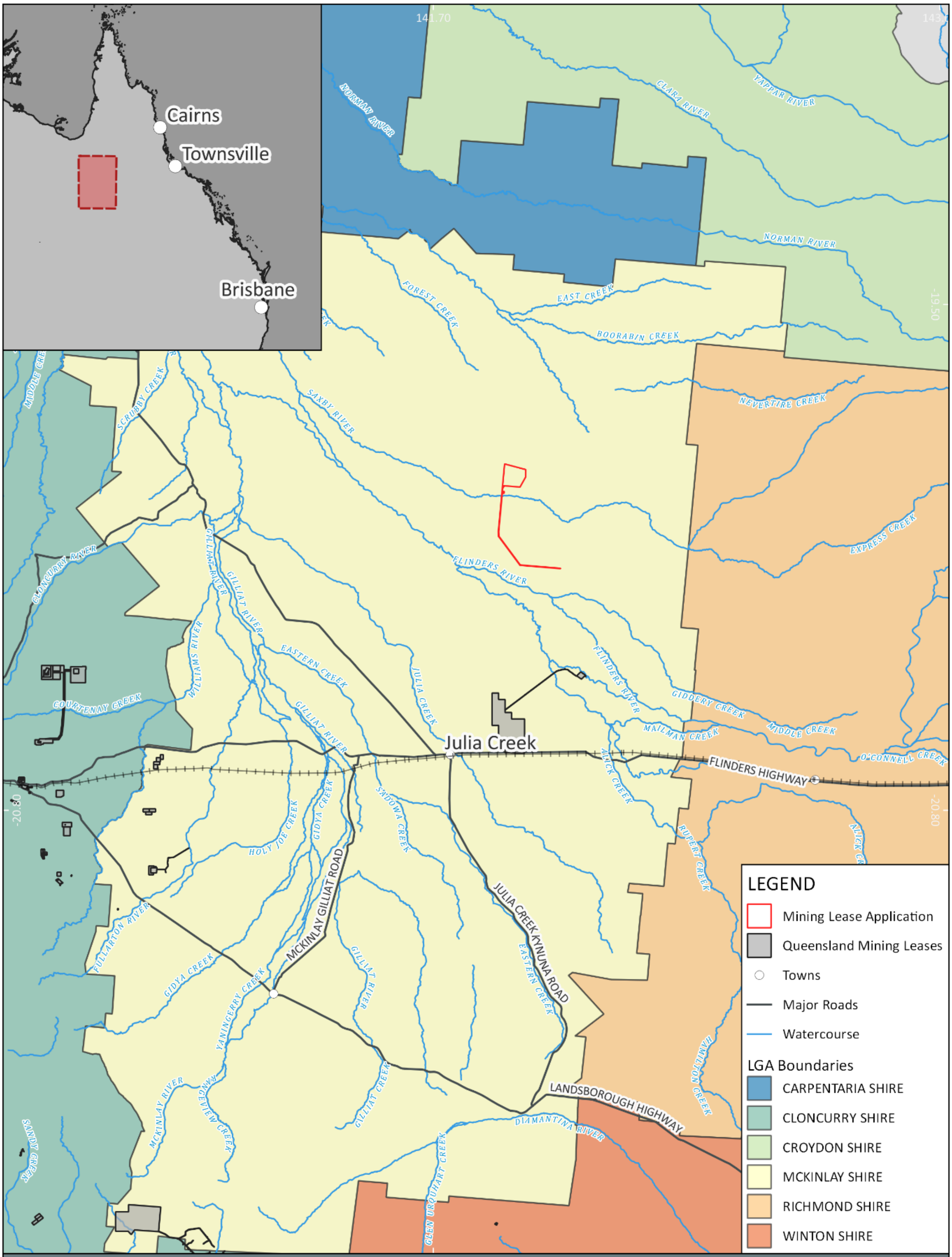
1.5 PROJECT BENEFITS

Localised and regional benefits of the Project come in the form of increased employment, development of services, patronage of local businesses and increased property prices. These will occur from the construction phase through to the end of mine and rehabilitation phase.

The Queensland government has recognised the important role of vanadium in supporting the government's plan in making Queensland a leading producer and exporter of diversified minerals by building a new common user vanadium demonstration facility in Townsville. The facility will provide smaller Projects with the opportunity to trial extraction and production processes, reducing costs to smaller companies and support the local economy through jobs and investment opportunities (DSDILGP, 2022).

Investment in renewable energy and energy storage technologies is required for the Queensland Government to achieve its renewable energy target of 70% by 2032, and 80% by 2035. To assist this, available energy storage batteries will be required to store excess energy during low demand and maximise energy reserves during peak demand. Vanadium redox flow batteries offer the industry a long term, cost effective, energy storage alternative to Lithium batteries (DSDILGP, 2022). Vanadium redox flow batteries have a life of at least 20 years, can be attached to an existing energy network and can store energy generated from solar and wind energy sources (DSDILGP, 2022). Vanadium redox flow batteries have a minimal environmental footprint and reduce waste (due to their long lifespan) which contributes to the circular economy (DSDILGP, 2022). The Project will offer a local source of vanadium and HPA (with Vecco Group also establishing a manufacturing facility in Townsville to produce vanadium battery electrolyte) to help meet both the domestic and global renewable energy market requirements.

The Australian Government has identified the importance of growth in the exploration, manufacturing, and mining of critical minerals, including vanadium in the “2022 Critical Minerals Strategy” (DISEP, 2022). Australia has the 2nd largest recoverable vanadium resource in the world and has been identified by the Australian Government as a priority critical mineral (DISEP, 2022). There is an increasing global demand for vanadium in the production of industrial-sized batteries for the storage of renewable energy and the advancements of technologies such as electric cars in the renewable energy sector (DISEP, 2022). The Project will support a stable supply of critical minerals, support supply chains, grow our capability in the critical mineral sector, export higher value-added products with battery electrolyte and support economic growth in regional communities.



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

arc ENVIRONMENTAL SOLUTIONS

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Figure 1.1: Project Locality

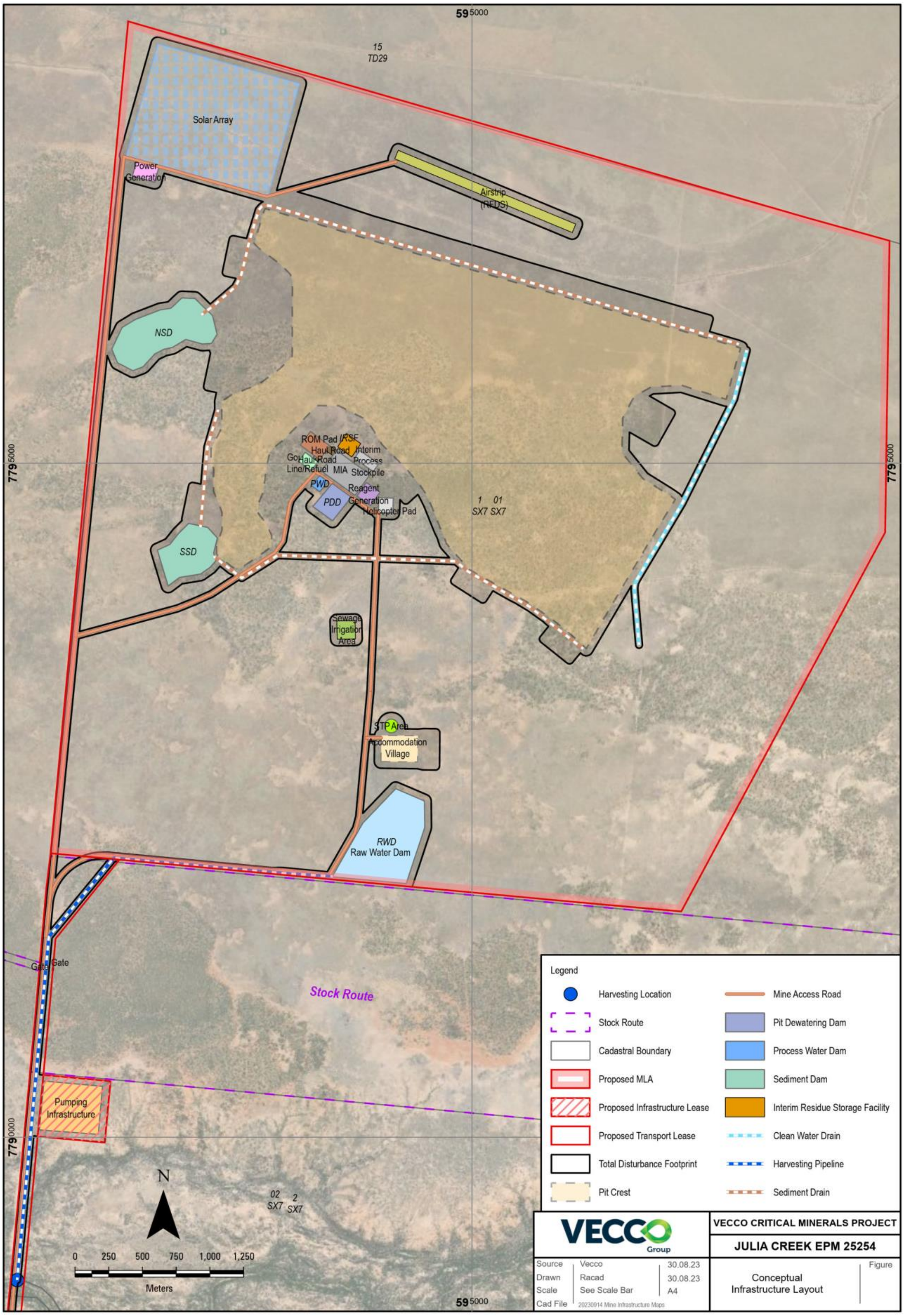
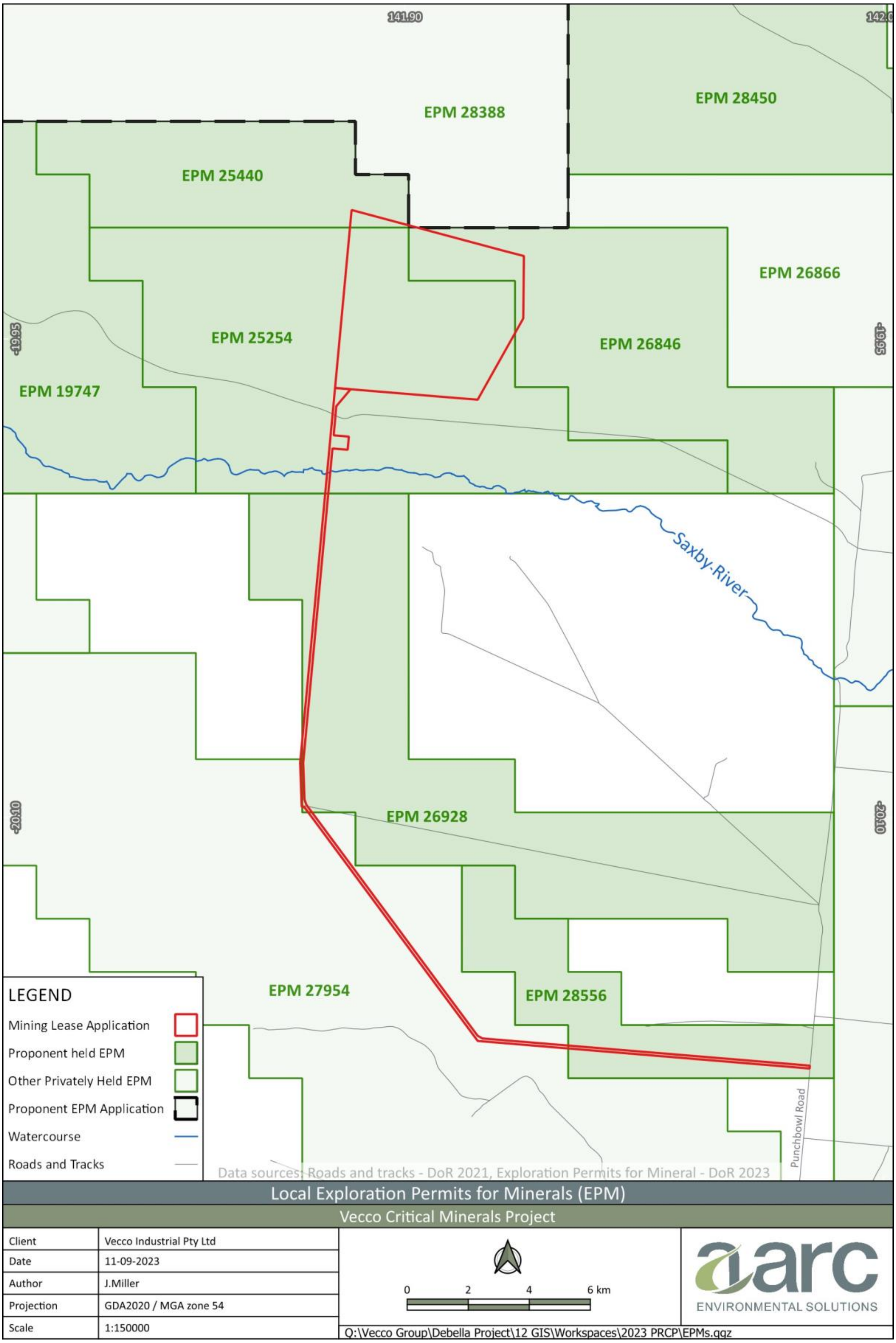


Figure 1.2: Proposed Project Conceptual Layout



Data sources: Roads and tracks - DoR 2021, Exploration Permits for Mineral - DoR 2023

Local Exploration Permits for Minerals (EPM)

Vecco Critical Minerals Project

Client	Vecco Industrial Pty Ltd
Date	11-09-2023
Author	J.Miller
Projection	GDA2020 / MGA zone 54
Scale	1:150000

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Figure 1.3: Local Exploration Permits for Minerals (EPM)

2 RECEIVING ENVIRONMENT

2.1 CATCHMENT OVERVIEW

2.1.1 Regional Catchment

The Project is located in Northern Queensland within the Flinders River Catchment area (Catchment E of Water Plan (Gulf) 2007), which drains north to the Gulf of Carpentaria (see Figure 2.1). The Flinders Basin has a total catchment of 109,516 km^2 with the main rivers being the Saxby River, Flinders River and Cloncurry River. The Flinders River discharges into the Gulf of Carpentaria, west of Normanton. The Flinders Basin catchment and its sub-catchments are presented in Figure 2.2.

2.1.2 Local Catchment/s

The Project is located on the northern banks of the Saxby River, around 70 km to the north of the Julia Creek township (Figure 2.1). The Saxby River is one of the major tributaries to the Flinders River. The Saxby River sub-basin total catchment area is 10,147 km^2 and makes up 9.2% of the Flinders Basin catchment. The Saxby River headwaters are within the western reaches of the Einasleigh Uplands bioregion and the river flows typically in a north-west direction. Approximately 225 km downstream of the Project, the Saxby River joins the Flinders River, however there is some convergence of the Saxby and Flinders Rivers when in flood around 60 km downstream of the proposed site.

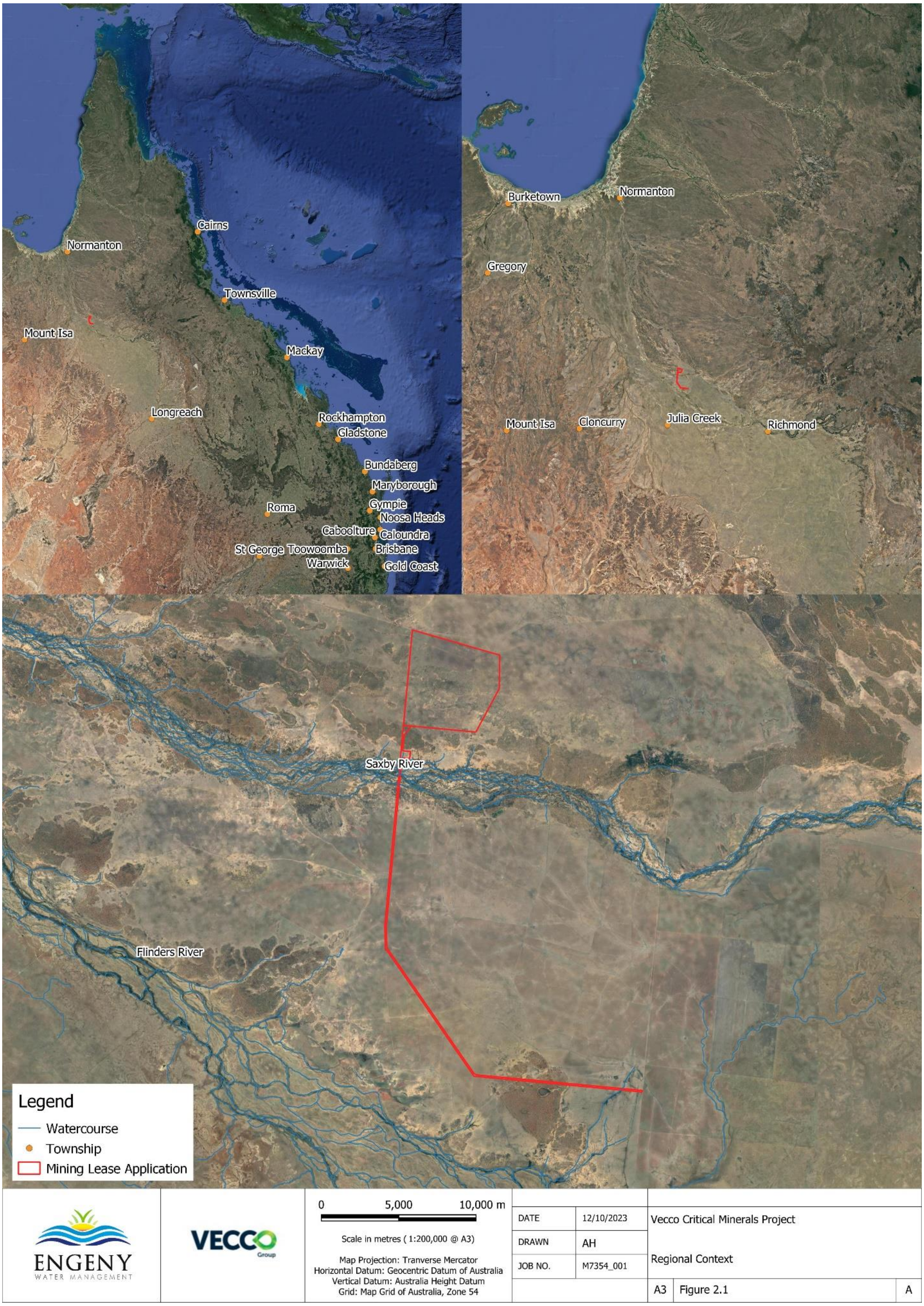


Figure 2.1: Regional Context

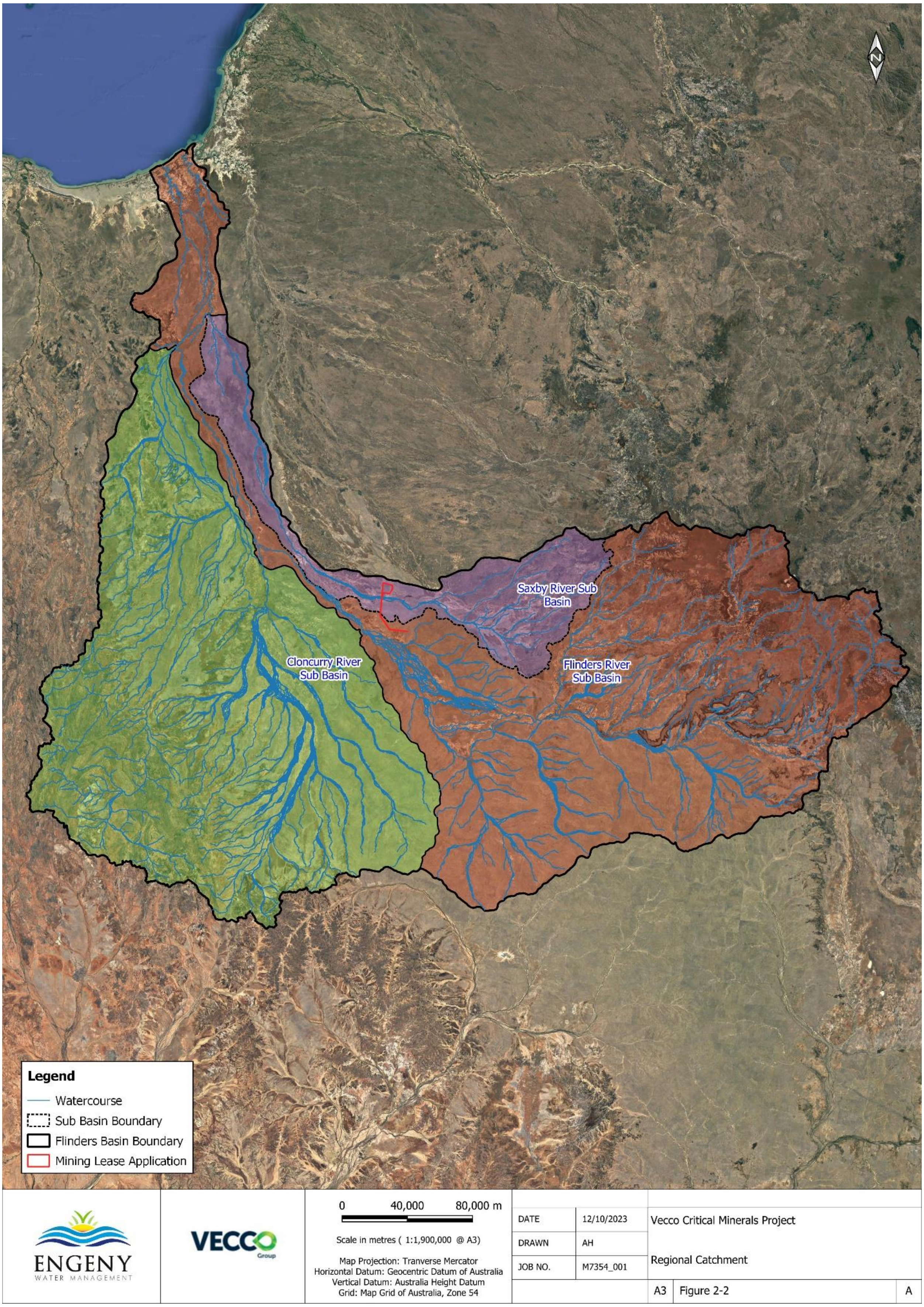


Figure 2.2: Regional Catchments

2.2 CLIMATE

The regional climate of the area can be described as sub-tropical with wet season dominated rainfall and mild, dry winter months. Rainfall is highly seasonal and is typically associated with monsoonal, thunderstorm and cyclone weather patterns.

A long-term representative historical rainfall data set for the surface water assessment was developed from nearby recorded data from Bureau of Meteorology (the Bureau) rainfall gauging stations and infilled with SILO Data Drill when gauged data was unavailable. Monthly pan evaporation data was adopted from the SILO data drill at the location of the Project (DES, 2022). The SILO data drill is a derived data set from a combination of interpolated recorded data between weather stations and derived long-term average values.

A summary of rainfall gauges operated by the Bureau near the Project with significant rainfall records is provided in Table 2.1: . Typical rainfall and evaporation rates for the site are presented in Figure 2.3: and Figure 2.4.

Due to poor distribution of evaporation monitoring stations near the Project, the interpolated evaporation data at the location of the Project may be inaccurate. Therefore, the long-term pan evaporation derived from the SILO data drill has been compared against the average monthly recorded data from the station at Julia Creek Post Office (29025) (nearest station available) to validate the SILO data. The long-term average data from the SILO data drill matches well with the data recorded at the Julia Creek Post Office from the period 1970 to 2022.

Table 2.1: Nearby Rainfall Gauging Stations

Source	Proximity to Site	Data Range
Zonia Downs (029051)	7 km	1924-2017
Crowfels Station (029011)	25 km	1916-2020
Bunda Bunda (029005)	34 km	1889-2022
Millungera Station (029036)	37 km	1890-2022
Manfred Downs (029132)	53 km	1887-2022

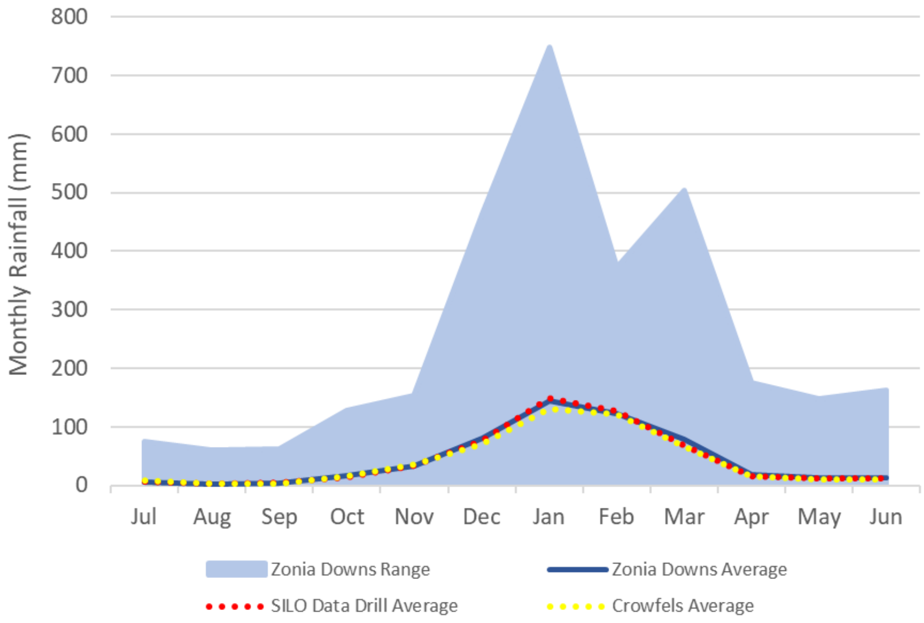


Figure 2.3: Monthly Rainfall (Range and Mean)

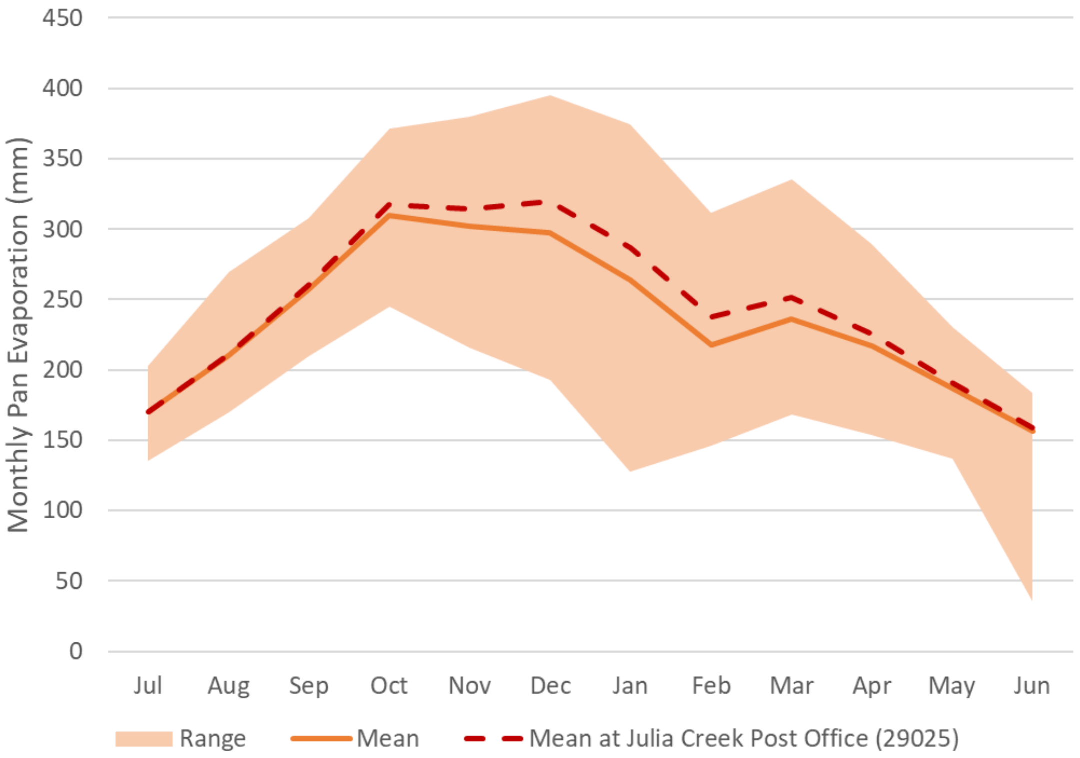


Figure 2.4: Monthly Evaporation (Range and Mean)

2.3 EXISTING WATERWAYS

The Project is located adjacent to the Saxby River floodplain. The Saxby River is a tributary of the Flinders River and flows into the Flinders main branch around 220 km downstream of the site; however, there is some interaction between the Saxby River and Flinders River floodplains around 55 km downstream of the Project.

There are no major waterways (i.e., defined as a watercourse under the Water Act 2000) or unnamed waterways that traverse or intersect the Projects Production ML. The Transport Lease crosses the Saxby River to the south of the Production ML.

2.3.1 Saxby River

The Saxby River is defined as a watercourse under the Water Act 2000 and is the largest watercourse in the vicinity of the Project with a catchment of approximately 5,700 km^2 adjacent to the Project site.

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). Since records began in 2014, the Saxby River at Punchbowl Road streamflow gauging 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 influenced by the prolonged intense flood event in early February 2019 caused by a near-stationary monsoonal trough.

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 Projects 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 flowing from the Saxby River into the Flinders River during significant floods.

The closest channel of the Saxby River lies approximately 900 m south of the Projects Production ML. The Saxby River's proximity to the Production ML is shown in Figure 2.1.

2.3.2 Flinders River

As the longest river in Queensland, the Flinders River is defined as a watercourse under the Water Act 2000 and 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 helps 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 Richmond streamflow gauge (Station Number 915008A) in comparison with a dry season baseflow volume of 0.1 GL at the Cloncurry River at Damsite streamflow gauge (Station Number 915204A), which is a similar distance inland in the adjacent sub catchment.

2.3.3 Unnamed Waterways

There are no unnamed waterways within the Projects Production ML boundary.

2.3.4 Streamflow Monitoring

There are a number of streamflow gauging stations operated by the Department of Regional Development, Manufacturing and Water (DRDMW) located within 100 km of the Project on the Saxby, Flinders and Cloncurry Rivers. These stations are summarised in Table 2.2 and Figure 2.6.

The nearest flow gauges are Saxby River at Punchbowl Road (915017A) upstream of the Project and Flinders River at Etta Plains (915012A) downstream of the Project. The Saxby River at Punchbowl Road (915017A) streamflow gauging station is the only gauge (current or historical) available for the Saxby River. The Saxby River at Punchbowl Road gauge is located 18 km upstream of the Project and started operation in 2014, having recorded 8 years of data. Flow duration curves for gauging stations 915017A, 915012A and 915016A from 2014 to present are shown on Figure 2.6.

Table 2.2: Streamflow Gauges within 100 km of the Project

Station	Proximity to Site	Catchment Area	Data Range
915017A Saxby River at Punchbowl Road (U/S)	18 km east	5,624 km^2	2014-Present (8 years)
915012A Flinders River at Etta Plains (D/S)	70 km west	46,131 km^2	1972-Present (50 years)
915016A Flinders River at Punchbowl (U/S)	55 km south	29,690 km^2	2014-Present (8 years)
915213A Gilliat River at Will Developmental Road	81 km west	14,200 km^2	2014-Present (8 years)
915208A Julia Creek at Julia Creek	81 km south	1,353 km^2	1970-Present (52 years)

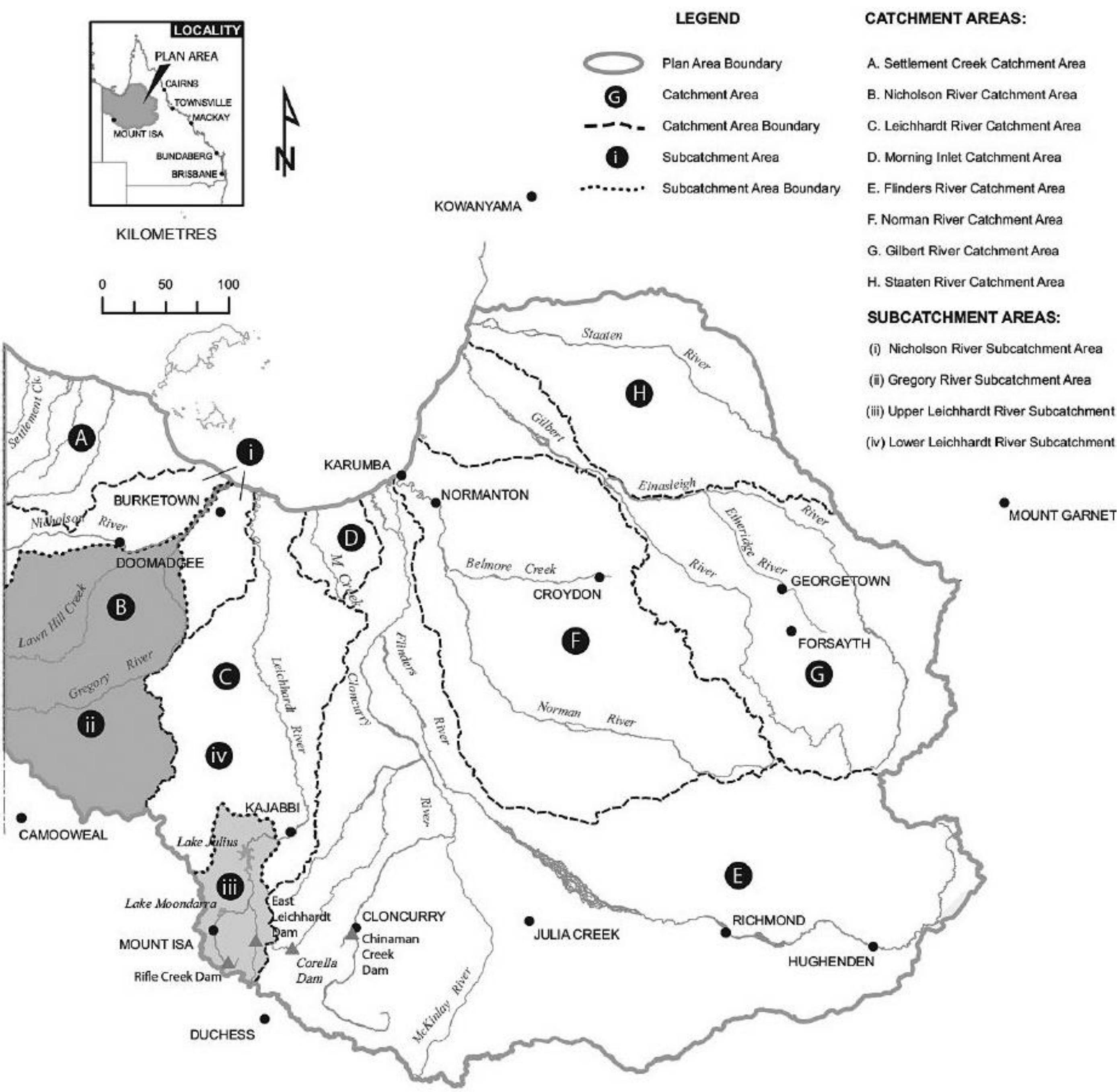


Figure 2.5: Flinders River Basin, within the greater Gulf drainage region (Water Plan (Gulf) 2007)

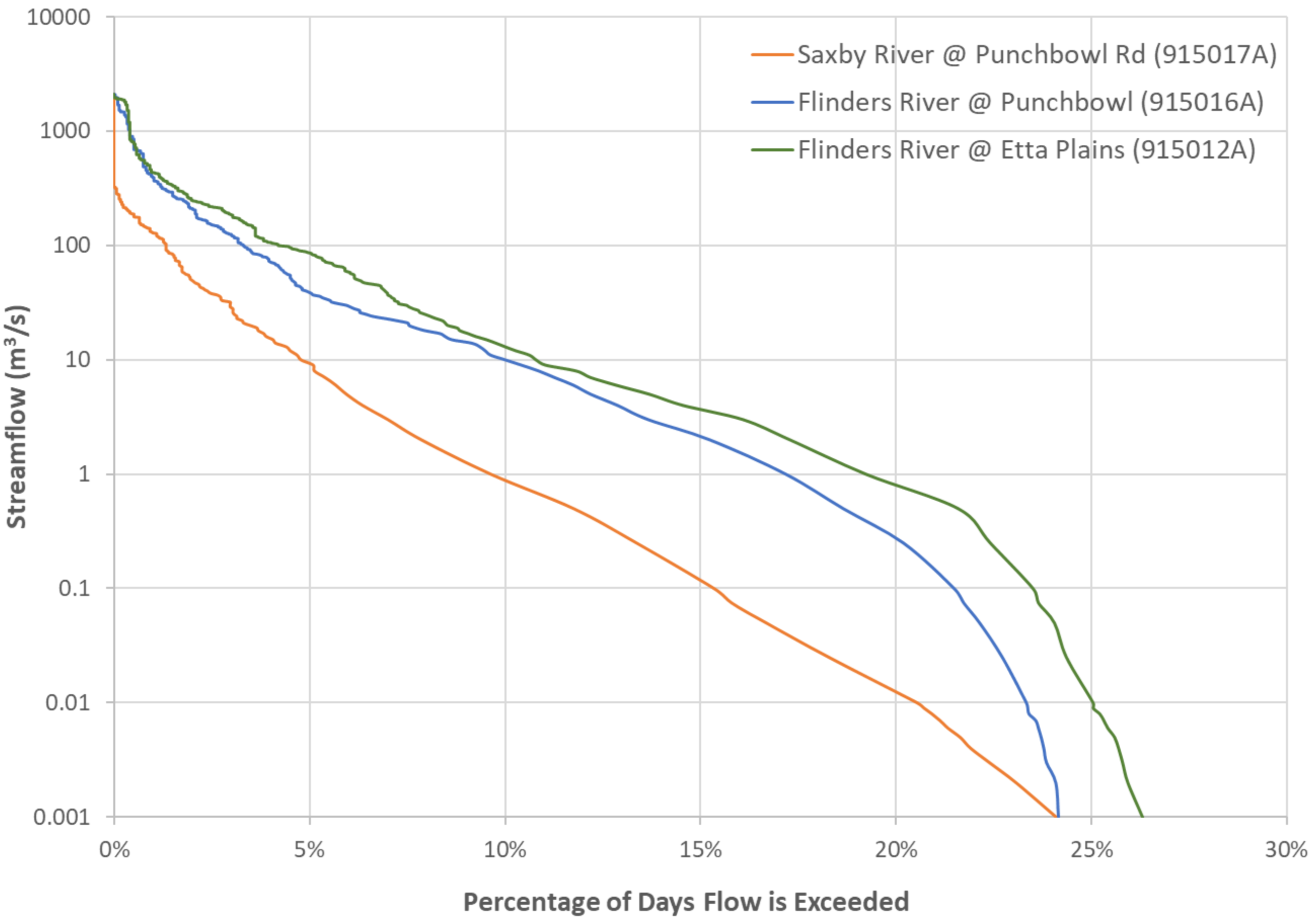


Figure 2.6: Flow Duration Curves for Streamflow Gauges 915017A, 915016A & 915012A

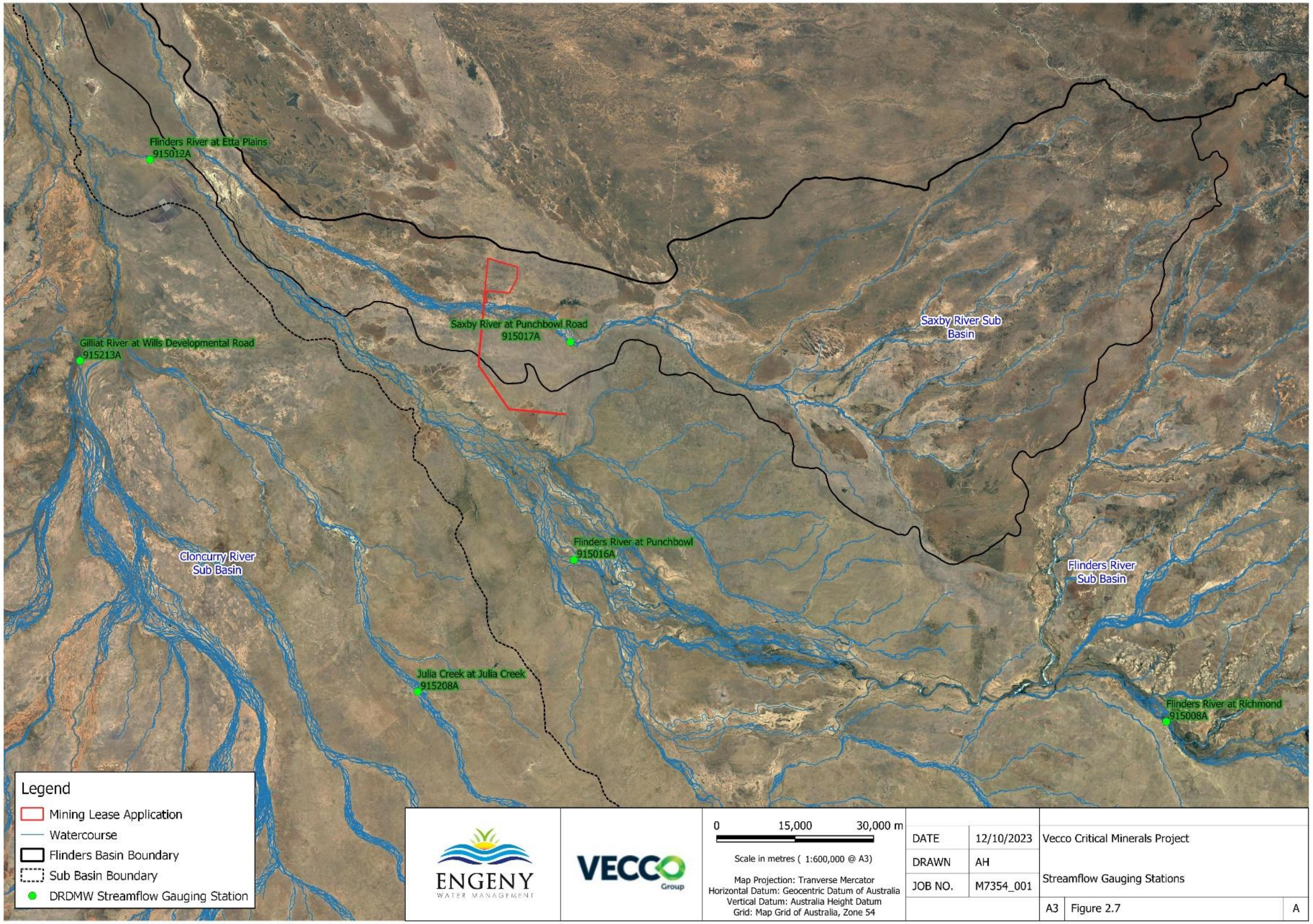


Figure 2.7: Streamflow Gauging Stations

2.4 SURFACE WATER QUALITY

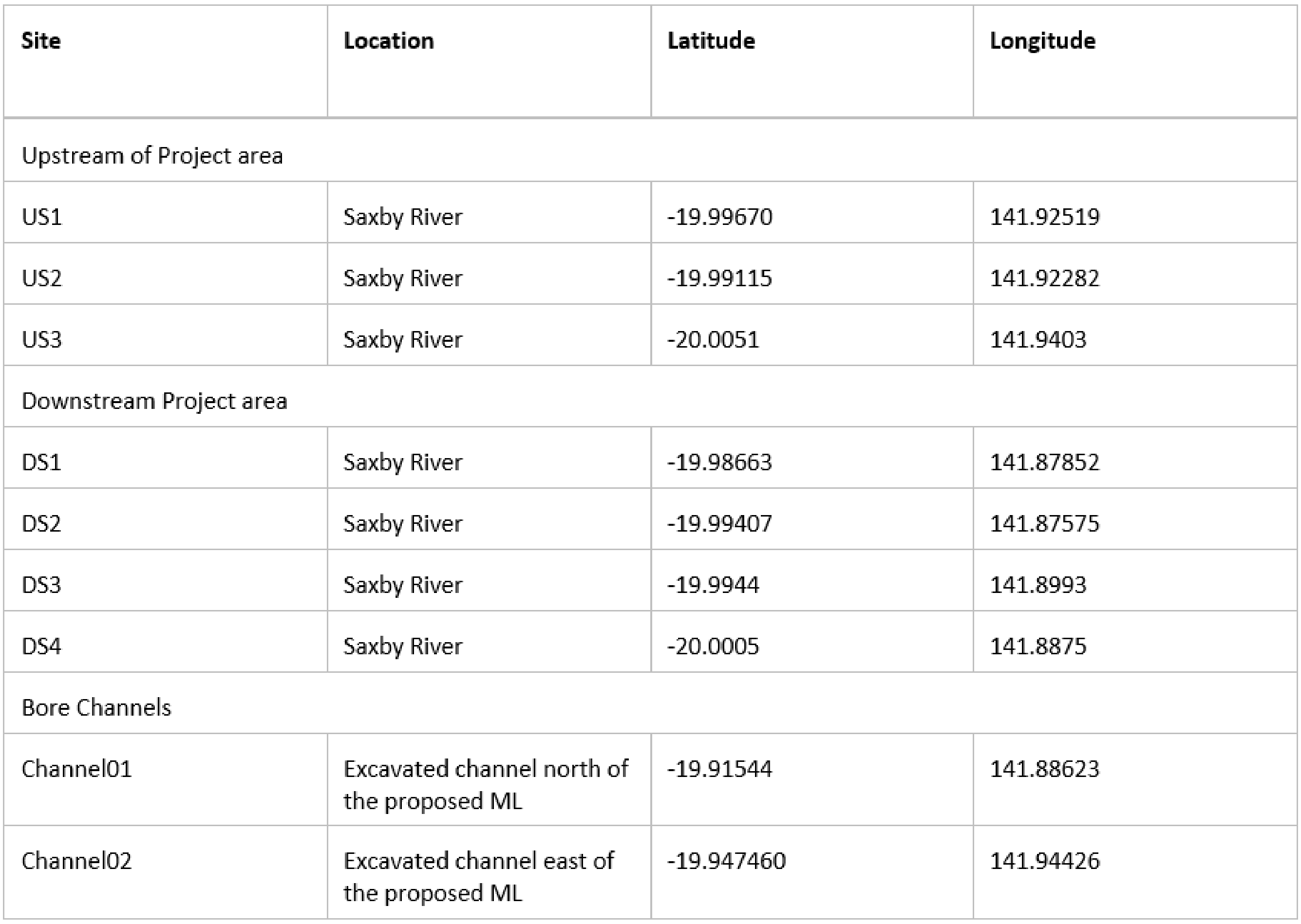
Baseline surface water quality monitoring was undertaken as part of the aquatic ecology assessment for the Project (AARC, 2023) and included seven aquatic survey sites on the Saxby River adjacent to the Projects Production ML area and two additional sites on excavated bore channels near the Projects Production ML boundary. The locations of the surface water quality monitoring sites are detailed in Table 2.3 and Figure 2.8.

Surface water quality monitoring was only performed for three monitoring events in February 2022, May 2022 and March 2023. The water quality monitoring results are summarised in Table 2.4 (dissolved metals), Table 2.5 (total metals), Table 2.6 (physio-chemical parameters) and Table 2.7 (petroleum hydrocarbons).

The surface water quality data was compared to ANZECC (2020) Water Quality Objectives (WQOs) in the Aquatic Ecology Assessment report (AARC, 2023). 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 2.3: Surface Water Quality Monitoring Locations (AARC, 2023)



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

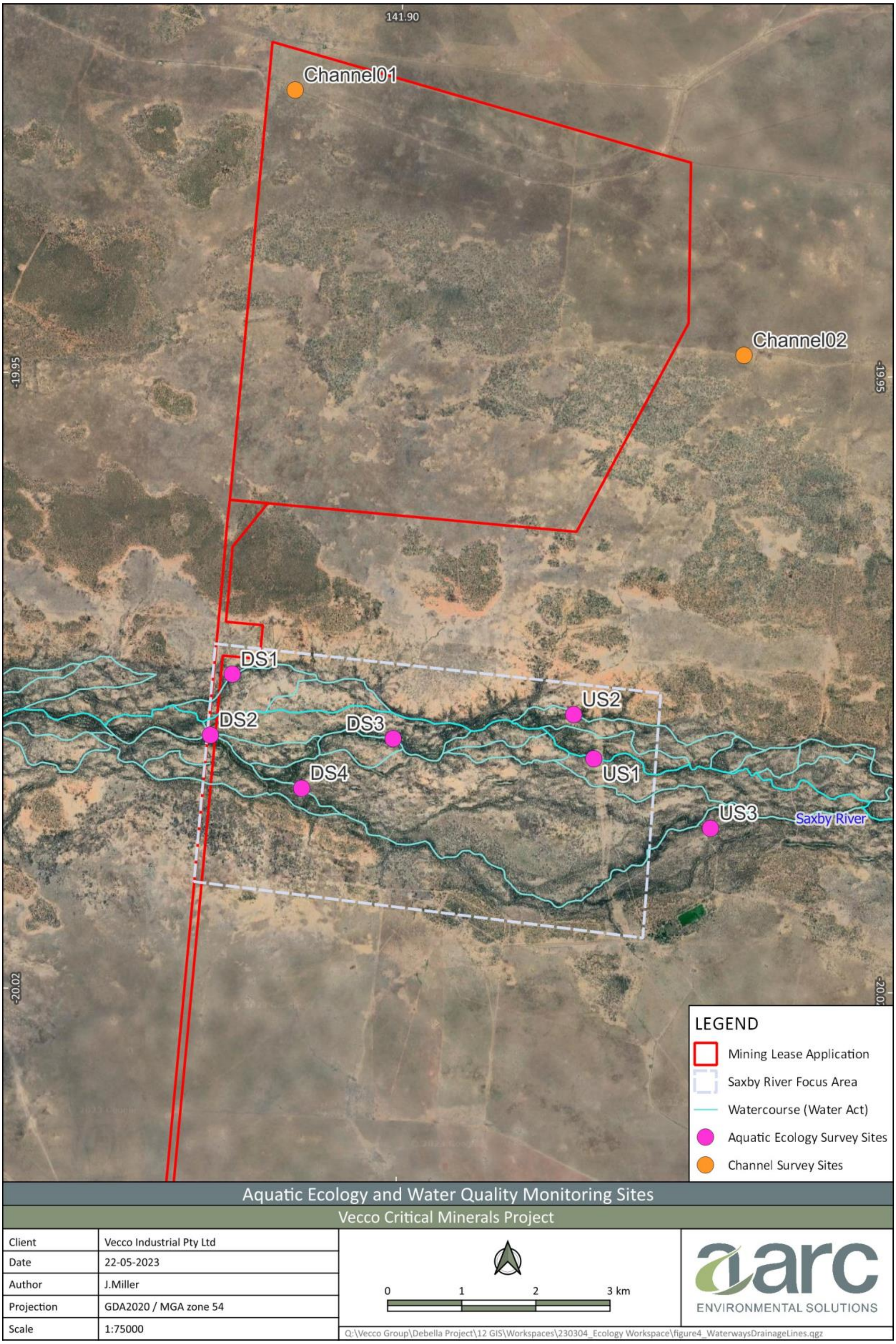


Figure 2.8: Surface Water Quality Monitoring Locations (AARC, 2023)

Table 2.4: Surface Water Quality Monitoring Results – Dissolved Metals (AARC, 2023)

Parameter	**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	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	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	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	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	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	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	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	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	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	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

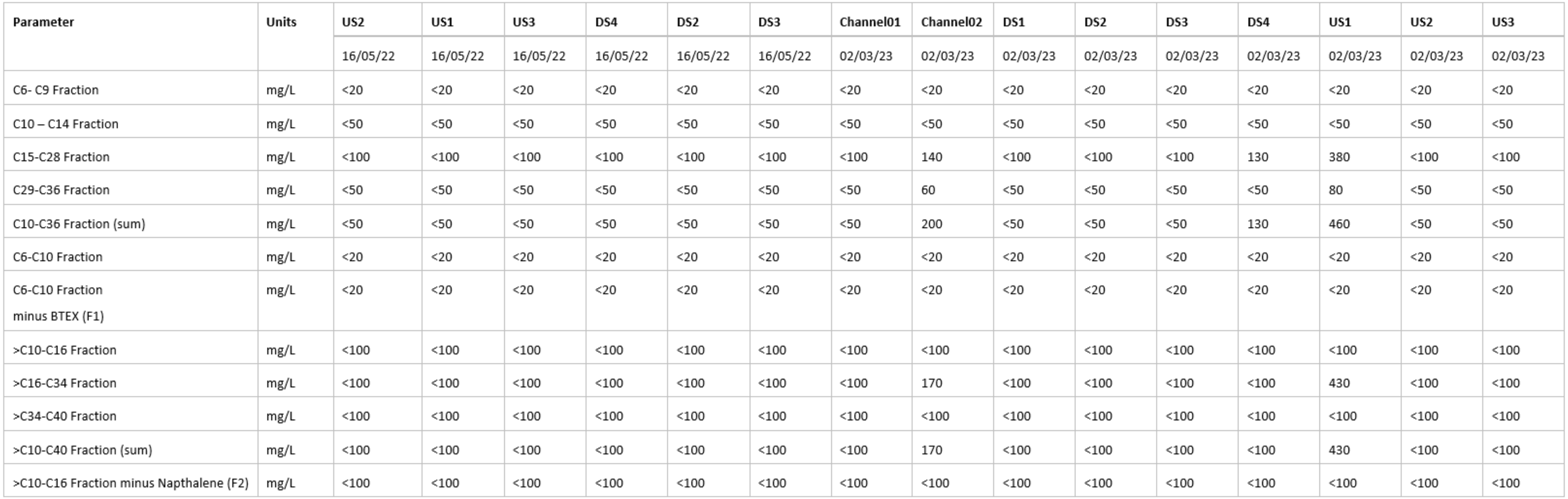
Table 2.5: Surface Water Quality Monitoring Results – Total Metals (AARC, 2023)

Parameter	**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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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

Table 2.6: Surface Water Quality Monitoring Results – Physio-Chemical Parameters (AARC, 2023)

Parameter	**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	-	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	µS/cm	216	153	153	1170	104	46	101	69	99	99	150	136	73	56	141	145	164	103	147
Total Hardness	CaCO3 mg/L	-	-	-	67	33	12	33	23	31	31	45	57	22	18	54	47	61	33	54
Sulphate as SO4	mg/L	40	5	6	11	7	2	7	5	8	8	<1	<1	3	2	2	3	3	2	2
Ammonia as N	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	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	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	mg/L	<1	3	<1	2	2	4	4	3	<1	2	7	4	3	2	7	9	7	5	9
TSS	mg/L	-	-	-	141	46	9	92	31	263	149	28	22	49	32	41	78	34	16	54
Turbidity	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

Table 2.7: Surface Water Quality Monitoring Results – Petroleum Hydrocarbons (AARC, 2023)



Parameter	**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	mg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C10 – C14 Fraction	mg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C15-C28 Fraction	mg/L	<100	<100	<100	<100	<100	<100	<100	140	<100	<100	<100	130	380	<100	<100
C29-C36 Fraction	mg/L	<50	<50	<50	<50	<50	<50	<50	60	<50	<50	<50	<50	80	<50	<50
C10-C36 Fraction (sum)	mg/L	<50	<50	<50	<50	<50	<50	<50	200	<50	<50	<50	130	460	<50	<50
C6-C10 Fraction	mg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C6-C10 Fraction minus BTEX (F1)	mg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
>C10-C16 Fraction	mg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C16-C34 Fraction	mg/L	<100	<100	<100	<100	<100	<100	<100	170	<100	<100	<100	<100	430	<100	<100
>C34-C40 Fraction	mg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C10-C40 Fraction (sum)	mg/L	<100	<100	<100	<100	<100	<100	<100	170	<100	<100	<100	<100	430	<100	<100
>C10-C16 Fraction minus Napthalene (F2)	mg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100

2.5 WATER USE

2.5.1 Water Sharing within the Flinders River Basin

The Water Plan (Gulf) 2007 provides a framework for the sustainable management of water resources by providing sustainable water allocation while protecting ecological values in the river basins flowing into the Gulf of Carpentaria. The Gulf Water Plan provides information regarding the outcomes for sustainable management of water, performance indicators and objectives, strategies for achieving outcomes, and monitoring and reporting requirements. Water allocation in the Gulf Water Plan area falls within one of the following three categories:

- Supplemented water – surface water supplied under an interim resource operation licence, resource operations licence or any other authority to operate infrastructure in relation to designated supplemented water supplies. There are two supplemented water supply schemes which are situated within the Leichhardt River basin, and therefore not applicable to this study.
- Un-supplemented water – water that is not supplemented.
- Unallocated water – A volume of water that is reserved for other uses, such as regional development, industrial or agricultural use.

The Project study area is within the Saxby River catchment which falls within the Gulf Water Plan area (refer Figure 2.9). The Project location is within the Saxby River Zone 12 (refer Figure 2.10).

Figure 2.9: Gulf Water Plan area (Source: Water Plan (Gulf) 2007)

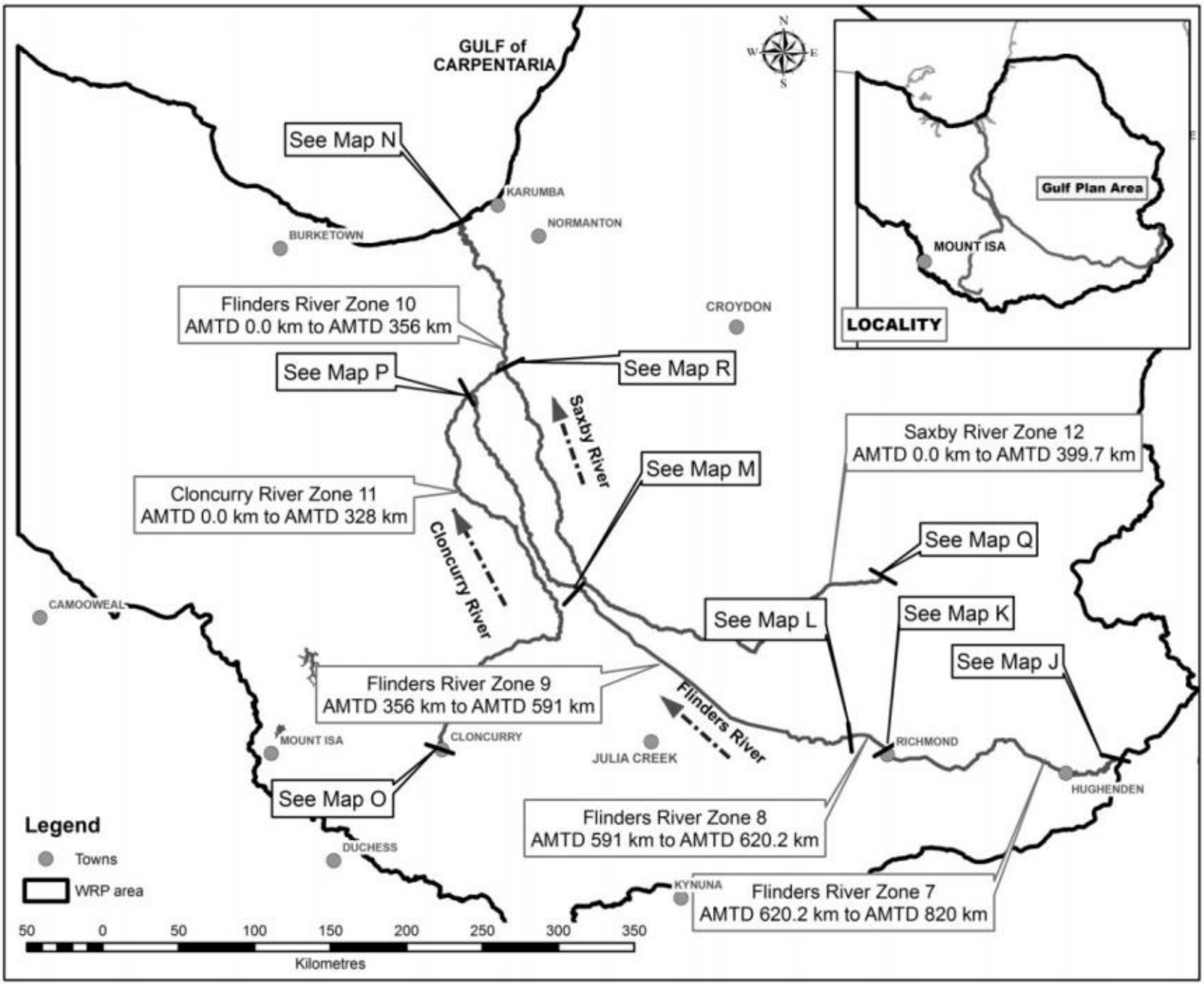


Figure 2.10: Flinders River Water Management Area (Source: Gulf Resource Operations Plan)

2.5.2 Existing Surface Water Entitlements

There are two existing water licence holders (unsupplemented water) downstream of the Project on the Saxby River for water take. The two licences are attached to the same property (2/TD1) and are located approximately 100 km downstream of the Project. The existing licences have a combined annual entitlement (Annual Volumetric Limit) of 20,000 ML/a and are authorised for rural use. The details of these licences are presented in Table 2.8 and the property location to which these licences are attached is shown in Figure 2.11.

Table 2.8: Details of Existing Saxby River Water Licences

Authorisation Number	Authorisation Type	Management Subgroup	Management Group	Authorised Purpose	Location (Lot/ Plan)	Annual Volumetric Limit (ML)
616859	Licence to Take Water	Saxby Zone 12 - Water Transfer Group B	Flinders River Water Management Area	Rural	2/TD1	12,500
616860	Licence to Take Water	Saxby Zone 12 - Water Transfer Group B	Flinders River Water Management Area	Rural	2/TD1	7,500

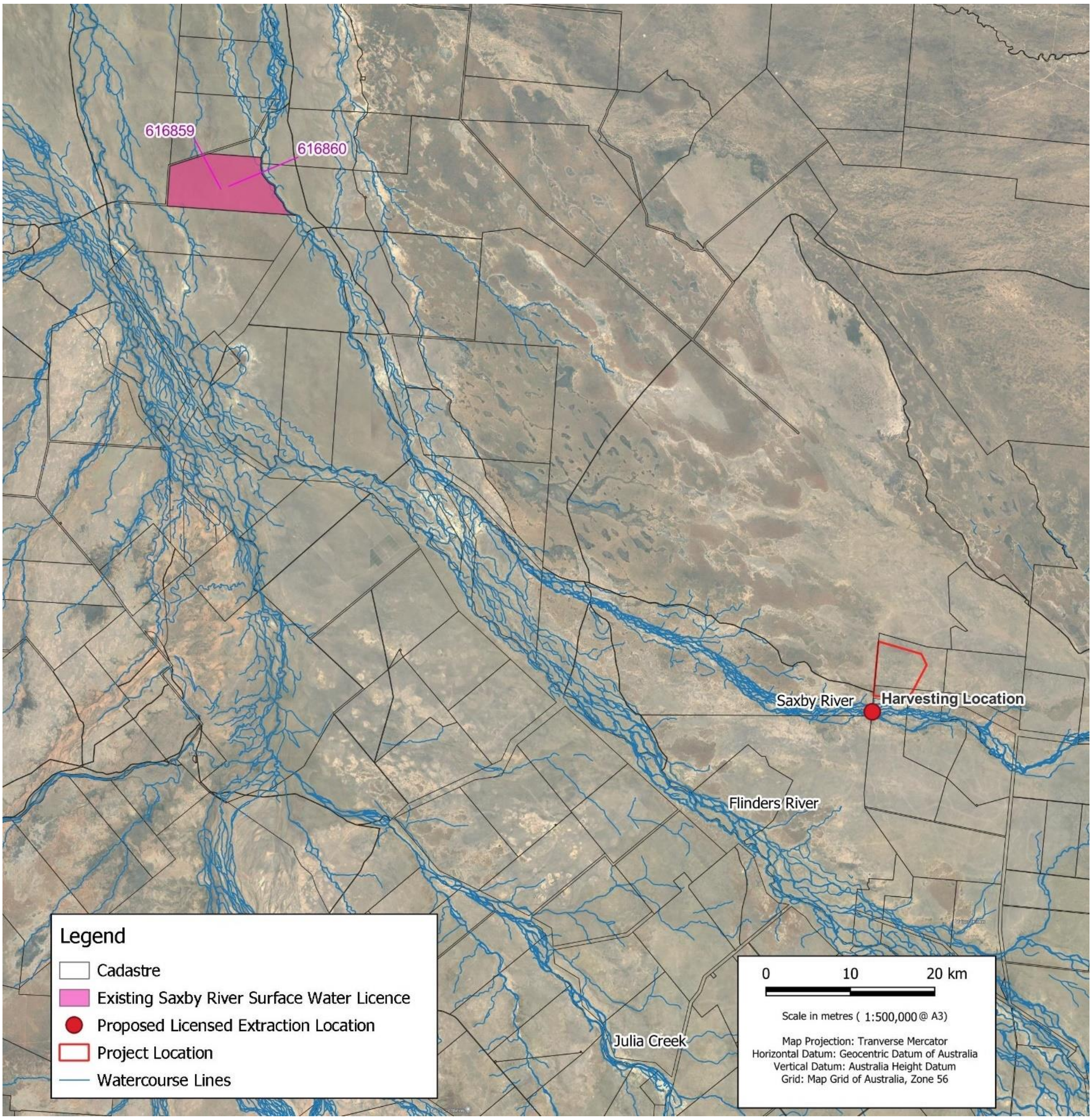


Figure 2.11: Location of Existing Saxby River Water Licences

2.6 WETLANDS

The Map of Queensland wetland environmental values is a state-wide statutory map under the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019*. It identifies wetlands of high ecological significance (HES) and general ecological significance (GES) across the state.

Matters of State Environmental Significance (MSES) HES wetlands and GES wetlands and Vegetation Management Wetlands are mapped in the locality of the Project (Figure 2.12 and Figure 2.13).

There are no HES wetlands mapped within the proximity of the Projects Production ML, nor are there any downstream. There are no GES or Vegetation Management wetlands within the Projects Production ML boundary; however, the Transport ML will intersect a small number of GES and Vegetation Management wetlands.

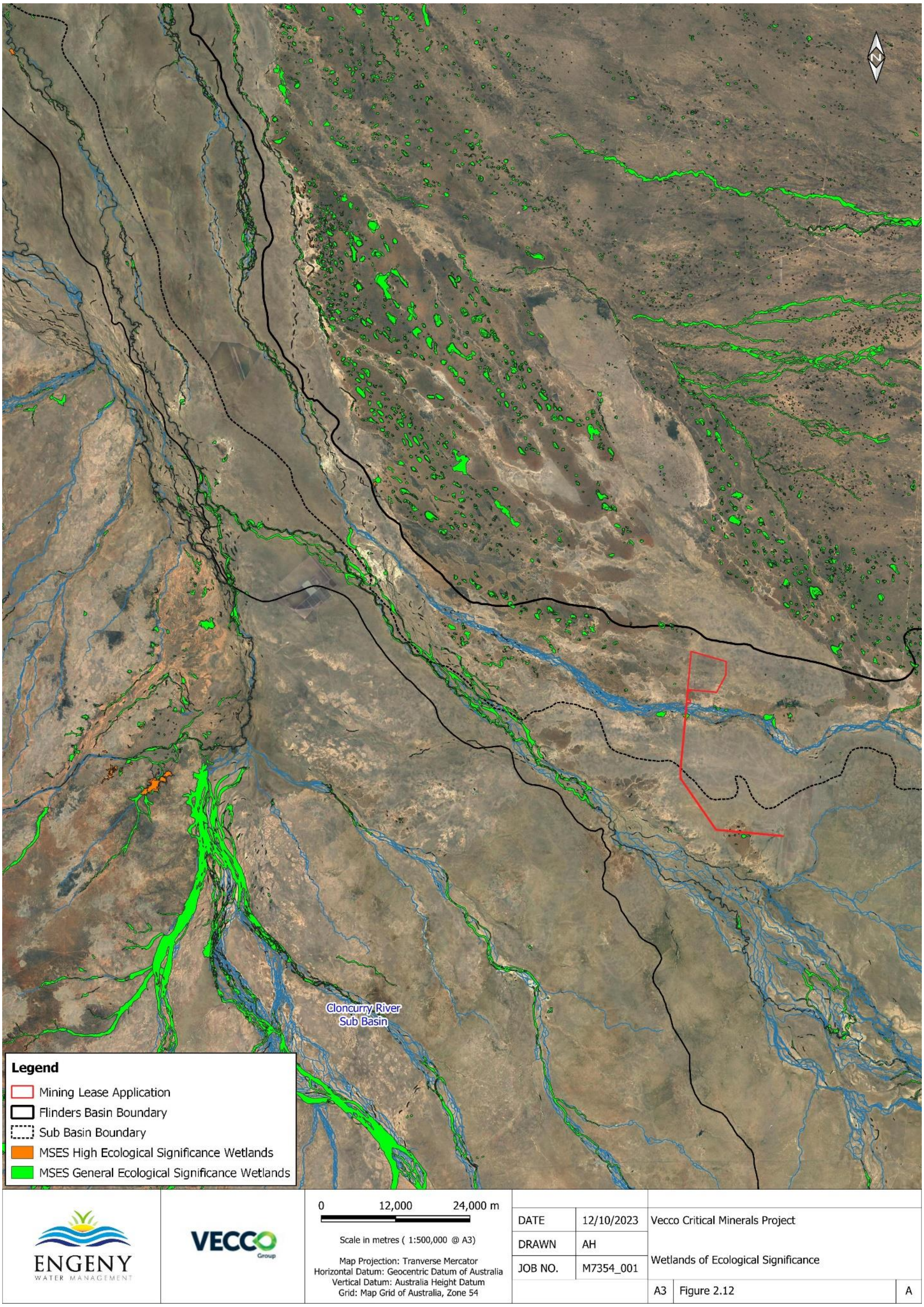


Figure 2.12: Wetlands of Ecological Significance

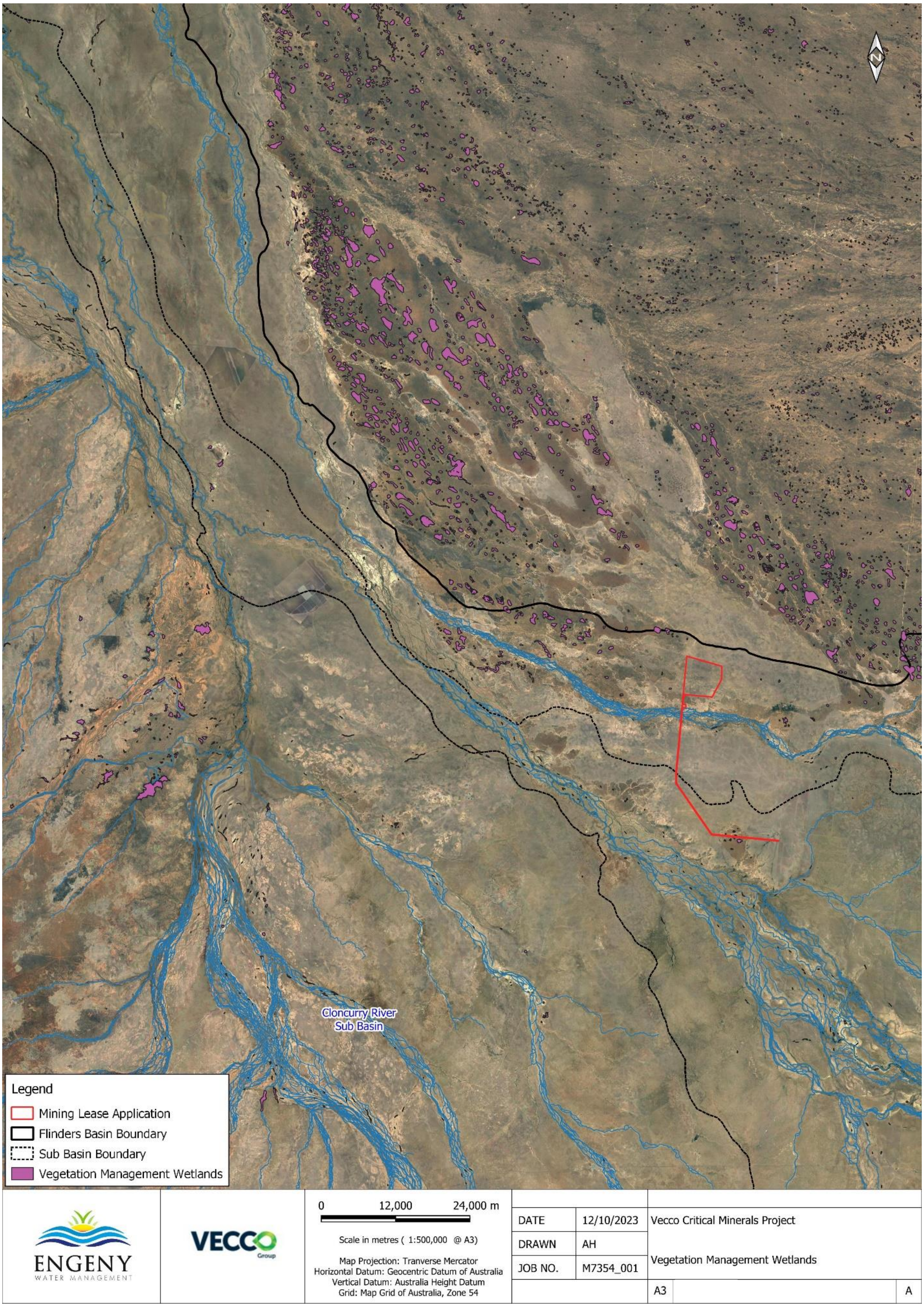


Figure 2.13: Vegetation Management Wetlands

2.7 LAND USE

2.7.1 Agriculture

The land within and surrounding the Project area is designated as ‘Rural’ zone under the McKinlay Shire Planning Scheme 2019. Existing land use of the Project area is low intensity cattle grazing (McKinlay Shire Council, 2019).

The Queensland Government’s land use mapping (Queensland Globe) indicates no current agricultural operations occurring within the Projects Production ML boundary. However, the mapping shows that the Agricultural Land Audit has classified the region within and surrounding the site boundary as “Important Agricultural Area” and has the potential for agricultural development (Figure 2.14). Potential agricultural regions mapped in the Project area include:

- QLD Agricultural Land Classes:
  - Class A1: Crop land that is suitable for a wide range of current and potential crops, with nil to moderate limitations to production.
  - Class B: Limited crop land that is suitable for a narrow range of current or potential crops, though highly unsuitable for pastures. The land might be suitable for cropping with engineering or agronomic improvements.
- QLD Agricultural Land Audit:
  - Potential annual horticulture.
  - Potential perennial horticulture (only along the southern boundary).
  - Potential intensive livestock.

There is a small area of ‘potential’ for sown pasture on the southern bank of the Saxby River, around 4.5 km south-east of the Project.

2.7.2 Nearby Mines and Industry

The Project will be the only mining operation located in the Saxby River catchment if approved, however there are several approved, active and inactive mineral mines located in nearby catchments. A recently approved but currently undeveloped vanadium mine (Saint Elmo Vanadium Project) is located approximately 60 km to the southwest in the Flinders River catchment and several gold and copper mines are located approximately 130 km away in the Julia Creek catchment near the Cloncurry township. Table 2.9 provides a summary of mines within 150 km of the Project.

Table 2.9: Nearby Mines

Name	Proximity	Activity
Saint Elmo Vanadium Project	60 km south-west (Flinders River catchment)	Approved vanadium mine.
Ernest Henry Mine	135 km south-west (Julia Creek catchment)	Active copper & gold mining complex
Mt Margaret Mine	128 km south-west (Julia Creek catchment)	Inactive copper mine
Eloise Copper Mine	145 km south-west (Julia Creek catchment)	Active copper mine

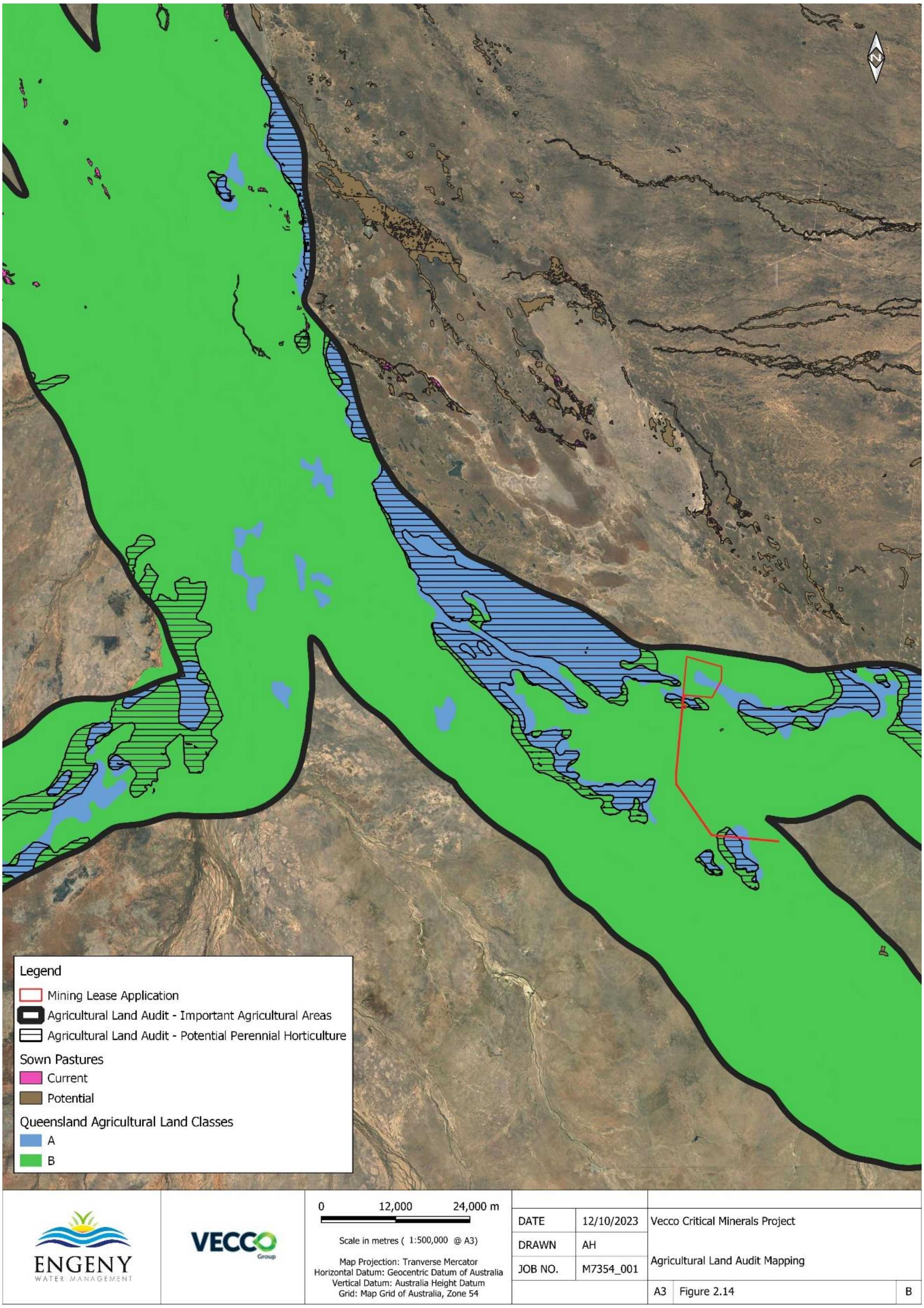


Figure 2.14: Agricultural Land Audit Mapping

2.8 ENVIRONMENTAL FLOW OBJECTIVES

The Water Plan (Gulf) 2007 outlines the environmental management issues relating to water use in the Flinders River catchment and its effect on the overall natural river system. These include considerations around ensuring that there is enough water available to maintain streamflows (both surface water and groundwater) to sustain the ecosystems that are dependent on them. Other management factors that need to be considered include the impacts of water usage on groundwater and surface water quality, natural movement of fish and aquatic animals, and cultural values.

Environmental Flow Objectives (EFOs) for the Flinders River catchment are detailed in Schedule 5 of the Water Plan (Gulf) 2007 and represent key performance objectives that must be achieved to meet the Water Plan outcomes for the sustainable management of surface water. The EFOs for the Flinders catchment are specified at Node 7 – Flinders River at Walkers Bend (Gauging Station 915003A) which is located 300 km downstream of the Project site, near the Flinders River outlet to the Gulf of Carpentaria. The EFOs specified for the Flinders River at Walkers Bend are summarised below.

- The proportion of no flow days in the simulation period should be no more than 70%.
- The mean annual flow as a percentage of pre- development flow should be at least 90%.
- The median annual flow as a percentage of pre-development flow should be at least 78%.
- The median wet season (January to March) flow as a percentage of pre-development flow should be at least 75%.
- The 1.5 year daily flow volume as a percentage of pre-development flow volume should be at least 90%.
- The 5 year daily flow volume as a percentage of pre-development flow volume should be at least 96.5%.
- The 20 year daily flow volume as a percentage of pre-development flow volume should be at least 98%.

3 ENVIRONMENTAL VALUES AND WATER QUALITY OBJECTIVES

3.1 RELEVANT LEGISLATION

3.1.1 Environmental Protection Act 1994 (EP Act)

The EP Act defines environmental value as:

- A quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or
- Another quality of the environment identified and declared to be an environmental value under an environmental protection policy or regulation.

3.1.2 Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) defines the legal framework to protect and manage nationally and internationally important flora, fauna and ecological places defined as Matters of National Environmental Significance (MNES).

3.1.3 Environmental Protection Regulation (EP Regulation) 2019

The Environmental Protection Regulation (EP Regulation) 2019 further defines specified environmental objectives and performance outcomes for key environmental aspects. The Water and Wetlands environmental objectives and performance outcomes are summarised in Section 3.3.2.

3.1.4 Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The purpose of the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP) is to identify environmental values (EV) and associated water quality objectives (WQO) for Queensland waters. The Project is located within the Flinders River sub-catchment of the Gulf Rivers basin. A Program to define EVs and WQOs for the Flinders River sub-catchment has not currently been completed and therefore EVs and WQOs are not currently scheduled under the EPP.

3.1.5 Water Act 2000 (Queensland)

The Water Act 2000 is the key regulatory document in Queensland for the allocation and use of water resources. The Water Act provides a range of plans, licence and permits for surface and groundwater resources throughout the state. These include Water Plans and Resource Operations Plans/Water Management Protocols.

3.1.6 Water Plan (Gulf) 2007

Water resources within the Flinders and Saxby River Basins are managed under the Water Plan (Gulf) 2007. The purposes of the plan are defined as:

- To define availability of water in the plan area.
- To provide a framework for sustainably managing water and the taking of water.
- To identify priorities and mechanisms for dealing with future water requirements.
- To provide a framework for establishing water allocations to take supplemented surface water.
- To provide a framework for reversing, where practicable, degradation of natural ecosystems.
- To regulate the taking of overland flow water.
- To regulate the taking of groundwater.

The Plan defines Environmental Flow Objectives (EFOs) which define the flow conditions which must be maintained at defined management nodes in the Gulf basin. EFOs are defined for a range of conditions including flow volume, flow duration, low flow, medium to high flow and wet season flow events.

The identified location nearest to the Project is the Water Plan (Gulf) 2007 management node 7 which is the Flinders River at Walkers Bend gauging station. Node 7 is located on the Flinders River around 300 km downstream from the Project and is the only EFO node in the Flinders River catchment. The EFOs for the Flinders River at Walkers Bend monitoring station are provided in Section 2.8.

3.1.7 Gulf Resource Operations Plan 2010

The Gulf Resource Operations Plan (ROP) 2010 is a document prepared to outline strategies for the implementation of the Water Plan (Gulf) 2007. The Gulf ROP regulates water allocations and licensing within the Gulf basin. The ROP sub-divides the Gulf Basin into water management areas and zones. The Project is located within the Saxby River Zone 12 of the Flinders River Water Management Area (refer Figure 2.10).

3.1.8 Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017

Groundwater resources with the Flinders and Saxby River Basins are managed under the Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017. The purposes of the Plan are defined as:

- To define availability of water in the plan area.
- To provide framework for sustainably managing water and the taking of water in the plan area; and
- To identify priorities and mechanisms for dealing with future water requirements; and
- To provide a framework for reversing, if practicable, the degradation of groundwater-dependent ecosystems.

The Plan's main outcomes are to allocate (using water permits and licenses) and manage water in a way to mitigate the impact on groundwater-dependent ecosystems due to taking and interfering with water. The Plan aims to achieve a sustainable balance between the following outcomes:

- To protect the flow of water to groundwater-dependent ecosystems that support significant cultural or environmental values.
- To protect the continued use of authorisations to take or interfere with water.
- To maintain, and if practicable increase, water pressure in aquifers to preserve the supply of water to bores.
- To make water available for future development and social and cultural activities that depend on water, including for the aspirations of Aboriginal peoples and Torres Strait Islanders.
- To encourage the efficient use of water by requiring water bores to have watertight delivery systems or be controlled.
- To facilitate the operation of efficient water markets and opportunities for the temporary or permanent movement of water.

3.1.9 Great Artesian Basin and Other Regional Aquifers Water Management Protocol 2017

The Great Artesian Bains and Other Regional Aquifers Water Management Protocol (The Protocol) 2017 is a document prepared to implement parts of the Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017. The protocol regulates groundwater allocations and licensing as well as protection and monitoring of groundwater-dependent ecosystems within the Plan area.

3.2 ENVIRONMENTAL VALUES

As there are no prescribed environmental values for the Saxby River catchment under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP), the following sections justify and outline the perceived environmental values for the Project surface waters based on all available information and legislative requirements.

3.2.1 Aquatic Ecosystems

Aquatic ecosystem health is considered to be an environmental value for the Project. There are no published ecosystem condition categories of the waterways surrounding Project under the EPP or other Queensland guidelines such as the Queensland Water

Quality Guidelines 2009 (QWQG). The ecosystem condition categories are used to define the value of the aquatic ecosystem (and consequent objectives for its protection) and are based on a number of factors including water quality and extent to which the waterway has been modified by human activity.

The EPP defines the categories as follows:

- High ecological value waters: waters in which the biological integrity of the water is effectively unmodified or highly valued.
- Slightly disturbed waters: waters that have the biological integrity of high ecological value waters with slightly modified physical or chemical indicators but effectively unmodified biological indicators.
- Moderately disturbed waters: waters in which the biological integrity of the water is adversely affected by human activity to a relatively small but measurable degree.
- Highly disturbed waters: waters that are significantly degraded by human activity and have lower ecological value than high ecological value waters or slightly or moderately disturbed waters.

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC Guidelines) and the QWQG provide further guidance for classification of aquatic ecosystem condition where:

- High value ecosystems are effectively unmodified or other highly valued systems, typically (but not always) occurring in national parks, conservation reserves or in remote and/or inaccessible locations (ANZECC & ARMCANZ, 2000).
- Slightly to moderately disturbed ecosystems for freshwater systems would have slightly to moderately cleared catchments and/or reasonably intact riparian vegetation. This could include rural streams receiving runoff from land disturbed to varying degrees by grazing or pastoralism (ANZECC & ARMCANZ, 2000).
- Highly disturbed ecosystems are measurably degraded systems, for example shipping ports, urban streams or rural streams receiving runoff from intensive horticulture (ANZECC & ARMCANZ, 2000).

Based on the above definitions and guidance, the waterways surrounding the Project are likely to be classed as ‘slightly to moderately disturbed’ as the surrounding areas are used for grazing purposes (with large areas of cleared remnant vegetation) and are therefore modified (not high value waters) but likely not to the extent to be classified as highly disturbed.

3.2.2 Aquaculture and Human Consumption

There are no known users of local surface water sources for aquaculture or the production of aquatic foods for human consumption. The closest surface water entitlement on the Saxby River is located 100 km downstream of the Project as discussed in Section 2.5.2. It is expected that water obtained from the existing surface water entitlements are used for agricultural use. Based on the above, aquaculture and human consumption are not considered to be a likely environmental value for the Project.

3.2.3 Crop Irrigation

There are no known cropping or irrigation operations that source water from the Saxby River downstream of the Project location. Therefore, crop irrigation is not considered to be a likely environmental value for the Project.

3.2.1 Agriculture

There are two existing surface water entitlements authorised under the Water Plan (Gulf) 2007 on the Saxby River, 100 km downstream of the Project that have an authorised purpose of ‘rural’ which is described as being permitted for ‘any’ purpose (Refer Section 2.5.2). Based on this the agriculture in the form of grazing and farm supply/use is considered to be a relevant environmental value for the Project.

3.2.2 Recreational Uses

Flow within the Saxby River is seasonal however segregated waterholes within the river channel can persist for longer periods of time into the dry season without additional inflows. It is not known if the Saxby River is used for recreational use however it is possible that, when water persists within the channel, recreational purposes would include activities such as swimming (primary recreational use) and fishing (secondary recreational use). For this reason, primary and secondary recreational use are considered to be relevant environmental values for the Project.

3.2.1 Drinking Water

There are no known dams, weirs or surface water entitlements located downstream of the Project for drinking water supplies. Nearby land holders and homesteads are expected to receive drinking water supplies from groundwater sources including the Great Artesian Basin (GAB). Based on this, drinking water is not considered to be a likely environmental value for the Project.

3.2.1 Industrial Use

There are no known surface water supply for industrial purposes or mining activities downstream of the Project from the Saxby River or Flinders River (downstream of the Saxby River and the Flinders River confluence). Therefore, industrial use is not considered to be a likely environmental value for the Project.

3.2.2 Visual Recreation and Cultural and Spiritual Values

It is also possible that the Saxby River provides aesthetic quality or recreational fishing for visual recreational use. Similarly, it is also possible that the waterways provide cultural and spiritual value. For this reason, visual recreation and cultural and spiritual values are considered to be relevant environmental values for the Project.

3.3 WATER QUALITY OBJECTIVES AND ENVIRONMENTAL OBJECTIVES

Water Quality Objectives (WQOs) for protection of the identified category of waters (including specific thresholds for water quality parameters) are usually scheduled under the EPP (Water and Wetland Biodiversity) for the relevant catchment. WQOs for the Gulf Catchment are yet to be derived and scheduled under the EPP (Water and Wetland Biodiversity). In the absence of scheduled WQOs, 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. However, both guidelines strongly encourage the collection of local data, where available, to develop guidelines relevant to the area in question (DEHP, 2009) and provide guidance on minimum monitoring program requirements to obtain suitable water quality datasets that capture both spatial and temporal variation. A surface water monitoring program for the Project has been developed in Section 10.2 to meet these objectives. The water quality monitoring program outlines water quality monitoring locations and indicators which will allow development of site-specific WQOs during the project commencement.

The ANZECC Guidelines were updated in late 2018 for the purposes of updating the water quality management framework and revising some of the default guideline values based on more recent, and longer, water quality datasets. At the time this report was being prepared the 2018 ANZECC Guidelines are on an online platform and in the early stage of implementation with many supporting guidelines yet to be released. The Project will address and incorporate the future revisions and releases of the ANZECC Guidelines as part of the ongoing surface water monitoring program for the Project (refer Section 10.2).

The ANZECC Guideline 2000 categorises the water types for several broad regions based on physio-chemical parameters. The Project is classified as lowland freshwater based on the Project being situated at 90m AHD and the transition between highland and lowland being 150 m AHD.

3.3.1 Draft Water Quality Objectives

In the absence of published WQOs for the Gulf catchment and insufficient existing water quality monitoring data at the time of developing this report for the development of site-specific WQOs, interim WQOs for the Project have been adopted from guideline values from ANZECC 2000 for protection of the EVs described in Section 3.2. The draft WQOs developed for the Project are presented in Table 3.1. The proposed ANZECC thresholds for lowland freshwater have been adopted as the Project is situated at 90m AHD and the transition between highland and lowland freshwaters being 150 m AHD.

The water quality ANZECC thresholds for each of the Project EVs were reviewed, and the most conservative threshold was adopted to ensure all EVs were considered and protected. Table 3.4 includes all water and sediment quality indicators that have documented thresholds assigned within the ANZECC Guidelines. Indicators listed in Table 10.3 that don’t have ANZECC guideline thresholds (e.g., dissolved organic carbon) will have appropriate thresholds developed once sufficient representative baseline data has been collected for the Project.

Table 3.1: Draft Surface Water Quality Objectives

Monitoring Category	Indicator	Adopted Guideline Value Threshold	Relevant EV / Source
Surface Water - Physio-chemical	pH	6.0-7.5	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Salinity (EC)	550 µS/cm	QWQG - 80th percentile for the Gulf catchment defined in the
	Sulphate	400 mg/L	ANZECC - Recreational Use
	Dissolved Oxygen (DO)	85 - 120%	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Turbidity	15 NTU	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Ammonium	10 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Nitrogen Oxide	10 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Total Nitrogen	300 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Nitrate/Nitrite	400 mg/L Nitrate (90 mg/L Nitrate-N) 30 mg/L Nitrite (9.1 mg/L Nitrite-N)	ANZECC - Livestock Drinking Water Quality
	Total Phosphorus	10 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Filterable Reactive Phosphorus	4 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
Surface Water - Toxicants	Aluminium	55 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Arsenic	13 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Barium	1,000 µg/L	ANZECC - Recreational Use
	Boron	370 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Cadmium	0.2 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Chromium	1 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Copper	1.4 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Iron	300 µg/L	ANZECC - Recreational Use
	Lead	3.4 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Manganese	100 µg/L	ANZECC - Recreational Use
	Nickel	11 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Selenium	10 µg/L	ANZECC - Recreational Use

Monitoring Category	Indicator	Adopted Guideline Value Threshold	Relevant EV / Source
	Silver	0.05 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Uranium	200 µg/L	ANZECC - Livestock Drinking Water Quality
	Zinc	8 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Calcium	1000 mg/L	ANZECC - Livestock Drinking Water Quality
	Radium 226	5 Bq/L	ANZECC - Livestock Drinking Water Quality
	Radium 228	2 Bq/L	ANZECC - Livestock Drinking Water Quality
	Uranium 238	0.2 Bq/L	ANZECC - Livestock Drinking Water Quality
	Gross alpha	0.1 Bq/L	ANZECC - Recreational Use
	Gross beta (excluding K-40)	0.1 Bq/L	ANZECC - Recreational Use
Surface Water - Biological Indicators	Microalgal (Chlorophyll-a)	5 µg/L	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
Sediment and Soil	Arsenic	20 mg/kg	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Cadmium	1.5 mg/kg	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Chromium	80 mg/kg	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Copper	65 mg/kg	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Lead	50 mg/kg	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Mercury	0.15 mg/kg	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Nickel	21 mg/kg	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Silver	1 mg/kg	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)
	Zinc	200 mg/kg	ANZECC - Aquatic Ecosystems - Lowland Rivers, SMD (Northern QLD Region)

3.3.2 Environmental Objectives and Performance Outcomes

Schedule 8, Part 3 of the EP Regulation lists environmental objectives and associated performance outcomes that will guide the development of the Project water management system. These are summarised in Table 3.2. The environmental objective is considered achieved if Item 1 or Item 2 of the performance outcomes are achieved by the Project application.

Table 3.2: EP Regulation Environmental Objectives and Performance Outcomes

Category	Environmental Objective	Performance Outcomes (must achieve Item 1 or Item 2)
Water	The activity will be operated in a way that protects environmental values of waters.	Item 1 - There is no actual or potential discharge to waters of contaminants that may cause an adverse effect on an environmental value from the operation of the activity.
		Item 2 - All of the following— (a) the storage and handling of contaminants will include effective means of secondary containment to prevent or minimise releases to the environment from spillage or leaks (b) contingency measures will prevent or minimise adverse effects on the environment due to unplanned releases or discharges of contaminants to water (c) the activity will be managed so that stormwater contaminated by the activity that may cause an adverse effect on an environmental value will not leave the site without prior treatment (d) the disturbance of any acid sulfate soil, or potential acid sulfate soil, will be managed to prevent or minimise adverse effects on environmental values (e) acid producing rock will be managed to ensure that the production and release of acidic waste is prevented or minimised, including impacts during operation and after the environmental authority has been surrendered (f) any discharge to water or a watercourse or wetland will be managed so that there will be no adverse effects due to the altering of existing flow regimes for water or a watercourse or wetland (g) for a petroleum activity, the activity will be managed in a way that is consistent with the coal seam gas water management policy, including the prioritisation hierarchy for managing and using coal seam gas water and the prioritisation hierarchy for managing saline waste (h) the activity will be managed so that adverse effects on environmental values are prevented or minimised.
Wetlands	The activity will be operated in a way that protects the environmental values of wetlands.	Item 1 - There will be no potential or actual adverse effect on a wetland as part of carrying out the activity.
		Item 2 - The activity will be managed in a way that prevents or minimises adverse effects on wetlands.
Critical Design Requirements	The design of the facility permits the operation of the site, at which the activity is to be carried out, in accordance with best practice environmental management.	Item 1 - The activity does not involve the storage, production, treatment or release of hazardous contaminants, or involve a regulated structure.
		Item 2 - All of the following apply— (a) all storage provided for hazardous contaminants includes secondary containment to prevent or minimise releases to the environment from spillage or leaks (b) regulated structures comply with the document called 'Manual for assessing consequence categories and hydraulic performance of structures', published by the department (c) containers are provided for the storage of hazardous contaminants that are secured to prevent the removal of the containers from the site by a flood event (d) the design of the facility prevents or minimises the production of hazardous contaminants and waste (e) if the production of hazardous contaminants and waste is not prevented or minimised under paragraph (d)—the design of the facility contains and treats hazardous contaminants rather than releasing them.

4 CONTAMINANT SOURCES

4.1 POTENTIAL CONTAMINANT SOURCES

Potential contaminant sources associated with the Project include:

- Surface runoff from disturbed areas.
- Surface runoff from mine waste or ore.
- Accumulated water in the mining pits.
- Incidental runoff from chemical/hydrocarbon spills within the processing plant area.
- Process waste streams and entrained water.
- Seepage, overtopping or dam failure of mine water storages.

4.1.1 Surface Runoff from Disturbed Areas

Disturbance activities for the Project will include an open cut mining pit, overburden dumps, ROM stockpiles, mine infrastructure hardstand areas, access and haul roads, disturbance for water management storages, infrastructure corridors and the processing plant. Runoff from these areas could contain sediment and other contaminants above natural surface water runoff concentrations. The source of the runoff will influence the contaminant types and concentrations, however, generally there are two overarching categories:

- Runoff from cleared areas, overburden dumps or roads that would be expected to have elevated sediment load.
- Runoff from processing areas and/or mine pits that may contain other contaminants in addition to sediment (e.g. dissolved salts and metals, hydrocarbons, nutrients etc).

The strategies for the mitigation and management of these two categories will therefore differ to ensure they are suitably managed to protect the receiving environment and associated environmental values. Typically, erosion and sediment control strategies are implemented for runoff in which sediment is the primary contaminant of concern for treatment before release, whereas more comprehensive mine water management systems are developed for waters containing other contaminants to prevent releases.

4.1.2 Processing

The mining and processing of the vanadium ore will involve the use of a number of reagents and produce some hazardous waste streams which contain various compounds and hazardous contaminants. Waters that come into contact with the vanadium ore may therefore contain some of the identified contaminants. The proposed processing method is a hydrometallurgical process designed to extract and refine vanadium, High Purity Alumina (HPA) and Rare Earth Elements (REE). The vanadium extraction process is based on the capacity of sulphuric acid to dissolve the vanadium contained within the iron oxides and clays within the orebody. Vanadium is refined through selective solvent extraction. The process uses a number of acids, flocculants, reagents and solvents to extract the ore and neutralise the waste material before disposal. The HPA process uses HCl to leach and precipitate an Alumina Chloride Hexahydrate (ACH) through multiple purification stages. Rare earths are beneficiated, leached and concentrated into a mixed carbonate product for further processing off-site. Water is used within the processing plant and is expected to contain some contaminants used within the process. Processing water will be recirculated through a dedicated processing pond to isolate potential contaminants within the processing circuit and reduce the risk of environmental harm.

Waste streams from the processing circuit will be neutralised and disposed in the floor of the open cut pit before being encapsulated with overburden and topsoil materials prior to rehabilitation.

Rainfall runoff from the processing plant area has the potential to contain some of the chemicals used in the process. Runoff will be contained by the Process Water Dam and reused as supply to the process.

4.1.3 Chemical and Hydrocarbon Storage

The storage of chemicals and hydrocarbons will be required as part of ongoing operations. A dedicated fuel and lube facility will be required, which will be constructed in line with the containment and spill response requirements of Australian Standard 1940 – The Storage and Handling of Flammable and Combustible Liquids, however, will still remain a potential source of contaminants for the Project.

4.1.4 Seepage, Overtopping and Dam Failure of Storages

Mine water will be stored in dams on site and is a potential contaminant source via pathways of seepage, overtopping and dam failure. Dams will be suitably engineered to minimise the risk of occurrence of these pathways. A more detailed description of the proposed dam design can be found in Section 5.3 and the consequence category assessment for seepage, overtopping and dam failure scenarios for these dams is provided in Section 9.2.

5 WATER MANAGEMENT SYSTEM

5.1 OBJECTIVES

The water management system for the Project has been developed to preserve the environmental values of the receiving environment as well as to provide runoff containment and meet the water demands of the Project. The objectives of the mine water management strategy include:

- Minimise capture of clean surface water from external catchments via catchment diversion.
- Maximise recycle and reuse of first mine affected water, then sediment runoff (Section 5.2), for site demands including processing and dust suppression.
- Preferential supply of water demands from site water storages over external raw water supply.
- Prevent uncontrolled release of mine affected water in 99% of years (1% Annual Exceedance Probability containment).

5.2 SURFACE WATER CATEGORIES

The mine water management strategy for the Project provides separation of water types based on anticipated water quality. The proposed water management system has separation of water types by:

- Mine Affected Water - Mine affected water is defined as water which has interacted with mining activities consistent with the Mine Affected Water definition from the Queensland Model Mining Conditions (DES, 2017). This includes water runoff and groundwater collected within the mining pit, recycled water from the processing plant, runoff from the mine infrastructure area (MIA) and excess water in the Interim Residue Storage Facility.
- Sediment Water - rainfall and runoff generated by disturbed landforms including overburden dumps, pre-cleared areas and rehabilitation that is not yet established. This water does not contain elevated concentrations of contaminants other than suspended solids and must be treated through the erosion and sediment control system.
- Raw Water – untreated water supplied from an external surface water or groundwater source, permitted under the Water Act 2000.
- Clean Water – runoff from undisturbed or established rehabilitation areas.
- Potable Water – treated water suitable for human consumption.

5.3 WATER MANAGEMENT SYSTEM

5.3.1 Proposed Water Management Strategy Overview

The water management system includes mine affected water storages, sediment storages, raw water harvesting system and storage and drainage diversion of undisturbed catchments. The water management strategy for the Project is summarised as:

- Diversions of clean catchment around mine infrastructure and disturbed land through diversion drains to reduce external catchment area reporting to the mining pit and site storages.
- Containment of mine affected runoff in dedicated storages for reuse in the Project.
- Dedicated processing ponds for recirculation and treatment of water used in various stages of the processing circuit.
- External water supply from streamflow harvesting from the Saxby River and storage in an off-stream raw water storage (Raw Water Dam) to maintain supply to Project water demands.
- Capture and treatment of disturbed runoff in sediment basins and other sediment control infrastructure.
- Preferential re-use of mine affected water and sediment runoff captured by the Project to supply operational water demands.
- Progressive rehabilitation/stabilisation of spoil dump and mine infrastructure areas to reduce the generation of sediment water.

A schematic of the Project water management system is provided in Figure 5.1 and layout plans of the water management system are shown in Figure 5.2 to Figure 5.6. The proposed water management infrastructure is summarised in the following sections.

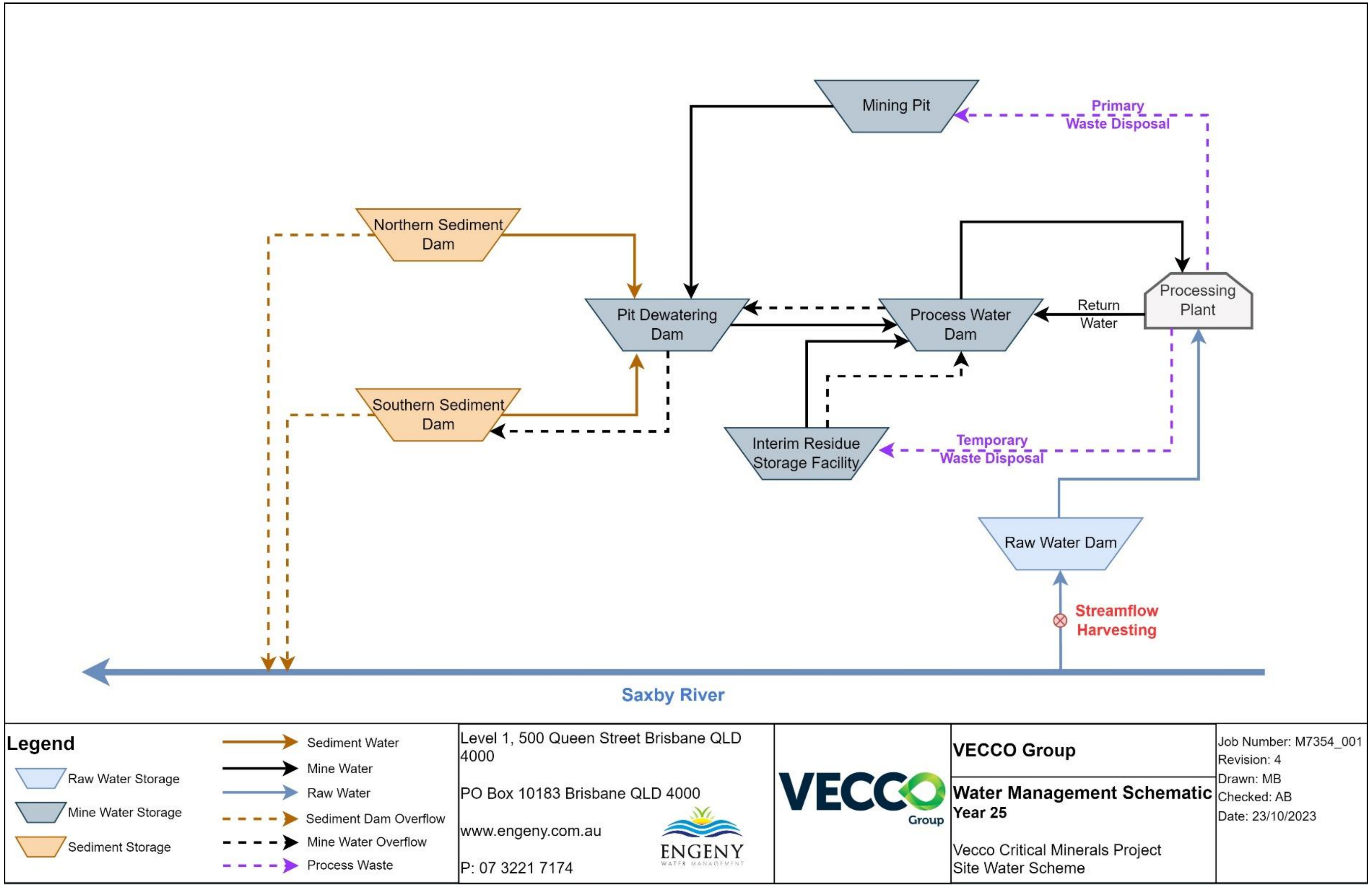


Figure 5.1: Water Management System Schematic

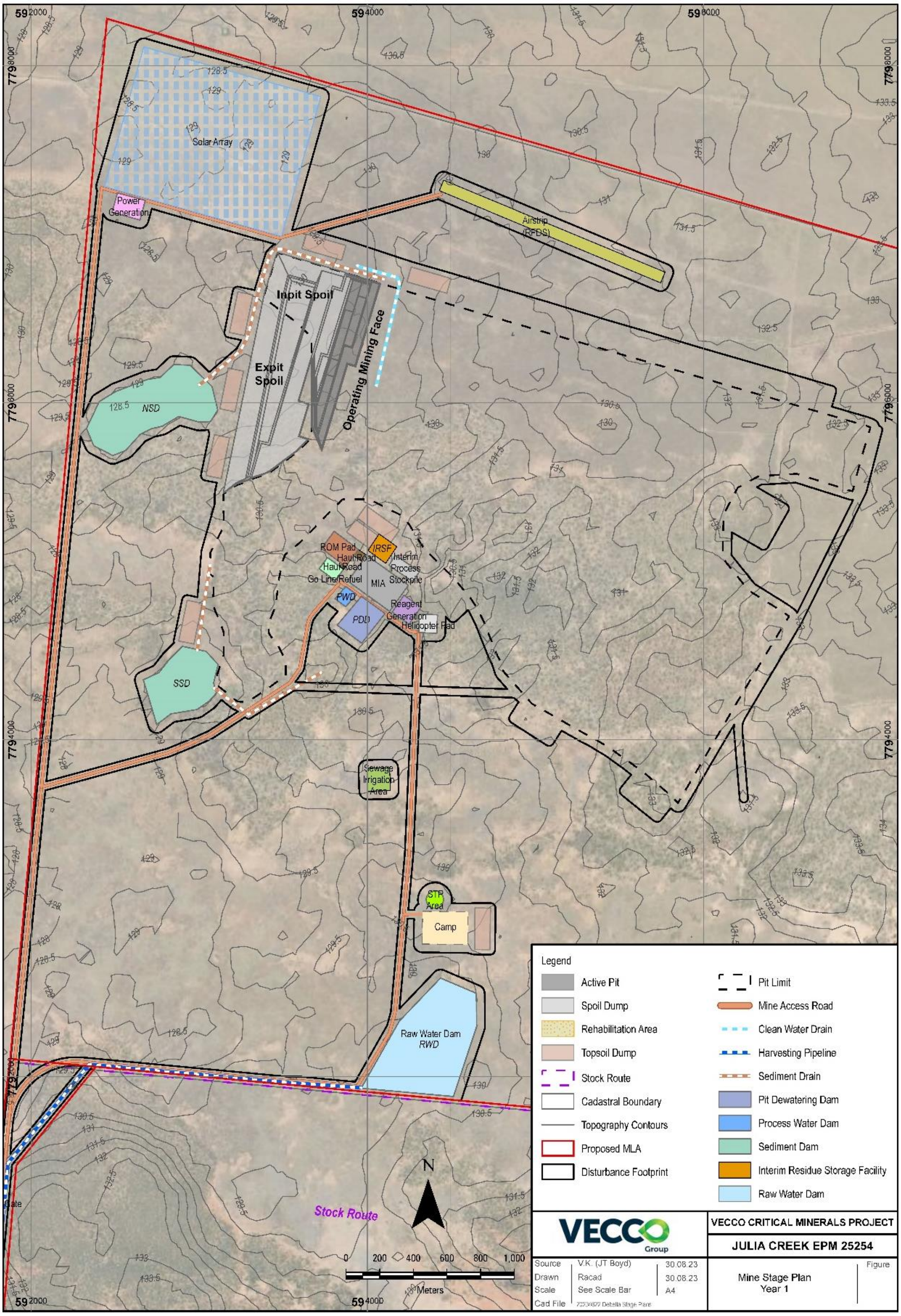


Figure 5.2: Year 1 Water Management Infrastructure

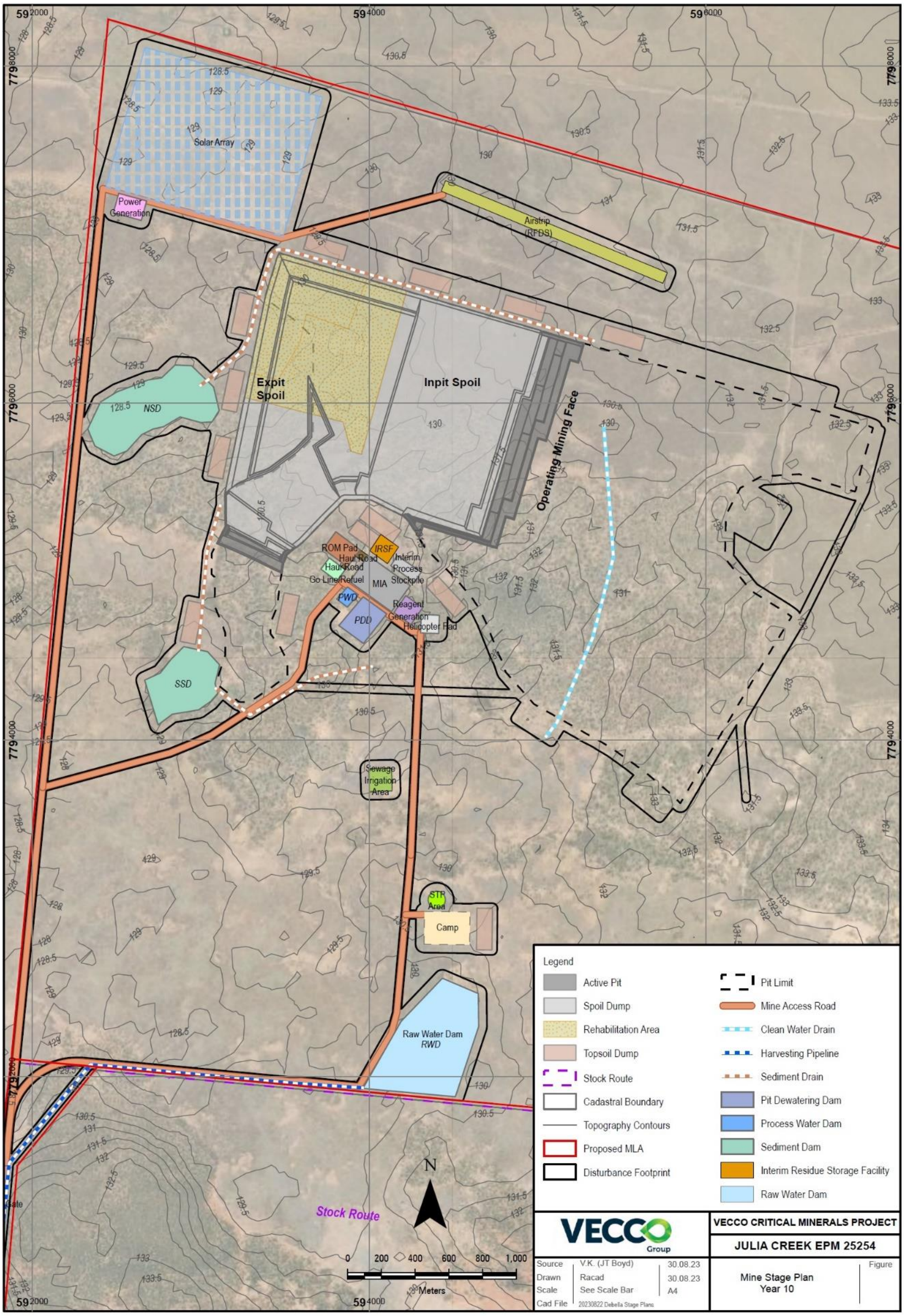


Figure 5.3: Year 10 Water Management Infrastructure

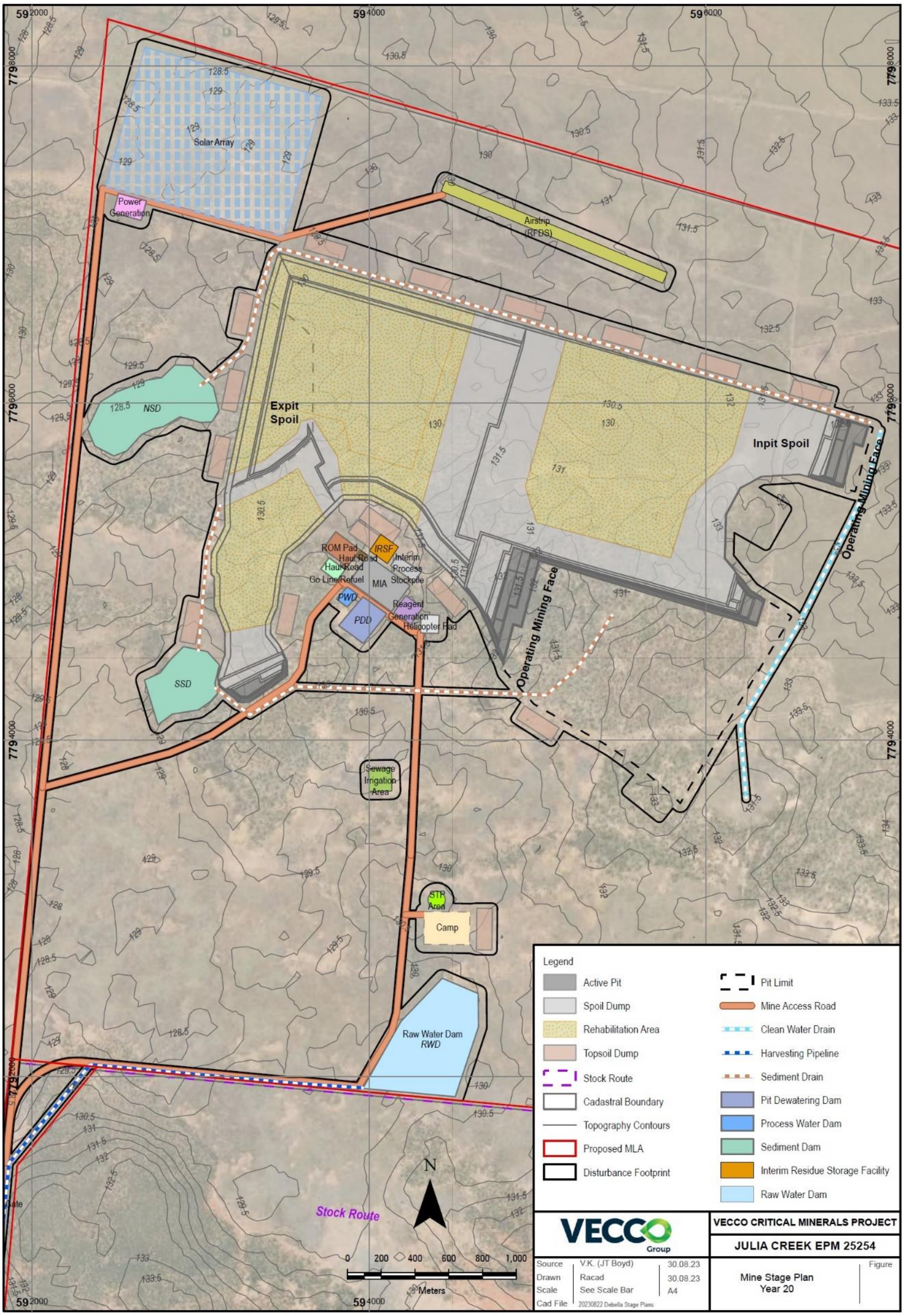


Figure 5.4: Year 20 Water Management Infrastructure

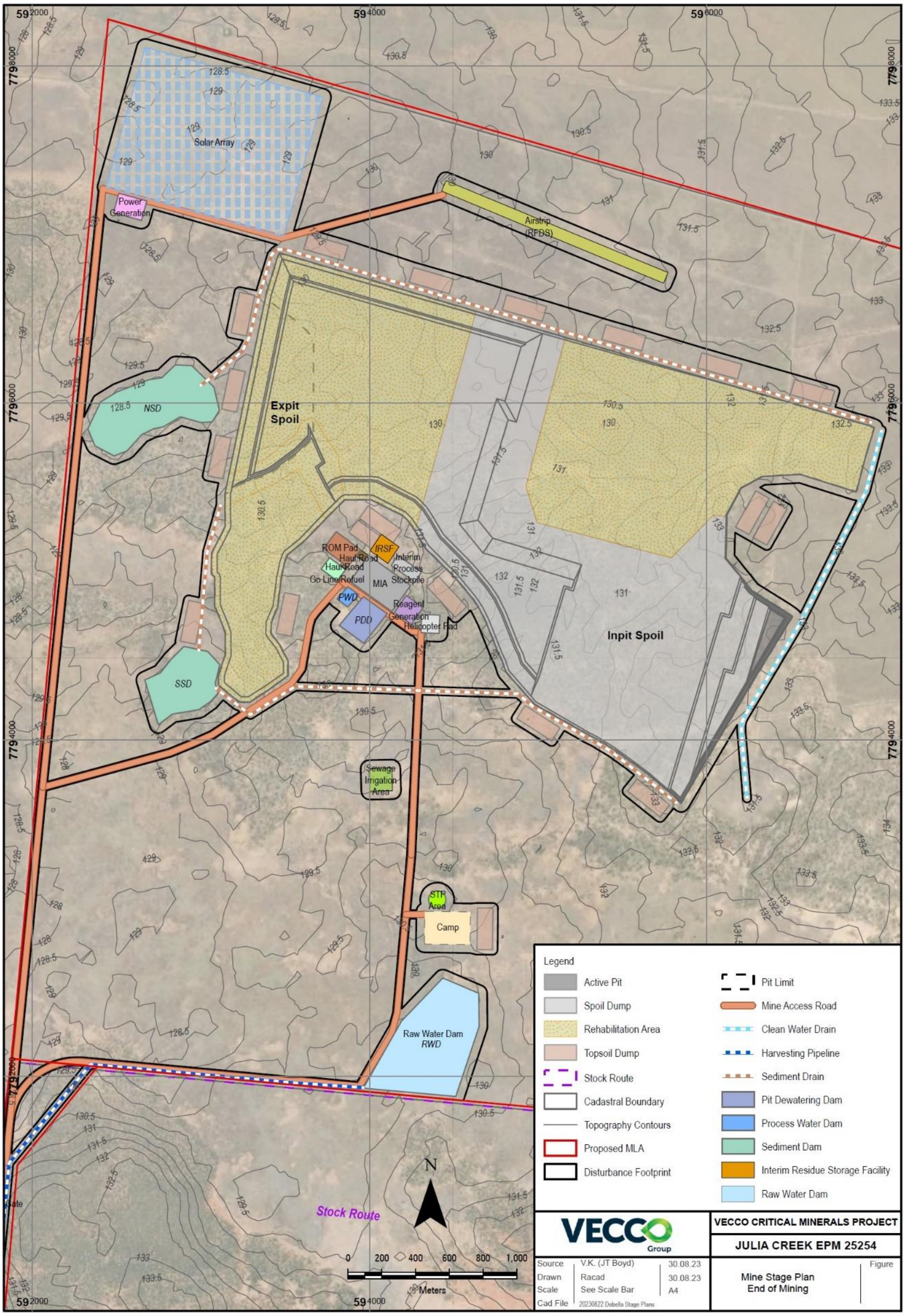


Figure 5.5: End of Mining Water Management Infrastructure

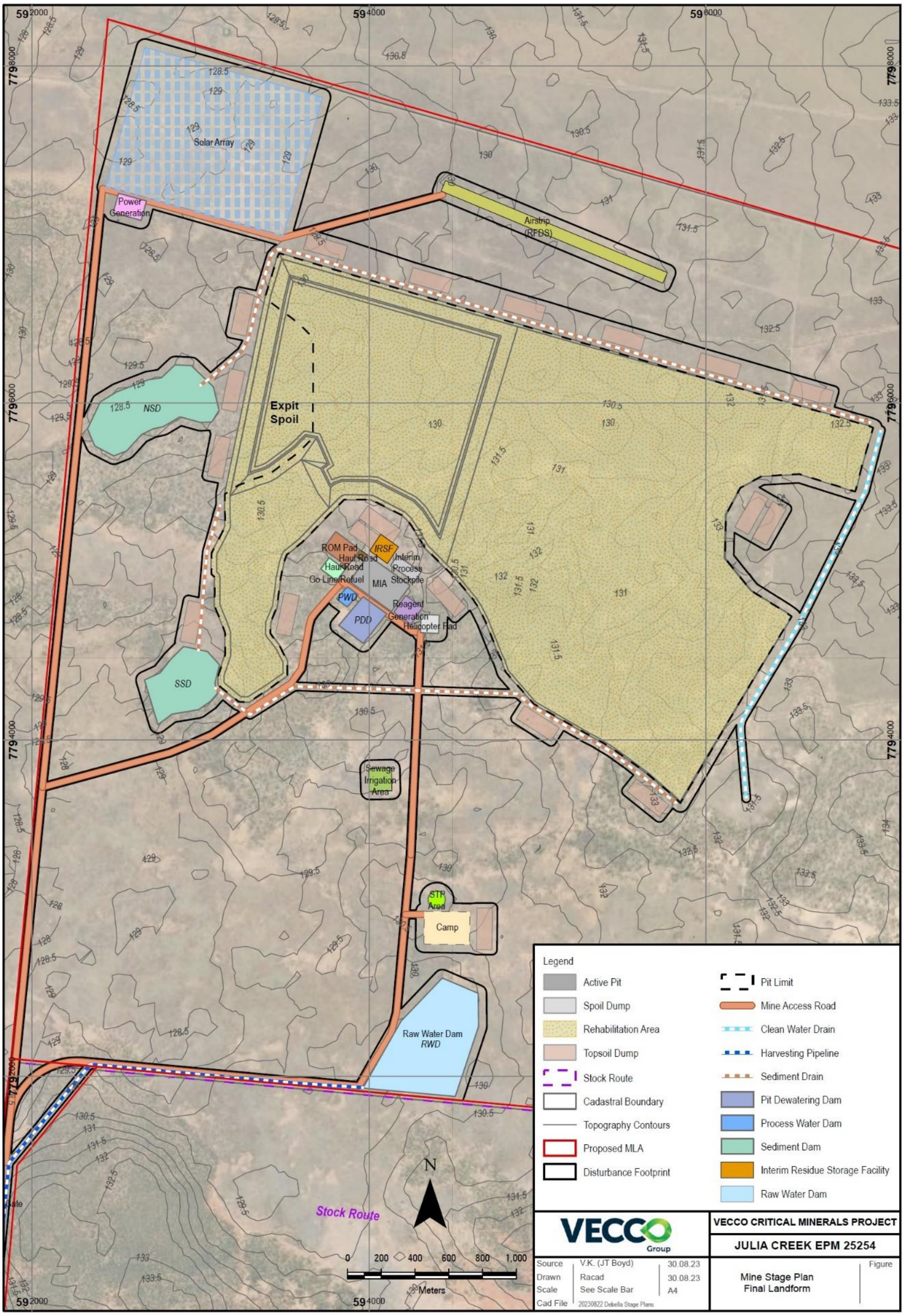


Figure 5.6: Post Closure Water Management Infrastructure

5.3.2 Mine Water Storages

Mine water storages will be used to contain surface water runoff and groundwater collected within the mining pit, recycled water from the Processing plant, and runoff from the Industrial areas.

Site storages for the management of mine affected water are summarised in Table 5.1.

Process Water Dam (PWD) is the central storage to the processing plant and is used for supply of water to the plant and collection of return flows. The PWD is supplied from the other mine water storages as first priority, followed by the sediment dams and then the Raw Water Dam. It is proposed to line PWD to reduce risk of environmental harm due to seepage. The preliminary consequence category assessment determined PWD as having a “low” consequence for the “failure to contain – Seepage” (Section 9.2), however a liner is proposed until additional information is available on the processing plant recycled water quality.

Water collected within the pits from rainfall runoff and groundwater ingress, is dewatered to the Pit Dewatering Dam (PDD) which is then transferred to PWD for use in the processing plant. The Interim Residue Storage Facility (IRSF) is used for drying and temporary storage of processing residue when the pit is inaccessible during and after significant rainfall events, which is then re-handled for disposal in the mining pit during dry conditions.

The preliminary consequence category assessment of the dams (Section 9.2) determined each dam as having a “low” consequence for the “failure to contain – overtopping” scenario and therefore the dams are not required to provide a design storage allowance (containment standard). The mine affected water storages however have been conservatively sized to overtop in less than 1% of years (99th percentile containment). The containment standard of the proposed mine water storages is assessed in Section 6.2.2 which shows no predicted spills of the mine water storages.

Table 5.1: Mine Affected Water Storages

ID	Description	Catchment Area	Full Supply Volume	Estimated Maximum Embankment Height
PWD	Lined excavated storage within the processing plant area used to supply process water demands and receive recycled water flows from the plant. The process water dam will also capture runoff from the plant area and receives pump inflows from the other site storages to maintain supply to water demands.	26 ha	70 ML	None
PDD	Excavated storage used for pit dewatering and supply of water to the process plant via the PWD. The PDD capacity has been sized to maximise pit dewatering.	4 ha	300 ML	None
IRSF	Used for storage of processing residue when the pit is inaccessible which is then rehandled for disposal in the mining pit during dry conditions. The storage will be actively dewatered and maintained empty (other than for temporary storage of residue) during operations.	1.5 ha	247 ML	None

5.3.3 Sediment Storages

Sediment dams are proposed as the primary mechanism to manage runoff from overburden and disturbed areas, which have elevated concentrations of suspended solids. Sediment dams form a key part of the erosion and sediment control management strategy to protect the environmental values of the receiving environment. The principles to be implemented for the Project in managing erosion and sediment control include:

- Minimising surface disturbance.
- Progressive rehabilitation of spoil dumps and disturbed areas to minimise sediment generation.
- Separation of runoff from disturbed and undisturbed areas through drainage controls.
- Construction of sediment dams to contain and treat sediment laden runoff.

The principles for managing erosion and sediment control for the Project are to first minimise the generation of sediment runoff through minimising disturbance, progressive rehabilitation and separation of water types and then secondly treat sediment runoff using sediment dams when prevention is not possible or practical.

Sediment dams will be required to capture runoff from disturbed areas including access roads, unrehabilitated spoil and cleared land. Sediment dams will be constructed at the start of mining to the maximum required capacity to allow capture of runoff or unplanned disturbance in the catchment. The sediment dams are located at the lowest discharge point within the northern section of the Projects Production ML which ensures all water discharging the operational areas will pass through either the Northern Sediment Dam or Southern Sediment Dam.

The sediment dams are sized to contain runoff generated by a 24-hour storm event with an Annual Exceedance Probability (AEP) of 20% (DEHP, 2017) plus 50% of settling volume for sediment storage. The 20% AEP, 24-hour storm event rainfall at the Project location is estimated to be 122 mm (Bureau of Meteorology, 2023). This containment standard is in accordance with the Model operating conditions–ERA 16-Extractive and screening activities (DEHP, 2017) while incorporating sediment storage design standards from the International Erosion Control Association Guidelines (IECA, 2018). Therefore, no further authorisation is anticipated for dirty water overflows from sediment dams, when operated in accordance with this design basis and under a future WMP/ESCP. Placement of sediment dams was determined based on topographical low points. Sediment dams are required around the out-of-pit spoil dump at the North-west side of the Projects Production ML to treat sediment laden runoff before discharging off site. Multiple drains are also proposed to capture and direct runoff from disturbed areas into the sediment dams.

Sediment dams will also be dewatered to the PWD to supply processing demands, which enables the dams to be operated at low volumes improving their availability to contain and treat sediment-affected runoff. Under normal operating conditions the sediment dams will dewater to the mine water system to maintain water supply for processing and miscellaneous dust-suppression demands to reduce reliance on a raw water supply system. In large rainfall events the sediment dams will overflow to the receiving environment.

The design of sediment dams is based on the proposed in-pit waste dump development strategy of covering the backfilled mine spoil with at least 2 m of sub-soils and topsoils to prevent rainfall runoff from coming in contact with the mine spoils. Ongoing monitoring of water quality during operations will be undertaken to confirm runoff from the in-pit waste dump does not include contaminants other than sediment.

Site storages for the management and treatment of sediment runoff are summarised in Table 5.2. Table 5.2 provides details of the concept dam arrangement. The sediment dams are expected to be entirely excavated with small embankments to provide spillway freeboard. The sediment dams will be utilised for the entire mine life and during closure until surface water runoff from the rehabilitated final landform is suitable for discharge without treatment.

The embankment heights and dam configuration will be reviewed as part of the future detailed design for each dam however is not expected to differ significantly from the arrangement described in this surface water assessment.

Table 5.2: Sediment Dams

ID	Description	Maximum Catchment Area During Project Life	Full Supply Volume	Estimated Maximum Embankment Height	Associated Mine Stages
Northern Sediment Dam	Manage sediment runoff generated from northern areas of the Project	526 ha (End of Mining)	467 ML	~ 0.5 m (Embankment to provide spillway freeboard)	Year 1 – End of Mining
Southern Sediment Dam	Manage sediment runoff generated from southern areas of the Project	290 ha (End of Mining)	247 ML	~ 0.5 m (Embankment to provide spillway freeboard)	Year 1 – End of Mining

5.3.4 Raw Water System

To facilitate the Project, a sufficient and reliable raw water supply is required for both the construction and operational stages of the mine and associated infrastructure. The local Project area catchments will not provide sufficient rainfall runoff volumes to maintain supply to project water demands and therefore an external water source is required. Water is planned to be sourced from stream flow harvesting from the Saxby River. Vecco is in the process of applying for a water licence from the unallocated water Strategic Reserve to authorize the raw water supply strategy as well as investigating options to obtain groundwater entitlements. The surface water harvesting system is proposed to be licenced by unallocated water in catchment E (Flinders River Catchment Area) of the Water Plan (Gulf) 2007 from the Strategic unallocated water reserve. The application for the surface water entitlement under the Water Plan (Gulf) 2007 is not associated with the Environmental Authority application for the Project and potential surface water impacts associated with a surface water harvesting system will be assessed and approved through the application process in the Water Plan (Gulf) 2007.

The proposed water supply strategy target for the Project is 95% monthly reliability (water supplied in 95% of months). The streamflow harvesting system currently planned for the Project (pending outcomes of water licence application) includes:

- A pump station in the Saxby River near the mine access road (the access road will train water to the pump station sump).
- A rising main to an off-stream storage (RWD).
- Delivery pipeline from RWD to the PWD/processing plant.

The water licence application included a system reliability assessment to determine the licencing and infrastructure requirements for the water supply system. The Raw Water Dam is required to store water harvested from the Saxby River to supply processing and other operational water demands. Details of the Raw Water Dam are provided in Table 5.3.

The Raw Water Dam will include two excavated storage cells within the dam footprint, with the cells being sequentially filled and dewatered to minimise evaporation and seepage losses to reduce water take requirements and improve the Project water security.

In addition to a water harvesting supply, Vecco continues to investigate the availability of alternate water supply options, including water sharing agreements with surrounding stakeholders and water supplied from existing authorised groundwater sources.

Table 5.3: Raw Water Dam Details

Item	Description
Dam Capacity	2,500 ML.
Dam Construction	Excavated storage with two cells approximately 10m deep. (Geotechnical investigations and detailed design to confirm construction arrangement to be undertaken prior to construction)
Dam Flood Immunity	Probable Maximum Flood (PMF)

5.3.5 Clean Water Management

Diversion of clean catchment has been maximised to reduce clean catchment runoff entering the active mining pit and the mine water management system. Clean water is proposed to be diverted by diversion drains that will redirect upslope drainage around the active mining operations. It is proposed to stage the clean catchment diversion drains with the mining progression to minimise disturbance.

The clean water diversion drains will be small (approximately 1m deep) and will be mostly excavated with small earthen bunds as required.

5.3.6 Flood Protection

The project disturbance and infrastructure (except for the mine access road) will be located outside of the Saxby River Probable Maximum Flood (PMF) extent and therefore flood protection measures are not required for the Project (refer Section 8.4).

5.4 WATER DEMAND AND SUPPLY

As part of the current development strategy, water requirements for various construction and operational activities have been reviewed and it has been estimated that the Project requires an average 1,400 ML/year (pending further metallurgical and pilot plant testing to refine estimates) of secure supply for the Project. The target water supply reliability for the Project is greater than 95% monthly reliability (water demands supplied in 95% of months for the Project life). Water demands for the project include:

- Construction of off-lease and on-lease infrastructure, including dust suppression, washdown, earthworks, civil works, firewater system, and commissioning,
- Potable water supply to meet the needs of the workers, and
- Operation of the mine, including mineral processing, dust suppression (stockpiles, transfer stations, and roads), residue management, equipment and vehicle washdown.

Water for Project demands is expected to be primarily supplied from external raw water supplies and supplemented from rainfall runoff collected in storages and open cut mining areas, process water recycling and water recovered from residue material.

6 WATER BALANCE MODEL

6.1 OPERATIONAL WATER BALANCE MODEL

A site water balance model was developed using the GoldSim modelling software. This model has been designed to represent the water management system and surrounding waterways over the operational life of mine. The site water balance model is used to calculate water volume as well as salinity using a mass balance approach. The model uses the Australian Water Balance Model (AWBM) to estimate rainfall runoff from climate data inputs.

Key model outputs used to assess the water management system include:

- Containment performance of key water storages.
- Pit inundation frequency, volume, and duration.
- Water supply demands and shortfalls.
- External water supply requirements.
- Changes to streamflow regime in surrounding waterways.

The general water management system operation is described in Table 6.1 below. A schematic of the water management system is provided in Figure 5.1. The water balance model replicates the transfer rates and destinations of the schematic. Figure 5.2 to Figure 5.6 provide conceptual site layouts of the water management system at key mine stage horizons and post closure.

For detailed descriptions and design standards for the storages refer to Section 5.3.

Table 6.1: Water Management System Operation of Storages

Storage	FSV (ML)	Max Operating Volume (ML)	Pump Rate (L/s)	Maximum Catchment Area during Project (ha)	Pump Destination	Years Active
Raw Water Dam	2,500	2,400	100	30	Process Water Dam/ Processing Plant	Year 1 – End of Mining
Mining Pit	>5000 ML[1]	-	100	179	Pit Dewatering Dam	Year 1 – End of Mining
Pit Dewatering Dam	300	280	100	4	Process Water Dam	Year 1 – End of Mining
Process Water Dam	70	30	(Based on Demand)	26	Processing Plant	Year 1 – End of Mining
Interim Residue Storage Facility	246	Empty[3]	30	1.5	Process Water Dam	Year 1 – End of Mining
Northern Sediment Dam	109.8[2]	76.9	30	527	Process Water Dam	Year 1 – End of Mining
Southern Sediment Dam	79.3[2]	55.5	30	292	Process Water Dam	Year 1 – End of Mining

[1] Pit storage volume varies and is actively dewatered.

[2] Sediment Dam volume includes sediment storage volume and settling zone volume.

[3] The Interim Residue Storage Facility is maintained empty as it is only used for storage of processing residue when the pit is inaccessible which is then rehandled for disposal in the mining pit during dry conditions.

6.1.1 Climate Inputs

Climate data inputs to the water balance model were sourced from both BOM rainfall stations and Silo Data Drill (DES, 2022). The continuous daily rainfall series was developed by adopting recorded data from the nearest gauge in operation over the time period. A 132-year data set was used to allow continuous simulation of scenarios.

Table 2.1: summarises the rainfall data sources utilised in the model in order of proximity to the Project and Table 6.2 presents the available record for each of the gauges.

Table 6.2: Available Rainfall Record

Rainfall Station/Data	Record Available													
	1889	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020
Zonia Downs (029051)	0%	0%	0%	54%	100%	42%	100%	100%	100%	100%	98%	99%	72%	0%
Bunda Bunda (029005)	51%	63%	100%	97%	70%	86%	100%	99%	94%	83%	59%	54%	52%	51%
Crowfels Station (029011)	0%	0%	37%	77%	94%	94%	24%	37%	94%	100%	100%	100%	99%	20%
Millungra Station (029036)	27%	70%	98%	76%	98%	100%	100%	97%	99%	100%	99%	97%	93%	75%
Manfred Downs (029132)	98%	40%	51%	20%	57%	50%	30%	95%	84%	49%	100%	100%	100%	100%
SILO Climate Database	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Daily Lake evaporation and evapotranspiration data were also input to the water balance model for the purpose of estimating evaporation losses from storages and informing the daily rainfall runoff model (AWBM) respectively. 132-year data sets for these data types were sourced from SILO Data Drill (DES, 2022). Monthly average rainfall, lake evaporation and potential evapotranspiration for the Project are summarised in Table 6.3.

Table 6.3: Monthly Average Climate Data

Month	Rainfall (mm)	Lake Evaporation (mm)	Potential Evapotranspiration (mm)
January	140	218	291
February	126	189	247
March	71	191	271
April	18	158	253
May	12	125	211
June	11	103	174
July	7	113	193
August	2	143	242
September	4	175	289
October	14	214	343
November	34	221	340
December	78	229	332
Annual Totals	**517**	**2079**	**3187**

6.1.2 Catchment Runoff

Catchment runoff has been simulated using the Australian Water Balance Model (AWBM). The model represents the catchment using three surface stores to simulate partial areas of runoff. The water balance of each surface store is calculated independently of the others. The model calculates the water balance of each partial area at daily time steps. At each time step, rainfall is added to each of the three surface stores and evapotranspiration is subtracted from each store. If the value of water in the store exceeds the capacity of the store, the excess water becomes runoff. Part of this runoff becomes recharge of the base flow store if there is a base flow component to the stream flow. A schematic representation of the AWBM model is provided in Figure 6.1.

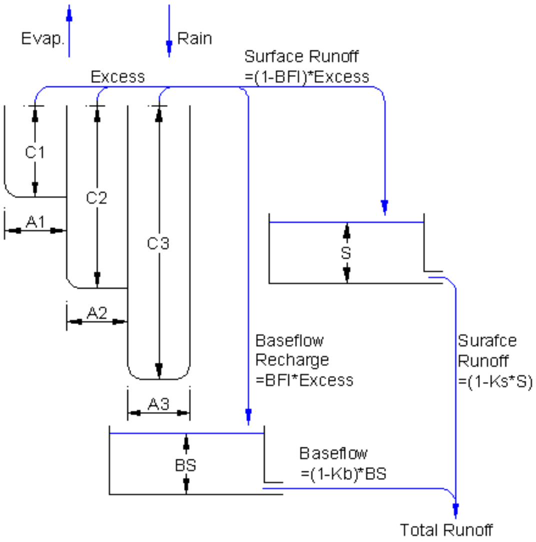


Figure 6.1: AWBM Schematic

The natural and rehabilitation landuse parameters have been calibrated to the Saxby River at Punchbowl (915017A) gauging station as described in Section 6.1.3. The waste dump and hardstand AWBM parameters were sourced from the recently approved St Elmo Vanadium Project water balance assessment (Engeny, 2020) in the absence of better local information. The adopted AWBM parameters are shown in Table 6.4.

Table 6.4: AWBM Parameters

Parameter	Natural	Waste Dump	Hardstand and Mining Pit	Rehabilitated Spoil
A1	0.134	0.134	0.134	0.134
A2	0.433	0.433	0.433	0.433
A3	0.433	0.433	0.433	0.433
C1 (mm)	40	10	5	40
C2 (mm)	290	100	10	290
C3 (mm)	370	400	25	370
BFI	0.5	0.8	0.1	0.5
Kb	0.72	0.5	0.5	0.75
Ks	0.05	0.05	0.05	0.05
Average annual runoff coefficient	**5.4%**	**12.84%**	**44.8%**	**5.4%**

The AWBM runoff parameters represent the surface rainfall runoff component of the catchment areas. The deep seepage volume that reports to the pit floor from the rehabilitation and spoil areas was considered to be negligible as described in Section 0.

The performance of the adopted AWBM parameters will continue to be validated as part of the model update and review program described in Section 10.3.

6.1.3 Natural Runoff Model Calibration

Natural and rehabilitation landuse AWBM parameters were calibrated to recorded flows at the Saxby River at Punchbowl (915017A) stream gauging station for the period 2014 to 2022, using gridded SILO Data Drill climate data (rainfall and evapotranspiration). The calibrated AWBM was then used to generate a long-term Saxby River stream flow sequence for the period 1889 to 2022.

AWBM calibration results comparing modelled and recorded daily streamflow duration are provided in Figure 6.2 and cumulative flow in Figure 6.3. Results comparing recorded and modelled daily flow volumes for several large flow events during the period are also provided in Figure 6.4.

Table 6.5 presents the gauged and modelled (AWBM) number of days flow exceeded 10 m^3/s during the calibration period which is the current proposed environmental flow threshold before water extraction could occur from the Saxby River. The calibration results show:

- Predicted streamflow volumes were generally consistent with the observed streamflow volumes.
- The predicted daily streamflow duration results match very well for flows above 0.1 ML/day.
- The AWBM predicted daily flows for the individual events matched generally well in timing and peak flows considering the limited recorded rainfall data available in the catchment during the calibration period.
- The comparison of the gauged and modelled flows for the period 2014 to 2022 shows the AWBM predicts a very similar number of days per year that flow exceeded 10 m^3/s for both dry and wet years (refer Table 6.5).

Two key limitations of the AWBM calibration were:

- The AWBM calibration period was limited to 8 years based on the available gauging and the accuracy of the AWBM may be limited to the climate conditions during that period.
- There was limited spatial distribution of rainfall monitoring stations within the Saxby River catchment during the calibration period which limits the accuracy of the model calibration.

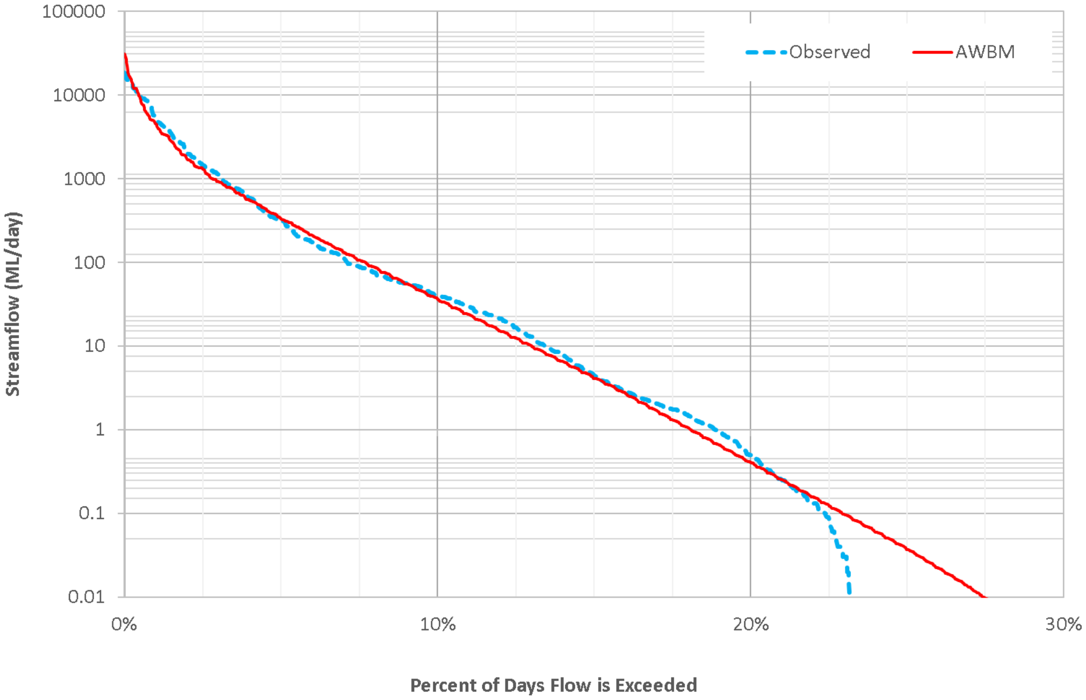


Figure 6.2: Saxby River AWBM Calibration Result – Daily Streamflow Duration

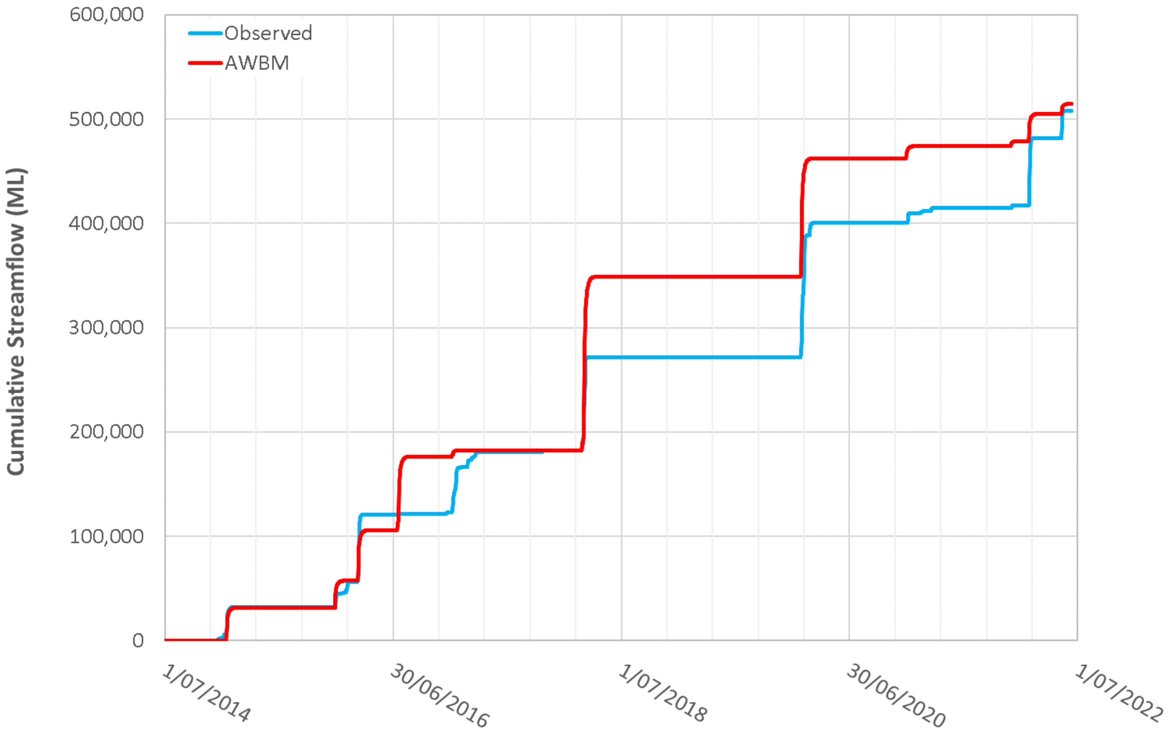


Figure 6.3: Saxby River AWBM Calibration Result - Cumulative Flow Volume

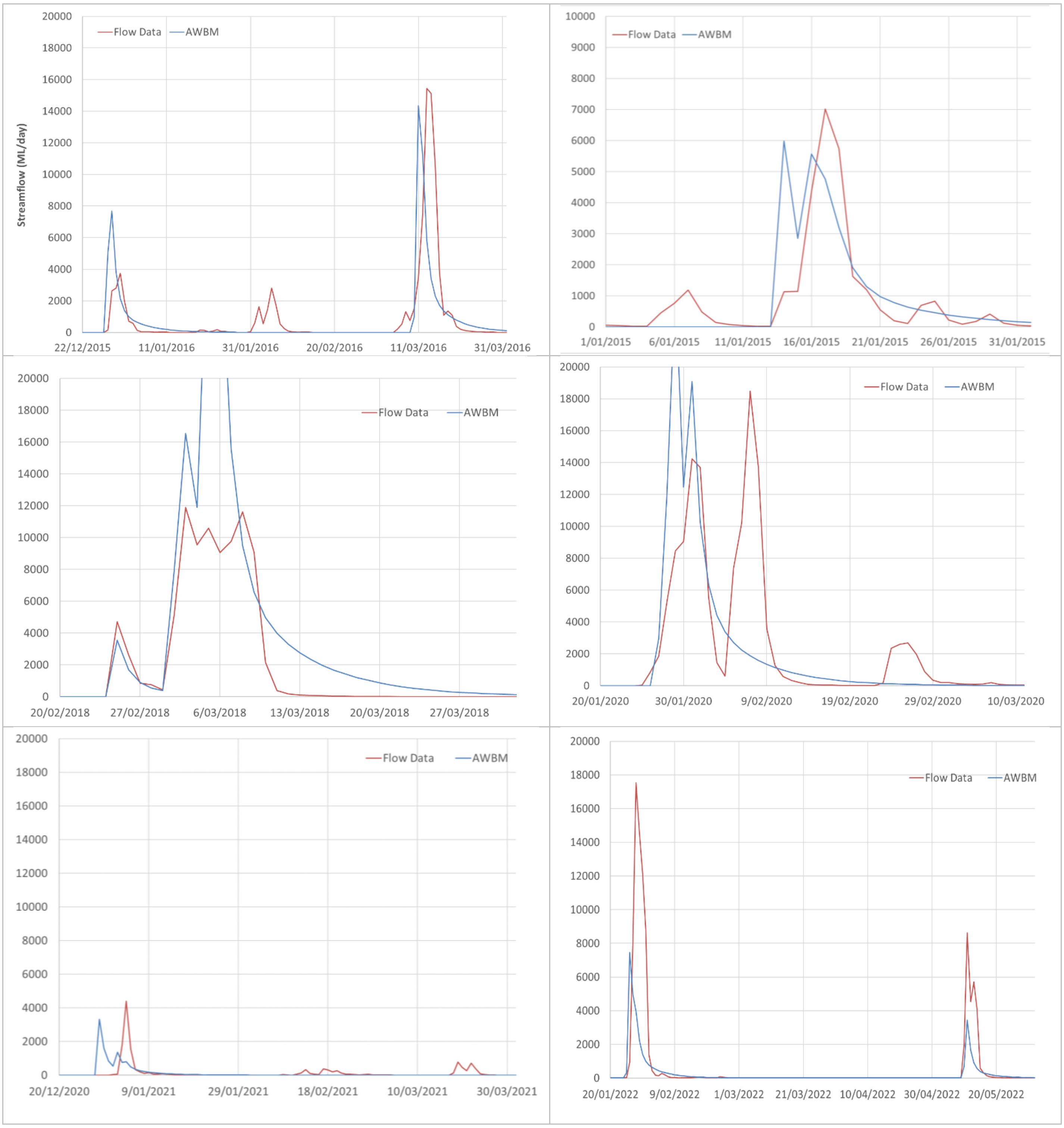


Figure 6.4: Saxby River AWBM Calibration Result – Daily Flow for Individual Events

Table 6.5: Comparison of Gauged and Modelled Annual Duration Saxby River Flow Exceeds 10m^3/s

Year (July-June)	Number of Days Saxby River Flow Exceeded 10m^3/s (Proposed flow trigger to allow streamflow harvesting)	
	Recorded (GS 915017A)	**Model (AWBM)**
2014-15	8	8
2015-16	19	16
2016-17	21	16
2017-18	11	22
2018-19	16	39
2019-20	19	16
2020-21	3	3
2021-21	13	11

6.1.4 Catchment Areas

Catchment areas were determined for all storages across the life of the mine. Catchment boundaries were defined using the proposed mine and dump planning in conjunction with topographical survey of the Project Area. It is assumed that rehabilitation areas will require a 5-year establishment period before runoff would be of suitable quality for being able to be discharged from site. All rehabilitated catchments were however modelled to continually report to the sediment storages as the project will continually require water supply for water demands.

A summary of the site storage catchment areas is presented in Table 6.6.

Table 6.6: Total Site Storage Catchment Area by Landuse and Mining Stage (hectares)

Landuse	Year 1	Year 10	Year 20	End of Mining
Natural	297	234	321	248
Waste Dump	55	204	376	265
Hardstand and Mining Pit	108	120	119	100
Rehabilitated Spoil	0	26	103	366
Total Area	**459**	**585**	**919**	**980**

6.1.5 Groundwater

Negligible groundwater ingress into the mining pit is expected. This is due to:

- The pits will be relatively shallow with a maximum depth of 35 m and high evaporation rates will reduce any ingress volumes incurred as a result of potential interaction with the water table (JBT Consulting, 2023).
- The permeability of the Toolebuc Formation in which the vanadium deposit is located, is low to very low (JBT Consulting, 2023).

For these reasons no groundwater ingress has been modelled in the water balance model, as rainfall and evaporation will have much greater influence on the project and the performance of the surface water management system.

6.1.6 Water Storage Seepage Losses

Seepage losses were included from the Raw Water Dam and the sediment dams at a constant nominal rate of 1 mm/day. Seepage rates are highly dependent on the geotechnical conditions under the dam impoundment and will be determined through targeted investigations during detailed design. No seepage losses were modelled from the mine water storages as it is expected they will be constructed to minimise seepage losses for the containment of mine affected water.

6.1.7 Starting Conditions

All storages besides the Raw Water Dam and the Process Water Dam were assumed to be empty at the start of the simulation, in compliance with their design standard. Raw Water Dam has been modelled starting with an initial inventory of 1000 ML which is assumed to be harvested from the Saxby River prior to starting mining operations. The Process Water Dam was modelled with a starting inventory of 30ML which is assumed to be supplied from the Raw Water Dam.

Water demands associated with the initial construction of the mine, levees and water storages is assumed to be supplied from the Raw Water Dam via surface water harvesting. The water supply strategy for the construction phase of the mine will be developed as part of the detailed construction plan for the Project.

6.1.8 Saxby River Flow

The Saxby River streamflow adopted to assess raw water harvesting opportunity has been calculated using the calibrated AWBM rainfall runoff model for the Saxby River catchment described in Section 6.1.3. The AWBM model was used to calculate a continuous daily streamflow model for the Saxby River that aligned with the climate period used for the operational model simulations.

Figure 6.5 shows the flow duration curve for the modelled long term streamflow series compared to the available recorded data at the Saxby River at Punchbowl gauging station. The comparison shows the modelled streamflow duration is higher than the gauging station data which is due to the short period of available gauging data compared to the 130 years of climate data used to inform the model.

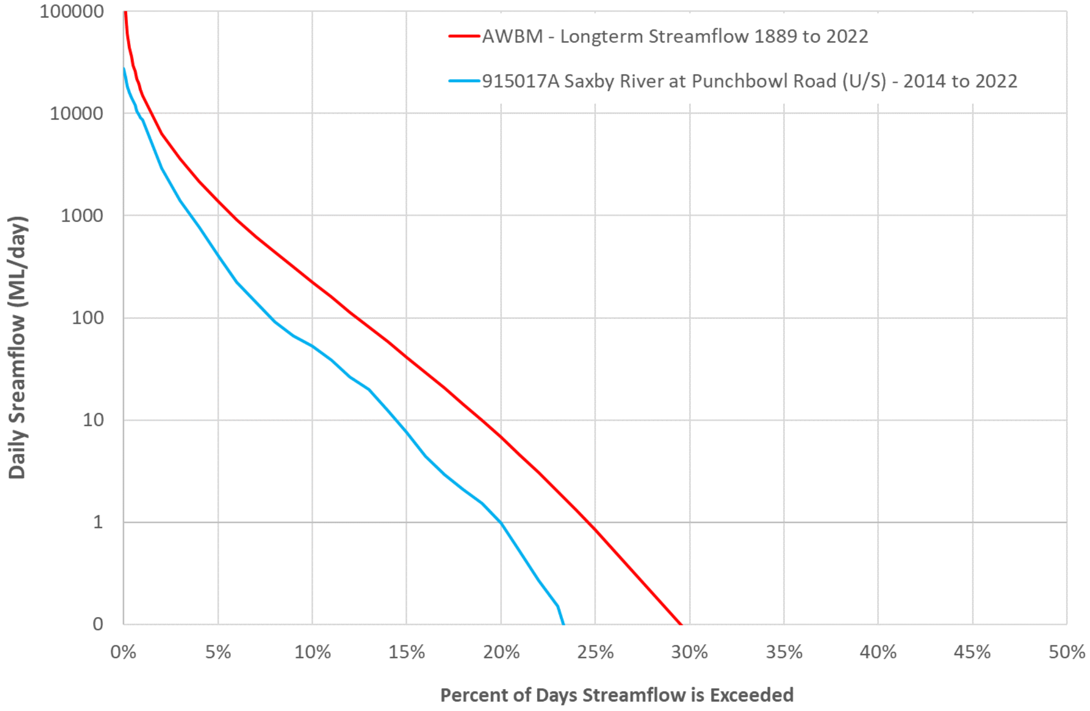


Figure 6.5: Modelled Long Term Saxby River Streamflow Duration Curve

6.1.9 Simulation Details

The GoldSim model was run with a daily timestep as a probabilistic simulation for a period of 25 years, for the operational life of the mine. The model was simulated for 106 realisations stepping through 25-year sequences of the 132 years of available climate data for the mine site (1889 to 2022). The first model simulation realisation uses climate data from 1889 to 1913, the second realisation uses climate data from 1890 to 1914 and so on. Climate data was not "wrapped" to allow for additional realisations because the interannual climate patterns captured by running a simulation for an extended period of time cannot be accurately modelled using non-consecutive climate years.

6.2 WATER MANAGEMENT SYSTEM PERFORMANCE

The Project average annual water balance (inflows and outflows) for the key mine plan stages are summarised in Table 6.7 and shown for year 20 in Figure 6.6. The average annual water balance provides an indication of the interaction between the mine plan and the water demands and supply. The key outcomes from the average annual water balance include:

- The water management system is generally in deficit with external water supply from the streamflow harvesting system required to maintain supply to the Project water demands.
- Rainfall and runoff volumes are highest towards the end of the mine plan (year 20 to End of Mining) when catchments reporting to the pit and sediment dams are largest.
- Rainfall and runoff collected in site storages accounts for on average 45% of total water inflows to the system with the remainder being supplied from streamflow harvesting.
- Process water demands are the largest system outflow followed by evaporation.
- Evaporation losses from the Raw Water Dam are expected to be high as the dam will aim to remain full to provide a reliable supply of water during prolonged dry periods where flow conditions in the Saxby River are not suitable for harvesting.

Table 6.7: Average Annual Water Balance (ML/year)

Inflow / Outflow	Year 1	Year 10	Year 20	End of Mining
Direct rainfall on ponded areas	128	144	168	163
Rainfall runoff to mine water and sediment dams	287	415	588	553
Groundwater inflow to mining pit	0	0	0	0
Surface Water Harvesting (Saxby River to RWD)	1,654	1,364	1,306	1,349
Total Inflows	2,070	1,923	2,063	2,066
Evaporation	405	495	558	538
Seepage	65	81	92	90
Project Water Demands	1,360	1,309	1,343	1,336
Sediment Dam Overflow	17	24	83	102
Mine Water Storage Overflows	0	0	0	0
Total Outflows	1,846	1,909	2,077	2,066
Change	**224**	**14**	**-14**	**0**

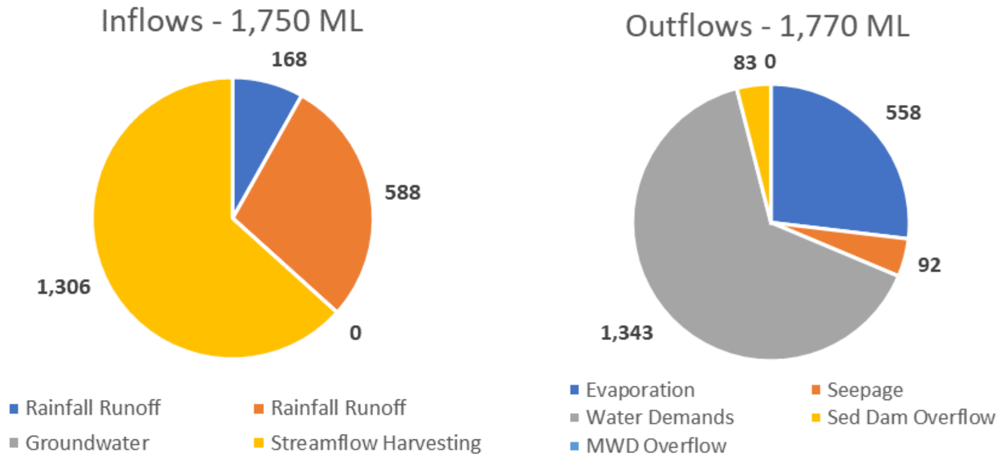


Figure 6.6: Average Annual Inflow/Outflow – Year 20

6.2.1 Site Water Inventory

Modelled total site inventory and the mine water inventory are presented in Figure 6.7 and Figure 6.8 respectively for the project duration. The site has a modelled maximum stored inventory of approximately 3.4 GL in Year 20 in the 95th percentile. Year 20 corresponds to the largest combination of catchment runoff reporting to the mining pit. The majority of the total site inventory is contained within the Raw Water Dam (2.5GL capacity) which is supplied by raw water harvesting from the Saxby River.

The total 95th percentile mine water inventory (including the mining pit) is expected to peak at approximately 300 ML in year 20 however the model results show inventory is quicky reduced due to preferential reuse of mine water over raw water. The median mine water inventory remains low and is only expected to increase during significant rainfall events.

When out-of-pit mine water storage inventory is exceeded, mine water will be stored temporarily in the mining void. Water balance modelling indicates a maximum pit inventory of 70 ML in the 95th percentile.

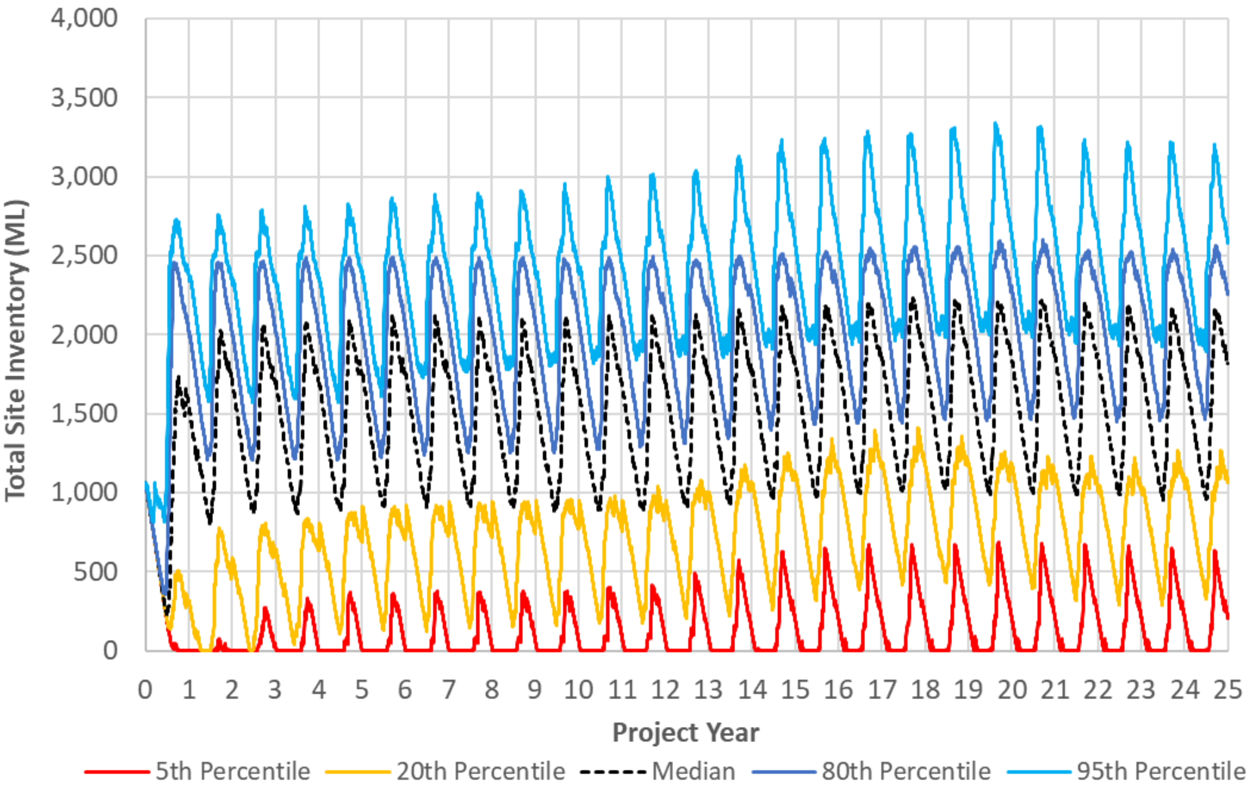


Figure 6.7: Total Site Inventory Results

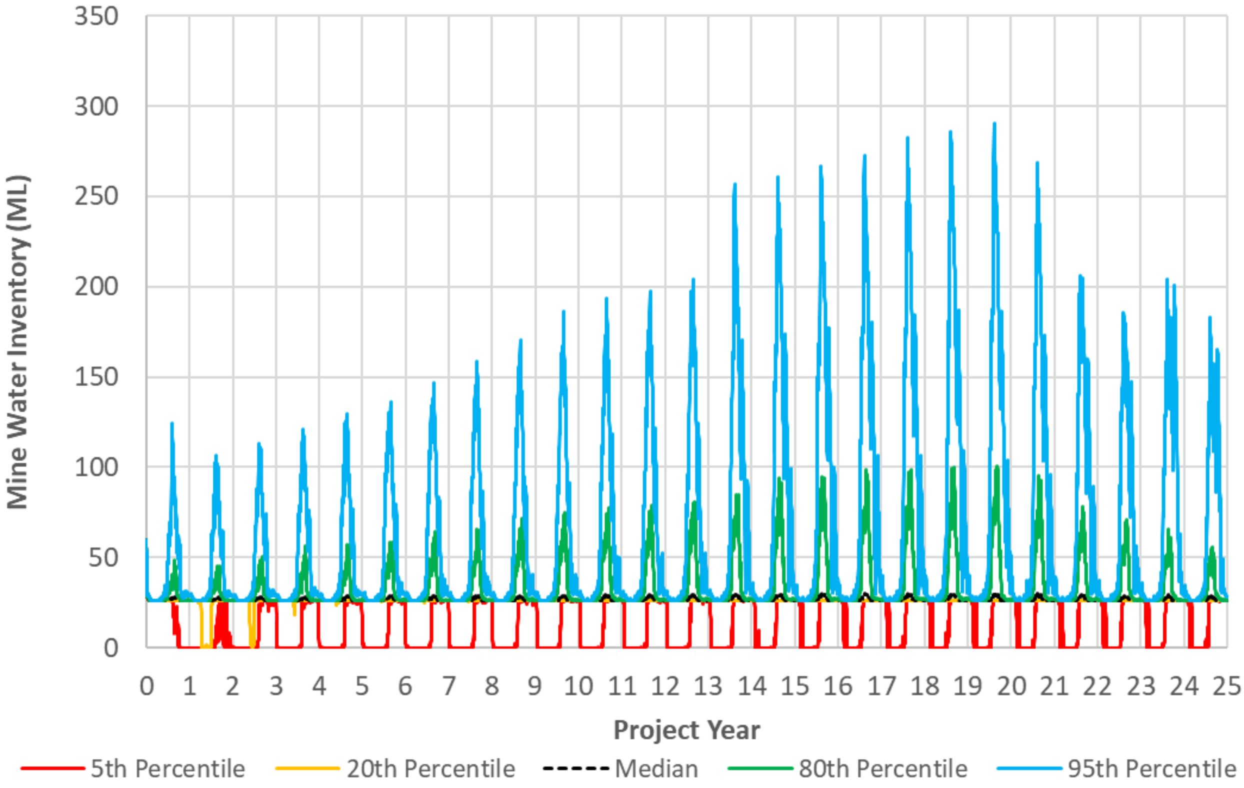


Figure 6.8: Mine Water Storage Inventory Results (Excludes RWD and North/South Sediment Dams)

6.2.2 Mine Water Dams Containment

The site water balance model was then used to determine the overflow frequency of the mine water storages. The Pit Dewatering Dam which receives overflows from the Process Water Dam and the Interim Residue Storage Facility showed no overflows for the model simulation period indicating a greater than 1% AEP annual containment standard. Emergency pumping from the Process Water Dam and/or the Pit Dewatering Dam to the mining pit will be undertaken to prevent overtopping from the mine water system during periods of extended rainfall where the process plant may be not operational.

6.2.3 Sediment Dam Overflows

Sediment dams were designed to contain the 20% AEP 24-hour rainfall depth with allowance for sediment storage (see Section 5.3.3). The overflow frequency of the sediment dams was assessed in the operational water balance model to confirm the containment standard and determine potential overflow volumes. The maximum annual overflow frequency of the sediment dams and the year which this occurs is provided in Table 6.8. Figure 6.9 shows modelled sediment dam overflow volumes in large wet years.

The operational water balance model results show the sediment dams overtop in 11% to 13% of years during Year 20 however for the first 10 years of the Project the sediment dams are expected to overflow in less than 5% of years. This is a higher containment standard than the adopted design standard of 20% AEP. The sediment dam catchment areas change over the life of the project with the progression of the mining pit. The sediment dams are designed to achieve the required containment standard for the largest reporting catchment area over the project life.

During overtopping events, coarse sediments will continue to settle out as water flows through the dam reservoirs providing residence time. Sediment dams will be designed such that overtopping velocities are managed so they do not cause scour in the overtopping flow paths. Spillway control structures may include or be a combination of rock chutes, rock aprons and/or level spreaders.

Table 6.8: Maximum Sediment Dam Overflow Frequency

Sediment Dam	Maximum Annual Overflow Frequency (% of years)	Year with Highest Overflow Frequency
Northern Sediment Dam	11%	Year 20
Southern Sediment Dam	13%	Year 20

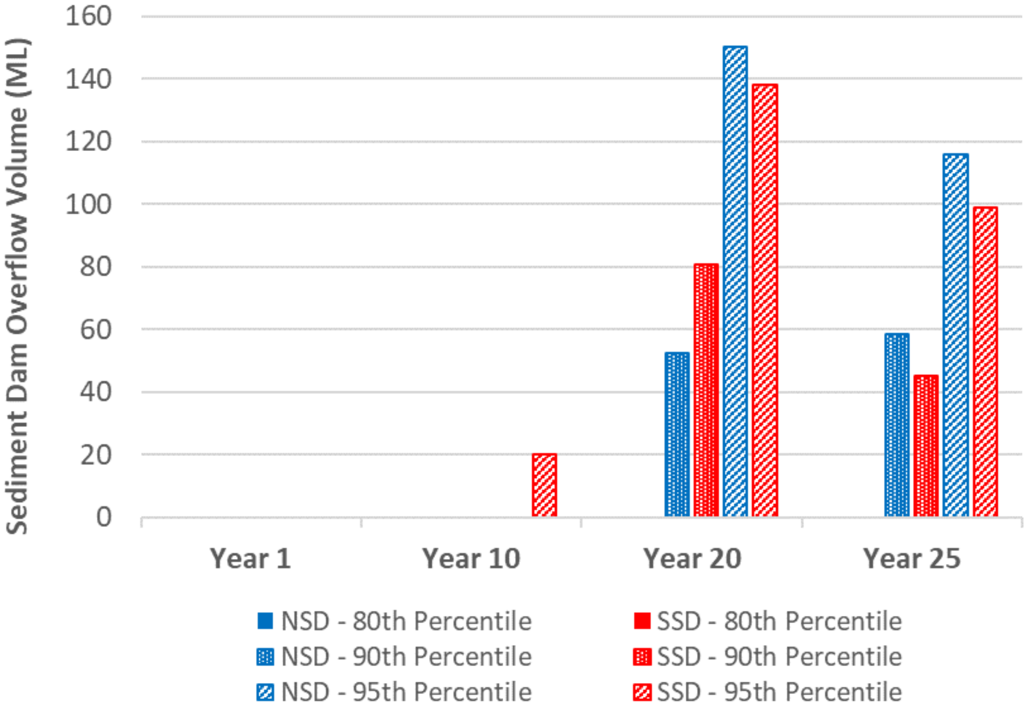


Figure 6.9: Modelled Sediment Dam Annual Overflow Volumes

6.3 CLIMATE CHANGE SENSITIVITY ASSESSMENT

A climate change sensitivity assessment was undertaken to understand the impact of climate change on the outcomes derived from the operational and final void water balance assessments. The model climate data inputs were adjusted using the methodologies outlined in “Climate Change in Australia Technical Report” (CSIRO, 2015) to undertake the sensitivity assessment. The CSIRO report provides projections of future climate variables for several greenhouse gas and aerosol emission scenarios (Representative Concentration Pathways).

Climate projections for the Project were obtained using the projection builder tool (Whetton P, 2012) provided on the Climate Change Australia website which was developed using the climate model evaluations detailed in the CSIRO report. Projections were obtained for the “Best” and “Worst” case scenarios which are based on the following:

- Best Case – lower rainfall and higher evaporation, reducing rainfall runoff resulting in reduced risk of overflows from storages.
- Worst Case – higher rainfall and lower evaporation, increasing rainfall runoff resulting in increased risk of overflow from storages.

Projections are also provided for the “Maximum Consensus” which is the climate future projected by at least 33% of the climate models and which comprises at least 10% more models than any other. The “Maximum Consensus” is considered the most representative forecast of all the climate models.

Projected changes to annual rainfall and evapotranspiration were obtained for the Representative Concentration Pathway 8.5 (RCP8.5) for the 2050 projection year. RCP8.5 represents no intervention to reducing greenhouse gas and aerosol emissions.

The predicted change in evapotranspiration has increased for all climate change scenarios while annual rainfall is predicted to vary by +10% to -7% with the maximum consensus showing a reduction of 2.6%.

Table 6.9: Climate Change Sensitivity Parameters

Projection Year	Scenario	Change in Annual Rainfall	Change in Annual Evapotranspiration	Climate Model
2050	Best Case	-10.3%	5.0%	GFDL-ESM2M
	Worst Case	7.2%	3.8%	NorESM1-M
	Maximum Consensus	-2.6%	6.2%	CESM1-CAM5

6.3.1 Operational Water Balance Climate Change Sensitivity Assessment

The Project operational water balance model daily climate inputs were adjusted using the year 2050 climate projections in Table 6.9 to assess the impact of the "Best" case, "Worst" case and "Maximum consensus" climate change scenarios on the water balance assessment results. The year 2050 projected climate change variables are expected to reduce the volume of runoff reporting to the water management system and increase evaporation losses from storages. This is expected to result in lower site water inventories with a reduced risk of uncontrolled release which reduces the overall risk to the receiving surface water environment.

7 FLOOD ASSESSMENT

7.1 OVERVIEW

Flooding impacts associated with the Project have been assessed through the development of hydrologic and hydraulic models of the Saxby River and Flinders River systems to assess extreme flooding and potential interactions with the Project. The Project is located on the northern side of the Saxby River where topography is higher than the southern bank with flooding interactions with the Project only expected to be possible in extreme events.

The surface topography in the vicinity of the Project area slopes southwest from the Saxby River towards the Flinders River. Figure 7.1 represents a cross section of the survey data taken from the Project area, extended to Julia Creek showing extreme flooding is expected to spread in a southwest direction from the Saxby River towards the Flinders River and Julia Creek. For periods of high flows within the Saxby River, flood waters are likely to break out of the Saxby River channel and flow towards the Flinders River limiting the potential for flooding on the northern bank of the Saxby River where the Project is located.

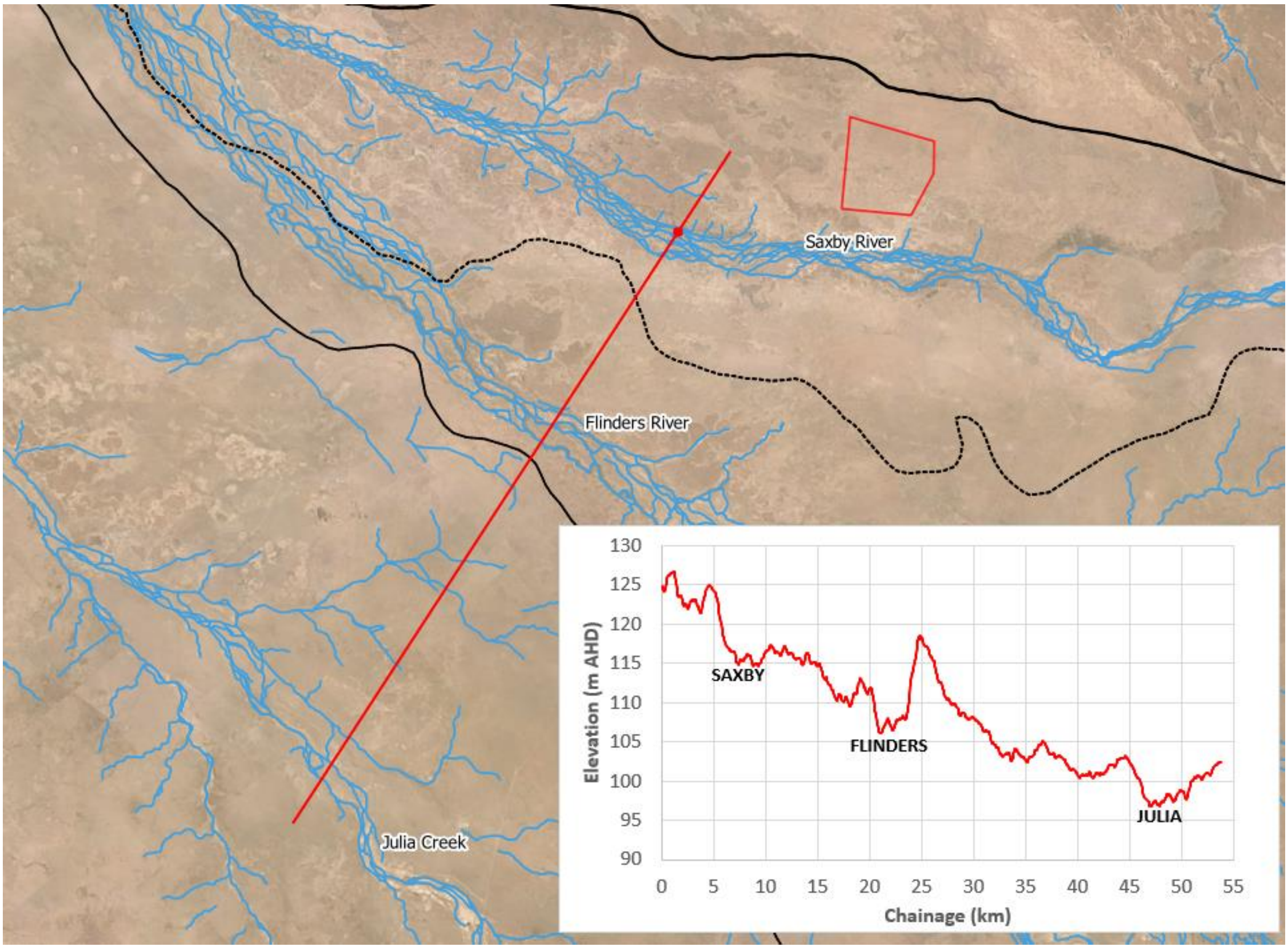


Figure 7.1: Floodplain Topography Adjacent the Project

The subsequent sections described the development and application of hydrologic and hydraulic models and the assessed flooding interactions and outcomes for the Project.

7.2 HYDROLOGY

7.2.1 Overview

A hydrology model of the Flinders and Saxby River catchments was developed to assess design event hydrology and produce flood hydrograph inputs to the hydraulic model to assess flooding and associated impacts for the Project. The hydrology model was parameterised based on available standard regional relationships and then validated to the January 2019 historical flood event and flood frequency analysis of a streamflow gauge in the Flinders River catchment with a sufficient length of record. The historical flood event was not used entirely to calibrate the hydrology model parameters due to the following reasons:

- The streamflow gauges in the Flinders River and Saxby River catchments are all very poorly rated with manual gauging used to develop the rating curves being generally less than 3% of the reported peak flow during the 2019 flood event.
- The available gauged rainfall data for the Flinders River and Saxby River catchments is poor with significant distances between available pluviograph rainfall records which are required to determine rainfall distribution during historical events.
- Flooding in the Flinders River is very widespread with flooding downstream of the Richmond Township spreading between other major river systems (Cloncurry River) which cannot be represented in a standard hydrology model.

7.2.2 URBS Model Development

An URBS (Unified River Basin Simulator) hydrologic model of the entire Flinders and Saxby River catchments was developed and calibrated to the January/February 2019 flood event. The 2019 version of the URBS software was used. The Basic Model approach of URBS was used which combines the catchment and channel routing calculations. The URBS hydrologic model was validated and then used to derive design flood hydrographs for the Saxby and Flinders Rivers for the 0.1% AEP flood event and the Probable Maximum Flood (PMF) event.

7.2.3 Model Definition

The URBS model structure was generated automatically using the CatchmentSIM software. The sub-catchment and channel parameters were determined based on the 28 m cell size Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) of the Flinders and Saxby River catchments surfaces.

The catchment was subdivided into 190 sub-catchments as follows:

- 25 sub-catchments for the Saxby River catchment (total area 7,707 km^2).
- 165 sub-catchments for the Flinders River catchment (total area 46,649 km^2).

The sub-catchment delineation adopted for the hydrology model is shown in Figure 7.2.

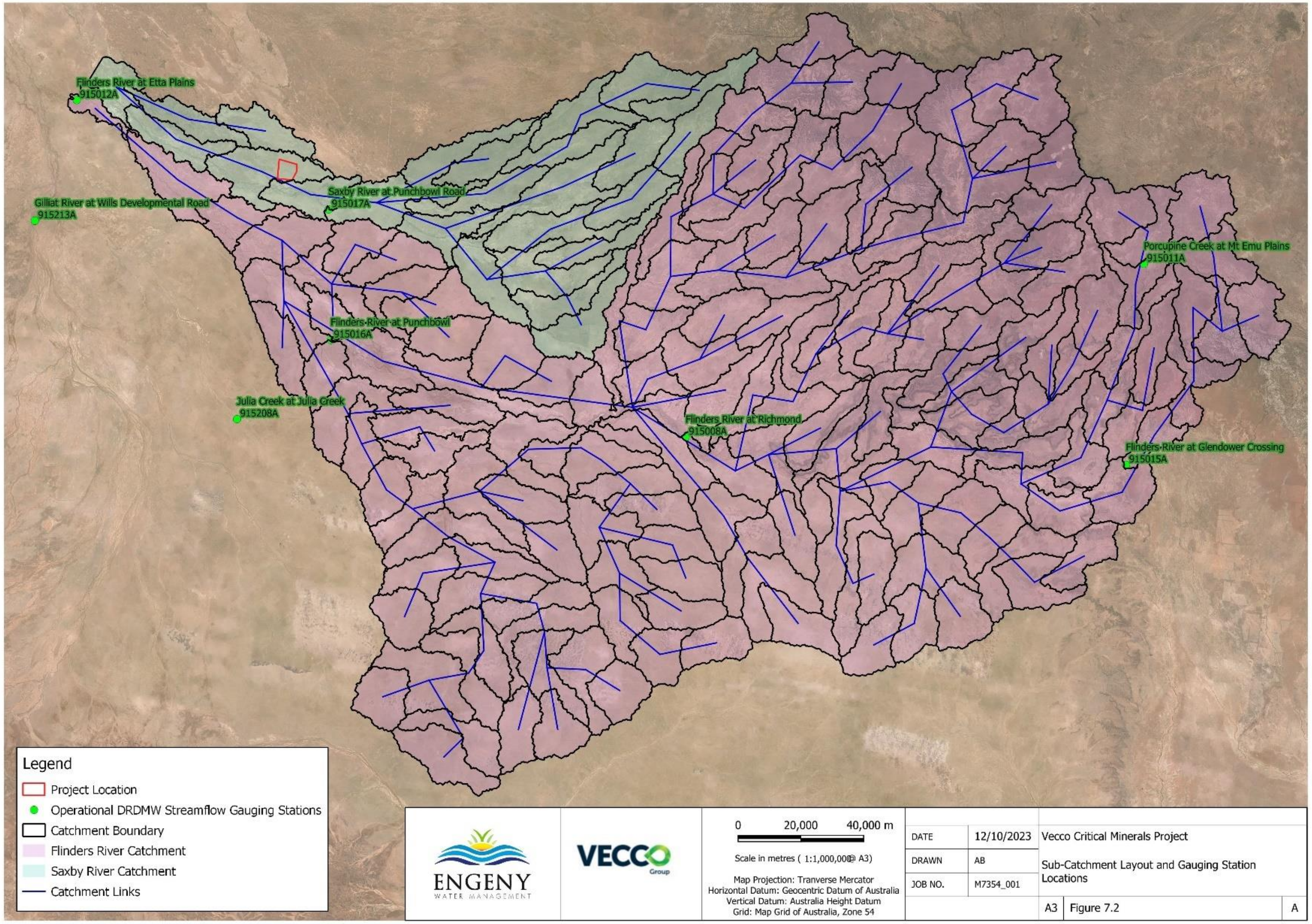


Figure 7.2: Sub-Catchment Layout and Gauging Station Locations

7.2.4 Model Routing Parameters

The URBS Model was simulated using the Basic modelling approach which assumes that the catchment and channel storage for each sub-catchment is lumped together and represented as a single non-linear reservoir (Carroll, 2020). This modelling approach is a similar runoff routing method to the RORB model (Laurenson, Mein, & Nathan, 2010). The reach length was adopted as the main routing parameter input to the model which allows the model to be calibrated by adjusting the alpha (α) and non-linearity exponent (m) parameters.

As the Basic model closely resembles the RORB model, routing parameter alpha (α) can be translated to regional relationships developed for the RORB routing parameter (K_c) using the following relationship (Carroll, 2020):

$$\alpha = \frac{K_c}{f_{av}}$$

Where: α = *URBS routing parameter*
K_c = *RORB routing parameter*
f_{av} = *Model routing constant output by URBS based on modelled catchment area and stream length*

The Flinders River and Saxby River systems have a number of gauging stations available to validate the model with a recent significant flood event in 2019. However the quality of the streamflow gaugings and particularly the rating tables for high flows (once floodwaters escape the main river channels) is poor making calibration of the model not possible without detailed survey of the gauging station locations to redefine the rating curves for larger flows. Therefore the model routing parameters have been adopted based on regional relationships developed for the RORB routing parameter K_c and then translated to the URBS routing parameter alpha (α) using the relationship above. The standard RORB relationship for determining K_c based on total catchment area and a non-linearity exponent (m) of 0.8 (Laurenson, Mein, & Nathan, 2010) was adopted for defining a K_c routing parameter which was then related to the URBS alpha (*α*) routing parameter as shown below:

- RORB K_c relationship (Carroll, 2020) $K_c = 2.2A^{0.5}$ with *A* being the total catchment area in km^2.
- With a total catchment area (A) of 54,355 km^2, the relationship provides a K_c of 513.
- Using the relationship described above and the URBS model output for f_{av} 16,012, this provides an alpha (α) value of 0.032.

The adopted alpha (*α*) routing parameter of 0.032 and a non-linearity exponent (m) of 0.8 were then validated against streamflow gauging for the recent 2019 flood event in the Saxby River and Flinders River and flood frequency analysis of the Flinders River at Richmond Gauging station (915008A). The validation of the hydrology model and adopted routing parameters is detailed in Section 7.2.5 and Section 7.2.6.

7.2.5 URBS Model Validation to Historical Events

The adopted URBS model parameters were validated against rainfall and stream flow gauging data within the Flinders and Saxby River catchments. The January/February 2019 flood event was adopted for the validation as it is the largest flood event captured by the gauging network. The validation process involved adopting the model routing parameters presented in Section 7.2.4 and adjusting rainfall loss parameters (initial and continuing rainfall losses) to match hydrograph timing and volume to allow comparison of modelled and recorded flow hydrographs at the stream gauging station locations.

The January/February 2019 flood event was caused by a monsoonal trough that remained almost stationary over the Flinders River catchment between 29 January 2019 to 9 February 2019. Significant rainfall amounts were recorded within the overall catchment for all 12 days of the event, however, due to the large catchment area, the days that recorded the highest intensity for the event occurred on different days depending on the gauge location within the catchment.

Stream Gauging Data

Stream flow gauging stations within the Flinders and Saxby River catchments which were operational during the January 2019 validation event are summarised in Table 7.1. Locations of the stream flow gauging stations are shown in Figure 2.7. The gauging stations available for the validation are all very poorly rated with all gauges besides the Flinders River at Richmond gauging station having a highest manually gauged flow less than 3% of the peak flow recorded during the January 2019 flood event. The Flinders River at Richmond gauge has the highest gauged flow however is still only 7% of the reported peak flow for the January 2019 flood event.

Additional observations include the Flinders River at Punchbowl gauging station (Station Number 915016A) recorded a peak flow below half of the upstream Flinders River at Richmond gauging station(Station Number 915008A). This highlights the uncertainty in the available gauging information to perform an accurate validation of the hydrology model and therefore used as a validation method only. Stream gauging data captured by the available flow monitoring stations for the January/February 2019 flood event is shown in Figure 7.3.

Table 7.1: Stream Flow Gauging Stations Within Flinders/Saxby River Catchments

Station Number	Station Name	Catchment Area (km2)	Maximum Gauged Level	Maximum Gauged (m3/s)	Jan/Feb 2019 Recorded Peak Flood Level (m RL)	Jan/Feb 2019 Recorded Peak Flow Rate (m3/s)
915017A	Saxby River at Punchbowl Road	5,624	2.947	10.3	6.05	325
915011A	Porcupine Creek at Mt Emu Plains	540	1.86	11.4	6.62	1,032
915015A	Flinders River at Glendower Crossing	2,146	1.102	20.9	4.55	1,167
915008A	Flinders River at Richmond	17,382	6.310	389.8	9.79	5,200
915016A	Flinders River at Punchbowl	29,693	2.742	45.6	8.49	2,090

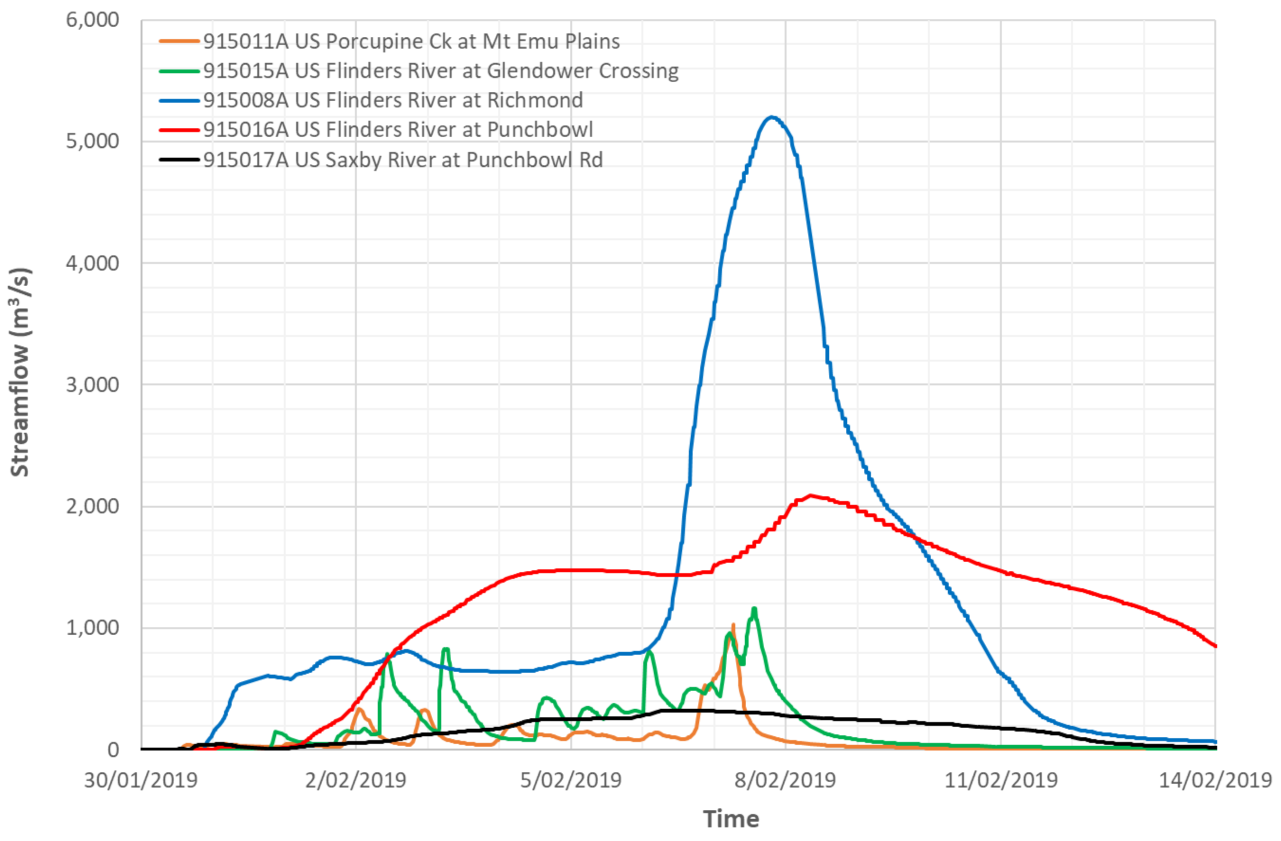


Figure 7.3: Recorded Streamflow data for January/February 2019 Flood Event

Historical Rainfall

Operational pluviometer and daily rainfall stations in the Flinders River and Saxby River catchments and the recorded rainfall total during the 2019 flood event are listed in Table 7.2. The locations of the rainfall stations and the spatial variation of rainfall during the event is presented in Figure 7.5 and the time distribution of rainfall recorded at the available pluviometer stations is displayed in Figure 7.4. The available rainfall gauging information shows there are large distances between the available pluviometer rainfalls stations that are required to inform the temporal distribution of rainfall during the event.

Table 7.2: Rainfall Stations Operational during the 2019 Flood Event

Station Number	Station Name	Station Type	Agency	Latitude	Longitude	Jan/Feb 2019 Rainfall Total (mm)
002105A	Mills Creek at Oondooroo	Pluvio	DRDMW	143.16	-22.18	233
030022	Hughenden Airport	Pluvio	BOM	144.23	-20.82	231
030161	Richmond Airport	Pluvio	BOM	143.11	-20.70	631
915008A	Flinders River At Richmond	Pluvio	DRDMW	143.13	-20.70	603
915011A	Porcupine Creek at Mt Emu Plains	Pluvio	DRDMW	144.52	-20.18	376
915012A	Flinders River at Etta Plains	Pluvio	DRDMW	141.27	-19.74	548
915015A	Flinders River at Glendower Crossing	Pluvio	DRDMW	144.48	-20.76	258
915016A	Flinders River at Punchbowl	Pluvio	DRDMW	142.04	-20.43	520
915017A	Saxby River at Punchbowl Road	Pluvio	DRDMW	142.03	-20.05	692
915208A	Julia Creek at Julia Creek	Pluvio	DRDMW	141.76	-20.66	444
029005	Bunda Bunda	Daily	BOM	142.21	-20.07	583
029036	Millungera Station	Daily	BOM	141.56	-19.86	802
029132	Manfred Downs Station	Daily	BOM	141.43	-20.14	767
030019	Gilberton	Daily	BOM	143.69	-19.26	495
030021	Glendower Station	Daily	BOM	144.49	-20.74	284
030022	Hughenden Airport	Daily	BOM	144.23	-20.82	231
030025	Hughenden Station	Daily	BOM	144.23	-20.85	224
030030	Lyndhurst Station	Daily	BOM	144.37	-19.20	611
030039	Oak Park Station	Daily	BOM	144.15	-19.25	685
030045	Richmond Post Office	Daily	BOM	143.14	-20.73	667
030068	Oak Valley Station	Daily	BOM	144.32	-19.46	663
030072	Low Holm Station	Daily	BOM	144.99	-20.10	413
030081	Burleigh Station	Daily	BOM	143.11	-20.26	343
030082	Gregory Springs Station	Daily	BOM	144.38	-19.70	746
030088	Werrington Station	Daily	BOM	144.12	-19.38	598
030090	Bagstowe Station	Daily	BOM	144.00	-19.20	413
030107	Robin Hood Station	Daily	BOM	143.71	-18.84	349

Station Number	Station Name	Station Type	Agency	Latitude	Longitude	Jan/Feb 2019 Rainfall Total (mm)
030112	North Head	Daily	BOM	143.25	-18.82	336
030144	Plainby Station	Daily	BOM	142.62	-21.40	739
030149	Hillview Station	Daily	BOM	144.10	-21.04	265
030161	Richmond Airport	Daily	BOM	143.11	-20.70	631
036012	Cameron Downs	Daily	BOM	144.28	-21.37	124
037000	Alni	Daily	BOM	142.49	-22.15	324
037001	Ayrshire Downs	Daily	BOM	142.72	-21.97	572
037030	Malboona	Daily	BOM	143.60	-21.89	247
037039	Winton Airport	Daily	BOM	143.08	-22.36	219
037046	Elderslie	Daily	BOM	142.47	-22.29	445
037081	Corfield-Manuka St	Daily	BOM	143.38	-21.71	323
037116	Woodstock Station	Daily	BOM	141.95	-22.26	497
037120	Wyora	Daily	BOM	143.10	-21.90	400

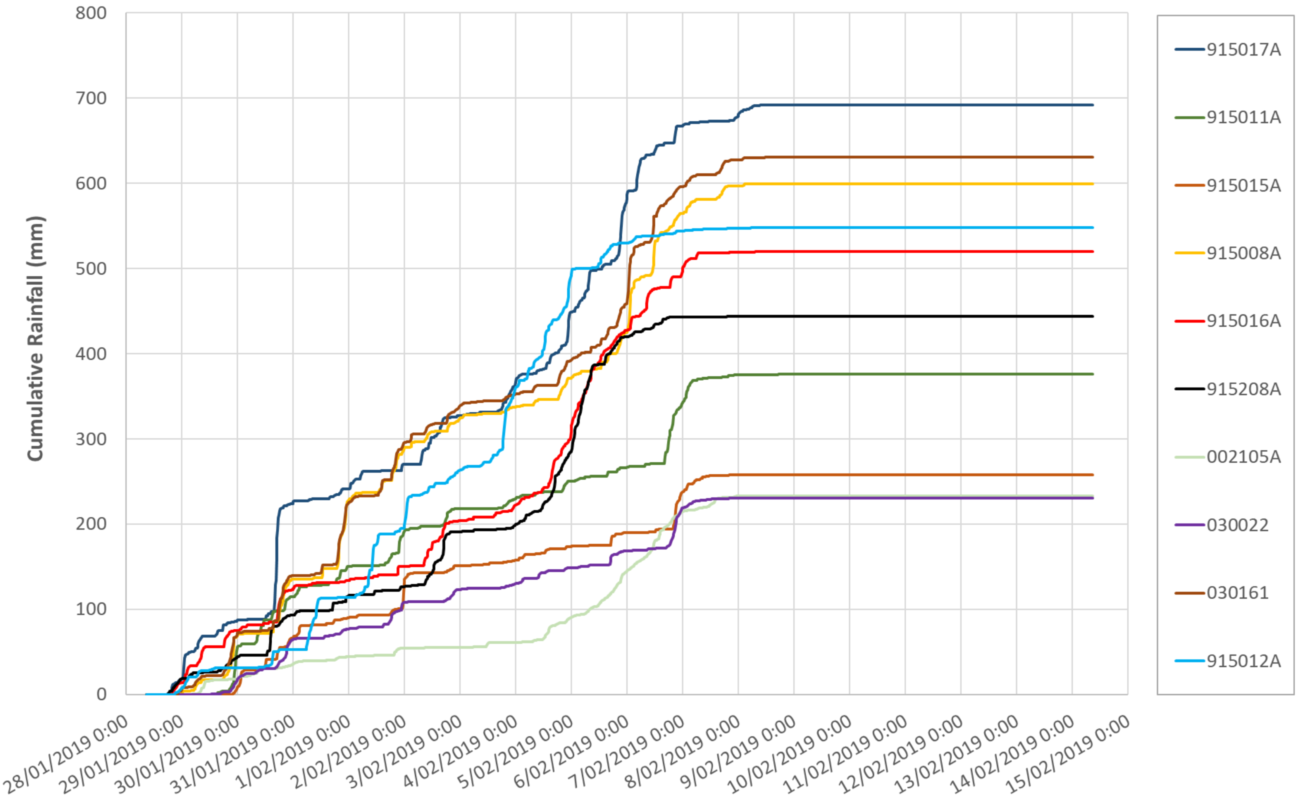


Figure 7.4: Time Distribution of Rainfall – January/February 2019 Rainfall Event

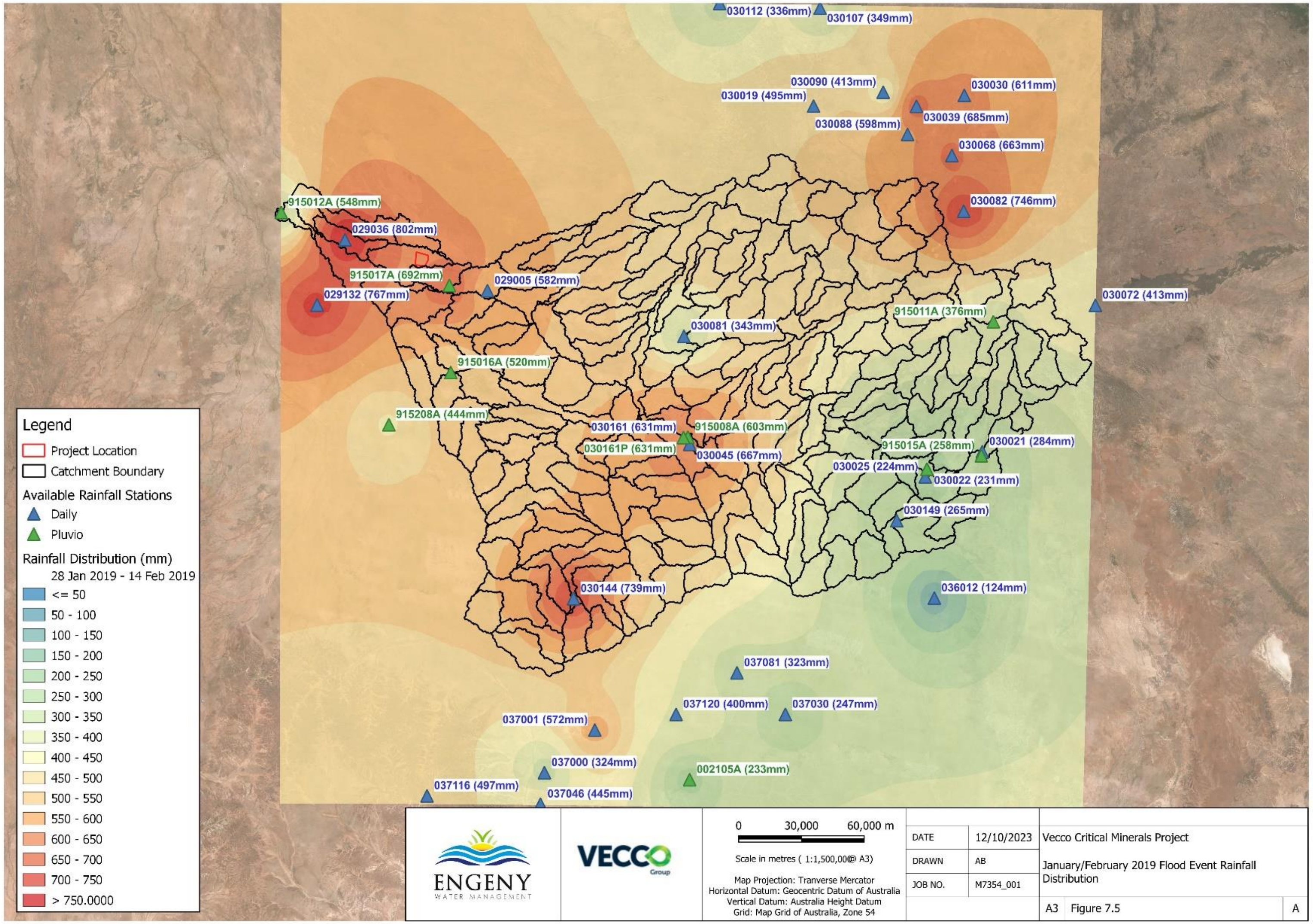


Figure 7.5: January/February 2019 Flood Event Rainfall Distribution

Validation Event Simulations

The validation event (January/February 2019 flood event) was simulated for the Flinders River and Saxby River catchments using the URBS model as follows:

- The rainfall depth assigned to each sub-catchment was calculated using the ‘subrain’ utility within the URBS software package. The ‘subrain’ utility calculates an inverse distance weighted average rainfall based on the closest four (4) rainfall stations.
- The temporal pattern of rainfall was determined for each sub-catchment by assigning the temporal pattern from the nearest pluviometer station (distance from pluviometer station to sub-catchment centroid). The assignment of temporal pattern was also undertaken using the ‘subrain’ utility.

The URBS model was validated by adopting the routing parameters derived in Section 7.2.4 and varying initial and continuing losses to match streamflow volume and timing to compare modelled and recorded flood hydrographs at the stream gauging stations listed in Table 7.1.

The following URBS model parameters and rainfall losses were adopted for the model validation:

Channel lag parameter, α:	0.032
Catchment non-linearity parameter, m:	0.8
Initial rainfall loss, IL:	150 mm
Continuing rainfall loss, CL:	3 mm/hour

Validation results for the URBS model are presented in Figure 7.6. The following observations are made regarding the model parameter validation to the historical 2019 flood event:

- The adopted URBS model parameters showed a reasonable validation to the 2019 flood event at the Flinders River at Richmond (GS915008A), Flinders River at Glendower Crossing (GS915015A) and Porcupine Creek at Mt Emu Plains (GS915011A) gauging stations.
- The Saxby River at Punchbowl and Flinders River at Punchbowl Gauging Stations (GS915017A and GS915016A) showed poor comparisons between modelled and recorded hydrographs. These gauges were recently developed in 2014 with rating curves informed by minimal manual gauging which makes the recorded flows at these stations unreliable during the 2019 flood event.
- The timing differences between modelled and recorded hydrographs are heavily influenced by the limited pluviometer rainfall data which limited opportunity to refine the model parameters and improve the fit of the validation.
- The historical model validation simulation required a very high initial rainfall loss which may be because the antecedent rainfall leading up to the event was very dry.

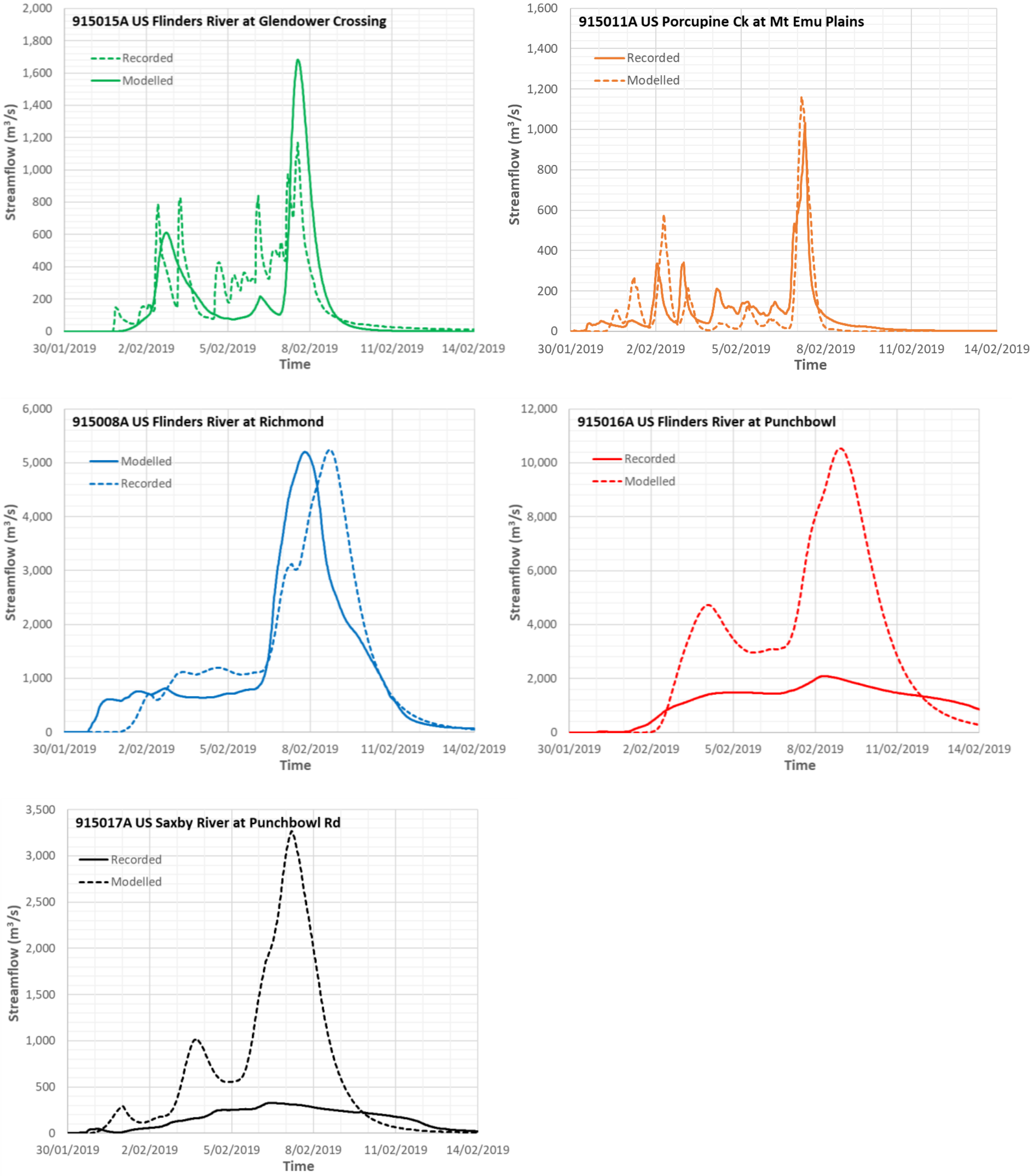


Figure 7.6: URBS Validation Results (915008A) - January/February 2019 Flood Event

7.2.6 Design Flood Hydrology

The URBS model was used to assess design flood hydrology for the Saxby River and Flinders Rivers to produce design flood hydrographs to undertake hydraulic flood modelling. The design flood hydrology has been undertaken in accordance with the Australian Rainfall and Runoff, a Guide for Flood Estimation (J, et al., 2019) (ARR 19). The following sections outline the design event hydrology simulation and validation of the design event peak flow estimates to flood frequency analysis of streamflow gauging.

Design Rainfall

Design rainfall data for the Flinders River catchment was derived for rainfall events between the 0.1% AEP event and the Probable Maximum Flood (PMF) event. The design rainfall data was derived using the following methods:

- Rainfall totals for events from the 10% AEP to the 0.1% AEP were generated for all sub-catchment centroids using the BoM IFD tool (www.bom.gov.au/water/designRainfalls/revised-ifd/). Each sub-catchment has been assigned an individual Intensity Frequency Duration (IFD) table.
- PMF rainfall estimates were calculated using the Revised Generalised Tropical Storm Method, GTSM-R (Bureau of Meteorology, 2003) for durations 24 hours and longer. The AEP of the PMF was assigned a value of 1:200,000 in accordance with Figure 8.3.2 Book 8 of ARR 19 (J, et al., 2019).

Design rainfall totals (point values) were generated for the centroid of each sub-catchment within the URBS model.

Aerial Reduction Factors

Aerial Reduction Factors (ARFs) have been used to convert point rainfall estimates to areal rainfall estimates. ARFs for all the creeks have been calculated using the methodology for catchments between 10 km2 and 30,000 km2 for the Monsoonal North QLD Zone (J, et al., 2019). ARF’s are calculated based on the total catchment area (lower rainfall for larger catchments) and therefore depending on the focal point (reporting location of peak flow) the ARF changes. For the design event simulation to assess flooding for the Project, ARFs were calculated for the Saxby River catchment area at the project location.

Design Temporal Patterns

An ensemble of 10 temporal patterns was simulated for each design storm AEP and storm duration as recommended by ARR 19 (J, et al., 2019) Temporal patterns for the design storm events were assigned as follows:

- 10% AEP to 0.1% AEP design storms – ensemble temporal patterns for “Monsoonal North” sourced from ARR Data Hub (Babister, Trim, Testoni, & Retallick, 2016) were applied.
- For the PMF event, the GTSMR ensemble temporal patterns were applied (Bureau of Meteorology, 2003).

The ensemble result closest to the average of all ensemble results was adopted as the design flood estimate for all events other than the PMF event which utilised the maximum of all ensemble results.

Design Rainfall Losses

Design rainfall losses were sourced from the ARR Data Hub (Babister, Trim, Testoni, & Retallick, 2016) for the Flinders-Norman Rivers catchment. The median pre-burst rainfall depths sourced from the ARR Data Hub (Babister, Trim, Testoni, & Retallick, 2016) were then subtracted from the initial storm loss to produce the design storm burst loss. The adopted design rainfall losses were then validated to flood frequency analysis. It is noted the continuing loss value of 2.6 mm/hr is similar to the value of 3.0 mm/hr adopted for the model validation to the January 2019 flood event.

No initial loss and a continuing loss of 1 mm/hr were adopted for the PMF event.

URBS Model Parameters

Table 7.3 provides the URBS model parameters adopted for the design event hydrology. The adopted parameters have been validated to the historical 2019 flood event as presented in Section 7.2.5. The design event hydrology results were then further validated to streamflow gauging flood frequency analysis as presented in Section 7.2.1.

Table 7.3: Design Hydrology URBS Model Parameters

Parameter	Value	
	0.1%	PMF
Initial Loss (mm)	41	0
Continuing Loss (mm/hr)	2.6	1
Channel lag parameter, α	0.032	0.032
Catchment non-linearity parameter, m.	0.8	0.8

Design Event Simulation

Design event simulations were undertaken using the URBS model for storm events ranging from the 10% AEP to the 0.1% AEP and the Probable Maximum Flood (PMF) and for a range of design storm durations. The design event peak flow results from the hydrology model are provided in Table 7.4.

The critical duration is the storm duration which produced the highest average peak flow for the catchment. The reported peak flow and ensemble number in the table represents result for the next highest peak flow from the average of all ensembles for the critical duration.

Table 7.4: Design Hydrology Peak Flow Results – Saxby River at the Project Site Location

AEP	Peak Flow (m3/s)	Critical Duration (h)	Ensemble/Storm Number
10%	1,701	36	8
5%	2,418	36	8
2%	3,709	24	6
1%	4,751	24	6
0.1%	8,945	24	6
PMF	49,441	36	3

7.2.1 Design Hydrology Validation to Flood Frequency Analysis

Design event hydrology results from the URBS model were validated against Flood Frequency Analysis (FFA) from streamflow gauging within the Flinders catchment. The FFA validation was undertaken for the Flinders River at Richmond gauging station as it has the longest available streamflow record (50 years).

The FFA for the Flinders River at Richmond gauging station was performed on annual peak flows generated using the DRDMW derived rating curve. The FFA was based on 51 years of estimated annual peak flow data.

Tabulated results of the at-site FFA for the Flinders River at Richmond (915008A) gauging station compared to the URBS model results are shown in Table 7.5 and a comparison is provided in Figure 7.7.

The design hydrology developed using the calibrated URBS model shows reasonable consistency with the FFA results at Flinders River at Richmond gauging station considering the accuracy of the gauging station rating curve. Compared to the expected values from the FFA, the URBS model results are approximately 50% larger for the more frequent AEPs and 17% higher for the 1% AEP.

Based on the FFA validation, it is considered that the design hydrology estimates from the URBS model are conservative. Considering the purpose of the model is to identify flooding impacts associated with the Project, adopting conservative hydrology inputs to the flood modelling is preferred as potential flooding interactions and impacts will likely be overstated. Further refinement of the model is not considered practical due to the many uncertainties in the available streamflow gauging and rainfall data.

Table 7.5: Comparison of FFA and URBS Hydrology Results – Flinders River at Richmond

AEP	URBS Results (m^3/s)	Flood Frequency Analysis		
		Expected Value (m^3/s)	10% Quantile Limit (m^3/s)	90% Quantile Limit (m^3/s)
10%	**2,020**	**1,369**	986	2,129
5%	**3,396**	**2,141**	1,334	3,953
2%	**5,393**	**3,958**	1,921	9,103
1%	**7,549**	**6,450**	2,485	17,394

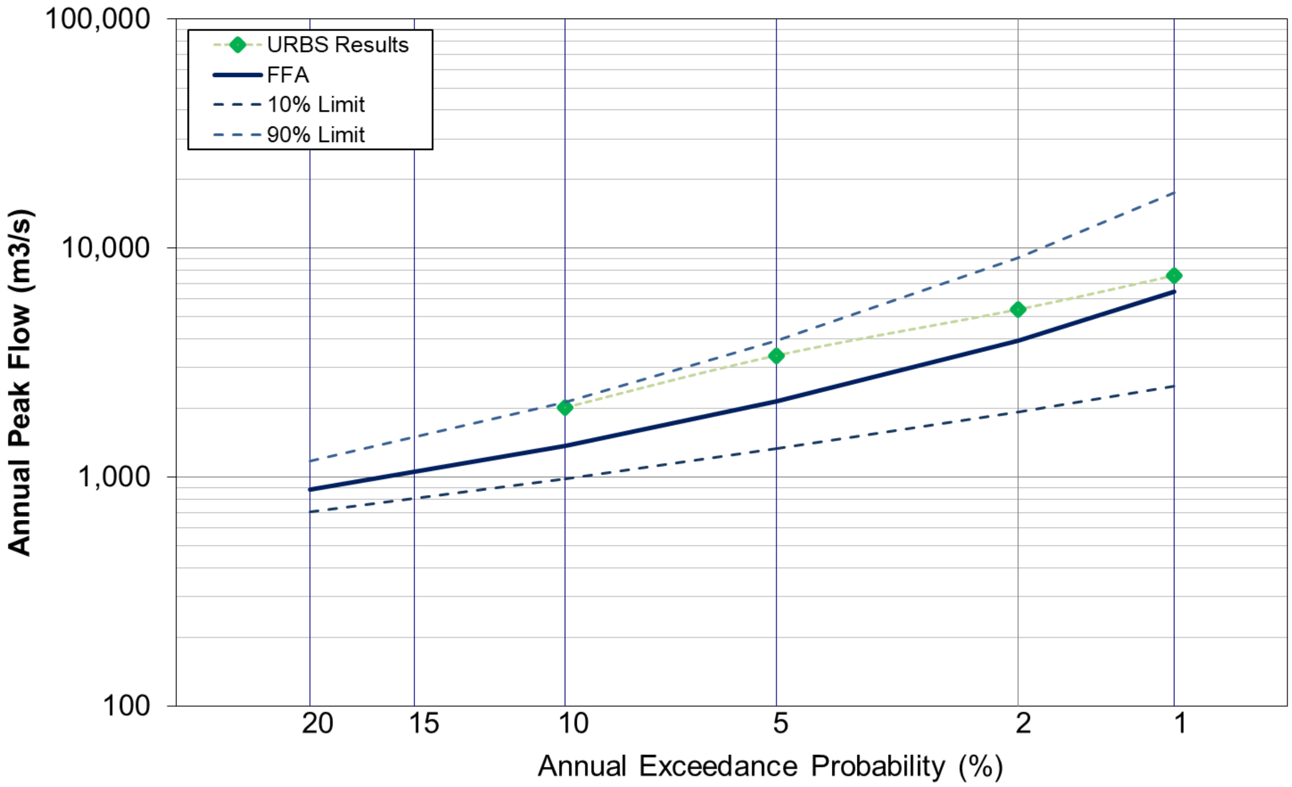


Figure 7.7: Comparison of FFA Results and URBS Hydrology Results

7.3 HYDRAULIC MODELLING

The following sections outline the development of the hydraulic model and provide an assessment of flooding interactions and potential flood impacts associated with the Project.

7.3.1 Modelling Software

This study has used the two-dimensional modelling software TUFLOW to quantify the flood behaviour and characteristics of each of the creek systems. Two dimensional models are best suited to scenarios where flow direction and water surface are not uniform across a section (i.e., floodplain and overbank areas).

7.3.2 Model Development

Model Topography and Extent

The model bathymetry has been developed based on the following topography survey (order of priority):

- Shuttle survey data of the Project area which was re-processed by John T Boyd Company which included the process of removing spikes from the survey and triangulation to approximately 100 spaced Real-time kinematic (RTK) survey points to produce a 25m grid. The resulting DEM was verified by John T Boyd Company against known survey points and was observed to correlate within 1 m of vertical accuracy.
- SRTM Hydrologically Enforced DEM.

The accuracy of the SRTM data used in the modelling is considered low and is not expected to provide correct definition of the river channels resulting in the model underestimating active channel flow capacity. The model has been used to model large flood events where the majority of flow engages the floodplain. Considering all this the survey data used in the model is only considered suitable to define indicative flood events and relative flooding impacts. Figure 7.8 shows the hydraulic model configuration and model extent.

Boundary Conditions

Boundary conditions are required in the model to define hydrology inflows, flow leaving the model domain and interfaces between the one dimensional and two-dimensional model domains. The following boundary conditions were used in the models:

- Upstream: The upstream boundary condition used a combination of ‘SA’ type boundaries, allocating flow to the defined model grid cells based on the design flood hydrographs from the hydrologic model (flow per unit of time). Total inflow hydrographs were applied for Saxby River and Flinders River and residual were applied as local catchment runoff hydrographs.
- Downstream: The outflow boundary conditions of all models have been represented as a normal depth based on low flow channel grades at the downstream extent of the models. These boundaries are located a sufficient distance downstream to not influence the modelled flood behaviour adjacent to the Project.

The influence of the adopted downstream boundary condition was checked from reviewing the hydraulic model results which showed negligible change in hydraulic grade or velocity in the model cells upstream of the boundary. This indicated the adopted boundary conditions are unlikely to have a significant impact on model results in the vicinity of the Project.

Hydraulic Roughness

The Manning’s roughness coefficients used in the model are based on visual observation of aerial photography of the site. Roughness values have been tabulated in Table 7.6. The adopted hydraulic roughness extents are shown in Figure 7.9.

Table 7.6: TUFLOW Hydraulic Roughness Values

Land Use Category	Manning’s “n”
River channel	0.035
Floodplain, light brush and trees	0.050
Floodplain, light to medium brush and trees	0.060
Floodplain, medium to dense brush	0.070

Hydraulic Structures

No hydraulic structures were represented in the two-dimensional hydraulic model. There are no major road crossing or structures on the Saxby River or Flinders River in the hydraulic model extent. There are multiple low or bed level crossings and farm access roads, however due to their small size relative to the flood extents, they are not expected to have a significant impact on the modelling results or outcomes of the flooding assessment.

7.3.3 Flood Model Simulation and Results

The flood model was simulated for the critical 0.1% AEP and PMF flood events in the Saxby River and Flinders River at the Project Location to identify flooding interactions and potential impacts with the project. The flood model simulation adopted hydrology results simulated with an Aerial Reduction Factors (ARF) for the Saxby River catchment resulting in modelled flows for the Flinders River being conservatively high. Flood velocity and water surface contour mapping for the 0.1% AEP design flood event and the PMF are provided in Figure 7.10 and Figure 7.11 respectively. The flood model results show:

- The Project is not impacted by flooding in the 0.1% AEP design flood event and the Probable Maximum Flood (PMF) event.
- Peak flood levels in the Saxby River are limited by the level which water overflows the southern bank of the River towards the Flinders River which is shown by the peak flood level contours in Figure 7.10 and Figure 7.11.
- Due to flood water breaking out of the Saxby River in large events the results show a small increase in peak flood height between the 0.1% AEP and PMF events of 2.0m.
- Peak flood velocity in the Saxby River is expected to range from 1 m/s to 2 m/s in the 0.1% AEP flood event indicating localised maintenance to the access road crossing will be required following flood events.
- The flood assessment shows the Project is expected to be unaffected by flooding besides the access road.
- The proposed access road crossing of the Saxby River will be inundated in frequent flood events however the proposed bed level arrangement of the crossing is not expected to impact peak flood levels. The access road flooding interactions are described further in Section 7.4.

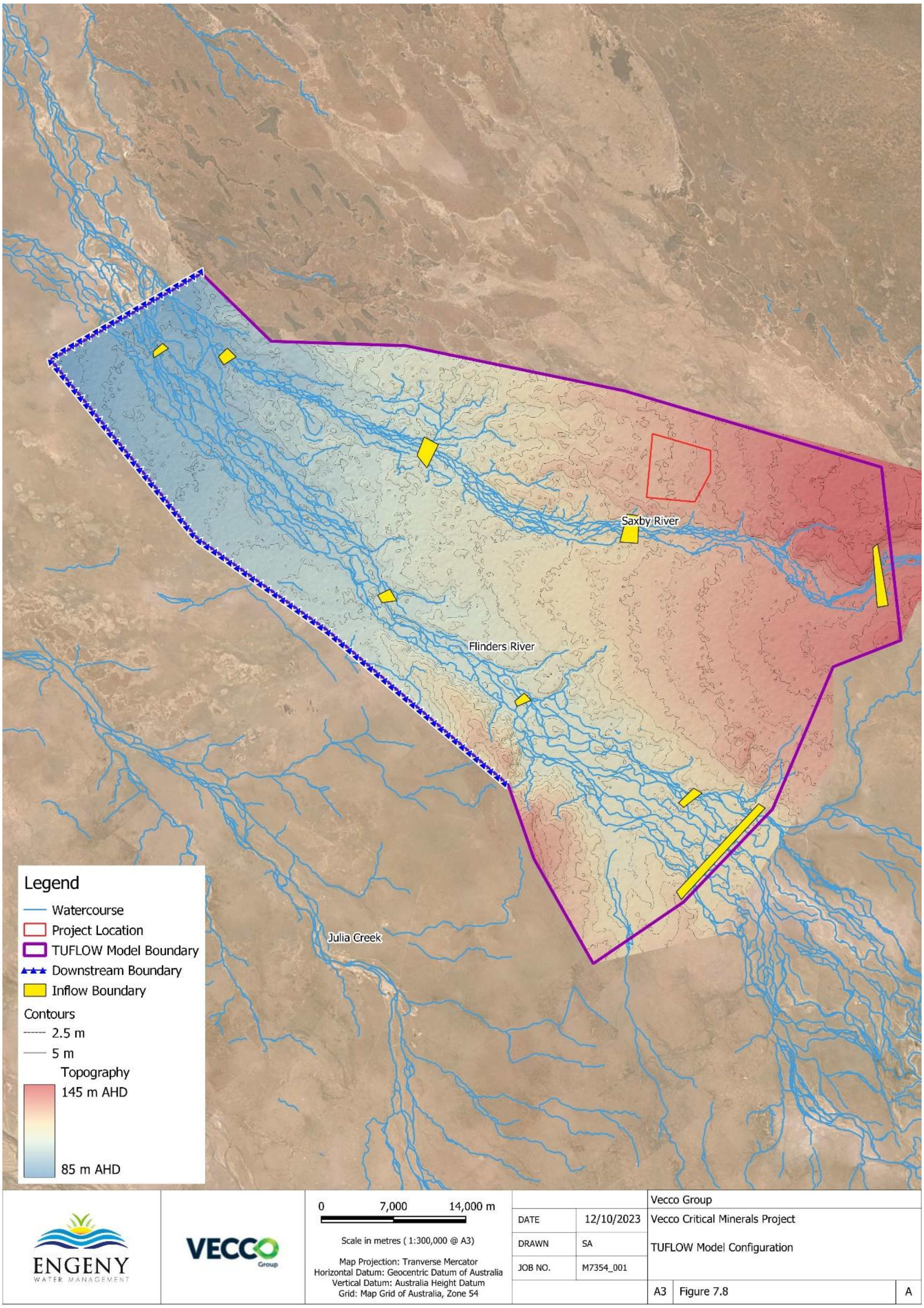


Figure 7.8: Hydraulic Model Configuration

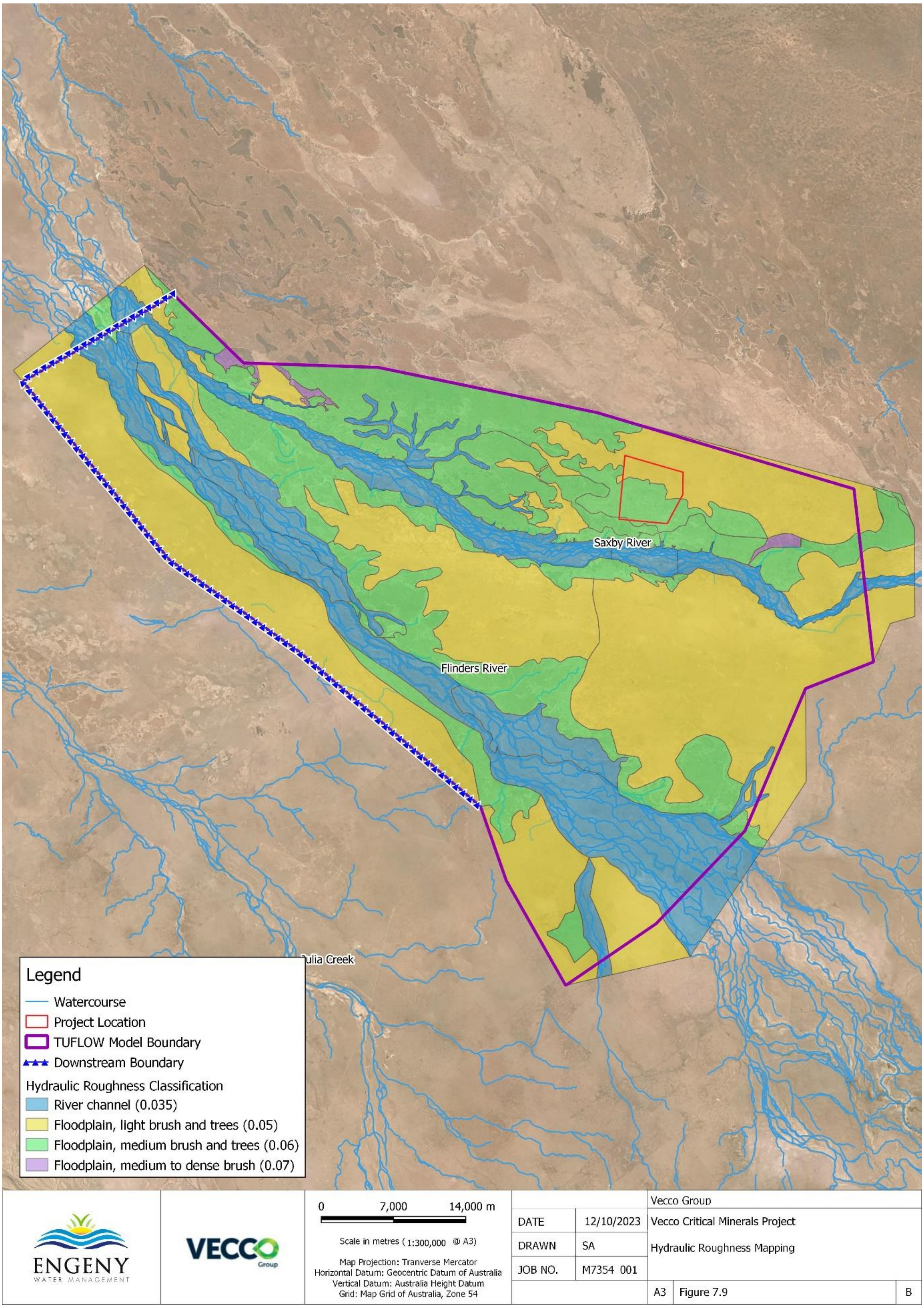


Figure 7.9: Hydraulic Roughness Mapping

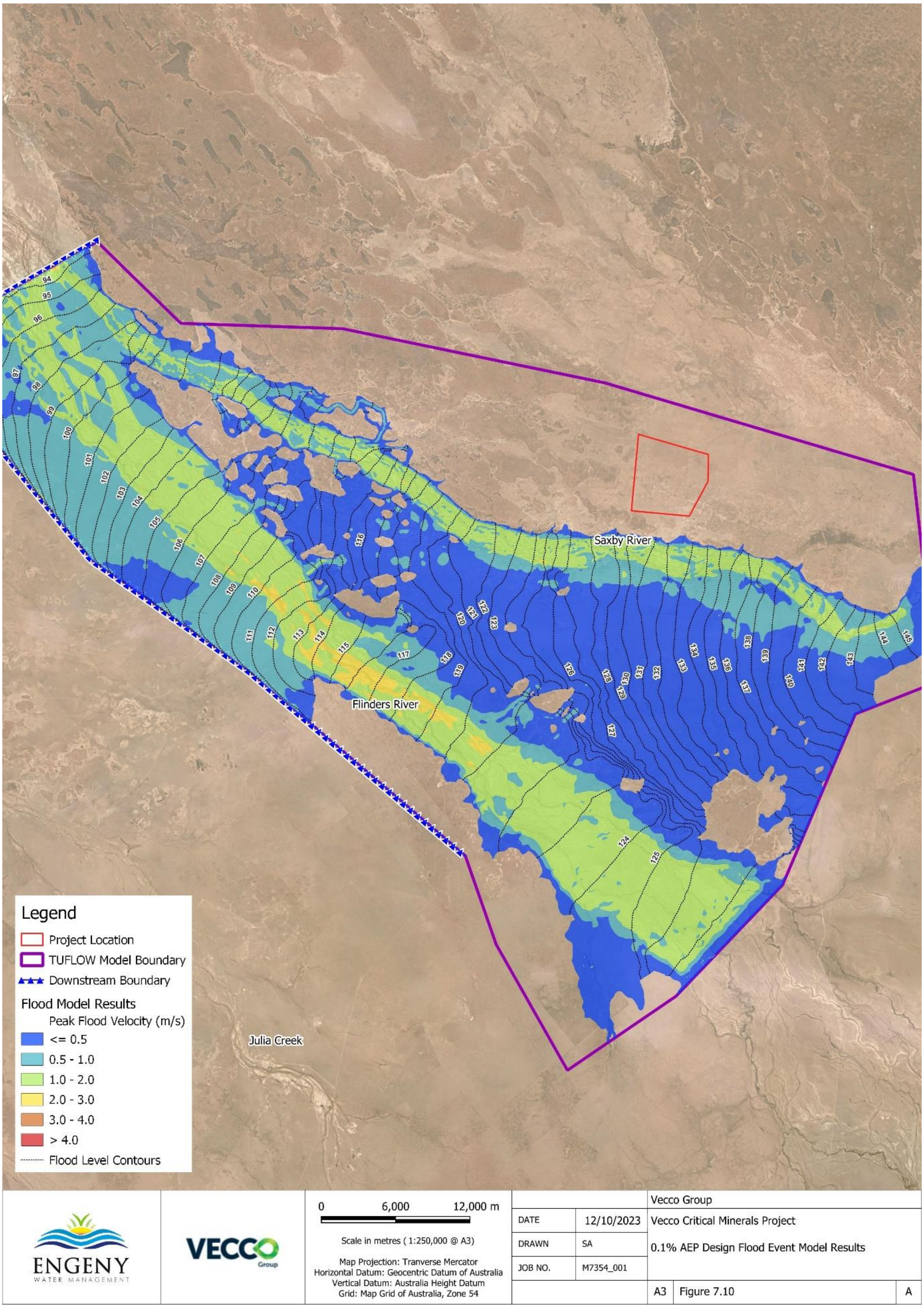
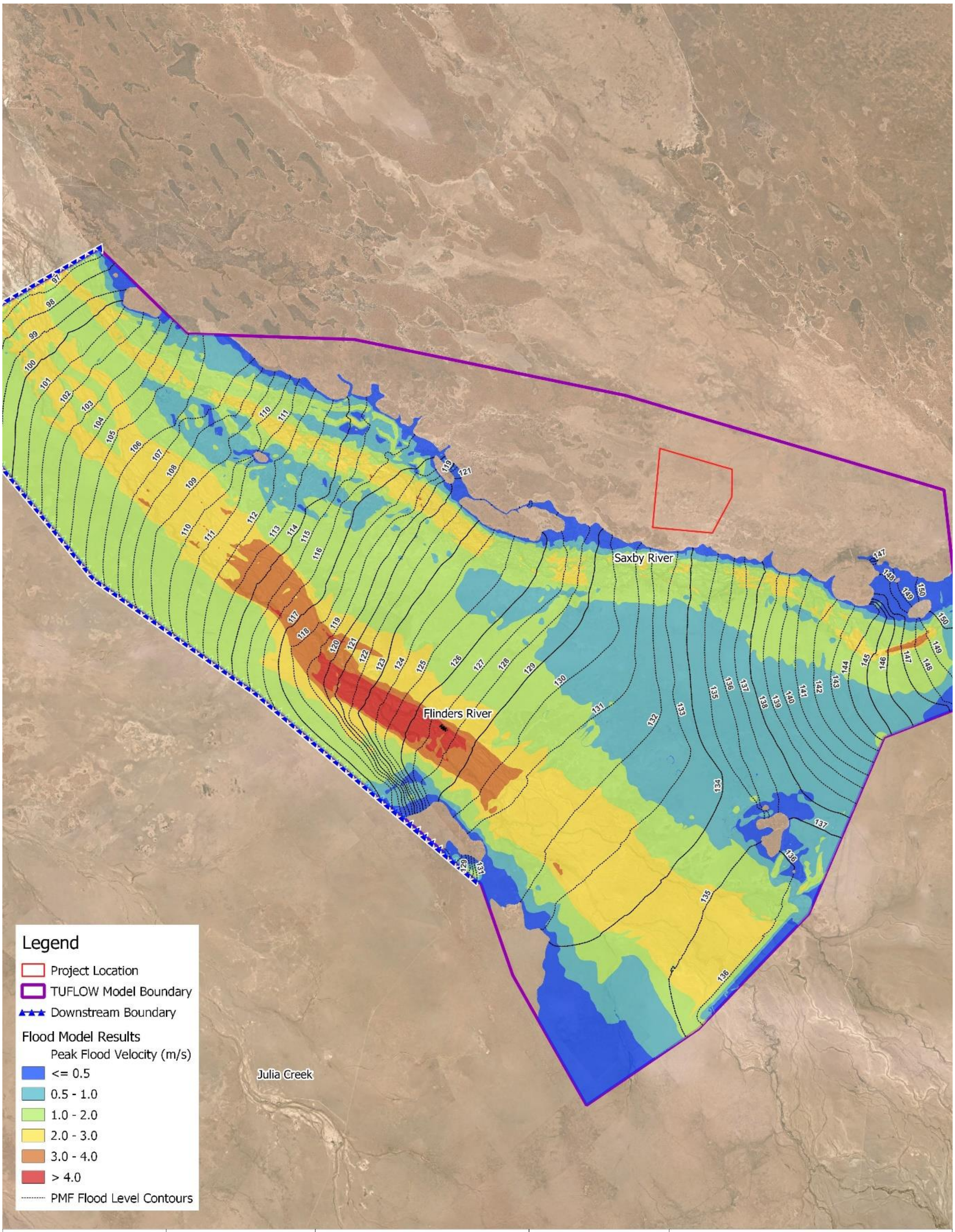


Figure 7.10: 0.1% AEP Flood Model Results



0 6,000 12,000 m

Scale in metres (1:250,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 54

		Vecco Group
DATE	12/10/2023	Vecco Critical Minerals Project
DRAWN	SA	Probable Maximum Flood Model Results
JOB NO.	M7354_001	
		A3 Figure 7.11 A

Figure 7.11: Probable Maximum Flood Model Results

7.4 ACCESS ROAD FLOOD IMPACTS

The Project includes access road located within the Transport Lease which crosses the Saxby River floodplain and channel, in a north south direction, joining the south-west corner of the Projects Production ML. The access road alignment is shown in Figure 1.2. The access road is proposed to be a total of 8 m wide and closely follow the existing topography elevation being 50mm to 100mm above existing ground elevations. The access road will cross a main low flow channel of the Saxby River where a number of low flow box culverts (1,200 mm wide by 600 mm high) with a capacity of 10 m^3/s will be constructed to allow access during low flow conditions. The box culverts will overtop in very frequent flow events and will incorporate a causeway design to allow safe and stable overtopping flows.

Due to the small size of the culvert structure and the road only being 100 mm above natural topography in the Saxby River floodplain, it is expected the road will become inundated and drowned out at low flood flows. This design will minimise disturbance and obstruction in the Saxby River channel and floodplain and is expected to have negligible impact on existing flood behaviour. There are a number of existing farm access road crossings and causeway structures (including the DRDMW Saxby River at Punchbowl gauging station) on the Saxby River which appear to be stable and not causing flood impacts, indicating the proposed crossing arrangement is suitable.

Peak flood velocity in the Saxby River is expected to range from 1 m/s to 2 m/s in the 0.1% AEP flood event indicating localised maintenance to the access road crossing may be required following flood events (such as regrading). Concept design details of the proposed access crossing are shown in Figure 7.12 and Figure 7.13.

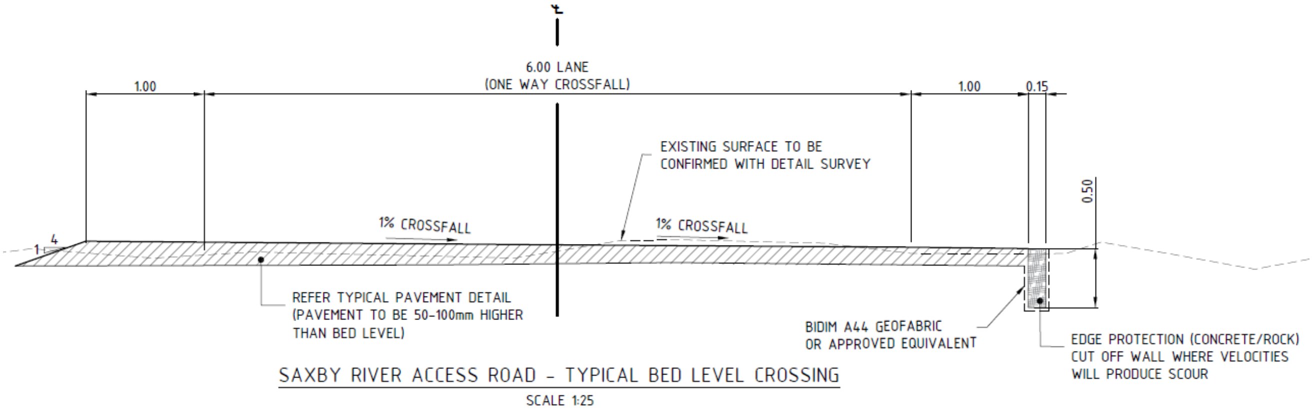


Figure 7.12: Site Access Road Concept Design

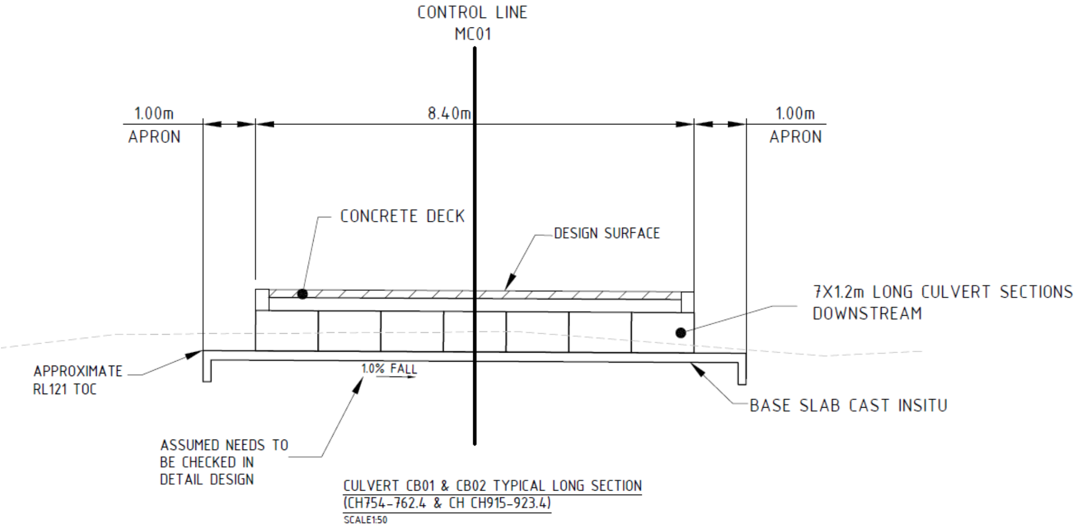


Figure 7.13: Site Access Road Low flow Culvert Crossing Concept Design

8 SURFACE WATER IMPACT ASSESSMENT

The potential impacts of the Project on surface water resources include:

- Impacts to streamflow in minor local drainage paths downstream of the Project.
- Impacts on streamflow volumes and duration in the Saxby River due to the catchment area contained by the Project.
- Impacts on environmental values in the Saxby River from uncontrolled releases from mine water storages.
- Impacts on environmental values of receiving waterways from uncontrolled overflows from sediment dams.
- Impacts on flood flows and behaviour in the Saxby River.
- Cumulative surface water impacts of Projects in the region on the environmental values of the receiving waters.

These potential impacts of the Project are assessed in the following sections.

8.1 STREAMFLOW IMPACTS TO LOCAL AND REGIONAL WATERWAYS

There are no defined drainage features that flow through the Projects Production ML as the topography is very flat and undulating with water ponding and spreading during large storm events. The catchment area reduction during the operational phase of the mine is expected to have negligible impact on the drainage of the waterways downstream of the Project boundary. Where possible clean water drains are proposed to redirect catchment around disturbed areas to reduce clean water entering mining operations and reduce impacts to the local waterways.

The largest catchment area intercepted by the Project in year 25 is 9.2 km^2 which is approximately 0.15 % of the Saxby River catchment area adjacent to the Project (6,000 km^2). Based on the small proportion of the Saxby River catchment area intercepted by the Project during operations, negligible impact to streamflow behaviour or water resources downstream of the Project location are expected. At closure the mining pit will be entirely backfilled and rehabilitated reinstating the pre-mining catchment area to the Saxby River catchment.

8.2 MINE WATER DAM OVERFLOWS

The three mine water storages associated with the Project have the potential to overflow to the Southern Sediment Dam which ultimately overflows to the neighbouring land reporting to the Saxby River. These dams have been designed to prevent overflows during the Project life using the water balance model described in Section 6.2.2. The water balance model assessment identified there are no expected occurrences of uncontrolled mine water overflows during the operational phase of the mine. Should an overflow occur in an extreme event not assessed by the model, the small catchment area reporting to the mine water storages indicates an overflow would be of short duration and small volume relative to the receiving catchment flows that would provide significant dilution.

The design containment standard for the mine water dams, and the water balance modelling results, ensure that there would be minimal actual or potential discharge of contaminants to waters that may or have the potential to cause an adverse effect on identified environmental values. Refer to Section 5.3.1 for further information on the design containment standards.

8.3 SEDIMENT DAM OVERFLOWS

Sediment dams have been designed to contain the 20% AEP 24-hour design storm event with allowance for sediment storage. It is proposed to continually dewater the sediment dams to the mine water system to improve containment above what is required. The catchments reporting to the sediment dams are progressively rehabilitated over the Project life which reduces sediment runoff generation which further improves the performance of the sediment dams. The water balance modelling shows overflows from sediment dams occur in approximately less than 5% of years for the first 10 years of the Project and between 15% and 11% of years for the last 15 years of the Project (Table 6.8) which exceeds the design containment standards.

The sediment dams have been designed to provide sufficient storage for settlement of suspended solids so that water quality during overtopping events has negligible impact on the water quality in the receiving waterway. Sediment dams will also include overflow control structures with scour protection (rock chutes, rock aprons or level spreaders) to ensure non-erosive discharges. Monitoring of overtopping events will be undertaken to assess the performance of the sediment dams and ensure downstream environmental values are maintained and validate the design assumptions. Sediment dam overflows and associated water quality are not expected to have impacts downstream of the Project.

8.4 FLOODING

Potential flood impacts of the Project have been assessed using hydrology and hydraulic models developed for the Saxby River and Flinders River systems. The flood assessment identified all Project infrastructure remains outside of the PMF extent. The site access road crossing of the Saxby River is proposed to be a low-level crossing with minimal disturbance and obstruction of the main river channel and culverts to pass flow through the low-level crossing. Based on this the Project is not expected to result in any flooding impacts.

The Project location is on the northern bank of the Saxby River which is higher than the southern bank. In extreme flood events, flood waters break out of the southern bank of the Saxby River and flow towards the Flinders River limiting potential flood risk of the Project area.

8.5 SEEPAGE

As discussed in Section 0, there is potential for seepage to be generated from rainfall infiltration through the in-pit waste dump. The in-pit waste dump remains at or slightly above natural surface elevation and the potential for seepage to express at natural surface is extremely low. Any seepage generated from the in-pit dump is expected to report to the pit sump and be dewatered for reuse in the processing plant.

Uncontrolled release of seepage is not expected to occur from site and recovered seepage flows in the pit sump will be managed in accordance with the mine water management system. It is not expected that seepage from the waste dumps will cause impacts to surface water quality in the receiving environment.

8.6 CUMULATIVE IMPACTS

The Project is the only known planned mining operation or future project in the Saxby River catchment and therefore no cumulative impacts associated with this Project are expected.

8.7 CLIMATE CHANGE IMPACTS

Section 6.3 outlines the predicted climate change impacts on rainfall and evaporation for the “Best” case, “Worst” case and “Maximum consensus” climate model prediction scenarios. The year 2050 projected climate change variables are expected to reduce the total runoff and increase evaporation from storages in the operational water balance model. This would further reduce the risk of an uncontrolled mine water release from the Project which reduces the risk of potential impacts to the receiving environment.

Climate change is also expected to impact the magnitude of extreme storm events and the associated flooding. The flooding assessment identified there are no impacts to the Project in the Probable Maximum Flood and therefore potential climate change impacts to extreme flooding Is not expected to increase flooding risks or the risk to environmental harm associated with the Project.

9 REGULATED STRUCTURES

A preliminary consequence category assessment of water and waste containment structures proposed for the Project has been undertaken in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* – version 5.01 (the Manual) (DEHP, 2016). The Manual specifies the procedure for consequence category assessment of regulated structures, constructed as part of environmental relevant activities under the Environmental Protection Act 1994.

Water retaining structures are assessed using the Manual to determine if their consequence category is low, significant, or high. Structures deemed to be of significant or high consequence category are referred to as regulated structures.

The Project water management system has been designed to minimise the requirement for regulated structures where possible and retain them where required to ensure appropriate design and management of structures assessed as possibly having significant or high consequence categories.

The manual requires the assessment of the consequences of the following failure event scenarios:

- 'Failure to contain – seepage' – spills or releases to ground and/or groundwater via seepage from the floor and/or sides of the structure.
- 'Failure to contain – overtopping' – spills or releases from the structure that result from loss of containment due to overtopping of the structure.
- 'Dam break' – collapse of the structure due to any possible cause.

For each failure event scenario, the Manual requires the consequences to be assessed for each of the following categories of harm.

- Harm to humans.
- General environmental harm.
- General economic loss or property damage.

The consequence category of each type of harm is assigned, based on the severity of harm as specified in Table 1 of the Manual (refer to Table 9.1).

Table 9.1: Consequence Category Assessment Criteria (Table 1 of Manual) (DEHP, 2016)

Environmental Harm	Consequence Category		
	High	Significant	Low
Harm to Humans	Location such that people are routinely present in the failure path and if present loss of life to greater than 10 people is expected[1]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario. Location such that contamination of waters (surface and/or groundwater[2]) used for human consumption could result in the health of 20 or more people being affected[3].	Location such that people are routinely present in the failure path and if present loss of life to 1 person or greater, but less than 10 people is expected[1]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario Location such that contamination of waters (surface and/or groundwater[2]) used for human consumption could result in the health of 10 or more people but less than 20 people being affected.	Location such that people are not routinely present in the failure path and loss of life is not expected[1]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario Location such that contamination of waters (surface and/or groundwater[2]) used for human consumption could result in the health of less than 10 people being affected.
General Environmental Harm	Location such that: a) Contaminants may be released to areas of MNES, MSES or HEV waters that are not already authorised to be disturbed to at least the same extent under other conditions of this authority subject to any applicable offset commitment (Significant Values); and b) Adverse effects[4] on Significant Values are likely; and c) The adverse effects are likely to cause at least one of the following: i) Loss or damage or remedial costs greater than $50,000,000; or ii) Remediation of damage is likely to take 3 years or more; or iii) permanent alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 5 km^2.	Location such that contaminants may be released so that adverse effects (that are not already authorised to be disturbed to at least the same extent under other conditions of this authority subject to any applicable offset commitment) either: a) Would be likely to be caused to Significant Values but those adverse effects would not be likely to meet the thresholds for the High consequence category and instead would be likely to cause at least one of the following: i) Loss or damage or remedial costs greater than $10,000,000 but less than $50,000,000; or ii) Remediation of damage is likely to take more than 6 months but less than 3 years; or iii) Significant alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 1 km^2 but less than 5 km^2. or b) Would be likely to be caused to environmental values classed as slightly or moderately disturbed waters[5], wetland of general ecological significance[6], riverine areas, springs or lakes and associated flora and fauna (Moderate Values), and the adverse effects are likely to cause at least one of the following: i) Loss or damage or remedial costs greater than $20,000,000; or ii) Remediation of damage is likely to take more than 1 year; or iii) Significant alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 2 km^2	Location such that either: a) Contaminants are unlikely to be released to areas of Significant Values or Moderate Values; or b) Contaminants are likely to be released to those areas but would be unlikely to meet any of the minimum thresholds specified for the Significant Consequence Category for adverse effects.
General economic loss or property damage	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require $10 million or greater in rehabilitation, compensation, repair or rectification costs[7].	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require $1 million and greater but less than $10 million in rehabilitation, compensation, repair or rectification costs[7].	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require less than $1 million in rehabilitation, compensation, repair or rectification costs[7].

[1] 'People routinely present in the failure path' could be considered to be people who occupy buildings or other places of occupation that lie within the failure impact zone. For the purposes of this Manual, this should refer to people other than site personnel engaged by the resource operation and located on the tenements and tenure associated with the resource operation; for other ERAs, it would be the 'premises referred to in the authority'. It should be noted that while this is appropriate for the assessment of consequence categories in accordance with this Manual, adherence to the requirements of this Manual does not limit, amend or change in any way, any other requirements to be complied with under relevant health and safety acts or legislation that requires the safety of site personnel to be considered.

[2] When considering potential impacts on groundwater, it is not envisaged that a full hydrogeological assessment will be required in all cases. Any consideration of potential impacts on groundwater systems should consider the water quality of the potential receiving aquifer as well as the quality of fluid stored in the regulated dam. Existing groundwater drawdown in areas surrounding resource operations (e.g. drawdown as a result of mine pit or underground mine dewatering) can also be considered when assessing the consequence of dam seepage on groundwater systems.

[3] 'An adverse effect on human health means a physiological effect on human health and does not include an impact on the quality of downstream water that merely negatively affects taste and which is unlikely to cause persons to become physically ill.

[4] Adverse effects includes chronic and acute effects where an acute effect is on living organism/s which results in severe symptoms that develop rapidly, and a chronic effect is an adverse effect on a living organism/s which develops slowly. In some instances, it may be necessary to carry out or reference existing ecological/toxicological studies to assess the impacts of contaminants on living organisms.

[5] See Water EPP for definitions.

[6] Wetland of general ecological significance' means a wetland shown on a map of referable wetland as a 'general ecologically significant wetland' or 'wetland of other environmental value'.

[7] This does not include the holder's own mine or gas production, on-site industrial or commercial assets, the holder's workers' accommodation, agricultural facilities on the holder's land such as a farm shed or farm dam or infrastructure solely for servicing the holder.

9.1 PRELIMINARY ASSESSMENT OF FAILURE MODES

9.1.1 Dam Break

The Project storages are all expected to be excavated structures with the stored contents of each storage remaining below ground. Dam break is therefore not considered a feasible failure mode for any of the water or tailings containment structures associated with the Project.

9.1.2 Failure to Contain Overtopping

Water stored in the mine water dams (PWD, PDD and IRSF) is expected to be poor quality with low pH and elevated concentrations of metals and salinity based on the chemicals used in the Process Plant that will come into contact with these waters (refer Section 5.4). The mine water storages all have small catchment areas and overflows would be expected to be of short duration and volume and likely be contained within the drainage path between the process plant area and the Southern Sediment Dam or the Southern Sediment Dam impoundment. In the occurrence of an overtopping failure the drainage paths and possibly the Southern Sediment Dam can be desilted and removed of contaminants without significant environmental impacts, harm to humans or impacts to third parties. The overflow pathways of the site storages is shown on Figure 10.1

Water stored in the sediment dams is expected to contain only elevated concentrations of suspended solids following rainfall events. The structures are designed to allow for storm water detention to remove suspended solids before overflowing to the receiving environment. An overtopping failure of these structures is not expected to have significant impacts to the receiving waters.

The Raw Water Dam will contain clean water harvested from the Saxby River. Overflows from the Raw Water Dam are not expected to cause any adverse impacts to humans, third party infrastructure or the environment.

9.1.3 Failure to Contain Seepage

The deeper GAB aquifer (Gilbert River Formation) underlying the Project is a water source for a large number of local landholders and farming industries. The GAB has been determined to be hydraulically disconnected from the groundwater units in which the Project will be located and seepage from the Project is not expected to travel downwards into the GAB (JBT Consulting, 2023).

Water stored in the mine water dams (PWD, PDD and IRSF) is expected to be poor quality with low pH and elevated concentrations of metals and salinity. The Process Water Dam and the Pit Dewatering Dam are the only structures that are expected to store mine affected water for extended periods of time. These storages are located in fairly close proximity to the pit and seepage (if it occurs) from these structures will likely report to the mining pit for containment. In addition to this the geology in the Project area indicates fairly low conductivity with low potential for lateral movement of water. The impacts associated with failure to contain seepage from the mine water storages is not expected to result in significant environmental impacts, harm to humans or impacts to third parties.

Water stored in the sediment dams is expected to contain only elevated concentrations of suspended solids following rainfall events. Seepage from these structures is not expected to contain dissolved concentrations of contaminants that could have a significant impact to the receiving groundwater or surface water environment.

The Raw Water Dam will contain clean water harvested from the Saxby River. Seepage discharges from the Raw Water Dam are not expected to cause any adverse impacts to humans, third party infrastructure or the environment.

9.2 PRELIMINARY CONSEQUENCE CATEGORY ASSESSMENT

Table 9.2 outlines the preliminary Consequence Category Assessment (CCA) outcomes for the relevant Project water infrastructure, including the likely Regulated status and the determination for this classification. The CCA results are based on the concept design, intended operational strategy, and expected contaminant concentrations of stored contents for each structure.

The adopted purpose, conceptual location, and key infrastructure details for each structure are outlined in Sections 5 and 6. The mining pit does not require assessment as it is not an intended water storage for the Project and will be actively dewatered after rainfall events.

Whilst the preliminary CCAs have been completed for the purpose of the EA application during detailed design of the Project water infrastructure, a detailed CCA will be completed, which will be undertaken and certified as part of the design process required by the Manual.

Table 9.2: Preliminary Consequence Category Assessment Outcomes and Determination

Structure	Scenario	Category of Harm	Consequence Category	Regulated	Determination
Process Water Dam	Failure to Contain - Seepage	Harm to Humans	Low	No	The structure receives process return flows from the processing plant which is considered to have greater potential for contamination. The storage has a minor external catchment area (processing plant) and overflows from the storage are expected to be of low volume and duration and are likely to be contained within the downstream drainage path or Southern Sediment Dam which is expected to result in limited consequences. Seepage from the storage is considered unlikely due to low hydraulic conductivity of the underlying geology and due to the close proximity of the pit, any seepage is expected to report to the active mining pit for containment. The structure is an excavated storage with no potential for a dam break scenario.
		General Environmental Harm	Low		
		General Economic Loss or Property Damage	Low		
	Failure to Contain - Overtopping	Harm to Humans	Low		
		General Environmental Harm	Low		
		General Economic Loss or Property Damage	Low		
	Dam Break	Harm to Humans	Low		
		General Environmental Harm	Low		
		General Economic Loss or Property Damage	Low		
Pit Dewatering Dam	Failure to Contain - Seepage	Harm to Humans	Low	No	The structure receives mine water from the pit which is considered to have greater potential for contamination. The storage has no external catchment area and overflows from the dam are expected to be of low volume and duration and are likely to be contained within the downstream drainage path or Southern Sediment Dam which is expected to result in limited consequences. Seepage from the storage is considered unlikely due to low hydraulic conductivity of the underlying geology and due to the close proximity of the pit, any seepage is expected to report to the active mining pit for containment. The structure is an excavated storage with no potential for a dam break scenario.
		General Environmental Harm	Low		
		General Economic Loss or Property Damage	Low		
	Failure to Contain - Overtopping	Harm to Humans	Low		
		General Environmental Harm	Low		
		General Economic Loss or Property Damage	Low		
	Dam Break	Harm to Humans	Low		
		General Environmental Harm	Low		
		General Economic Loss or Property Damage	Low		
		Harm to Humans	Low	No	

Structure	Scenario	Category of Harm	Consequence Category	Regulated	Determination
Interim Residue Storage Facility	Failure to Contain - Seepage	General Environmental Harm	Low		The structure will be maintained empty and only be used for the temporary storage of residue from the Processing Plant when access to the mining pit is unavailable. When access to the pit becomes available, water and residue material from the storage will be removed and continued to be maintained empty. Seepage from the structure is considered unlikely and standing water will not remain in the structure for long periods of time with the potential to create a hydraulic connectivity to the groundwater system. Therefore failure to contain seepage is expected to result in limited consequences. The storage has no external catchment area and overflows from the dam are expected to be of low volume and duration and are likely to be contained within the downstream drainage path or Southern Sediment Dam which is expected to result in limited consequences. The structure is an excavated storage with no potential for a dam break scenario.
		General Economic Loss or Property Damage	Low		
	Failure to Contain - Overtopping	Harm to Humans	Low		
		General Environmental Harm	Low		
		General Economic Loss or Property Damage	Low		
	Dam Break	Harm to Humans	Low		
		General Environmental Harm	Low		
		General Economic Loss or Property Damage	Low		
Northern Sediment Dam and Southern Sediment Dam	Failure to Contain - Seepage	Harm to Humans	Low	No	Water stored in the sediment dams is expected to contain only elevated concentrations of suspended solids following rainfall events. Seepage from these structures is not expected to contain dissolved concentrations of contaminants that could have a significant impact to the receiving groundwater or surface water environment. The structures are designed to allow for storm water retention to remove suspended solids before overflowing to the receiving environment. Overflows from the sediment dams are not expected to contain dissolved concentrations of contaminants that could have a significant impact to the receiving environment.
		General Environmental Harm	Low		
		General Economic Loss or Property Damage	Low		
	Failure to Contain - Overtopping	Harm to Humans	Low		
		General Environmental Harm	Low		
		General Economic Loss or Property Damage	Low		
	Dam Break	Harm to Humans	Low		
		General Environmental Harm	Low		

Structure	Scenario	Category of Harm	Consequence Category	Regulated	Determination
		General Economic Loss or Property Damage	Low		The structure is an excavated storage with no potential for a dam break scenario.
Raw Water Dam	Failure to Contain - Seepage	Harm to Humans	Low	No	The Raw Water Dam will continue clean water harvested from the Saxby River. Seepage and overflow discharges from the Raw Water Dam are not expected to cause any adverse impacts to humans, third party infrastructure or the environment. The structure is an excavated storage with no potential for a dam break scenario.
		General Environmental Harm	Low		
		General Economic Loss or Property Damage	Low		
	Failure to Contain - Overtopping	Harm to Humans	Low		
		General Environmental Harm	Low		
		General Economic Loss or Property Damage	Low		
	Dam Break	Harm to Humans	Low		
		General Environmental Harm	Low		
		General Economic Loss or Property Damage	Low		

9.3 PRELIMINARY CONSEQUENCE CATEGORY ASSESSMENT SUMMARY

Table 9.3 below summarises the preliminary consequence category assessment of the structures associated with the Project. All structures were assessed as having a preliminary consequence category of Low and are not expected to be classified as regulated structures.

A certified consequence category assessment will be completed for all structures in accordance with the Manual during detailed design. If the assessed consequence category of any structure increases to Significant or High during detailed design, hydraulic performance design criteria will need to be adopted in accordance with the Manual. This would include:

- Failure to Contain -Overtopping: Adoption of a Design Storage Allowance (DSA) and Maximum Reporting Level (MRL).
- Dam Break: Spillway capacity upgrade for the nominated design flood event.
- Failure to Contain – Seepage: Installation of a dam liner to prevent seepage from the structure.

It is proposed to line PWD to reduce risk of environmental harm due to seepage, besides PWD assessed as having a "low" consequence for the "failure to contain – Seepage". The need for a liner for the other storages will be determined during detailed design when additional information on water quality of the processing plant recycled water is available.

Table 9.3: Preliminary Consequence Category Assessment Summary

Structure	Failure to Contain - Seepage	Failure to Contain - Overtopping	Dam Break	Regulated
Process Water Dam	Low	Low	Low	**No**
Pit Dewatering Dam	Low	Low	Low	**No**
Temporary Residue Storage Facility	Low	Low	Low	**No**
Northern Sediment Dam	Low	Low	Low	**No**
Southern Sediment Dam	Low	Low	Low	**No**
Raw Water Dam	Low	Low	Low	**No**

10 MITIGATION AND MANAGEMENT MEASURES

Surface water mitigation strategies have been discussed throughout the development of the water management system and water balance model (Sections 5 to 6) and the risk of regional flooding to the Project (Section 7). The water management system has been specifically designed to minimise impacts to the surrounding environment and water resources in the region.

This section summarises how the mitigation strategies address the impacts outlined in Section 7.4. The water management system infrastructure has been developed to achieve the water resource and water quality objectives of:

- Equitable, sustainable, and efficient use of water resources.
- Maintenance of environmental flows, water quality, in-stream habitat diversity and naturally occurring inputs from riparian zones (including groundwater dependent ecosystems) support the long-term maintenance of the ecology of aquatic biotic communities.
- The condition and natural function of water bodies are maintained including the stability of beds and banks of watercourses.
- Protecting the environmental values of waters.
- Protecting the environmental values of wetlands and groundwater dependent ecosystems (GDEs), and
- Protecting the environmental values of groundwater and any associated surface ecological systems.

A range of management strategies has been proposed to mitigate any negative environmental impacts on water resources and water quality, and to assist in meeting the water quality objectives and protection of identified environmental values. The proposed management strategies and contingency measures are summarised in Table 10.1 against the management hierarchy and intent of the EPP (Water).

Table 10.1: Management and Mitigation Strategies

Mitigation/Monitoring Measure	Function
Diversion of clean catchments around disturbed areas	Diverting clean catchment around the Project reduces the risk of overwhelming the mine water storage inventory and the risk of an uncontrolled overflow as well as reduces impact to streamflow in the receiving waterway. The proposed implementation of clean catchment diversions over the Project life is expected to mitigate the risk of an uncontrolled mine water overflow and minimise streamflow impacts downstream of the Project (refer Section 6.2.2 and Section 8.1).
Progressive rehabilitation	Progressive rehabilitation allows the restoration of natural runoff properties to disturbed catchment which, after establishment, can be allowed to runoff into the receiving waterways. This reduces the exposure period of disturbed areas with the potential to produce sediment runoff. monitoring the performance of rehabilitation techniques and establishment over the Project life.
	Diversion of clean water catchment reduces the quantity of contaminated water generated by reducing the amount of runoff interacting with mine affected or sediment water storages.
	Progressive rehabilitation allows for monitoring the performance of rehabilitation methods, establishment timeframes and performance over the Project life. Water quality within sediment dams collecting runoff from rehabilitated areas will be monitored to demonstrate the success of the rehabilitation and to determine when rehabilitated catchments can begin to be released to the environment.
Erosion and sediment controls for treatment of sediment runoff	The erosion and sediment control strategy has been developed to prevent erosion through minimising disturbance and drainage control structures. Where minimising disturbance is not possible, sediment basins have been design designed to contain sediment runoff from disturbed areas including rehabilitated areas until they are suitably established. Sediment and erosion control structures are designed in accordance with relevant guidelines to ensure adequate catchment and treatment of suspended solids in disturbed catchment runoff and minimise impacts from excessive sediment loads on the receiving waterways.

Mitigation/Monitoring Measure	Function
Design containment standard of mine affected water storages	Mine affected water storages have been designed such that the standard of containment for all water infrastructure containing mine water meets the environmental objectives for regulated structures containing contaminants from the DEHP Guideline for Structures which are Dams or Levees Constructed as part of Environmentally Relevant Activities (DEHP, 2017a). The design containment standard for the mine water dams and the water balance modelling results demonstrate uncontrolled mine water releases are expected to occur in less than 1% of years.
Treatment and release of waters to facilities, land or waters.	Sediment dam water quality will be monitored regularly to validate expected water quality of runoff from disturbed areas and confirm that the proposed operating strategy achieves the desired water quality outcomes. Monitoring of the receiving environment will be undertaken during operations as well as during and after all uncontrolled releases from sediment dams. Outcomes of the monitoring data will be used to identify any potential environmental harm and provide recommendations for improvements to erosion and sediment control measures.
	Review of the water quality data for water storages will occur as part of updates to the Water Management Plan, while surface water quality data for the receiving waterways will be reviewed as part of the Receiving Environment Monitoring Program (REMP) (see Section 10.2). The reviews will identify any deviations from assumed or predicted water quality and whether the current management controls are appropriate to meet water quality objectives for environment values within the receiving environment. In an unlikely event of a non-compliant water release from the mine water management system, a review of the system operation and performance will be conducted by a suitably qualified and experienced person including recommendations for any corrective action and changes to management controls if required.
Flooding	Flooding risks and potential impacts for the project have been assessed using detailed hydrology and hydraulic models which have been validated to recent significant flood events and regional flood frequency analysis. The flooding assessment identified there are no expected flood impacts in all events up to the Probable Maximum Flood. Review of the flood model and flooding risks associated with the Project can be re-assessed following capture of detailed survey of the Project location and future streamflow monitoring data captured of significant flood events in the Saxby River and Flinders River.
Spill response and containment	Appropriate procedures, containment and spill control measures will be implemented at appropriate locations where the transportation and loading, as well as storage of materials occurs onsite. The design and management of all required fuels and hydrocarbons will ensure there are effective means of secondary containment to prevent or minimise releases to the environment from any fuel and oil storage onsite.
Recycle, re-use or treat waste waters or contaminants. Reduction in stored inventory through preferential process use	Water dewatered from the pit and contained in mine water storages will be used preferentially for supply to Project water demands to reduce mine water inventories and accumulation of contaminated water in the water management system.
	Water contained within sediment dams on site will be used wherever possible for dust suppression and other operational demands prior to utilising external raw water supply.
Final landform design	The mine plan and final landform has been developed to allow complete backfill of the mining pit with a final elevation that replicates the existing topography level and drainage. This allows the entire Project area to be freely draining with no ongoing water management risks or potential impacts post closure.

10.1 WATER BALANCE MODEL UPDATE AND REVIEW PROGRAM

The operational water balance model developed for the Project will receive continual updates and validation throughout the Project life as more data and information become available. The updated model will then be used to review the water management system and performance against what was determined for the surface water impact assessment.

The following data and information will be collected for the duration of the Project to inform the regular updating and validation of the operational water balance model:

- Water inventory of the mine water dams and sediment dams (dam water level).
- Water quality sampling of the mine water storages and sediment dams.
- Pumped flow meter data for major transfer and water demand offtakes (pit dewatering, process water transfers, fill points).
- Aerial survey of the mine topography to review catchment area and land use development.
- Daily rainfall.

The model will be validated (or calibrated) to recorded dam inventories captured from the monitoring activities described above. The update and review of the model will be used to assess validity of the following model parameters, inputs, and assumptions:

- Surface water runoff parameters for the various site land uses.
- Pumpable groundwater volumes reporting to the mining pit (using pit dewatering information).
- Project water demands.
- The classification of storages using water quality information (sediment storage or mine affected storages).

10.2 WATER QUALITY MANAGEMENT AND MONITORING

A water quality monitoring program is one of the key controls for the ongoing performance assessment of the site. Monitoring of upstream, downstream and site water quality and streamflow will be used to:

- Continue to collect local water quality and streamflow data.
- Detect and identify any causes in changes from baseline conditions.
- Develop a statistically sufficient dataset of baseline local water quality data to produce site-specific WQOs.
- Identify any impacts and corrective actions required; and,
- Assess the performance of the water management system and the effectiveness of any mitigation and management measures.

The water quality indicators (as listed in Section 10.2), will be measured against the WQOs for the receiving waterway (refer to Section 3.3.1) throughout the construction, operation and decommissioning stages of the Project.

The Project will be required to develop site-specific plans to outline the management of surface waters during the construction, operational and decommissioning phases of the mine, for example:

- Water Management Plan (WMP).
- Receiving Environment Monitoring Program (REMP).
- Erosion and Sediment Control Plan (ESCP); and,
- Progressive Rehabilitation and Closure Plan (PRCP).

Any required changes or updates to the ongoing water quality and streamflow monitoring for the Project site will be assessed and documented through the development of and routine updates to these documents. These plans will also outline the routine assessment, reporting mechanisms and auditing of water quality data and WQO, as well as mitigation measures and triggers for any corrective actions.

10.2.1 Surface Water Monitoring Locations

Proposed surface water monitoring locations are summarised in Table 10.2: and shown in Figure 10.1. The Saxby River at Punchbowl Road (GS915017A) is an existing flow monitored by DRDMW. The additional locations are proposed to be monitored by the Project, prior to site establishment and during the Project duration.

Monitoring locations have been located such that there are sampling locations both upstream (reference or control) and downstream of the site and its potential impacts. The downstream monitoring stations have been located so they are downstream of the site storages overflow pathways confluence with the Saxby River. The site storages overflow pathways are shown on Figure 10.1.

Sampling of the Saxby River can only be undertaken during low flows due to the wide flood extent during medium to high flow events. An additional sampling location has been proposed on a tributary of the Saxby River which receives overflows from the site storages to allow assessment of potential surface water impacts between the Projects Production ML and the Saxby River. This sampling location is expected to maintain wet weather access and allow assessment of potential impacts if the Saxby River is inaccessible.

Monitoring locations upstream of the site have been selected such that they can transition into a Receiving Environment Monitoring Program (REMP) during the operational phase of the Project.

Additional or alternative monitoring locations (e.g., other water storages on site and/or surrounding environmental features) will be developed as part of site-specific plans as required. This will include dedicated sites to monitor channel and floodplain geomorphology throughout the life of the mine e.g., sediment dam discharge locations.

Table 10.2: Proposed Surface Water Monitoring Locations

Monitoring Location (ID)	Easting (GDA94)	Northing (GDA94)	Proposed Sampling	Purpose
Saxby River at Punchbowl Road (GS915017A)	142.035	-20.053	Streamflow	Monitor Saxby River flow rate to determine raw water harvesting potential.
Upstream Saxby River 1	141.923	-19.991	Water Quality Sediment	Background water quality site to assess potential impacts to downstream water quality and sediment and define site specific water quality objectives.
Upstream Saxby River 2	141.925	-19.997	Water Quality Sediment	
Upstream Saxby River 3	141.940	-20.005	Water Quality Sediment	
Saxby River Road Crossing	141.876	-19.994	Water Quality Sediment	Monitoring at the Saxby River crossing, upstream of the site storages overflow pathways confluence with the Saxby River to assess potential impacts to downstream water quality and sediment.
Saxby River Tributary	141.821	-19.970	Water Quality Sediment	Monitoring of the site storages overflow pathway to the Saxby River to assess potential impacts to downstream water quality and sediment without influence of dilution with Saxby River streamflow.
Downstream Saxby River 1	141.803	-19.994	Water Quality Sediment	Monitoring of the Saxby River, downstream of the confluence with the site storages overflow pathways to assess potential impacts to water quality and sediment.
Downstream Saxby River 2	141.777	-19.979	Water Quality Sediment	

10.2.1 Streamflow Sampling Locations

Streamflow gauging will be required during the operational phase of the Project to inform potential streamflow harvesting opportunities, assess impacts and to allow for ongoing refinement of surface water models. It is proposed to monitor streamflow at the Saxby River at Punchbowl Road gauging station (DRDMW) unless additional monitoring requirements are required as part of a separate water licence approval.

10.2.2 Water Storage Sampling

Sampling of the site water storages will be conducted quarterly to monitor stored water quality and the potential risk the storages pose to environmental harm. Sampling of water storages will also be completed during overflow events to determine the concentration and quantity of released contaminants to allow investigation into the extent of environmental harm. Water storages will be sampled for the water quality parameters presented in the following section.

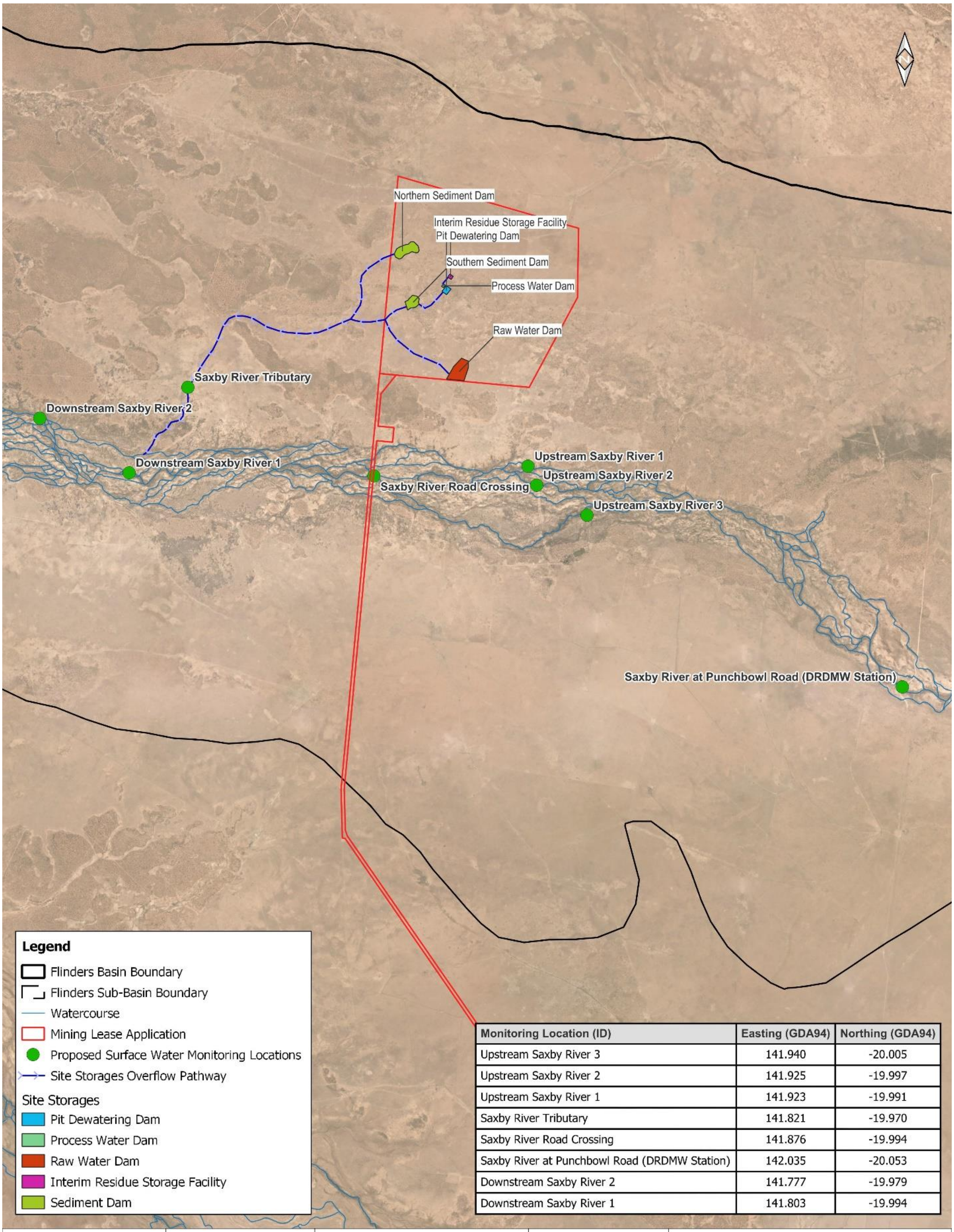
10.2.3 Sampling Methods and Parameters

Water quality monitoring parameters are proposed for the baseline monitoring program in Table 10.3. These parameters form the basis for ongoing operational monitoring of both physico-chemical parameters, as well as potential contaminants (e.g. metals). Water quality monitoring should be undertaken using a combination of laboratory and in situ sampling and in accordance with the Queensland Monitoring and Sampling Manual (DES, 2018).

During the operational phase of the mine, the surface water sampling frequency will be dictated and outlined within environmental approvals and/or site-specific plans. To best meet the Queensland Monitoring and Sampling Manual minimum sample quantity requirements, it is recommended the ongoing monitoring program sample frequency is monthly for discrete water quality parameters. Parameters such as streamflow, pH and electrical conductivity are generally monitored continuously (i.e., real time/in situ). It is recommended that monitoring be conducted for a period of at least one year prior to any statistical analysis being undertaken.

Water quality parameters will be measured against the WQOs and where they are not met, investigations will be undertaken to determine the cause and any required corrective actions.

However, WQOs associated with the water quality monitoring parameters will be able to be reviewed for the site once a statistically sufficient dataset of baseline local water quality data has been obtained in accordance with Guideline requirements. This review of local water quality data and any potential variation of WQOs will allow for local background correction if required, which will assist the Project develop adaptive and suitable management measures and responses.



Monitoring Location (ID)	Easting (GDA94)	Northing (GDA94)
Upstream Saxby River 3	141.940	-20.005
Upstream Saxby River 2	141.925	-19.997
Upstream Saxby River 1	141.923	-19.991
Saxby River Tributary	141.821	-19.970
Saxby River Road Crossing	141.876	-19.994
Saxby River at Punchbowl Road (DRDMW Station)	142.035	-20.053
Downstream Saxby River 2	141.777	-19.979
Downstream Saxby River 1	141.803	-19.994

0 2,500 5,000 m

Scale in metres (1:100,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 54

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Surface Water Monitoring Locations

A3 Figure 10-1 A

Figure 10.1: Proposed Surface Water Monitoring Locations

Table 10.3: Proposed Water Quality Monitoring Parameters

Monitoring Category	Indicator
Surface Water - Physio-chemical	pH
	Salinity (Electrical Conductivity (EC))
	Dissolved Oxygen (DO)
	Temperature
	Turbidity
	Sulphate
	Total Suspended Solids
	Nitrogen (Total N, Oxidised N, Kjeldahl Nitrogen, Ammonium)
	Phosphorus (Total P, Filterable Reactive Phosphorus)
	Dissolved Organic Carbon
Surface Water - Toxicants	Metals and Metalloids (As, Al, Ag, B, Ba, Be, Cd, Co, Cr, Cu, Fe, Hg, Mg, Pb, Ni, Se, U, V, Zn)
	Chloride, Fluoride, Calcium, Sodium
	Total Recoverable Hydrocarbons and Total Petroleum Hydrocarbons
	Radionuclides
Surface Water - Biological Indicators	Microalgal (Chlorophyll-a)
Sediment and Soil	Particle Size Distribution and soil classification
	EC
	pH
	Moisture Content
	Metals and Metalloids (As, Al, Ag, B, Ba, Be, Cd, Co, Cr, Cu, Fe, Hg, Mg, Pb, Ni, Se, U, V, Zn)
	Chloride, Fluoride, Calcium, Sodium
	Nitrogen (Total N, Oxidised N, Kjeldahl Nitrogen, Ammonium)
	Phosphorus (Total P, Filterable Reactive Phosphorus)
	Total Recoverable Hydrocarbons and Total Petroleum Hydrocarbons

10.3 WATER MANAGEMENT PLAN

The primary purpose of a mining project water management plan is to examine and address all issues relevant to the importation, generation, use, and management of water on a mining project in order to minimise the quantity of water that is contaminated and released by and from the project (DEHP, 2012). A water management plan detailing site water management infrastructure, maintenance requirements and containment performance standards will be prepared in accordance with EA conditions. This document will provide a structure for achieving the adequate protection of EVs by achieving WQOs (as identified in Section 3.2 and 3.3). The water management plan will document the likelihood and consequence of risks to EVs and WQOs within and around the Project as well as the management controls in place to reduce risks to an acceptable level.

The water management plan is expected to address the following aspects of site water management:

- Background information and description of site activities relevant to water management including:
  - Identified environmental values and water quality objectives of the receiving waterways.
  - Description of receiving waterways.
  - Description of the local and regional groundwater aquifers.
  - Water quality monitoring of the receiving waterways and groundwater aquifers used to establish baseline conditions.
  - Description of current and historical mining and associated activities.
  - Site climate conditions.
- Description of contaminant sources for the different water sources and uses associated with the project.
- Water management system including:
  - Objectives of water management system.
  - Site storages details and locations.
  - Transfer infrastructure.
  - Identification of bulk water storages.
  - Proposed actions to maintain water infrastructure.
  - Actions required to maintain required freeboard in containment structures.
- Site water balance details including:
  - Details of major water inflow and outflow mechanisms.
  - Water balance model development including:
    - Details of calibration of runoff parameters.
    - Key input assumptions.
  - Water balance forecast results.
- Details of water quality monitoring plan and monitoring outcomes.
- Emergency and contingency planning.
- Assignment of responsibility for water management plan actions.

The water management plan will be updated annually prior to the wet season (November) for the life of the Project. This will enable identification of changes to the water management system and the site water balance and allow implementation of mitigation measures to prevent impacts to receiving Environmental Values. The update process will identify risks associated with the water management system and feedback to infrastructure and operational management improvements.

10.4 EROSION AND SEDIMENT CONTROL PLAN

An erosion and sediment control plan (ESCP) detailing design and maintenance requirements will be prepared in accordance with EA requirements, to manage erosion and sediment control measures implemented in association with the Project.

Management of erosion and sediment control will be undertaken in accordance with the Best Practice Erosion and Sediment Control (BPESC) guideline (IECA, 2018), which provides guidance on sediment basin sizing and operation. Further details on the sizing of sediment basins for the Project are provided in Section 5.3.3. The ESCP will define the following aspects of the erosion sediment control requirements for the Project:

- Limiting disturbance to prevent sediment runoff generation.
- Erosion control measures such as revegetation and rehabilitation, aimed to prevent soil erosion from disturbed areas.
- Documenting soil types and disturbed catchment areas on the site and their potential for sediment generation.

- Design and management of drainage control measures to prevent erosion from concentrated flows and manage the flow of both clean water and sediment runoff.
- Erosion and sediment control requirements associated with temporary disturbance and construction activities.
- Design and management of sediment dams including dewatering and desilting requirements and the use of suitable construction materials.
- Water quality testing of sediment dams to assess their performance and inform continual improvements of the erosion and sediment control system.

10.5 RECEIVING ENVIRONMENT MONITORING PROGRAM

A receiving environment monitoring program (REMP) will be developed to monitor, identify, and assess any impacts to the EVs, water quality and flows within the receiving environment over the Project life. The REMP will require annual monitoring and reporting and analysis of long-term trends and potential impacts. Outcomes of the monitoring programs will inform further mitigation measures and remediation of existing mitigation measures as required.

The REMP will be developed to include the following:

- Background information and descriptions of:
  - Site location and history.
  - Catchment and watercourses.
  - Regional and local land use.
  - Local climate conditions.
  - Receiving environment EVs and WQOs.
- Monitoring aspects which are expected to include stream flow, surface water and sediment quality, ecology, and habitat.
- Monitoring methodology will be developed in accordance with the Queensland Monitoring and Sampling Manual (DES, 2018).
- Monitoring locations and selection of sites including consideration of temporal variation.

11 QUALIFICATIONS

a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

c) Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

  i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or

  ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

d) Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.

e) This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this Report.

f) If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the Report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.

g) This Report does not provide legal advice.

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engeny.com.au

P: 07 3221 7174
Lvl 2, 500 Queen Street, Brisbane QLD 4000 | PO Box 10183 Brisbane QLD 4000