water + environment

Lake Vermont Meadowbrook Project EIS

Surface Water Assessment

Bowen Basin Coal Pty Ltd
0622-27-B5, 29 September 2023

Report Title	Lake Vermont Meadowbrook Project EIS – Surface Water Assessment
Client	Bowen Basin Coal Pty Ltd
Report Number	0622-27-B5

Revision Number	Report Date	Report Author	Reviewer
3	24 November 2022	MJB	MPB
4	3 February 2023	MJB	MPB
5	29 September 2023	MJB	MPB

For and on behalf of WRM Water & Environment Pty Ltd
Level 9, 135 Wickham Tce, Spring Hill
PO Box 10703 Brisbane Adelaide St Qld 4000
Tel 07 3225 0200

Michael Batchelor

Senior Principal Engineer

Contents

List of Figures

List of Tables

1 Introduction

1.1 BACKGROUND

The proposed Meadowbrook Coal Mine is an extension of the existing Lake Vermont Coal Mine located approximately 25 km northeast of Dysart and approximately 160 km southwest of Mackay. It involves the construction and operation of an underground multiseam longwall coal mine and an open-cut pit and supporting infrastructure to produce pulverised coal injection (PCI) and coking coal, primarily for export. The proposed project layout is shown in Figure 1.1. The open-cut operation would commence operations in Project Year 20 (indicatively 2045) with a partially backfilled pit (to provide a post mining land use) at the conclusion of mining.

WRM Water & Environment Pty Ltd (WRM) was commissioned by Bowen Basin Coal to undertake a surface water assessment for the Project. The surface water assessment will form part of an Environmental Impact Statement (EIS) for the Project under the *Environment Protection Act 1994* (QLD).

This report briefly outlines the findings of the following detailed studies provided in the supporting detailed technical reports:

- flood modelling assessment (WRM, 2022a);
- geomorphology assessment (WRM, 2022b);
- site water balance and water management system (WRM, 2022c);
- rehabilitated landform water balance (WRM, 2022d).

1.2 PROJECT DESCRIPTION

The Project is proposed to include the development of a double-seam underground longwall coal mine, along with a small-scale open cut pit targeting coal resources adjacent to the north of the existing Lake Vermont Mine.

To support the operation of the proposed underground development, a new ‘satellite’ Mine Infrastructure Area (MIA) will be constructed. A new infrastructure corridor will also be constructed, linking the new MIA to the existing infrastructure located at Lake Vermont Mine. This infrastructure corridor will enable the delivery of power and water, provide personnel and materials access, as well as facilitate the clearance of ROM coal to the existing Coal Handling and Preparation Plant (CHPP). A conceptual project layout is shown in Figure 1.2.

The Project is expected to produce approximately nine Mtpa of metallurgical product coal (for the export and domestic market) over an operational life of approximately 30 years. The output from the Project will supplement the scheduled decline in production from the existing open cut operations, so that the total output from the Lake Vermont complex will be maintained within the existing EA limit of 12 Mtpa of ROM coal.

The proposed mine development will therefore be comprised of:

- a double seam underground longwall coal mine (supported by some bord and pillar mining development);
- a small open cut pit;
- a mine clean water dam as well as a dewatering dam;
- a new MIA;
- a surface ROM stockpile located within the new MIA;
- a truck haulage road to deliver ROM coal from the new MIA to the existing CHPP;

- an infrastructure corridor for the delivery of power and water as well as an access roadway for the movement of personnel and materials; and
- a network of gas drainage bores and associated surface infrastructure, including access tracks, across the underground mine footprint.

1.3 TERMS OF REFERENCE

This assessment forms part of an EIS which has been prepared in accordance with Part 4 of the SDPWO Act. This assessment has been prepared to satisfy the requirements of the site-specific Terms of Reference (TOR) issue in April 2020 (Queensland Government, 2020).

The EIS process applies to site-specific environmental authority (EA) applications for undertaking resource projects that meet any of the Department of Environment and Heritage Protection's (DEHP) EIS triggers in the guideline "*Environmental impact statement – Triggers for environmental impact statements under the Environmental Protection Act 1994 for mining, petroleum and gas activities*".

This assessment, which forms part of the EIS, addresses parts of the TOR relevant to surface water.

1.4 REPORT STRUCTURE

This report is structured as follows:

- Section 2 describes the regulatory framework that would apply to surface water management for the Project;
- Section 3 describes the environmental values of the regional receiving waters;
- Section 4 describes the existing surface water environment including the regional and local drainage characteristics;
- Section 5 describes the proposed surface water management system;
- Section 6 presents of summary of findings for the surface water assessment;
- Section 8 presents the references used throughout the report.

Further information is provided in the following detailed technical reports:

- flood modelling assessment report (WRM, 2022a);
- geomorphological assessment report (WRM, 2022b);
- site water balance and water management system report (WRM, 2022c);
- rehabilitated landform water balance report (WRM, 2022d).

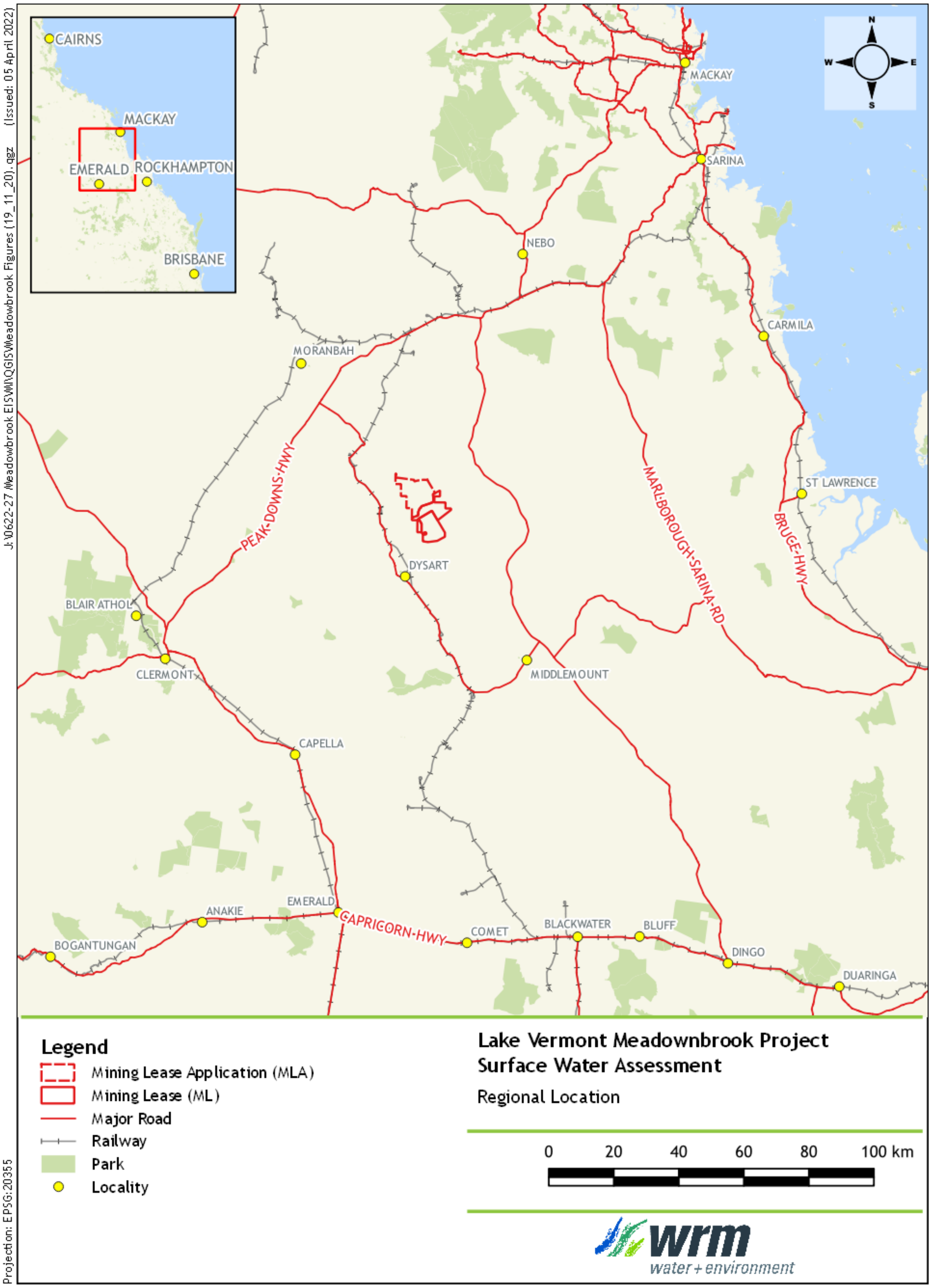


Figure 1.1 – Regional location

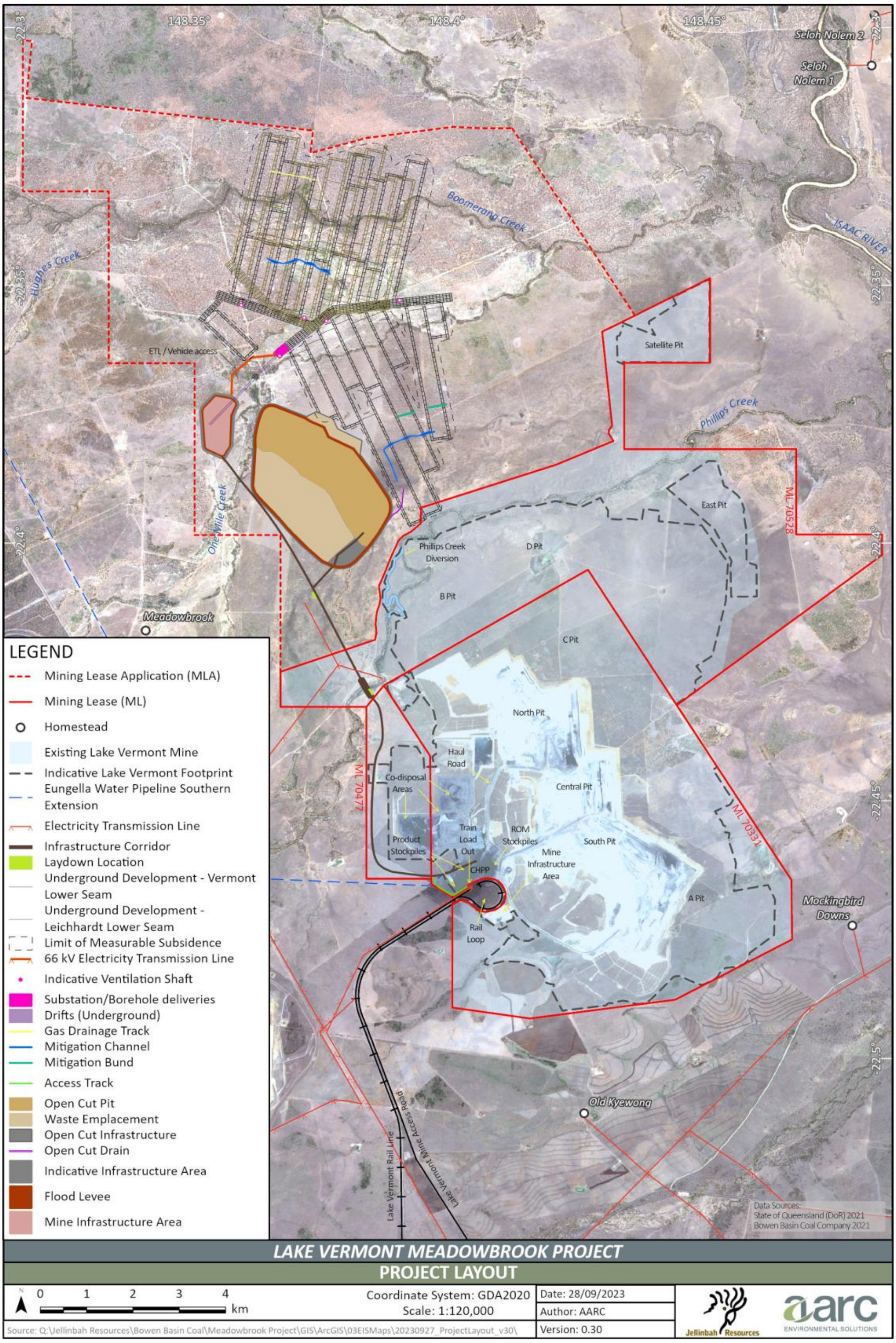


Figure 1.2 – Project layout

2 Regulatory framework

This section describes the regulatory framework (legislation, policies and standards) at Commonwealth and State level that would apply to surface water management for the Project.

2.1 COMMONWEALTH

2.1.1 Environment Protection and Biodiversity Conservation Act 1999

The Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act) outlines the requirements relating to the management and protection of matters of national environmental significance (MNES).

On 22 November 2019, the Department of the Environment and Energy (DoEE) determined the Project to be a controlled action (EPBC 2019/8485). The controlled action includes 'a water resource, in relation to coal seam gas development and large coal mining development (sections 24D & 24E)' as the controlling provision relevant to this assessment.

2.1.2 Independent Expert Scientific Committee

The Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Developments provides scientific advice to decision makers on the impact that coal seam gas and large coal mining development may have on Australia's water resources.

The IESC provides independent, expert scientific advice on coal seam gas and large coal mining proposals as requested by the federal and state government regulators. The IESC assess the proposals against the Information Guidelines for Independent Expert Scientific Committee advice (IESC, 2018) on coal seam gas and large coal mining development proposals where there is a significant impact on water resources. The core purpose of the guideline is to determine whether a coal seam gas (CSG) or large coal mining development has or is likely to have a significant impact on a water resource.

As described in Section 2.1.1, the Project has been deemed a controlled action under the EPBC Act, with one of the controlling provisions being 'a water resource, in relation to coal seam gas development and large coal mining development (sections 24D & 24E)' and therefore requires approval from the Australian Government Environment Minister (the Minister).

2.2 QUEENSLAND

2.2.1 Queensland Environmental Protection Act 1994

Resource activities are defined as environmentally relevant activities (ERAs) under the Queensland Environmental Protection Act 1994 (EP Act) and as such, the development and operation of the Project are governed by the EP Act. The object of the EP Act is to:

> *Protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development).*

2.2.1.1 Environmental Authority

An environmental authority (EA) is granted in accordance with the EP Act and details the conditions that govern the ERA. In the context of surface water management, the EA will set out conditions that will be relevant to the Project, including:

- management of contained water including release;
- water management plan requirements;
- regulation of water structures including dams and levees;

- saline drainage management;
- acid rock drainage management; and
- storm water and sediment laden runoff management.

2.2.1.2 Model Mining Conditions

New mining project applications should apply the model mining conditions as outlined in Model mining conditions (DEHP, 2017). The purpose of the model mining conditions is to provide a set of model conditions to form the general environmental protection commitments given for EAs for mining activities administered under the EP Act. The model conditions may be used as a basis for proposing environmental protection commitments in application documents (such as an EIS).

Model conditions can be modified to suit the specific circumstances of a mining project, subject to the assessment criteria outlined in the EP Act. It is unlikely that the administering authority will accept less rigorous environmental protection commitments or EA conditions without clear evidence that the risk of the environmental harm is addressed by environmental management practices, technologies or the nature of the EVs impacted by the project.

Schedule F – Water (Fitzroy model conditions) form the basis of the requirements for the Project Water Management System design.

2.2.1.3 Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water) is the primary instrument for surface water management under the EP Act. The EPP Water governs discharge to land, surface water and groundwater, aims to protect environmental values (EVs) and sets water quality guidelines and objectives.

The processes to identify Environmental Values (EVs) and to determine Water Quality Guidelines (WQGs) and Water Quality Objectives (WQOs) in Queensland waters based on the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ guidelines).

2.2.1.4 Isaac River Sub-basin Environmental Values and Water Quality Objectives 2011

The relevant document, pursuant to the EPP Water, for the Project is the *Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part)*, including all waters of the Isaac River Sub-basin (including Connors River), September 2011 (DEHP, 2011). The document is made pursuant to the provisions of the EPP Water. It contains Environmental Values (EVs) and Water Quality Objectives (WQOs) for waters in the Isaac River Sub-basin, and they are listed under Schedule 1 of EPP Water. Refer to Section 3.1 for further details.

2.2.1.5 Manual for Assessing Consequence Categories and Hydraulic Performance of Structures

The *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (the Manual) defines the methodology and assessment criteria to determine if a structure associated with an ERA should be regulated under the EP Act. The manual details the hydraulic design requirements for regulated structures and this document has been used as a reference in the preliminary design of the water management system and preliminary sizing of dams associated with the Project.

2.2.1.6 Guideline – Application Requirements for Activities with Impacts to Water

This guideline focuses on the types of impacts that environmentally relevant activities (ERAs) can have on water and outlines the information to be provided to the department as part of the ERA application process.

Section 4 of the guideline requires the applicant to provides details on a number of surface water-related issues, including:

- discharges and releases;
- unplanned and uncontrolled releases;
- water infrastructure;
- wetlands;
- hydrology of receiving waters; and
- mixing zones.

The guideline also refers to the department's technical guideline "Wastewater releases to Queensland waters", which is discussed in Section 2.2.1.7.

2.2.1.7 Technical Guideline - Wastewater Release to Queensland Waters

This guideline is provided to support a risk-based assessment approach to licensing releases of wastewater to surface water and applies the philosophy of the ANZECC & ARMCANZ (2000) Water Quality Guidelines and the intent of the Environmental Protection (Water) Policy 2009.

No controlled water releases are proposed as part of this proposal.

2.2.2 Water Act 2000

In Queensland, the Water Act 2000 (Water Act) is the primary statutory document that establishes a framework for the planning, allocation and use of non-tidal water. The Water Act is primarily administered by the Department of Regional Development, Manufacturing and Water (DRDMW).

The main purpose of the Water Act is to provide a framework for the following:

- The sustainable management of Queensland's water resources and quarry material by establishing a system for:
  - The planning, allocation and use of water; and
  - The allocation of quarry material and riverine protection.
- The sustainable and secure water supply for the south-east Queensland region and other designated regions;
- The management of impacts on underground water caused by the exercise of underground water rights by the resource sector; and
- The effective operation of water authorities.

A watercourse is defined by the Water Act as a river, creek or stream in which water flows permanently or intermittently and includes the bed and banks and any other element of a river, creek or stream confining or containing water. The DOR have published a watercourse identification map of the state that shows: watercourses (other than their lateral limits); the downstream limit of watercourses; drainage features; lakes; and springs.

2.2.2.1 Water plan (Fitzroy Basin) 2011

The Water Plan (Fitzroy Basin) 2011 was developed under the Water Act 2000 legislation to:

- Define the availability of water in the Fitzroy Basin;
- Provide a framework for sustainably managing water and the taking of water;
- Identify priorities and mechanisms for dealing with future water requirements;
- Provide a framework for establishing water allocations;
- Provide a framework for reversing, where practicable, degradation in natural ecosystems;

- Regulate the taking of overland flow water; and
- Regulate the taking of groundwater.

2.2.2.2 Water regulation 2016

Water Regulation 2016 is subordinate legislation to the Water Act and provides details, protocol and instruction for the following:

- Water rights and planning;
- Statutory authorisations to take or interfere with water;
- Matters relating to water licenses;
- Water allocations;
- Water supply and demand management; and
- Declarations about watercourses.

2.2.2.3 Water supply (safety & reliability) act 2008

The Water Supply (Safety and Reliability) Act 2008 provides for the safety and reliability of water supply in Queensland. The purpose is achieved primarily by:

- Providing a regulatory framework for providing water and sewerage services in the State;
- Providing a regulatory framework for providing recycled water and drinking water quality, primarily for protecting public health;
- The regulation of referable dams; and
- Stating flood mitigation responsibilities.

3 Environmental Values

The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP (Water)), which is subordinate legislation to the *Environmental Protection Act 1994*, provides a framework for identifying environmental values (EV) for a waterway and deciding water quality objectives (WQO) to protect or enhance those EV's. EV's for water are the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses. These EVs need to be protected from the effects of habitat alteration, contaminated runoff and releases and changed flow to ensure healthy aquatic ecosystems and waterways that are safe for community use.

The waterways in the vicinity of the Project (Phillips Creek, Boomerang Creek, One Mile Creek and Ripstone Creek) are located within the Isaac western upland tributaries region of the Isaac River Sub-Basin (WQ1301). The Isaac River channel is located within the Isaac and lower Connors River main channel region.

The EV's selected for protection include:

- aquatic ecosystem protection (slightly to moderately disturbed ecosystems, QWQG 2009);
- irrigation, farm use and stock watering;
- aquaculture (upland tributaries only);
- human consumption;
- primary, secondary and visual recreation;
- drinking water;
- industrial use; and
- cultural and spiritual values.

In summary, the key EV's for water that are to be protected are:

- physical, chemical and biological integrity of the watercourses within the catchment and their amenity as potential water sources for human use and to support aquatic ecosystems;
- the qualitive and quantitative integrity of local groundwater as a potential water source for agriculture or other suitable uses; and
- the integrity of raw water supplies and associated infrastructure in the region.

3.1 WATER QUALITY OBJECTIVES

The indicators and water quality guidelines relevant to the above environmental values are listed in the Queensland Water Quality (QWQ) Guidelines and ANZG (2018). The conditions of waterways located in the vicinity of the Project are classified as slightly to moderately disturbed ecosystems under the QWQ Guidelines (DEHP, 2013).

The WQOs relevant to the identified EV's are provided in Table 3.1 and are generally based on the trigger values or Default Guideline Values (DGVs) nominated in the QWQ and ANZECC guidelines. Where different EV's have different WQOs/DGVs, the lowest value has been adopted. WQOs/DGVs are displayed for physio-chemical parameters only.

Table 3.1 – Water quality objectives, Isaac and Lower Connors River Main Channel

Parameter	WQO	Relevant EV
Ammonia N	< 0.02 mg/L	Aquatic ecosystem[b]
Oxidised N	< 0.06 mg/L	Aquatic ecosystem[b]
Organic N	< 0.42 mg/L	Aquatic ecosystem[b]
Total nitrogen	< 0.5 mg/L	Aquatic ecosystem[b]
Filterable Reactive Phosphorus (FRP)	< 0.02 mg/L	Aquatic ecosystem[b]
Total Phosphorus	< 0.05 mg/L	Aquatic ecosystem[b]
Chlorophyll a	< 0.005 mg/L	Aquatic ecosystem[b]
Dissolved oxygen	85-110% saturation > 4 mg/L at surface	Aquatic ecosystem[b] Drinking water[c]
Turbidity	< 50 NTU	Aquatic ecosystem[b]
Suspended solids	< 55 mg/L	Aquatic ecosystem[b]
pH	pH 6.5-8.5	Aquatic ecosystem[b]
Conductivity (EC) baseflow	< 720 µS/cm	Aquatic ecosystem[b]
Conductivity (EC) high flow	< 250 µS/cm	Aquatic ecosystem[b]
Sulphate	< 25 mg/L	Aquatic ecosystem[b]
Total Dissolved Solids	< 2000 mg/L	Stock watering[d]
Colour	50 Hazen Units	Drinking water[c]
Total Hardness	150 mg/L as CaCO3	Drinking water[c]
Sodium	< 30 mg/L	Drinking water[c]
Aluminium	< 20 mg/L < 5 mg/L < 0.055 mg/L (pH > 6.5)	Irrigation[g,e] Stock watering[f] Aquatic ecosystem[a]
Arsenic	2.0 mg/L 0.5 mg/L up to 5 mg/L < 0.013 mg/L	Irrigation[g,e] Stock watering[f] Aquatic ecosystem[b]
Beryllium	< 0.5 mg/L	Irrigation[g,e]
Boron	< 5 mg/L < 0.94 mg/L	Stock watering[f] Aquatic ecosystem[k]
Cadmium	< 0.01 mg/L < 0.0002 mg/L	Stock watering[f] Aquatic ecosystem[a]
Chromium	< 1 mg/L < 1 mg/L < 0.001 mg/L	Irrigation[g,e] Stock watering[f] Aquatic ecosystem[a]
Cobalt	< 0.1 mg/L < 0.0014 mg/L	Irrigation[g,e] Aquatic ecosystem[h]
Copper	< 5 mg/L < 1 mg/L < 0.0014 mg/L	Irrigation[g,e] Stock watering (cattle)[f] Aquatic ecosystem[a]
Fluoride	< 2 mg/L	Irrigation[g,e]
Iron	< 10 mg/L < 0.18 mg/L	Irrigation[g,e] Aquatic ecosystem[l]

Parameter	WQO	Relevant EV
Lead	< 5 mg/L < 0.1 mg/L < 0.0034 mg/L	Irrigation[g,e] Stock watering[f] Aquatic ecosystem[a]
Lithium	< 2.5 mg/L	Irrigation[g]
Manganese	< 10 mg/L < 1.9 mg/L	Irrigation[g,e] Aquatic ecosystem[a]
Mercury	< 0.002 mg/L < 0.0002 mg/L	Irrigation[g] Aquatic ecosystem[i]
Molybdenum	< 0.05 mg/L < 0.034 mg/L	Irrigation[g,e] Aquatic ecosystem[h]
Nickel	< 2 mg/L < 1 mg/L < 0.011 mg/L	Irrigation[g,e] Stock watering[f] Aquatic ecosystem[a]
Selenium	< 0.05 mg/L < 0.02 mg/L < 0.005 mg/L	Irrigation[g,e] Stock watering[f] Aquatic ecosystem[a]
Silver	< 0.00005 mg/L	Aquatic ecosystem[a]
Uranium	< 0.1 mg/L < 0.001 mg/L	Irrigation[g,e] Aquatic ecosystem[i]
Vanadium	< 0.5 mg/L < 0.01 mg/L	Irrigation[g,e] Aquatic ecosystem[i]
Zinc	< 5 mg/L < 0.008 mg/L	Irrigation[g,e] Aquatic ecosystem[a]
Nitrate as N	< 1.1 mg/L	Stock watering[j]

a/ Table 3.4.1 of ANZECC & ARMCANZ (2000): trigger values for slightly-moderately disturbed systems (95% level of protection)
b/ Table 2 of Isaac River Sub-Basin EVs and WQOs: Aquatic ecosystem – moderately disturbed
c/ Table 4 of Isaac River Sub-Basin EVs and WQOs: Drinking water EV
d/ Table 10 of Isaac River Sub-Basin EVs and WQOs: Stock watering EV: salinity
e/ short-term trigger value
f/ Table 11 of Isaac River Sub-Basin EVs and WQOs: Stock watering EV: heavy metals and metalloids
g/ Table 9 of Isaac River Sub-Basin EVs and WQOs: Irrigation EV: heavy metals and metalloids
h/ Section 8.3.7 of ANZECC & ARMCANZ (2000): low reliability guideline
i/ Based on Limit of Reporting (LOR) for ICPMS/CV FIMS analytical methods
j/ Based on ambient WQGs (2006) for total nitrogen –standard trigger value for contemporary environmental authorities in Bowen Basin
k/ Based on 95% level of protection in Toxicant default guideline values for aquatic ecosystem protection: Boron in fresh water (ANZG, 2020)
l/ Based on 95% level of protection in Toxicant default guideline values for aquatic ecosystem protection: Total iron in fresh water (ANZG, 2020)
mg/L = milligrams per litre, NTU = Nephelometric Turbidity Units, µS/cm = microSiemens per centimetre.

4 Existing environment

4.1 CLIMATE

4.1.1 Existing climate

For this surface water assessment, long term daily rainfall and evaporation data for the area from January 1889 to December 2020 (132 years) was obtained from SILO (latitude: -22.45 longitude: 148.40 https://www.longpaddock.qld.gov.au/silo/). This data set is corrected for accumulated daily rainfall totals and missing data and is well suited to use in water balance modelling.

Average annual rainfall is 583 mm/a and average annual (pan) evaporation is 2,061 mm/a. Annual rainfall is presented in Figure 4.1. Monthly average rainfall and evaporation are shown in Figure 4.2.

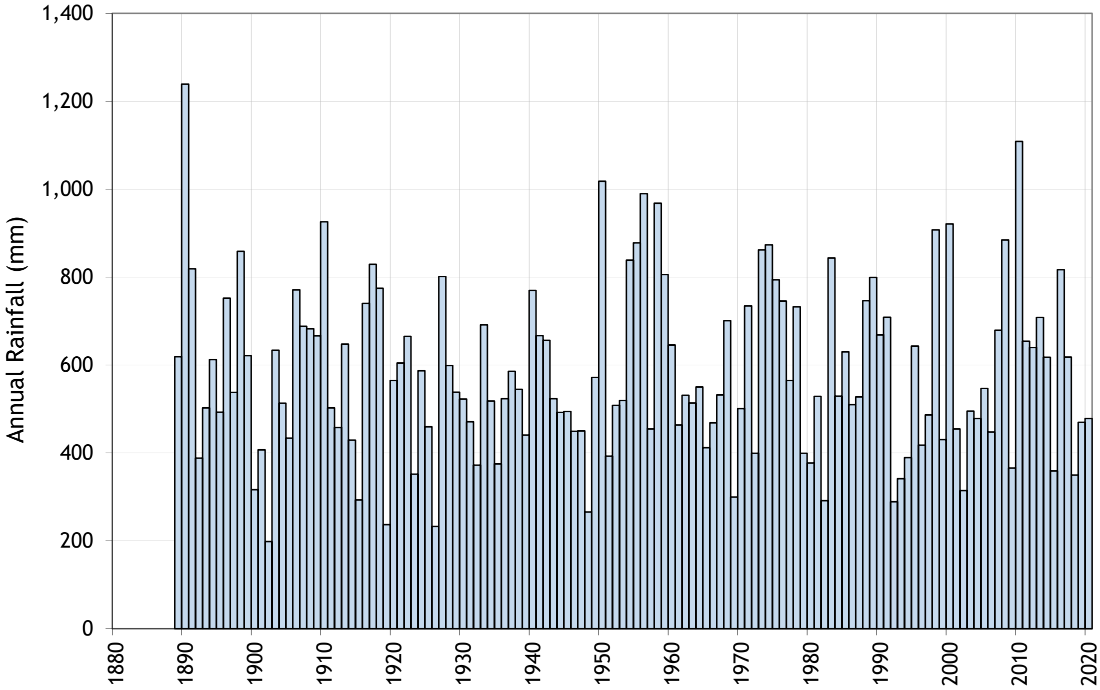


Figure 4.1 – Lake Vermont long-term annual rainfall (SILO)

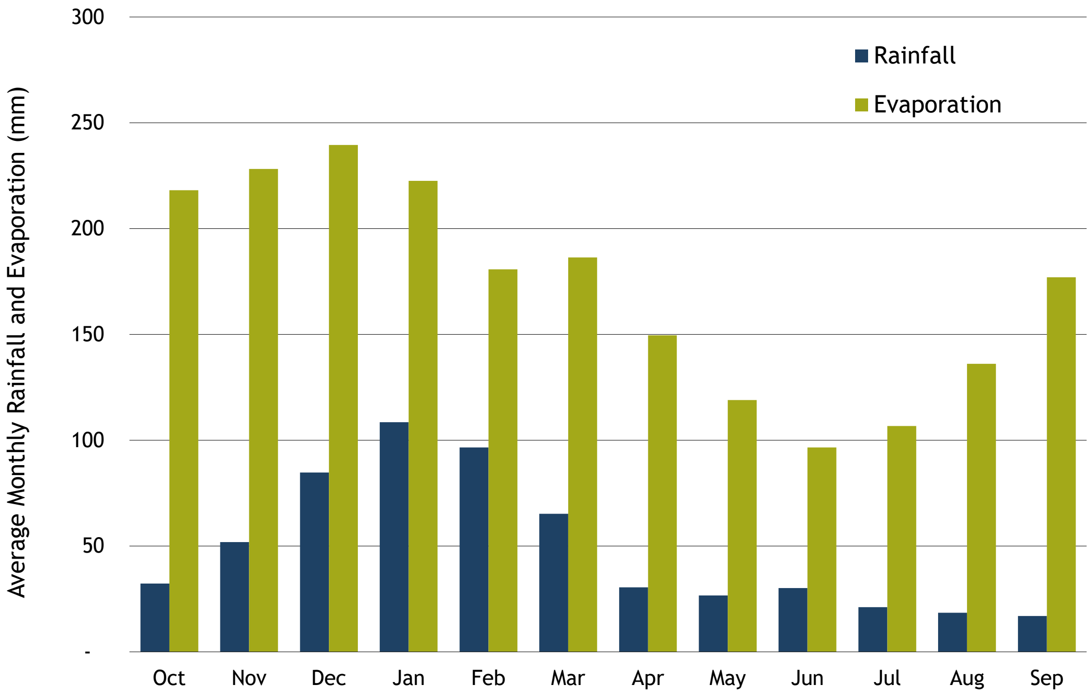


Figure 4.2 – Lake Vermont average monthly rainfall and evaporation (SILO Data

4.1.2 Future climate

Climate-change adjusted SILO climate data are available from the Queensland Government Department of Environment and Science (DES) and were developed as part of the Consistent Climate Scenarios (CCS) project. The CCS project hosts data from 19 separate global climate models (GCMs), which explore four emissions scenarios, three timing horizons and three climate warming sensitivities. The nineteen separate models can be split into four Representative Future Climate (RFC) partitions, defined below:

- HI: a high level of global warming, where the Eastern Indian Ocean (EIO) warms faster than the Western Pacific Ocean (WPO);
- HP: a high level of global warming, where the WPO warms faster than the EIO;
- WI: a low level of global warming, where the EIO warms faster than the WPO; and
- WP: a low level of global warming, where the WPO warms faster than the EIO.

Figure 4.3 is an excerpt from the CCS project user guide (DSITIA, 2015) showing the four RFC quadrants, component models and indicative rainfall trends. The caption associated with the original version of this figure has been reproduced as a footnote[1].

Data based on the mean result of all models within each RFC quadrant is offered by the CCS for applications where considering the output of all 19 models is not feasible/practical. This approach has been followed for the purposes of assessing climate change sensitivity as part of current investigations. Table 4.1 and Table 4.2 list the percentage change in evaporation and rainfall respectively, based on mean output for the four RFC quadrants. Data is based on the most conservative carbon emission rate (RCP8.5) available in the CCS dataset, and expected climate as at 2070. Data has been listed for the low, medium and high sensitivities. Information is for the Lake Vermont Mine location.

The adjustments listed in Table 4.1 and Table 4.2 have been applied to the long-term SILO daily climate time-series and passed through the AWBM rainfall runoff sub-model to produce daily estimates of runoff (rehabilitated land use AWBM parameter set used). Annual average runoff depths have been plotted against average annual net evaporation depths (evaporation minus rainfall) in Figure 4.4 . Note the naming convention used in the figure, and henceforth in this document, is XX.Y where XX is the scenario (e.g. HI) and Y is the sensitivity (medium).

Figure 4.4 shows that all scenarios predict increases in net evaporation, and that all scenarios except the WP scenarios predict reductions in runoff.

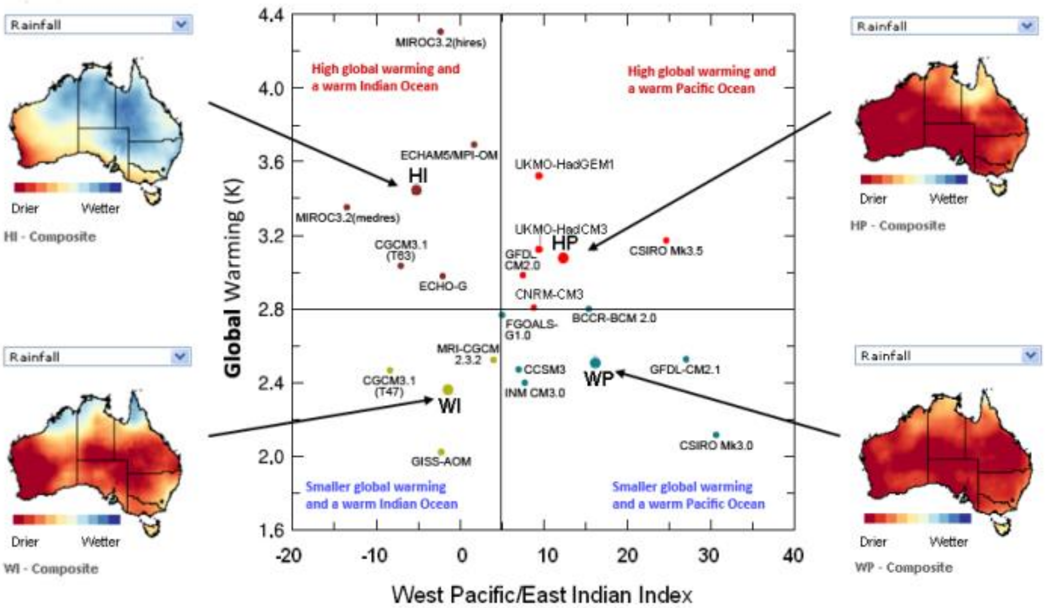


Figure 4.3 – A partition of Global Climate Models for future climate using global warming sensitivity and ocean warming indices (source: DSITIA, 2015)

[1] From DSITIA, 2015 – Figure 8.1 (verbatim): A partition of CMIP3 Global Climate Models (GCMs) for future climate using global warming sensitivity and ocean warming indices (adapted from Watterson, 2011). Values for nineteen individual GCMs (forced by the SRES A1B emissions scenario) are represented by the small dots and labelled by their GCM model code (Table 8.2). The central horizontal and vertical lines separate the four Representative Future Climate (RFC) partitions. The larger dots indicate the CCS composite means for GCMs within each of the four RFC responses: (HI) high global warming and a warmer Indian Ocean; (HP) high global warming and a warmer Pacific Ocean; (WI) lower global warming and a warmer Indian Ocean and (WP) lower global warming and a warmer Pacific Ocean. The maps show projected 21st Century changes in rainfall for the GCMs clustered in each of the four (HI, HP, WI and WP) RFC partitions.

Table 4.1 - Percentage change in evaporation by model and sensitivity

Model*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
HI (high)	17.3	18.1	20.9	12.8	12.2	10.2	8.3	6.7	11.2	11.6	17.0	11.8	12.9
HI (med)	10.7	11.2	12.9	8.0	7.5	6.0	5.0	4.0	7.0	7.3	10.7	7.3	7.6
HI (low)	5.8	6.1	6.9	4.3	4.0	3.1	2.6	2.1	3.8	4.0	5.9	4.0	3.7
HP (high)	18.9	19.0	19.8	15.9	16.2	17.3	13.4	14.2	14.3	15.7	15.4	14.8	15.4
HP (med)	11.9	11.9	12.4	10.0	10.2	10.8	8.3	8.9	9.0	10.0	9.8	9.4	9.4
HP (low)	6.6	6.5	6.8	5.4	5.6	5.9	4.5	4.9	5.0	5.5	5.4	5.2	4.8
WI (high)	16.7	16.1	12.7	8.8	7.8	10.3	10.8	7.6	10.2	8.0	9.9	11.8	10.3
WI (med)	10.5	10.1	7.9	5.4	4.7	6.2	6.6	4.6	6.4	4.9	6.2	7.4	6.1
WI (low)	5.8	5.5	4.2	2.9	2.4	3.3	3.5	2.4	3.5	2.7	3.4	4.1	2.9
WP (high)	30.4	16.7	23.0	21.0	25.0	18.5	14.5	10.5	10.2	15.0	20.9	14.0	17.5
WP (med)	19.1	10.3	14.4	13.3	15.7	11.3	8.8	6.4	6.3	9.4	13.2	8.7	10.6
WP (low)	10.5	5.6	7.9	7.3	8.6	6.0	4.7	3.4	3.4	5.2	7.3	4.7	5.4

Note: * model is RFC partition, text in brackets is the sensitivity

Table 4.2 - Percentage change in rainfall by model and sensitivity

Model*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
HI (high)	-20.9	16.6	-6.8	-51.5	49.0	-39.7	2.4	8.6	-6.6	-10.6	-46.4	0.7	-8.3
HI (med)	-14.0	11.1	-4.6	-34.5	32.9	-26.6	1.6	5.8	-4.4	-7.1	-31.1	0.5	-5.6
HI (low)	-8.1	6.5	-2.6	-20.0	19.1	-15.5	0.9	3.3	-2.5	-4.1	-18.0	0.3	-3.2
HP (high)	-11.9	-14.5	3.5	-15.9	-35.1	-34.8	-20.3	-34.3	-46.2	-61.4	-46.7	-30.3	-24.6
HP (med)	-8.0	-9.8	2.4	-10.6	-23.5	-23.3	-13.6	-23.0	-31.0	-41.2	-31.3	-20.3	-16.5
HP (low)	-4.6	-5.7	1.4	-6.2	-13.6	-13.5	-7.9	-13.3	-18.0	-23.9	-18.2	-11.8	-9.6
WI (high)	-13.8	-3.5	6.4	-3.8	-2.2	-14.8	-3.0	-1.9	-12.4	-9.9	-22.8	-20.3	-9.8
WI (med)	-9.3	-2.4	4.3	-2.5	-1.5	-10.0	-2.0	-1.3	-8.3	-6.6	-15.3	-13.6	-6.6
WI (low)	-5.4	-1.4	2.5	-1.5	-0.9	-5.8	-1.2	-0.7	-4.8	-3.8	-8.9	-7.9	-3.8
WP (high)	-9.3	16.3	-0.6	-15.0	-72.0	21.4	-5.1	54.8	8.9	-26.0	-39.1	13.3	-4.5
WP (med)	-6.2	10.9	-0.4	-10.0	-48.3	14.4	-3.4	36.7	6.0	-17.4	-26.2	8.9	-3.0
WP (low)	-3.6	6.3	-0.2	-5.8	-28.0	8.3	-2.0	21.3	3.5	-10.1	-15.2	5.2	-1.7

Note: * model is RFC partition, text in brackets is the sensitivity

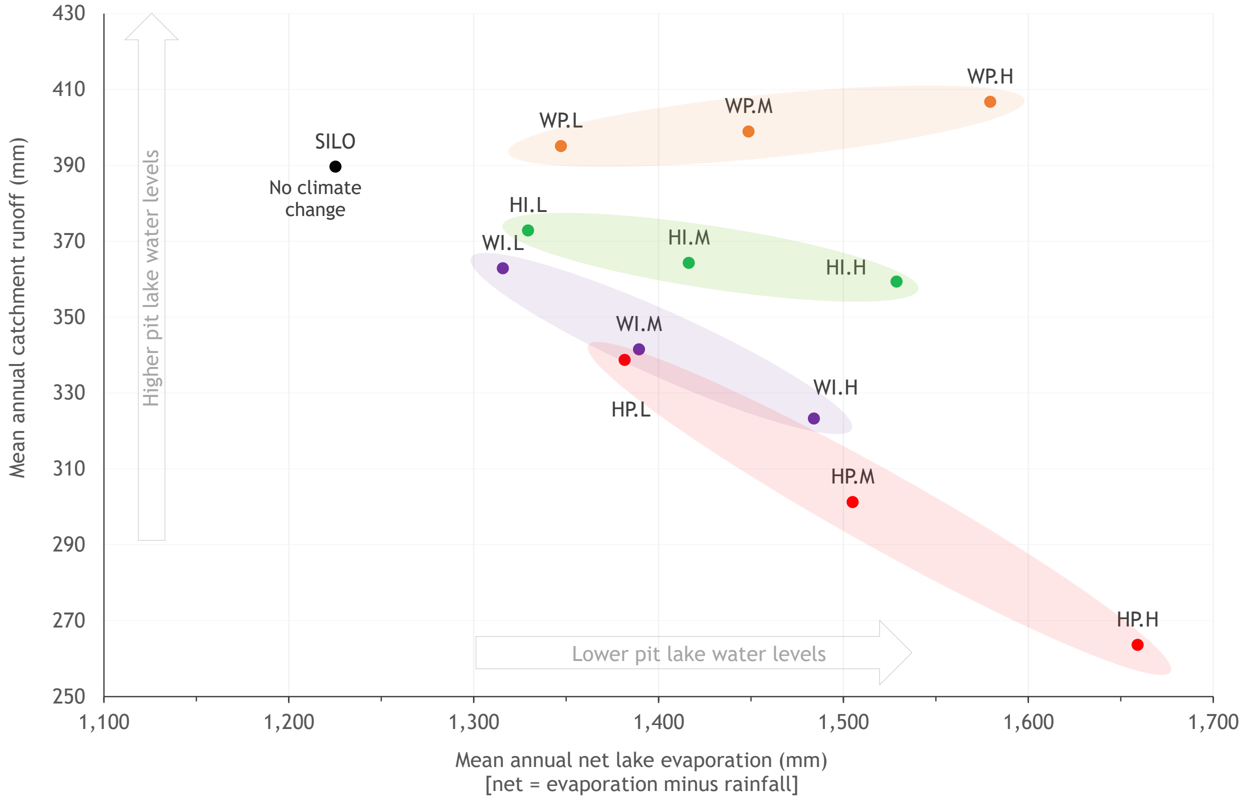


Figure 4.4 – Plot of net evaporation versus runoff for HI, HP, WI and WP GCM groupings

4.2 REGIONAL CATCHMENT CHARACTERISTICS

The Project is located within the Isaac-Connors sub-catchment of the greater Fitzroy Basin. The Isaac River is the main watercourse in the vicinity of the Project area and flows in a south-easterly direction to the east of the Project.

The Isaac River catchment commences at the Denham Range located about 97 km to the north of the Project. The Isaac River flows in a south-westerly direction through the Carborough and Kerlong Ranges before turning in a south-easterly direction near the Goonyella Riverside Mine. The Isaac River converges with the Connors River and then the Mackenzie River 150 km downstream of the Project.

Ultimately, the Mackenzie River joins the Fitzroy River, which flows initially north and then east towards the east coast of Queensland and discharges into the Coral Sea southeast of Rockhampton, near Port Alma.

Figure 4.5 shows the location of the Project and Isaac River catchment upstream of the Connors River confluence. Figure 4.6 shows the drainage characteristics of the Upper Isaac River to the Phillips Creek confluence, which drains through the Project area.

The greater Isaac-Connors sub-catchment area is approximately 22,364 square kilometres (km^2) (to the Mackenzie River confluence), out of a total Fitzroy River catchment of 142,665 km^2. That is, it represents around 15% of the overall Fitzroy River catchment.

The catchment area of the Isaac River to the Project is around 4,100 km^2. This represents around 2.9% of the overall Fitzroy River catchment and 18.3% of the Isaac-Connors sub-catchment.

The maximum Project disturbance footprint is approximately 70 km^2 and represents 0.05% and 0.3% of the overall Fitzroy River and Isaac-Connors catchment areas, respectively.

The Isaac River is a seasonally flowing watercourse, typically with surface flows in the wetter months from November to April, reducing to little or no flow from about May to October. All waterways and drainage lines in the vicinity of the Project area are ephemeral and experience flow only after sustained or intense rainfall in the catchment. Stream flows are highly variable, with channels drying out during winter to early spring when rainfall and runoff is historically low, although some pools hold water for extended periods. Therefore, physical attributes, water quality, and the composition of aquatic flora and fauna communities are highly variable over time.

The Isaac River catchment upstream of the Project comprises mainly scattered to medium dense bushland, grazing land and the township of Moranbah. There are several existing coal mines in the Isaac River catchment, including Burton, North Goonyella, Goonyella Riverside, Broadmeadow, Broadlea North, Isaac Plains, Moranbah North, Millennium, Daunia, Poitrel, Grosvenor, Peak Downs, Saraji, Norwich Park and Lake Vermont. In addition, Pembroke Resources' Olive Downs Project is an approved (but not constructed) mine to the north (see Figure 4.7).

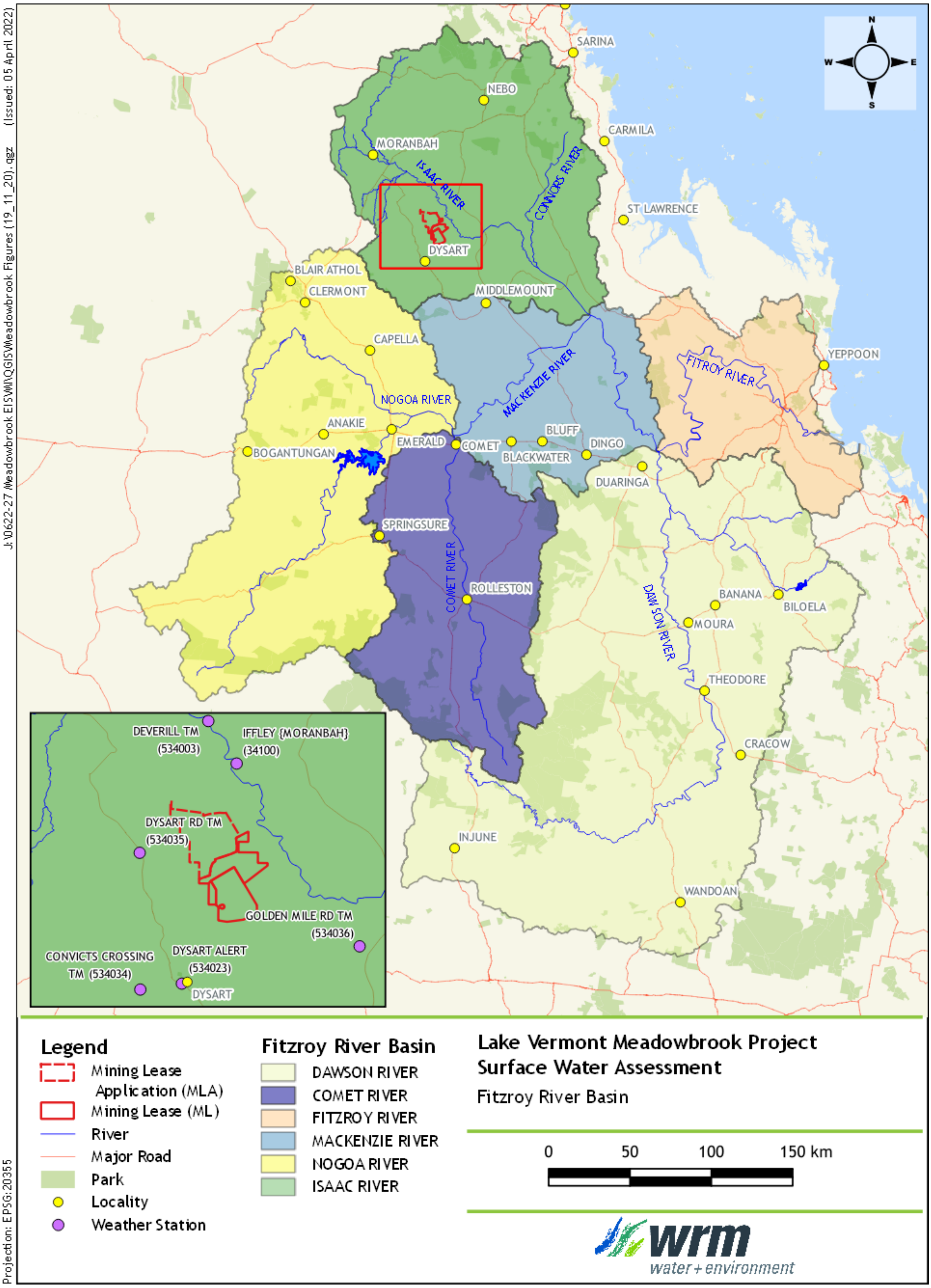


Figure 4.5 – Fitzroy River Basin

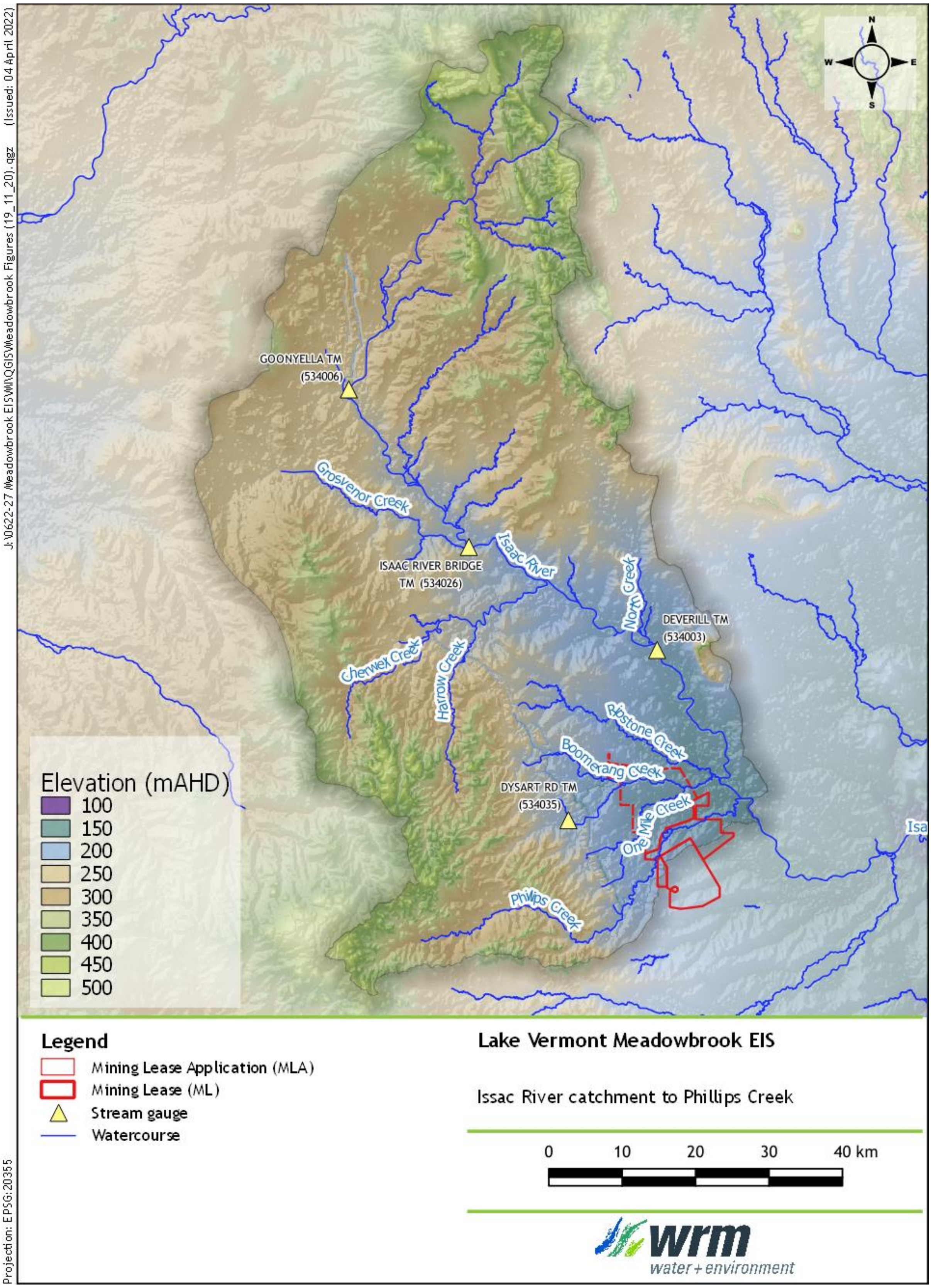


Figure 4.6 – Upper Isaac River catchment

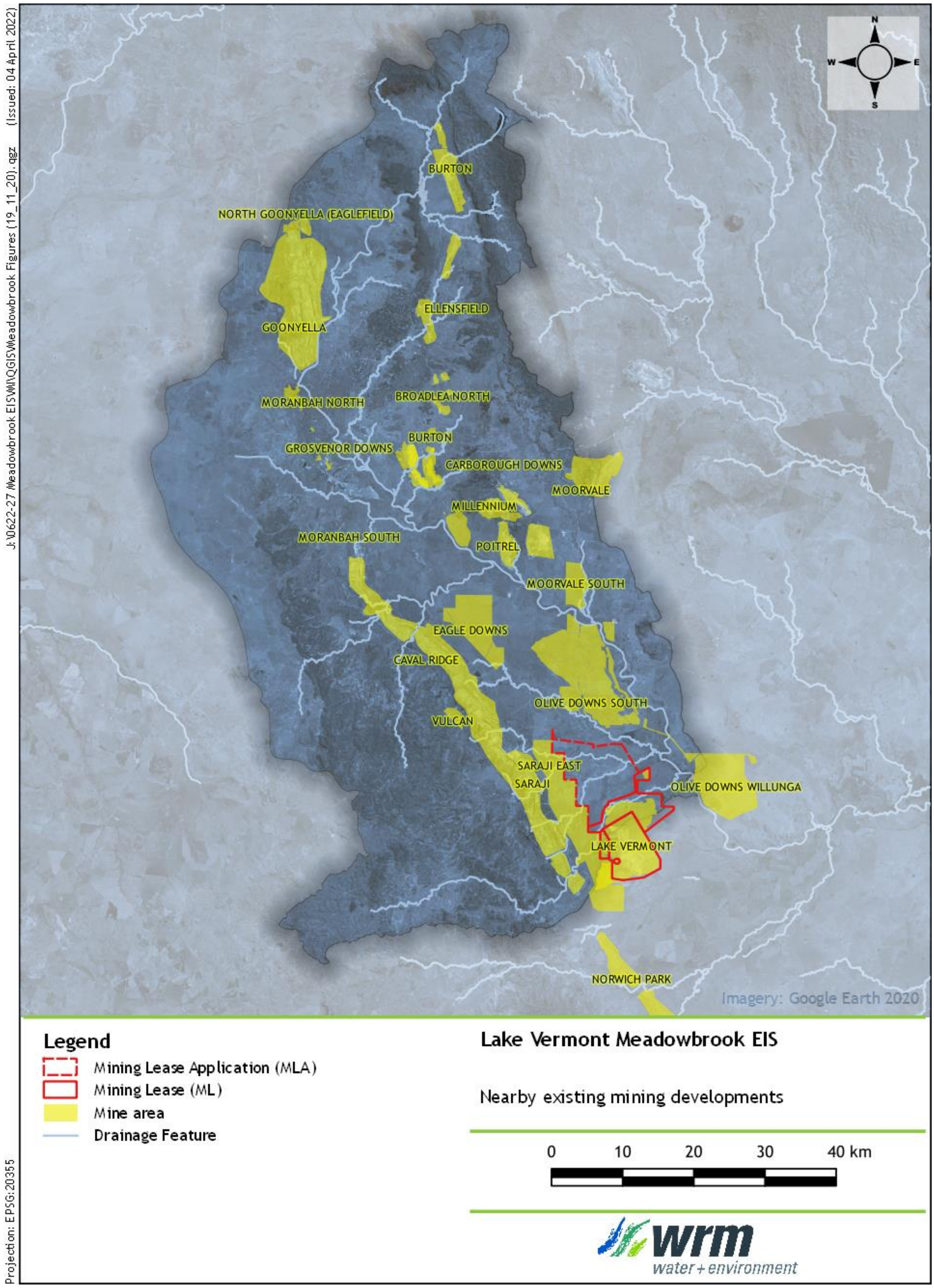


Figure 4.7 – Nearby existing mining developments

4.3 LOCAL CATCHMENT CHARACTERISTICS

The Project area drains to the Isaac River via tributaries of Phillips Creek (to the south) and Boomerang Creek (to the north) shown on Figure 4.8/Figure 4.9. The waterways passing through the Project area originate in the Harrow Range, where they are confined in narrow valleys by hillslopes and bedrock. Downstream of the range, they pass through Saraji mine, where they are diverted via narrow corridors between open cut pits. A description of the various waterways in the vicinity of the project is as follows:

- **Ripstone Creek** commences about 20 km to the northwest of the Project area and traverses in a southeasterly direction across the northern parts of the Project area before draining to Boomerang Creek approximately 0.5 km to the east of the Project area. Ripstone Creek has a catchment area of approximately 303 km^2 to the confluence with Boomerang Creek, of which 12% is within the Project area. The lower reaches of Ripstone Creek are relatively flat (0.12% slope) and the main channel of the creek is meandering with a sinuosity index of 1.5 (measured as the ratio of main channel length to valley length). A value of greater than 1.5 is meandering (Garcia, 2015). Ripstone Creek will not be impacted by the Project.
- **Boomerang Creek** catchment begins about 21 km to the west of the Project area and discharges into the Isaac River approximately 4 km east of the Project area. The Boomerang Creek catchment to its confluence with Isaac River is approximately 796 km^2 and comprises the sub-catchments of Ripstone Creek, Plumtree Creek, East Creek, Hughes Creek, Barrett Creek, East Creek, One Mile Creek and Spring Creek. The Project area covers an area of approximately 95.5 km^2, or 12% of the Boomerang Creek catchment. The lower reach of Boomerang Creek through the Project area is relatively flat (0.15% slope) and the main channel of the creek is of low sinuosity (sinuosity index of 1.2).
- **Hughes Creek** commences about 25 km west of the Project area and drains in an easterly direction to its confluence with Boomerang Creek near the upstream boundary of the Project area. Hughes Creek has a catchment area of 175 km^2, of which 0.2% is within the Project area. Barrett Creek drains into Hughes Creek upstream of Saraji Mine.
- **One Mile Creek** commences about 15 km southwest of the Project area and drains in a northeasterly direction through the Project area to Boomerang Creek. The channel and catchment of One Mile Creek have been modified significantly modified within the Saraji Mine. Spring Creek drains to One Mile Creek approximately 0.6 km upstream of the Project area. One Mile Creek has a catchment area (including Spring Creek) of approximately 132 km^2, of which 2.7% is within the Project area. One Mile Creek through the Project area is relatively flat (0.1% slope) and the main channel is meandering (sinuosity index of 1.6).
- **Phillips Creek** runs west to east into the Isaac River, south of the Project area. It has a catchment area of approximately 514 km^2 to its confluence with the Isaac River. The Project area covers an area of approximately 24.5 km^2, or 4.8% of the Phillips Creek catchment.

The proposed underground mining operations underly Boomerang Creek and One Mile Creek and the floodplain of Phillips Creek. The proposed open cut operations are located between Phillips Creek and One Mile Creek, and both these streams would be crossed by the proposed haul road. Phillips Creek and Hughes Creek/Boomerang Creek and One Mile Creek have been determined as watercourses under the *Water Act 2000* (QLD).

Land uses within these catchments include cattle grazing and open cut mining. Mining activities upstream at Peak Downs and Saraji mine have altered flow paths, with major diversions of Ripstone Creek, Boomerang Creek, East Creek, Hughes Creek, One Mile Creek, Spring Creek and Phillips Creek. Lake Vermont Resources has approval for a proposed diversion of Phillips Creek adjacent to the Project area and Pembroke Resources has approval for a diversion of Ripstone Creek, both of which have not yet been constructed.

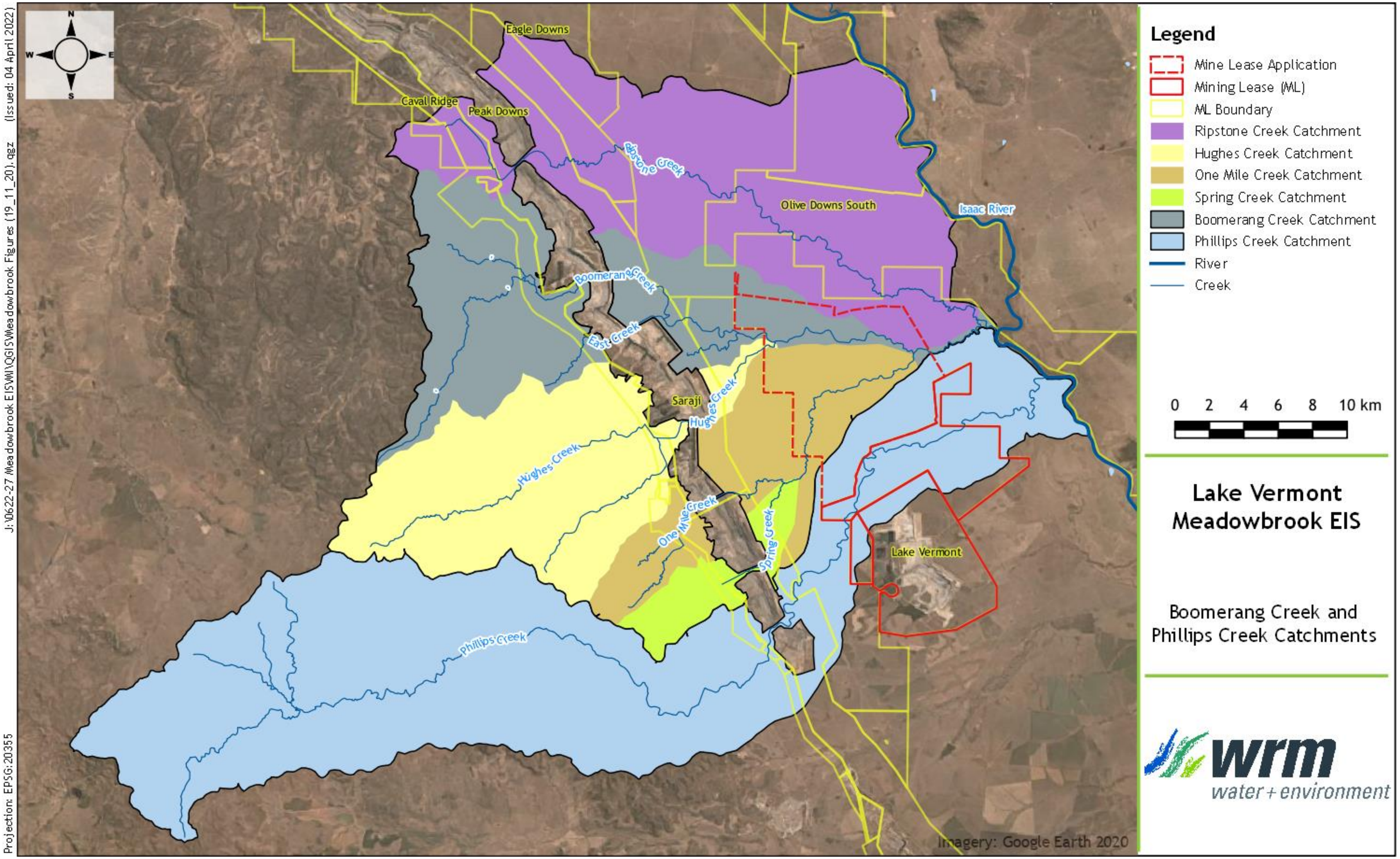


Figure 4.8 – Catchments draining through the Project area

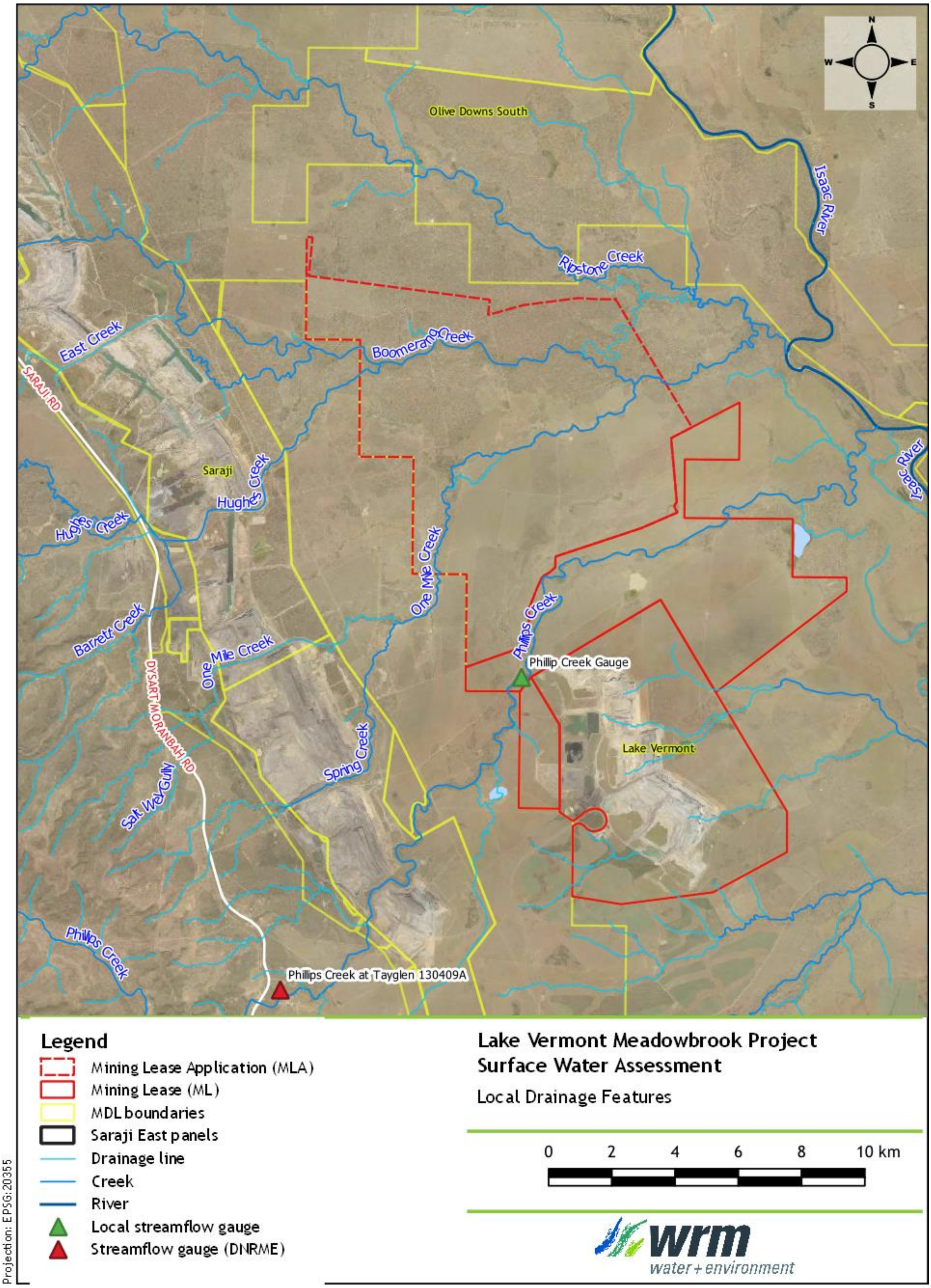


Figure 4.9 – Local drainage features

4.4 WATER USE ENTITLEMENTS

There is currently minimal use of surface water from the Isaac River downstream of the Project, and water use is limited to mining, irrigation, stock watering and potable water development. The Lower Fitzroy and Fitzroy Barrage Water Supply Schemes are located 250 km downstream of the confluence with the Isaac River.

A search of the Queensland Government Water Entitlement Viewer did not identify surface water users on either One Mile Creek or Boomerang Creek downstream of the project.

There are 5 licences to take water from the Isaac River downstream of the Project which have been issued for mining, irrigation, stock watering, domestic supply and water harvesting. Detailed information regarding individual licences for Isaac River surface water users was obtained through analysis of water licences data provided by DRDMW. Some limitations in the dataset include the absence of names of water users, and in some cases, allocated volumes for water licenses due to privacy restrictions. Details of the volume, source and purpose of the licences are included in Table 4.3.

The locations of the landholding associated with the licenses are shown in Figure 4.10. The nearest downstream water entitlement is for a property located on the Isaac River approximately 25 km downstream of the Project.

There are also several historical riparian water access notifications along the Isaac River which authorise stock and domestic supplies only. Section 96 of the Water Act states that an owner of land adjoining a watercourse may take water for domestic and stock purposes without the need for a permit or licence.

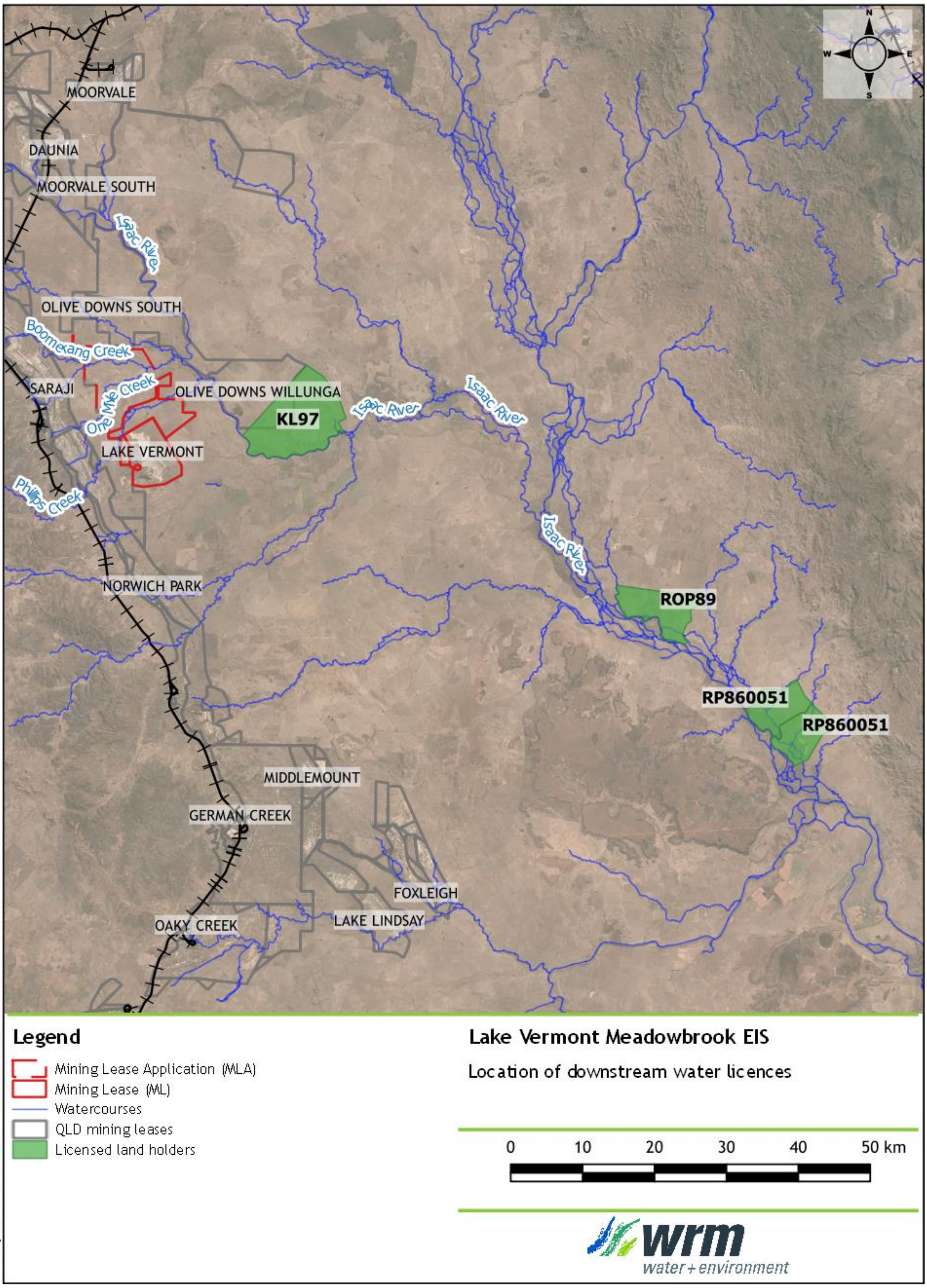


Figure 4.10 – Locations of downstream water use entitlements

Table 4.3 - List of Isaac River surface water licences

Study Sub-catchment	Watercourse	Authorisation reference	Authorisation type	Authorisation status	Authorisation expiry date	Purpose	Allocation	Location land list	Location
Fitzroy Basin	Isaac River	619255	Licence to take water		30/06/2111	Agriculture	1,250 ML	9/KL97	Upstream of the Stephens Creek confluence at Bombandy (approx. 25 km d/s of Project)
Fitzroy Basin	Isaac River	405577	Licence to take water	Issued	30/06/2111	Irrigation; Stock Intensive	60 ML	14/ROP89	Immediately downstream of Isaac & Connors River confluence (Approx. 90 km d/s of Project)
Fitzroy Basin	Isaac River	405578	Licence to take water	Issued	30/06/2111	Irrigation	150 ha	14/ROP89	
Fitzroy Basin	Isaac River	45321U	Licence to take water	Issued	30/06/2111	Irrigation	40 ha	14/ROP89	
Fitzroy Basin	Isaac River	54781U	Licence to take water	Issued	30/06/2111	Irrigation	40 ha	6/RP860051	Immediately upstream of Isaac & Mackenzie River confluence (Approx. 115 km d/s of Project)

4.5 LOCAL STREAMFLOW

The Queensland Department of Regional Development, Manufacturing and Water operates a nearby surface water monitoring site on the Isaac River at Deverill (GS 130410). Water monitoring data is also available from Phillips Creek at the Tayglen gauge (GS 130409) however this gauge is no longer operational. Figure 4.11 shows that over the period of record at Tayglen (1968 to 1988), flows occurred in Phillips Creek about 25% of the time.

Limited surface water monitoring data is also available from Lake Vermont Resources monitoring stations on Phillips Creek. The locations of these monitoring stations are shown in Figure 4.9.

The Tayglen gauge was located at the upstream extent of the Phillips Creek quaternary alluvium. While very low flows would be observed at that location, they would seep into the deep sandy bed of the downstream reaches of Phillips Creek and not reappear as surface flow. This is consistent with field observations during water sampling, and post-flood water level measurements at Lake Vermont, that indicate Phillips Creek typically ceases to flow within 24 hours of the cessation of rainfall.

The natural flow regime in One Mile Creek and Boomerang Creek would be similar to the characteristics of Phillips Creek. Flow monitoring data is not available for the reaches of these streams crossing the project area. Flows in One Mile Creek are significantly affected by upstream mining activities.

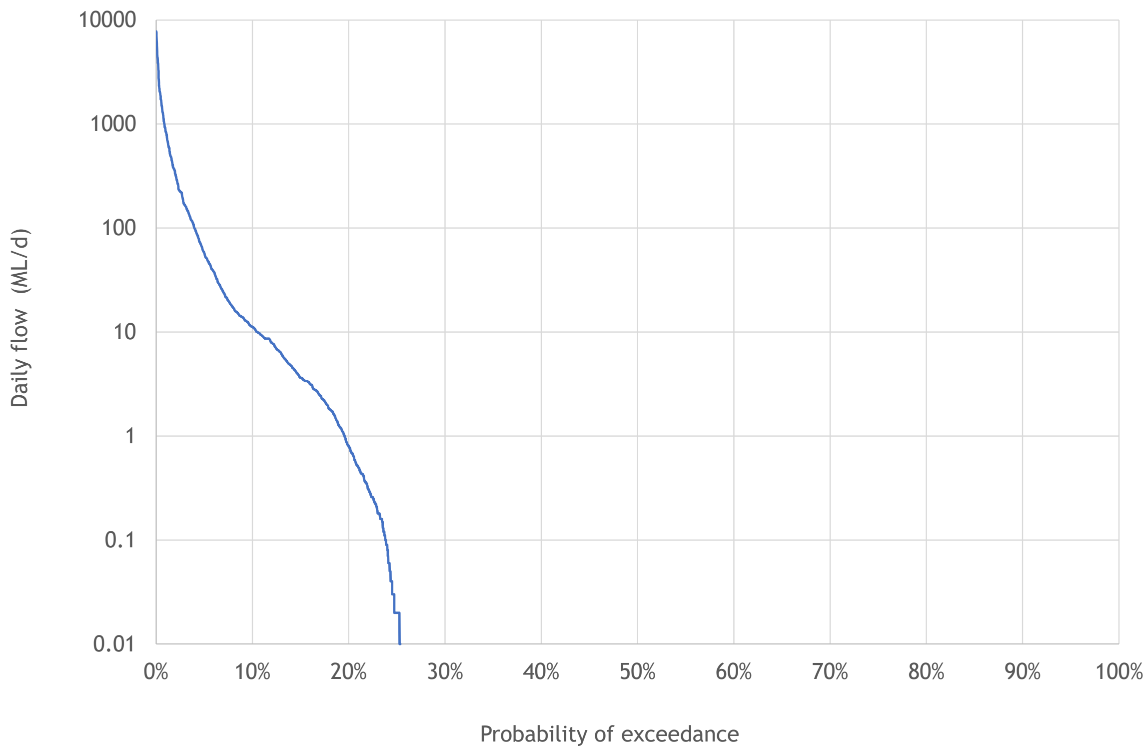


Figure 4.11 – Frequency of daily flows recorded at Phillips Creek at Tayglen

4.6 WATER QUALITY

Bowen Basin Coal conducts an ongoing water quality monitoring program across the Project Area. Water samples have been taken for testing regularly since January 2021 at the locations shown in Figure 4.12. The figure also shows the locations of water monitoring being undertaken for nearby projects. Data from samples collected at these locations are available through a data sharing agreement between the proponents and will be used to establish background water quality and site-specific guidelines when sufficient suitable data is available.

The results of laboratory analysis of samples collected in 2021 by Bowen Basin Coal are summarised in the following tables. A number of the baseline water quality samples do not meet the default DGVs for the region – (shown shaded).

4.6.1 Dissolved Inorganic Nitrogen

Elevated Dissolved Inorganic Nitrogen (DIN), which comprises nitrate, nitrite and ammonium, is a feature of the local surface water receiving environment and was one subject of the surface water monitoring program.

Nitrite, which is a short-term intermediate product from oxidative and reductive processes such as nitrification and denitrification, was below the limit of reporting in all samples.

All samples had total nitrate concentrations well below the default value in the Model Mining Conditions for Water (1.1 mg/L) - average nitrate was 0.05 mg/L in Boomerang Creek, 0.12 mg/L in One Mile Creek and only 0.07 mg/L in Ripstone Creek.

The default aquatic ecosystem guideline for total ammonia (0.02 mg/L) was exceeded in Boomerang Ck for five of the seven sampling events during 2021 (average 0.16 mg/L). In Ripstone Creek, the guideline was exceeded in 6 of 7 samples (average 0.16 mg/L). The highest concentration of 1.37 mg/L was recorded in Boomerang Creek in May 2021. Ammonia concentrations were lower in One Mile Creek - with all samples being at or below the guideline value.

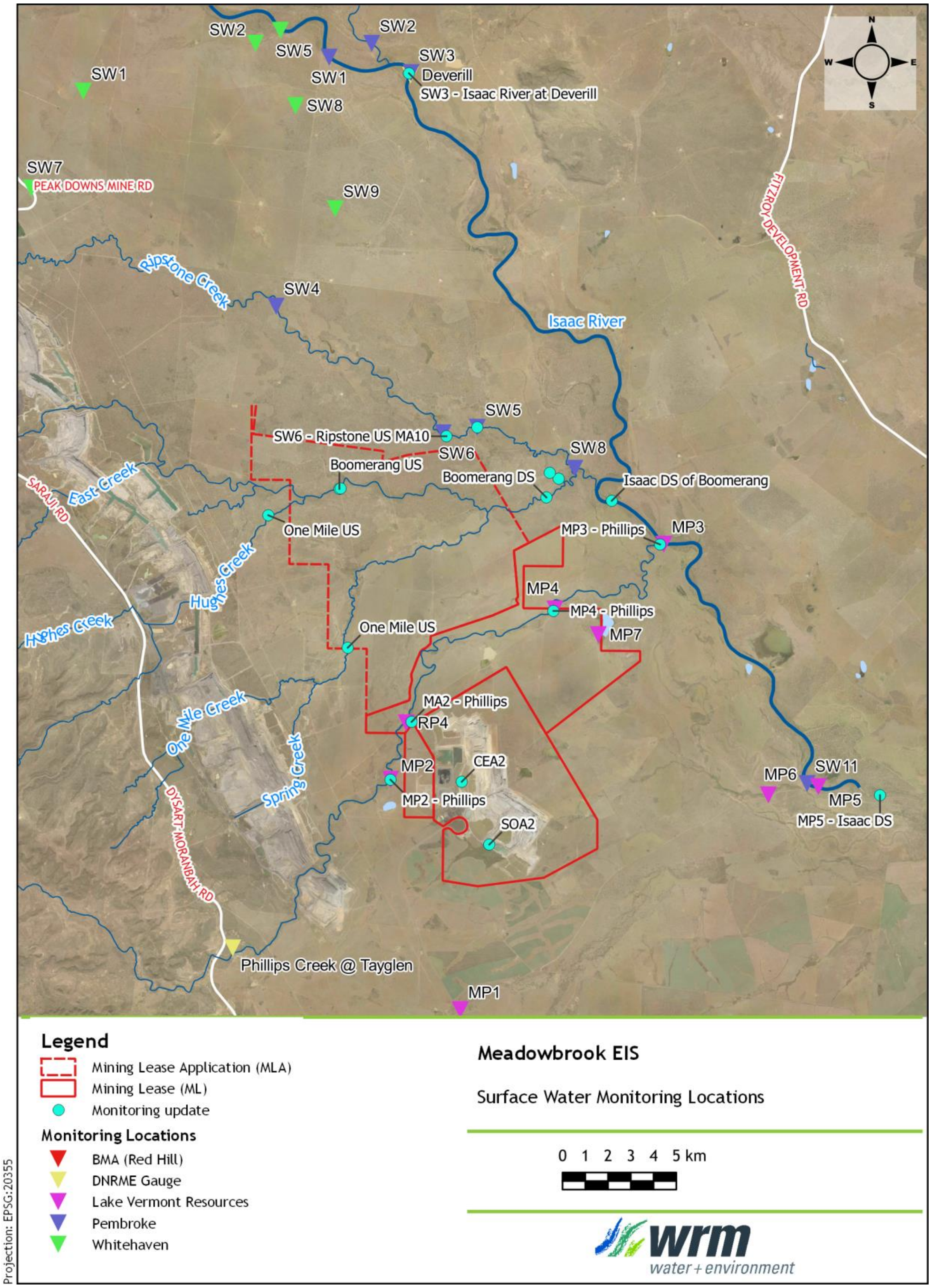


Figure 4.12 – Water quality monitoring locations

Table 4.4 - Water quality monitoring data – Boomerang Creek

Parameter		Boomerang DS							Boomerang US				Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	10/05/2021	06/07/2021	26/10/2021	10/11/2021	19/01/2021	22/03/2021	30/03/2021	06/07/2021	(refer Table 3.1)
pH	-	7.94	7.78	8.18	8.23	7.78	7.63	7.72	8.01	7.8	8.17	7.93	6.5-8.5 (aquatic)
Electrical Conductivity	µS/cm	1,410	309	456	758				666	319	472		< 720 (baseflow) < 250 (high flow)
Total Dissolved Solids	mg/L	916	201	296	493	399	298	196	433	207	307	263	< 2,000 (stock)
Total Suspended Solids	mg/L	24	36	6	14	104	671	258	12	17	8	74	< 55 (aquatic)
Chloride	mg/L	201	30	41	74	91	51	29	88	34	56	55	
Sulphate as SO4	mg/L	284	40	42	36	126	77	38	72	35	58	60	25 (aquatic)
Sodium (dissolved)	mg/L	219	43	61	86	93	69	43	76	38	55	57	< 30 (drinking)
Aluminium (dissolved)	mg/L	<0.01	0.08	<0.01	<0.01	<0.01	2.02	0.85	<0.01	<0.01	<0.01	<0.01	< 0.055 (aquatic)
Arsenic (dissolved)	mg/L	0.001	<0.001	0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.013 (aquatic)
Barium	mg/L	0.099	0.064	0.067	0.123	0.052	0.269	0.215	0.093	0.08	0.076	0.037	
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Cadmium (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0002 (aquatic)
Chromium (dissolved)	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 (aquatic)
Cobalt (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.0014 (aquatic)
Copper (dissolved)	mg/L	0.001	0.003	0.001	<0.001	0.002	0.004	0.003	0.001	0.002	0.001	0.001	< 0.0014 (aquatic)
Lead (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	< 0.0034 (aquatic)
Manganese (dissolved)	mg/L	0.054	0.003	0.146	0.153	0.002	0.024	0.034	0.016	0.02	0.005	0.002	1.9 (aquatic)
Mercury (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0002 (irrigation)

Parameter		Boomerang DS							Boomerang US				Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	10/05/2021	06/07/2021	26/10/2021	10/11/2021	19/01/2021	22/03/2021	30/03/2021	06/07/2021	(refer Table 3.1)
Molybdenum (dissolved)	mg/L	0.002	<0.001	0.001	0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	0.001	< 0.034 (aquatic)
Nickel (dissolved)	mg/L	0.002	0.004	0.006	0.004	0.002	0.005	0.004	0.002	0.002	0.002	0.002	< 0.011 (aquatic)
Selenium (dissolved)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.005 (aquatic)
Silver (dissolved)	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 (aquatic)
Uranium (dissolved)	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 (aquatic)
Vanadium (dissolved)	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 (aquatic)
Zinc (dissolved)	mg/L	<0.005	0.05	<0.005	<0.005	<0.005	0.136	0.048	<0.005	0.007	<0.005	<0.005	< 0.008 (aquatic)
Boron (dissolved)	mg/L	0.1	0.08	0.05	0.08	<0.05	0.14	0.1	0.1	0.08	0.05	<0.05	< 0.94 (aquatic)
Iron (dissolved)	mg/L	0.2	0.07	<0.05	0.08	<0.05	0.4	0.49	0.09	<0.05	<0.05	<0.05	< 0.7 (aquatic)
Aluminium (total)	mg/L	0.84	6.89	0.34	0.47	7.02	17.4	14.1	0.28	2.03	0.97	6.28	< 5 (stock)
Arsenic (total)	mg/L	0.001	0.002	0.001	0.002	0.002	0.004	0.003	<0.001	0.001	<0.001	0.002	< 2.0 (irrigation) < 0.5 (stock)
Barium (Total)	mg/L	0.104	0.089	0.075	0.13	0.105	0.253	0.139	0.093	0.075	0.087	0.079	
Beryllium (total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.001	<0.001	<0.001	<0.001	<0.001	< 0.5 (irrigation)
Boron (total)	mg/L	0.08	0.06	0.05	0.08	<0.05	<0.05	<0.05	0.08	0.06	0.05	<0.05	< 5 (stock)
Cadmium (total)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.01 (stock)
Chromium (total)	mg/L	0.002	0.01	<0.001	<0.001	0.01	0.019	0.022	0.001	0.002	0.002	0.007	< 1 (stock)
Cobalt (total)	mg/L	0.001	0.003	0.001	0.002	0.004	0.011	0.007	<0.001	0.001	<0.001	0.003	< 0.1 (irrigation)
Copper (total)	mg/L	0.002	0.007	0.002	0.001	0.008	0.017	0.01	0.001	0.003	0.002	0.006	<1 (stock)
Lead (total)	mg/L	<0.001	0.004	<0.001	<0.001	0.004	0.018	0.009	<0.001	0.002	<0.001	0.004	< 0.1 (stock)
Manganese (total)	mg/L	0.083	0.078	0.207	0.236	0.073	0.226	0.184	0.056	0.041	0.017	0.048	< 10 (irrigation)

Parameter		Boomerang DS							Boomerang US				Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	10/05/2021	06/07/2021	26/10/2021	10/11/2021	19/01/2021	22/03/2021	30/03/2021	06/07/2021	(refer Table 3.1)
Mercury (total)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.002 (irrigation)
Molybdenum (total)	mg/L	0.004	0.001	0.002	0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	< 0.05 (irrigation)
Nickel (total)	mg/L	0.004	0.013	0.006	0.005	0.012	0.026	0.019	0.002	0.004	0.003	0.007	< 1 (stock)
Selenium (total)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.02 (stock)
Silver (Total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Uranium (total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.1 (irrigation)
Vanadium (total)	mg/L	<0.01	0.01	<0.01	<0.01	0.01	0.03	0.03	<0.01	<0.01	<0.01	0.01	< 0.5 (irrigation)
Zinc (total)	mg/L	<0.005	0.014	<0.005	<0.005	0.016	0.052	0.03	<0.005	<0.005	<0.005	0.01	< 5 (irrigation)
Fluoride (total)	mg/L	0.3	0.1	0.2	0.3	0.1	0.2	0.1	0.2	0.2	0.2	0.2	< 2 (irrigation)
Ammonia (total)	mg/L	0.13	<0.01	<0.01	1.37	0.05	0.03	<0.01	0.06	<0.01	0.03	<0.01	< 0.02 (aquatic)
Nitrate as N	mg/L		<0.01	<0.01	<0.01	0.17	0.05	0.02		0.04	<0.01	0.13	< 1.1 (aquatic)
Phosphorus as P (total)	mg/L	0.05	0.13	0.04	0.11	0.22	0.47	0.25	0.03	0.06	0.04	0.14	< 50 (aquatic)

Table 4.5 - Water quality monitoring data – One Mile Creek

Parameter		One Mile US						Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	06/07/2021	25/10/2021	10/11/2021	(refer Table 3.1)
pH	-	8.04	8.09	8.19	8.09	7.85	8.09	6.5-8.5 (aquatic)
Electrical Conductivity	µS/cm	1,070	3,010	3,220				< 720 (baseflow) < 250 (high flow)
Total Dissolved Solids	mg/L	696	1960	2,090	2,020	696	1700	< 2,000 (stock)
Total Suspended Solids	mg/L	52	17	19	44	918	38	< 55 (aquatic)
Chloride	mg/L	147	453	474	457	136	417	
Sulphate as SO4	mg/L	199	871	948	919	245	575	25 (aquatic)
Sodium (dissolved)	mg/L	188	537	574	539	165	447	< 30 (drinking)
Aluminium (dissolved)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.055 (aquatic)
Arsenic (dissolved)	mg/L	0.002	<0.001	<0.001	0.001	<0.001	0.001	< 0.013 (aquatic)
Barium	mg/L	0.054	0.169	0.173	0.115	0.069	0.131	
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Cadmium (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0002 (aquatic)
Chromium (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	< 0.001 (aquatic)
Cobalt (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.0014 (aquatic)
Copper (dissolved)	mg/L	0.002	0.002	0.001	0.001	0.002	0.002	< 0.0014 (aquatic)
Lead (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.0034 (aquatic)
Manganese (dissolved)	mg/L	0.005	0.032	0.007	0.01	<0.001	0.093	1.9 (aquatic)
Mercury (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0002 (irrigation)

Parameter		One Mile US						Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	06/07/2021	25/10/2021	10/11/2021	(refer Table 3.1)
Molybdenum (dissolved)	mg/L	0.002	0.003	0.004	0.004	0.001	0.003	< 0.034 (aquatic)
Nickel (dissolved)	mg/L	0.003	0.003	0.003	0.002	0.002	0.004	< 0.011 (aquatic)
Selenium (dissolved)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.005 (aquatic)
Silver (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001 (aquatic)
Uranium (dissolved)	mg/L	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	< 0.001 (aquatic)
Vanadium (dissolved)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01 (aquatic)
Zinc (dissolved)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	< 0.008 (aquatic)
Boron (dissolved)	mg/L	0.09	0.09	0.08	<0.05	<0.05	0.08	< 0.94 (aquatic)
Iron (dissolved)	mg/L	0.3	0.13	<0.05	<0.05	0.07	<0.05	< 0.7 (aquatic)
Aluminium (total)	mg/L	2.22	0.67	0.26	1.58	20.8	0.94	< 5 (stock)
Arsenic (total)	mg/L	0.002	0.001	<0.001	0.001	0.006	0.002	< 2.0 (irrigation) < 0.5 (stock)
Barium (Total)	mg/L	0.064	0.187	0.187	0.129	0.236	0.142	
Beryllium (total)	mg/L	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	< 0.5 (irrigation)
Boron (total)	mg/L	0.08	0.09	0.07	<0.05	0.05	0.07	< 5 (stock)
Cadmium (total)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.01 (stock)
Chromium (total)	mg/L	0.003	<0.001	<0.001	0.002	0.023	0.001	< 1 (stock)
Cobalt (total)	mg/L	0.002	<0.001	<0.001	0.001	0.015	0.003	< 0.1 (irrigation)
Copper (total)	mg/L	0.004	0.003	0.002	0.002	0.02	0.003	<1 (stock)
Lead (total)	mg/L	0.003	<0.001	<0.001	<0.001	0.025	<0.001	< 0.1 (stock)

Parameter		One Mile US						Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	06/07/2021	25/10/2021	10/11/2021	(refer Table 3.1)
Manganese (total)	mg/L	0.054	0.066	0.042	0.029	0.338	0.276	< 10 (irrigation)
Mercury (total)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.002 (irrigation)
Molybdenum (total)	mg/L	0.002	0.004	0.004	0.004	0.002	0.004	< 0.05 (irrigation)
Nickel (total)	mg/L	0.006	0.004	0.004	0.004	0.029	0.005	< 1 (stock)
Selenium (total)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.02 (stock)
Silver (Total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Uranium (total)	mg/L	<0.001	<0.001	<0.001	0.001	0.001	<0.001	< 0.1 (irrigation)
Vanadium (total)	mg/L	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	< 0.5 (irrigation)
Zinc (total)	mg/L	0.015	<0.005	<0.005	<0.005	0.047	0.006	< 5 (irrigation)
Fluoride (total)	mg/L	0.4	0.4	0.4	0.3	0.2	0.4	< 2 (irrigation)
Ammonia (total)	mg/L	0.02	0.01	<0.01	0.02	<0.01	<0.01	< 0.02 (aquatic)
Nitrate as N	mg/L		<0.01	<0.01	0.27	0.29	<0.01	< 1.1 (aquatic)
Phosphorus as P (total)	mg/L	0.17	0.07	0.06	0.07	0.53	0.13	< 50 (aquatic)

Table 4.6 - Water quality monitoring data - Ripstone Creek

Parameter	Unit	SW6 Ripstone US						Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	06/07/2021	26/10/2021	10/11/2021	(refer Table 3.1)
pH	-	7.19	7.27	7.53	7.09	7.33	7.58	6.5-8.5 (aquatic)
Electrical Conductivity	µS/cm	1,040	165	206				< 720 (baseflow) < 250 (high flow)
Total Dissolved Solids	mg/L	676	107	134	38	47	99	< 2,000 (stock)
Total Suspended Solids	mg/L	32	10	64	10	30	54	< 55 (aquatic)
Chloride	mg/L	162	17	23	4	3	7	
Sulphate as SO4	mg/L	207	16	20	4	<1	<1	25 (aquatic)
Sodium (dissolved)	mg/L	144	20	26	5	2	6	< 30 (drinking)
Aluminium (dissolved)	mg/L	<0.01	0.36	0.35	1.37	0.1	0.02	< 0.055 (aquatic)
Arsenic (dissolved)	mg/L	0.002	0.002	0.001	<0.001	0.002	0.004	< 0.013 (aquatic)
Barium	mg/L	0.178	0.07	0.109	0.013	0.03	0.064	
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Cadmium (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0002 (aquatic)
Chromium (dissolved)	mg/L	0.004	0.004	0.003	<0.001	0.006	0.007	< 0.001 (aquatic)
Cobalt (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.0014 (aquatic)
Copper (dissolved)	mg/L	0.002	0.005	0.004	0.003	<0.001	<0.001	< 0.0014 (aquatic)
Lead (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.0034 (aquatic)
Manganese (dissolved)	mg/L	0.74	0.43	0.31	0.022	0.7	1.08	1.9 (aquatic)
Mercury (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0002 (irrigation)

Parameter	Unit	SW6 Ripstone US						Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	06/07/2021	26/10/2021	10/11/2021	(refer Table 3.1)
Molybdenum (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.034 (aquatic)
Nickel (dissolved)	mg/L	0.006	0.005	0.006	0.003	0.003	0.005	< 0.011 (aquatic)
Selenium (dissolved)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.005 (aquatic)
Silver (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001 (aquatic)
Uranium (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001 (aquatic)
Vanadium (dissolved)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01 (aquatic)
Zinc (dissolved)	mg/L	0.007	0.08	0.065	<0.005	<0.005	<0.005	< 0.008 (aquatic)
Boron (dissolved)	mg/L	0.08	0.08	0.06	<0.05	<0.05	<0.05	< 0.94 (aquatic)
Iron (dissolved)	mg/L	0.68	0.17	0.19	0.15	0.31	0.52	< 0.7 (aquatic)
Aluminium (total)	mg/L	1.19	1.6	7.86	2.79	0.73	0.69	< 5 (stock)
Arsenic (total)	mg/L	0.002	0.003	0.004	<0.001	0.002	0.009	< 2.0 (irrigation) < 0.5 (stock)
Barium (Total)	mg/L	0.188	0.066	0.118	0.03	0.036	0.091	
Beryllium (total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.5 (irrigation)
Boron (total)	mg/L	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	< 5 (stock)
Cadmium (total)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.01 (stock)
Chromium (total)	mg/L	0.001	0.001	0.008	0.003	<0.001	<0.001	< 1 (stock)
Cobalt (total)	mg/L	0.005	0.005	0.009	0.002	0.007	0.011	< 0.1 (irrigation)
Copper (total)	mg/L	0.003	0.003	0.011	0.004	0.002	0.001	< 1 (stock)
Lead (total)	mg/L	0.001	<0.001	0.008	0.001	<0.001	0.002	< 0.1 (stock)

Parameter	Unit	SW6 Ripstone US						Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	06/07/2021	26/10/2021	10/11/2021	(refer Table 3.1)
Manganese (total)	mg/L	0.79	0.477	0.458	0.076	0.789	1.42	< 10 (irrigation)
Mercury (total)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.002 (irrigation)
Molybdenum (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.001	< 0.05 (irrigation)
Nickel (total)	mg/L	0.008	0.007	0.014	0.004	0.003	0.006	< 1 (stock)
Selenium (total)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.02 (stock)
Silver (Total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Uranium (total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.1 (irrigation)
Vanadium (total)	mg/L	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	< 0.5 (irrigation)
Zinc (total)	mg/L	0.013	0.005	0.017	0.007	0.006	<0.005	< 5 (irrigation)
Fluoride (total)	mg/L	0.4	<0.1	0.1	<0.1	<0.1	0.1	< 2 (irrigation)
Ammonia (total)	mg/L	0.07	0.1	1.02	0.01	<0.01	<0.01	< 0.02 (aquatic)
Nitrate as N	mg/L		<0.01	<0.01	<0.01	<0.01	0.01	< 1.1 (aquatic)
Phosphorus as P (total)	mg/L	0.12	0.09	0.31	0.11	0.19	0.45	< 50 (aquatic)

Table 4.7 - Water quality monitoring data - Ripstone Creek SW5

Parameter	Unit	SW5 Ripstone						Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	06/07/2021	26/10/2021	10/11/2021	(refer Table 3.1)
pH	-	7.03	7.35	7.95	7.39	7.53	7.49	6.5-8.5 (aquatic)
Electrical Conductivity	µS/cm	995	152	314				< 720 (baseflow) < 250 (high flow)
Total Dissolved Solids	mg/L	647	99	204	31	59	84	< 2,000 (stock)
Total Suspended Solids	mg/L	470	76	32	97	30	385	< 55 (aquatic)
Chloride	mg/L	140	8	26	4	3	6	
Sulphate as SO4	mg/L	194	7	13	6	<5	2	25 (aquatic)
Sodium (dissolved)	mg/L	134	17	48	9	4	10	< 30 (drinking)
Aluminium (dissolved)	mg/L	<0.01	0.65	0.05	1.62	1.17	0.11	< 0.055 (aquatic)
Arsenic (dissolved)	mg/L	0.002	0.001	0.005	<0.001	0.004	0.002	< 0.013 (aquatic)
Barium	mg/L	0.217	0.074	0.06	0.217	0.115	0.05	
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Cadmium (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0002 (aquatic)
Chromium (dissolved)	mg/L	0.003	<0.001	0.002	0.002	0.005	0.002	< 0.001 (aquatic)
Cobalt (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.0014 (aquatic)
Copper (dissolved)	mg/L	0.002	0.004	0.002	0.004	0.002	0.002	< 0.0014 (aquatic)
Lead (dissolved)	mg/L	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	< 0.0034 (aquatic)
Manganese (dissolved)	mg/L	0.767	0.082	0.348	0.114	0.633	0.4	1.9 (aquatic)
Mercury (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0002 (irrigation)

Parameter	Unit	SW5 Ripstone						Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	06/07/2021	26/10/2021	10/11/2021	(refer Table 3.1)
Molybdenum (dissolved)	mg/L	0.001	<0.001	0.002	<0.001	<0.001	0.001	< 0.034 (aquatic)
Nickel (dissolved)	mg/L	0.003	0.003	0.004	0.003	0.004	0.003	< 0.011 (aquatic)
Selenium (dissolved)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.005 (aquatic)
Silver (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001 (aquatic)
Uranium (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001 (aquatic)
Vanadium (dissolved)	mg/L	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	< 0.01 (aquatic)
Zinc (dissolved)	mg/L	<0.005	0.042	<0.005	0.09	0.043	<0.005	< 0.008 (aquatic)
Boron (dissolved)	mg/L	0.09	0.07	0.1	<0.05	<0.05	0.05	< 0.94 (aquatic)
Iron (dissolved)	mg/L	0.85	0.06	0.16	0.1	0.61	0.12	< 0.7 (aquatic)
Aluminium (total)	mg/L	12.4	22.9	3.07	20.4	1.47	14.5	< 5 (stock)
Arsenic (total)	mg/L	0.004	0.005	0.007	0.003	0.004	0.007	< 2.0 (irrigation) < 0.5 (stock)
Barium (Total)	mg/L	0.351	0.246	0.087	0.192	0.066	0.301	
Beryllium (total)	mg/L	<0.001	<0.001	<0.001	0.002	<0.001	0.001	< 0.5 (irrigation)
Boron (total)	mg/L	0.08	0.05	0.1	<0.05	<0.05	<0.05	< 5 (stock)
Cadmium (total)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.01 (stock)
Chromium (total)	mg/L	0.013	0.021	0.003	0.019	0.002	0.012	< 1 (stock)
Cobalt (total)	mg/L	0.011	0.009	0.003	0.008	0.005	0.014	< 0.1 (irrigation)
Copper (total)	mg/L	0.014	0.015	0.006	0.014	0.002	0.015	<1 (stock)
Lead (total)	mg/L	0.009	0.011	0.004	0.011	<0.001	0.013	< 0.1 (stock)

Parameter	Unit	SW5 Ripstone						Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	06/07/2021	26/10/2021	10/11/2021	(refer Table 3.1)
Manganese (total)	mg/L	1.13	0.549	0.464	0.366	0.675	1.33	< 10 (irrigation)
Mercury (total)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.002 (irrigation)
Molybdenum (total)	mg/L	0.002	<0.001	0.002	<0.001	<0.001	<0.001	< 0.05 (irrigation)
Nickel (total)	mg/L	0.014	0.018	0.007	0.016	0.004	0.017	< 1 (stock)
Selenium (total)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.02 (stock)
Silver (Total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Uranium (total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.1 (irrigation)
Vanadium (total)	mg/L	0.03	0.04	0.01	0.04	<0.01	0.04	< 0.5 (irrigation)
Zinc (total)	mg/L	0.026	0.045	<0.005	0.034	<0.005	0.033	< 5 (irrigation)
Fluoride (total)	mg/L	0.2	0.1	0.5	0.1	<0.1	0.1	< 2 (irrigation)
Ammonia (total)	mg/L	0.1	0.12	0.06	0.13	<0.01	0.12	< 0.02 (aquatic)
Nitrate as N	mg/L		<0.01	<0.01	0.17	0.01	0.02	< 1.1 (aquatic)
Phosphorus as P (total)	mg/L	0.40	0.45	0.33	0.52	0.19	0.30	< 50 (aquatic)

Table 4.8 - Water quality monitoring data - Ripstone Creek DS

Parameter	Unit	SW8 Ripstone DS							Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	10/05/2021	06/07/2021	26/10/2021	10/11/2021	(refer Table 3.1)
pH	-	7.12	9.21	7.85	6.17	7.03	6.97	7.1	6.5-8.5 (aquatic)
Electrical Conductivity	µS/cm	385	308	397	845				< 720 (baseflow) < 250 (high flow)
Total Dissolved Solids	mg/L	250	200	258	549	34	49	47	< 2,000 (stock)
Total Suspended Solids	mg/L	215	50	147	239	40	94	103	< 55 (aquatic)
Chloride	mg/L	46	67	75	272	4	8	6	
Sulphate as SO4	mg/L	29	3	4	6	5	7	3	25 (aquatic)
Sodium (dissolved)	mg/L	44	46	49	92	5	10	8	< 30 (drinking)
Aluminium (dissolved)	mg/L	<0.01	0.02	0.02	<0.01	0.78	1.9	1.33	< 0.055 (aquatic)
Arsenic (dissolved)	mg/L	0.004	0.004	0.004	0.002	<0.001	0.001	0.002	< 0.013 (aquatic)
Barium	mg/L	0.065	0.122	0.023	0.204	0.012	0.243	0.189	
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Cadmium (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0002 (aquatic)
Chromium (dissolved)	mg/L	0.004	0.001	0.002	0.008	<0.001	0.002	0.001	< 0.001 (aquatic)
Cobalt (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.001	< 0.0014 (aquatic)
Copper (dissolved)	mg/L	<0.001	0.002	<0.001	0.001	0.001	0.007	0.007	< 0.0014 (aquatic)
Lead (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.003	< 0.0034 (aquatic)
Manganese (dissolved)	mg/L	0.489	0.008	0.072	1.36	0.011	0.122	0.078	1.9 (aquatic)
Mercury (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0002 (irrigation)

Parameter	Unit	SW8 Ripstone DS							Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	10/05/2021	06/07/2021	26/10/2021	10/11/2021	(refer Table 3.1)
Molybdenum (dissolved)	mg/L	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	< 0.034 (aquatic)
Nickel (dissolved)	mg/L	0.006	0.003	0.004	0.009	0.002	0.007	0.008	< 0.011 (aquatic)
Selenium (dissolved)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.005 (aquatic)
Silver (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001 (aquatic)
Uranium (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001 (aquatic)
Vanadium (dissolved)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01 (aquatic)
Zinc (dissolved)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	0.114	0.07	< 0.008 (aquatic)
Boron (dissolved)	mg/L	0.08	0.14	0.11	0.14	<0.05	0.10	0.08	< 0.94 (aquatic)
Iron (dissolved)	mg/L	1.76	0.18	0.23	<0.05	<0.05	0.68	1.04	< 0.7 (aquatic)
Aluminium (total)	mg/L	2.33	1.55	2.23	4.42	4.91	12.2	15.6	< 5 (stock)
Arsenic (total)	mg/L	0.007	0.005	0.008	0.005	0.001	0.003	0.005	< 2.0 (irrigation) < 0.5 (stock)
Barium (Total)	mg/L	0.094	0.015	0.08	0.247	0.047	0.123	0.129	
Beryllium (total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	< 0.5 (irrigation)
Boron (total)	mg/L	0.07	0.1	0.11	0.14	<0.05	0.06	<0.05	< 5 (stock)
Cadmium (total)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.01 (stock)
Chromium (total)	mg/L	0.003	0.002	0.003	0.007	0.006	0.016	0.020	< 1 (stock)
Cobalt (total)	mg/L	0.006	0.003	0.004	0.012	0.002	0.007	0.006	< 0.1 (irrigation)
Copper (total)	mg/L	0.002	0.004	0.004	0.009	0.006	0.014	0.014	< 1 (stock)
Lead (total)	mg/L	0.002	0.001	0.003	0.005	0.003	0.008	0.009	< 0.1 (stock)

Parameter	Unit	SW8 Ripstone DS							Default Guideline Value
		19/01/2021	22/03/2021	30/03/2021	10/05/2021	06/07/2021	26/10/2021	10/11/2021	(refer Table 3.1)
Manganese (total)	mg/L	0.612	0.21	0.532	1.41	0.069	0.254	0.167	< 10 (irrigation)
Mercury (total)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.002 (irrigation)
Molybdenum (total)	mg/L	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	< 0.05 (irrigation)
Nickel (total)	mg/L	0.009	0.007	0.009	0.016	0.007	0.019	0.021	< 1 (stock)
Selenium (total)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.02 (stock)
Silver (Total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Uranium (total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.1 (irrigation)
Vanadium (total)	mg/L	<0.01	<0.01	<0.01	0.01	<0.01	0.02	0.03	< 0.5 (irrigation)
Zinc (total)	mg/L	0.006	<0.005	<0.005	0.021	0.016	0.047	0.047	< 5 (irrigation)
Fluoride (total)	mg/L	0.1	0.3	0.3	<0.1	<0.1	<0.1	<0.1	< 2 (irrigation)
Ammonia (total)	mg/L	<0.01	0.11	0.04	0.87	0.05	0.10	0.16	< 0.02 (aquatic)
Nitrate as N	mg/L		<0.01	<0.01	0.03	0.79	0.06	0.05	< 1.1 (aquatic)
Phosphorus as P (total)	mg/L	0.41	0.29	0.54	0.81	0.24	0.56	0.48	< 50 (aquatic)

Table 4.9 - Water quality monitoring data - Phillips Creek

Parameter	Unit	MP2 - Phillips Creek US					MA2 - Phillips Creek US					Default Guideline Value
		19/01/2021	16/03/2021	30/03/2021	25/10/2021	10/11/2021	21/01/2021	16/03/2021	30/03/2021	25/10/2021	10/11/2021	(refer Table 3.1)
pH	-	8.01	7.99	7.8	7.57	7.55	7.85	8.02	7.84	7.44	7.63	6.5-8.5 (aquatic)
Electrical Conductivity	µS/cm	340	141	298			257	138	279			< 720 (baseflow) < 250 (high flow)
Total Dissolved Solids	mg/L	221	92	194	244	75	167	90	181	133	72	< 2,000 (stock)
Total Suspended Solids	mg/L	7	6760	8	283	571	14	5440	85	208	672	< 55 (aquatic)
Chloride	mg/L	17	8	16	43	7	10	8	15	17	6	
Sulphate as SO4	mg/L	24	3	17	54	4	12	3	15	23	3	25 (aquatic)
Sodium (dissolved)	mg/L	26	14	25	43	8	17	14	21	18	7	< 30 (drinking)
Aluminium (dissolved)	mg/L	<0.01	0.2	<0.01	1.86	0.07	<0.01	0.2	<0.01	1.72	0.15	< 0.055 (aquatic)
Arsenic (dissolved)	mg/L	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	< 0.013 (aquatic)
Barium	mg/L	0.068	0.054	0.045	0.124	0.018	0.05	0.056	0.046	0.212	0.018	
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Cadmium (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0002 (aquatic)
Chromium (dissolved)	mg/L	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	< 0.001 (aquatic)
Cobalt (dissolved)	mg/L	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	< 0.0014 (aquatic)
Copper (dissolved)	mg/L	0.002	0.002	0.001	0.003	0.001	0.002	0.002	0.002	0.004	0.001	< 0.0014 (aquatic)
Lead (dissolved)	mg/L	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.0034 (aquatic)
Manganese (dissolved)	mg/L	0.003	0.002	0.002	0.078	0.001	0.014	0.002	0.002	0.024	0.001	1.9 (aquatic)
Mercury (dissolved)	mg/L	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0002 (irrigation)

Parameter	Unit	MP2 - Phillips Creek US					MA2 - Phillips Creek US					Default Guideline Value
		19/01/2021	16/03/2021	30/03/2021	25/10/2021	10/11/2021	21/01/2021	16/03/2021	30/03/2021	25/10/2021	10/11/2021	(refer Table 3.1)
Molybdenum (dissolved)	mg/L	0.001	<0.001	0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001	< 0.034 (aquatic)
Nickel (dissolved)	mg/L	0.003	0.002	0.002	0.006	0.001	0.004	0.002	0.002	0.005	0.001	< 0.011 (aquatic)
Selenium (dissolved)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.005 (aquatic)
Silver (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001 (aquatic)
Uranium (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001 (aquatic)
Vanadium (dissolved)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01 (aquatic)
Zinc (dissolved)	mg/L	<0.005	0.02	<0.005	0.055	<0.005	<0.005	0.021	<0.005	0.118	<0.005	< 0.008 (aquatic)
Boron (dissolved)	mg/L	0.06	0.06	<0.05	<0.05	<0.05	0.07	0.06	<0.05	0.05	<0.05	< 0.94 (aquatic)
Iron (dissolved)	mg/L	<0.05	<0.05	<0.05	0.2	----	0.1	<0.05	<0.05	0.26	----	< 0.7 (aquatic)
Aluminium (total)	mg/L	0.26	35.9	0.51	9.1	16.4	0.68	44.6	5.87	12.9	22	< 5 (stock)
Arsenic (total)	mg/L	<0.001	0.004	<0.001	0.002	0.004	<0.001	0.004	<0.001	0.002	0.006	< 2.0 (irrigation) < 0.5 (stock)
Barium (Total)	mg/L	0.068	0.648	0.051	0.112	0.186	0.057	0.871	0.082	0.112	0.215	
Beryllium (total)	mg/L	<0.001	0.005	<0.001	<0.001	0.002	<0.001	0.006	<0.001	<0.001	0.003	< 0.5 (irrigation)
Boron (total)	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	0.09	0.05	<0.05	<0.05	<0.05	< 5 (stock)
Cadmium (total)	mg/L	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	0.0004	< 0.01 (stock)
Chromium (total)	mg/L	<0.001	0.044	0.001	0.017	0.019	<0.001	0.062	0.014	0.025	0.028	< 1 (stock)
Cobalt (total)	mg/L	<0.001	0.062	<0.001	0.006	0.01	<0.001	0.081	0.004	0.008	0.014	< 0.1 (irrigation)
Copper (total)	mg/L	0.002	0.046	0.002	0.009	0.013	0.004	0.06	0.007	0.012	0.019	< 1 (stock)
Lead (total)	mg/L	<0.001	0.043	<0.001	0.007	0.02	<0.001	0.053	0.001	0.006	0.027	< 0.1 (stock)

Parameter	Unit	MP2 - Phillips Creek US					MA2 - Phillips Creek US					Default Guideline Value
		19/01/2021	16/03/2021	30/03/2021	25/10/2021	10/11/2021	21/01/2021	16/03/2021	30/03/2021	25/10/2021	10/11/2021	(refer Table 3.1)
Manganese (total)	mg/L	0.016	1.34	0.036	0.154	0.238	0.044	1.91	0.11	0.196	0.315	< 10 (irrigation)
Mercury (total)	mg/L	0.0005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.002 (irrigation)
Molybdenum (total)	mg/L	0.002	<0.001	0.001	<0.001	<0.001	0.002	<0.001	0.001	<0.001	<0.001	< 0.05 (irrigation)
Nickel (total)	mg/L	0.004	0.086	0.004	0.018	0.022	0.002	0.114	0.018	0.028	0.031	< 1 (stock)
Selenium (total)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.02 (stock)
Silver (Total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Uranium (total)	mg/L	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	< 0.1 (irrigation)
Vanadium (total)	mg/L	<0.01	0.07	<0.01	0.02	0.03	<0.01	0.09	0.01	0.03	0.04	< 0.5 (irrigation)
Zinc (total)	mg/L	<0.005	0.116	<0.005	0.024	0.042	0.007	0.118	0.007	0.028	0.06	< 5 (irrigation)
Fluoride (total)	mg/L	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	< 2 (irrigation)
Ammonia (total)	mg/L	0.04	0.03	<0.01	<0.01	<0.01	0.04	<0.01	0.02	<0.01	<0.01	< 0.02 (aquatic)
Nitrate as N	mg/L		0.19	<0.01	0.1	0.34		0.18	<0.01	0.29	0.31	< 1.1 (aquatic)
Phosphorus as P (total)	mg/L	0.04	3.74	0.04	0.39	0.44	0.06	4.32	0.22	1.14	0.36	< 50 (aquatic)

Table 4.10 - Water quality monitoring data - Phillips Creek DS

Parameter	Unit	MP3 - Phillips DS							MP4 - Phillips DS					Default Guideline Value
		20/01/2021	17/03/2021	30/03/2021	10/05/2021	06/07/2021	25/10/2021	11/11/2021	20/01/2021	16/03/2021	30/03/2021	25/10/2021	11/11/2021	(refer Table 3.1)
pH	-	7.68	7.98	8.21	8.37	7.69	7.46	8.07	7.92	7.87	8.27	7.91	7.78	6.5-8.5 (aquatic)
Electrical Conductivity	μS/cm	368	144	307	415				332	138	294			< 720 (baseflow) < 250 (high flow)
Total Dissolved Solids	mg/L	239	94	200	270	136	155	431	216	90	191	124	83	< 2,000 (stock)
Total Suspended Solids	mg/L	12	7020	86	30	997	295	44	15	6020	11	91	533	< 55 (aquatic)
Chloride	mg/L	42	8	25	21	28	24	56	15	7	9	14	6	
Sulphate as SO4	mg/L	39	9	18	11	24	33	45	14	4	6	18	5	25 (aquatic)
Sodium (dissolved)	mg/L	44	16	27	26	29	33	72	19	13	16	27	7	< 30 (drinking)
Aluminium (dissolved)	mg/L	<0.01	0.1	<0.01	<0.01	0.04	1.75	<0.01	<0.01	0.16	<0.01	0.73	0.1	< 0.055 (aquatic)
Arsenic (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.001	<0.001	<0.001	<0.001	<0.001	< 0.013 (aquatic)
Barium	mg/L	0.075	0.071	0.063	0.116	0.031	0.204	0.135	0.067	0.055	0.064	0.122	0.023	
Beryllium	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	
Cadmium (dissolved)	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	< 0.0002 (aquatic)
Chromium (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.002	<0.001	<0.001	<0.001	<0.001	< 0.001 (aquatic)
Cobalt (dissolved)	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	< 0.0014 (aquatic)
Copper (dissolved)	mg/L	0.001	0.002	0.002	0.001	0.001	0.004	<0.001	<0.001	0.003	<0.001	0.003	0.001	< 0.0014 (aquatic)
Lead (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.0034 (aquatic)
Manganese (dissolved)	mg/L	0.028	0.002	0.002	0.031	<0.001	0.03	1.79	0.394	0.002	0.026	0.018	<0.001	1.9 (aquatic)

Parameter	Unit	MP3 - Phillips DS							MP4 - Phillips DS					Default Guideline Value
		20/01/2021	17/03/2021	30/03/2021	10/05/2021	06/07/2021	25/10/2021	11/11/2021	20/01/2021	16/03/2021	30/03/2021	25/10/2021	11/11/2021	(refer Table 3.1)
Mercury (dissolved)	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	< 0.0002 (irrigation)
Molybdenum (dissolved)	mg/L	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.002	<0.001	<0.001	< 0.034 (aquatic)
Nickel (dissolved)	mg/L	0.001	0.002	0.003	0.003	<0.001	0.004	0.004	0.006	0.002	0.004	0.004	0.002	< 0.011 (aquatic)
Selenium (dissolved)	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	< 0.005 (aquatic)
Silver (dissolved)	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 (aquatic)
Uranium (dissolved)	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 (aquatic)
Vanadium (dissolved)	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 (aquatic)
Zinc (dissolved)	mg/L	<0.005	0.028	0.021	<0.005	<0.005	0.112	<0.005	<0.005	0.027	<0.005	0.056	<0.005	< 0.008 (aquatic)
Boron (dissolved)	mg/L	0.07	0.08	<0.05	<0.05	<0.05	0.12	0.06	0.06	0.05	<0.05	<0.05	<0.05	< 0.94 (aquatic)
Iron (dissolved)	mg/L	0.09	<0.05	<0.05	<0.05	<0.05	0.41	<0.05	<0.05	<0.05	<0.05	0.13	<0.05	< 0.7 (aquatic)
Aluminium (total)	mg/L	1.92	52.1	4.47	0.83	24.3	11.9	1.41	0.33	49	0.39	3.84	19.8	< 5 (stock)
Arsenic (total)	mg/L	<0.001	0.006	0.001	0.001	0.003	0.002	0.005	0.001	0.005	<0.001	0.001	0.004	< 2.0 (irrigation) < 0.5 (stock)
Barium (Total)	mg/L	0.09	1.06	0.101	0.135	0.352	0.164	0.157	0.073	0.968	0.067	0.079	0.179	
Beryllium (total)	mg/L	<0.001	0.007	<0.001	<0.001	0.002	0.001	<0.001	<0.001	0.006	<0.001	<0.001	0.002	< 0.5 (irrigation)
Boron (total)	mg/L	0.06	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	< 5 (stock)
Cadmium (total)	mg/L	<0.0001	0.0003	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	< 0.01 (stock)
Chromium (total)	mg/L	0.004	0.09	0.009	0.001	0.029	0.014	0.002	0.001	0.074	<0.001	0.007	0.031	< 1 (stock)
Cobalt (total)	mg/L	0.001	0.106	0.003	0.002	0.016	0.007	0.006	0.002	0.098	<0.001	0.003	0.011	< 0.1 (irrigation)
Copper (total)	mg/L	0.002	0.08	0.005	0.002	0.025	0.012	0.001	<0.001	0.068	0.001	0.006	0.015	<1 (stock)

Parameter	Unit	MP3 - Phillips DS							MP4 - Phillips DS					Default Guideline Value
		20/01/2021	17/03/2021	30/03/2021	10/05/2021	06/07/2021	25/10/2021	11/11/2021	20/01/2021	16/03/2021	30/03/2021	25/10/2021	11/11/2021	(refer Table 3.1)
Lead (total)	mg/L	<0.001	0.066	0.002	<0.001	0.017	0.011	0.002	<0.001	0.058	<0.001	0.003	0.017	< 0.1 (stock)
Manganese (total)	mg/L	0.055	2.66	0.129	0.189	0.49	0.174	2	0.387	2.25	0.075	0.077	0.255	< 10 (irrigation)
Mercury (total)	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	< 0.002 (irrigation)
Molybdenum (total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.001	<0.001	<0.001	< 0.05 (irrigation)
Nickel (total)	mg/L	0.004	0.161	0.012	0.004	0.033	0.017	0.007	0.007	0.132	0.005	0.01	0.031	< 1 (stock)
Selenium (total)	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	< 0.02 (stock)
Silver (Total)	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	
Uranium (total)	mg/L	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	< 0.1 (irrigation)
Vanadium (total)	mg/L	<0.01	0.11	<0.01	<0.01	0.05	0.02	<0.01	<0.01	0.1	<0.01	0.01	0.04	< 0.5 (irrigation)
Zinc (total)	mg/L	<0.005	0.152	<0.005	0.01	0.059	0.034	0.008	<0.005	0.13	<0.005	0.017	0.043	< 5 (irrigation)
Fluoride (total)	mg/L	0.1	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.2	0.1	0.1	< 2 (irrigation)
Ammonia (total)	mg/L	0.02	0.12	<0.01	<0.01	0.02	0.01	<0.01	0.03	0.01	<0.01	<0.01	<0.01	< 0.02 (aquatic)
Nitrate as N	mg/L		0.1	<0.01	<0.01	0.29	0.04	<0.01		0.17	<0.01	0.07	0.27	< 1.1 (aquatic)
Phosphorus as P (total)	mg/L	0.08	5.68	0.15	0.09	0.84	0.37	0.13	0.08	4.64	0.05	0.13	0.27	< 50 (aquatic)

4.6.2 Regional Isaac River water quality

The Isaac River catchment has seen significant changes in land use over the past 50 years. Widespread land clearing and coal mine development have occurred throughout the catchment. The extent to which these activities have affected water quality is difficult to ascertain.

Coal mines have historically discharged mine-affected water immediately following significant rainfall events, but few records are available of the timing and quality of these releases.

Water quality monitoring results in the vicinity of the Project are available from a number of monitoring stations established for neighbouring projects.

Table 4.11 shows a summary of water quality data prepared from samples collected for the nearby Winchester South and Olive Downs Projects between March 2019 and January 2022 (in the 17 km reach of the Isaac River upstream of Deverill).

Table 4.11 shows that the DGVs for dissolved aluminium, iron, selenium (dissolved) and turbidity are below the measured 80th percentile values and below the 20th percentile values for ammonia in the vicinity of the Project. NOTE: values that were recorded as below the limit of reporting, have been assumed to be equal to the limit of reporting, for the purpose of this statistical analysis.

Table 4.11 - Isaac River water quality summary - composite dataset

Parameter	Unit	Composite Isaac River dataset				Default Guideline Value (refer Table 3.1)
		No. of samples	20th %ile value	Median value	80th %ile value	
Aluminium (total)	mg/L	38	0.15	0.37	3.36	< 5 (stock)
Aluminium (dissolved)	mg/L	38	<0.010	0.040	0.116	< 0.055 (aquatic)
Ammonia (total)	mg/L	40	0.03	0.06	0.18	< 0.02 (aquatic)
Arsenic (total)	mg/L	39	<0.001	0.002	0.003	< 2.0 (irrigation) < 0.5 (stock)
Arsenic (dissolved)	mg/L	40	<0.001	<0.001	0.002	< 0.013 (aquatic)
Beryllium (total)	mg/L	10	<0.001	<0.001	<0.001	< 0.5 (irrigation)
Boron (total)	mg/L	38	<0.05	<0.05	0.07	< 5 (stock)
Boron (dissolved)	mg/L	38	<0.05	<0.05	0.06	< 0.94 (aquatic)
Cadmium (total)	mg/L	40	<0.0001	<0.0001	0.0001	< 0.01 (stock)
Cadmium (dissolved)	mg/L	40	<0.0001	<0.0001	0.0001	< 0.0002 (aquatic)
Cobalt (total)	mg/L	38	<0.001	0.001	0.004	< 0.1 (irrigation)
Cobalt (dissolved)	mg/L	38	<0.001	<0.001	0.001	< 0.0014 (aquatic)
Chromium (total)	mg/L	40	<0.001	0.001	0.004	< 1 (stock)
Chromium (dissolved)	mg/L	40	<0.001	<0.001	0.001	< 0.001 (aquatic)
Copper (total)	mg/L	40	<0.001	0.001	0.004	<1 (stock)
Copper (dissolved)	mg/L	40	<0.001	<0.001	0.001	< 0.00014 (aquatic)
Electrical Conductivity	µS/cm	39	287	343	442	< 720 (baseflow) < 250 (high flow)

Parameter	Unit	Composite Isaac River dataset				Default Guideline Value (refer Table 3.1)
		No. of samples	20th %ile value	Median value	80th %ile value	
Filterable Reactive Phosphorus	mg/L	25	<0.01	<0.01	0.01	< 0.02 (aquatic)
Fluoride (total)	mg/L	40	0.2	0.2	0.2	< 2 (irrigation)
Iron (total)	mg/L	38	0.60	1.41	6.68	< 10 (irrigation)
Iron (dissolved)	mg/L	38	0.05	0.16	0.38	< 0.18 (aquatic)
Lead (total)	mg/L	40	<0.001	0.001	0.003	< 0.1 (stock)
Lead (dissolved)	mg/L	40	<0.001	<0.001	0.001	< 0.0034 (aquatic)
Manganese (total)	mg/L	38	0.22	0.44	1.09	< 10 (irrigation)
Manganese (dissolved)	mg/L	38	0.05	0.33	0.95	1.9 (aquatic)
Mercury (total)	mg/L	40	<0.0001	<0.0001	0.0001	< 0.002 (irrigation)
Mercury (dissolved)	mg/L	40	<0.0001	<0.0001	0.0001	< 0.0002 (irrigation)
Molybdenum (total)	mg/L	38	<0.001	<0.001	0.001	< 0.05 (irrigation)
Molybdenum (dissolved)	mg/L	38	<0.001	<0.001	0.001	< 0.034 (aquatic)
Nickel (total)	mg/L	40	0.001	0.003	0.007	< 1 (stock)
Nickel (dissolved)	mg/L	40	0.001	0.002	0.002	< 0.011 (aquatic)
pH	-	39	7.31	7.67	8.26	6.5-8.5 (aquatic)
Phosphorus (total)	mg/L	38	0.02	0.06	0.11	< 50 (aquatic)
Selenium (total)	mg/L	38	<0.01	<0.01	0.01	< 0.02 (stock)
Selenium (dissolved)	mg/L	38	<0.01	<0.01	0.01	< 0.005 (aquatic)
Sulphate (total)	mg/L	40	3	5	8	< 25 (aquatic)
Total Dissolved Solids	mg/L	12	206	264	303	< 2,000 (stock)
Total Suspended Solids	mg/L	39	11	19	48	< 55 (aquatic)
Turbidity	NTU	37	11	30	144	< 50 (aquatic)
Uranium (total)	mg/L	37	<0.001	<0.001	0.001	< 0.1 (irrigation)
Uranium (dissolved)	mg/L	37	<0.001	<0.001	0.001	< 0.001 (aquatic)
Vanadium (total)	mg/L	38	<0.01	<0.01	0.01	< 0.5 (irrigation)
Vanadium (dissolved)	mg/L	38	<0.01	<0.01	0.01	< 0.01 (aquatic)
Zinc (total)	mg/L	40	<0.005	0.006	0.020	< 5 (irrigation)
Zinc (dissolved)	mg/L	40	<0.005	<0.005	0.005	< 0.008 (aquatic)

Publicly available regional water quality data for the Isaac River at the Burton Gorge, Goonyella and Deverill gauging stations have been analysed and a comparison of the water quality statistics at these sites are displayed in Table 4.12. These sites were selected because complete datasets (i.e. individual sample analysis results) are publicly available as opposed to only summary data being publicly available.

The Isaac River (Burton Gorge) and Isaac River (Goonyella) stations are located downstream of the Goonyella, North Goonyella, Broadlea and Burton mines and therefore measured water quality may be affected by mine releases. The Isaac River (Burton Gorge) and Isaac River (Goonyella) stations are about 95 km and 60 km upstream of the Project, respectively. However, these stations provide an indication of water quality, including metal toxicants, in the Isaac River upstream of the Project.

Table 4.12 shows that some readings at the DRDMW monitoring locations along the Isaac River are at or above the regional default guideline values (DGVs), including the following:

- Dissolved aluminium at Goonyella and Deverill (80^{th} percentile);
- Dissolved copper at Goonyella and Deverill (median and 20^{th}/80^{th} percentile);
- EC at Goonyella (80^{th} percentile) exceeds the DGV based on the model water conditions;
- Dissolved iron at Burton Gorge (median and 80^{th} percentile);
- Nitrate at all three gauges (median and 80^{th} percentile values);
- Total suspended solids at all Burton Gorge and Goonyella (80th percentile values);
- Turbidity at Burton Gorge (median and 20^{th}/80^{th} percentile) and Goonyella/Deverill (median and 80^{th} percentile); and
- Dissolved zinc at Goonyella/Deverill (median and 20^{th}/80^{th} percentile).

Table 4.12 – Regional Isaac River water quality summary – DRDMW gauges

Parameter	Unit	Isaac River @ Burton Gorge				Isaac River @ Goonyella				Isaac River @ Deverill				Default Guideline Value (refer Table 3.1)
		No. of samples	20th %ile value	Median value	80th %ile value	No. of samples	20th %ile value	Median value	80th %ile value	No. of samples	20th %ile value	Median value	80th %ile value	
Aluminium (dissolved)	mg/L	-	-	-	-	13	0.004	0.050	0.056	14	0.03	0.05	0.15	< 0.055 (aquatic)
Boron (total)	mg/L	4	0.030	0.030	0.034	30	0.04	0.08	0.12	21	0.04	0.06	0.096	< 5 (stock)
Copper (dissolved)	mg/L	-	-	-	-	13	0.012	0.030	0.050	16	0.006	0.030	0.036	< 0.0014 (aquatic)
Electrical Conductivity	µS/cm	19	169	458	644	33	195	512	1,140	49	120	261	398	< 720 (baseflow) < 250 (high flow)
Fluoride (total)	mg/L	19	0.10	0.19	0.22	33	0.10	0.20	0.32	46	0.1	0.14	0.2	< 2 (irrigation)
Iron (dissolved)	mg/L	5	0.4	1.0	7.0	30	0.01	0.04	0.234	17	0.02	0.06	0.34	< 0.7 (aquatic)
Manganese (dissolved)	mg/L	-	-	-	-	13	0.012	0.030	0.050	16	0.006	0.030	0.036	< 1.9 (aquatic)
Nitrate (total)	mg/L	-	-	-	-	15	0.008	0.01	0.02	13	0.001	0.01	0.01	< 1.1 (aquatic)
pH	-	9	0.4	1.5	3.6	30	0.98	1.96	3.48	12	0.004	0.02	0.25	6.5-8.5 (aquatic)
Phosphorus (total)	mg/L	19	7.4	7.8	8.0	33	7.2	7.7	8.0	49	7.19	7.6	8	< 50 (aquatic)
Sodium (total)	mg/L	19	18	33	58	33	21	67	188	49	12	22	40	< 30 (drinking)
Sulphate (total)	mg/L	13	2.7	4.3	9.8	33	4.7	10.0	75.4	42	6.92	10	18.8	< 25 (aquatic)
Total Dissolved Solids	mg/L	19	122	255	353	33	114	280	622	47	81	155	224	< 2,000 (stock)
Total Suspended Solids	mg/L	15	10	230	2,002	33	14	74	2,752	41	10	135	1,340	< 55 (aquatic)
Turbidity	NTU	4	66	100	100	32	16	100	147	19	11	50	910	< 50 (aquatic)
Zinc (dissolved)	mg/L	-	-	-	-	12	0.01	0.015	0.02	14	0.01	0.01	0.06	< 0.008 (aquatic)

NOTE: values that were recorded as below the limit of reporting, have been assumed to be equal to the limit of reporting, for the purpose of this statistical analysis.

DRDMW has collected daily EC data at the Isaac River at the Deverill and Yatton gauges. The Deverill gauge is located near the downstream boundary of the Project and would be representative of water quality that drains past the site. The Yatton gauge is located downstream of the Connors River confluence but includes mining releases from all mines within the Isaac River catchment.

Figure 4.13 presents a time history of recorded instantaneous EC and stream flow for the Isaac River at Deverill gauging station. Figure 4.14 details the relationship between instantaneous flow and EC at the Isaac River at Deverill gauging station. The data collected by DoR at the Deverill gauging station spans the period from 2011 to 2022 and indicates:

- The EC for high flows greater than 200 m^3/s are generally below the high flow WQO EC of 250 µS/cm.
- The EC of instantaneous flows below 100 m^3/s varies significantly from 50 µS/cm to 1,870 µS/cm with many recorded values exceeding the low flow WQO EC of 720 µS/cm.
- The mean daily EC has exceeded the low flow WQO on a total of 23 days over this period and all of these days experienced some flow (not stagnant flow).
- The stream flows are highly ephemeral with baseflows ceasing within a few days or weeks of a runoff event, or at least flowing below the top of the sandy bed.

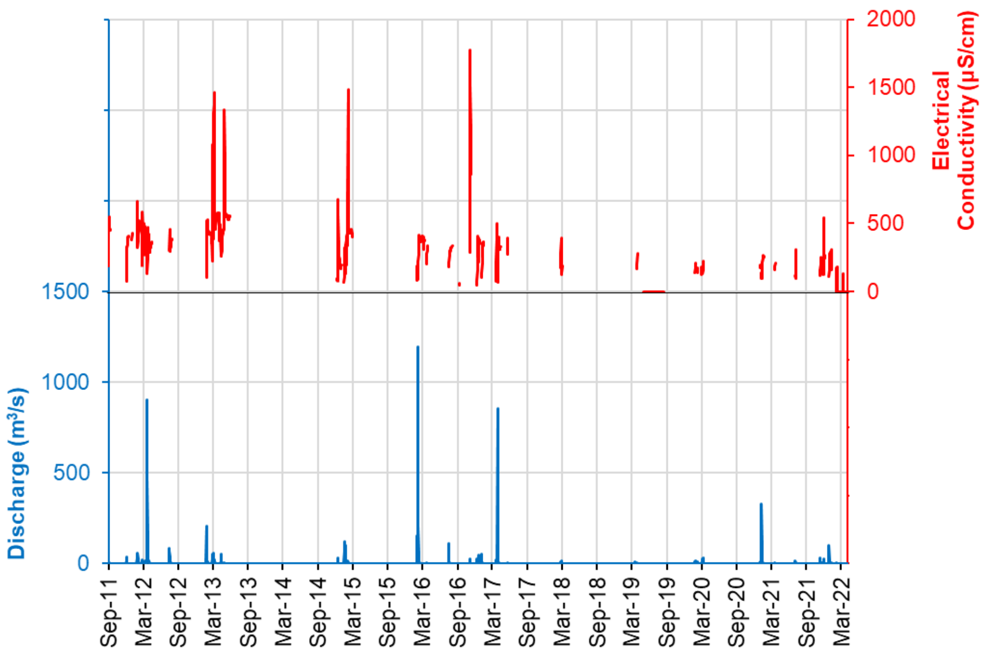


Figure 4.13 – Electrical Conductivity and flow (Isaac River at Deverill gauge)

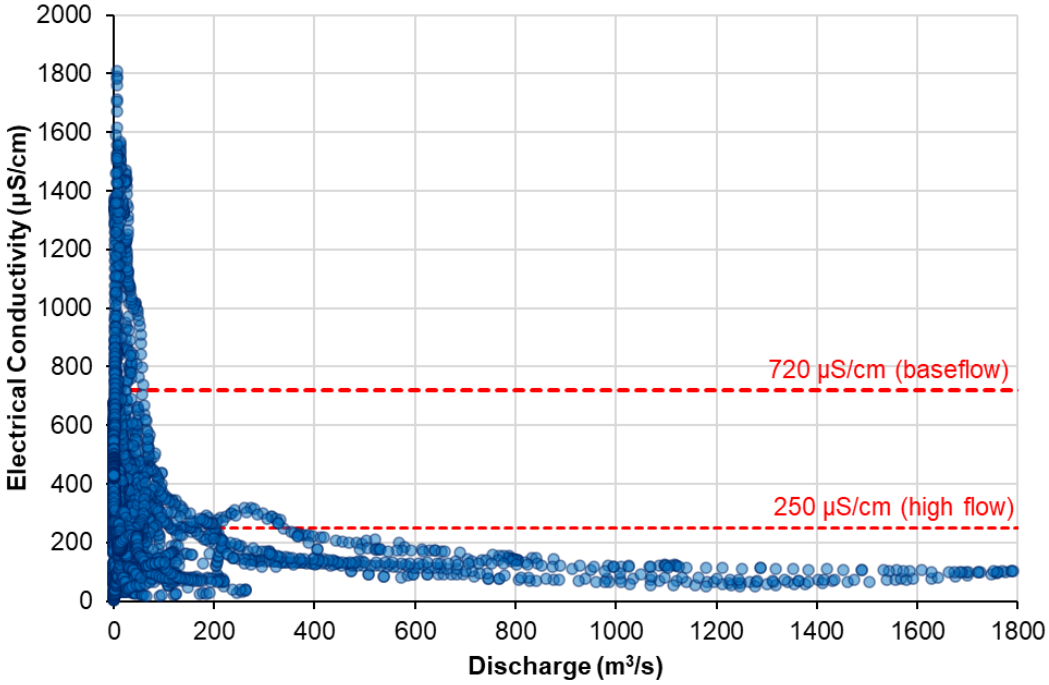


Figure 4.14 – Flow vs Electrical Conductivity (Isaac River at Deverill gauge)

4.7 FLOODING CHARACTERISTICS

4.7.1 Flood hydrology

The development, validation and calibration of the hydrological and hydraulic models are described in detail in the Lake Vermont Meadowbrook Project Flood Modelling Assessment report.

In summary, separate XP-RAFTS runoff-routing models of the Isaac River and local creek catchments were used to estimate the 50%, 10%, 2%, 1%, and 0.1% annual exceedance probability (AEP) peak design discharges as well as the probable maximum flood (PMF) for a range of durations up to 48 hours. Rainfall data (rainfall depths, areal reduction factors and temporal patterns) were applied in accordance with ensemble event procedures in Australian Rainfall & Runoff (AR&R) (Ball et al., 2019).

Design peak flows from the regional Isaac River model were reconciled against a flood frequency analysis (FFA) of the peak annual flow series at the Deverill gauge. The local flood model was calibrated to flows recorded at the Lake Vermont Mine Phillips Creek streamflow gauge, for the Cyclone Debbie flood event (March 2017). Design peak flows in Phillips Creek were reconciled against the flood frequency analysis of the peak annual flow series of historical flow data recorded at the Tayglen gauge. All local creek design flows were validated by comparing against the design discharges from the Regional Flood Frequency Estimation Model (RFFE). The adopted design flows to the outlet of each of the main waterways crossing the Project area shown in Table 4.13.

Table 4.13 - Design flow rates at outlets of main waterways in the vicinity of the Project area

Design event	Adopted peak flow rate (m^3/s)			
	Boomerang Creek	One Mile Creek	Ripstone Creek	Phillips Creek
50% AEP	108	32	67	104
10% AEP	469	152	305	469
2% AEP	892	296	587	900
1% AEP	1,097	370	734	1,130

4.7.2 Flood hydraulics

The TUFLOW hydrodynamic model (BMT, 2018) was used to simulate the flow behaviour (flood extents, depths and velocities) of the Isaac River, Ripstone Creek, Boomerang Creek, Hughes Creek, One Mile Creek and Phillips Creek in the vicinity of the Project.

TUFLOW represents hydraulic conditions on a fixed grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow (BMT, 2018). The TUFLOW model was run using the Heavily Parallelised Compute (HPC) GPU solver which uses adaptive time stepping. The grid size was varied throughout the model using a quadtree mesh. Complex areas within the Project area were modelled using a fine mesh, while floodplain areas of less importance to the impact assessment were modelled using a coarse mesh. Sub-grid sampling (SGS) was enabled so that each 2d cell face was represented by multiple elevation values. The number and spacing of SGS sampling points varies with cell size.

The hydrological model outputs were used as inputs to the hydraulic model to derive flood depths, extents and velocities for the 50%, 10%, 2%, 1%, 0.1% AEP and PMF design flood events.

For this investigation, all flood modelling focussed on storm event durations causing the largest flood peaks in the waterways crossing the Project area. While Isaac River flooding can have a minor impact on flood levels in the eastern part of the Project area, the Isaac River does not impact on the mine subsidence areas impacted by the Project. Therefore, the local catchment flooding is of most importance when considering the geomorphic response of these waterways.

The existing conditions modelling assumed that the Phillips Creek diversion has been constructed in accordance with the approved functional design (WRM, 2022a) but no infrastructure is located across the Boomerang Creek or One Mile catchments.

4.7.3 Flood extent, depths and velocities

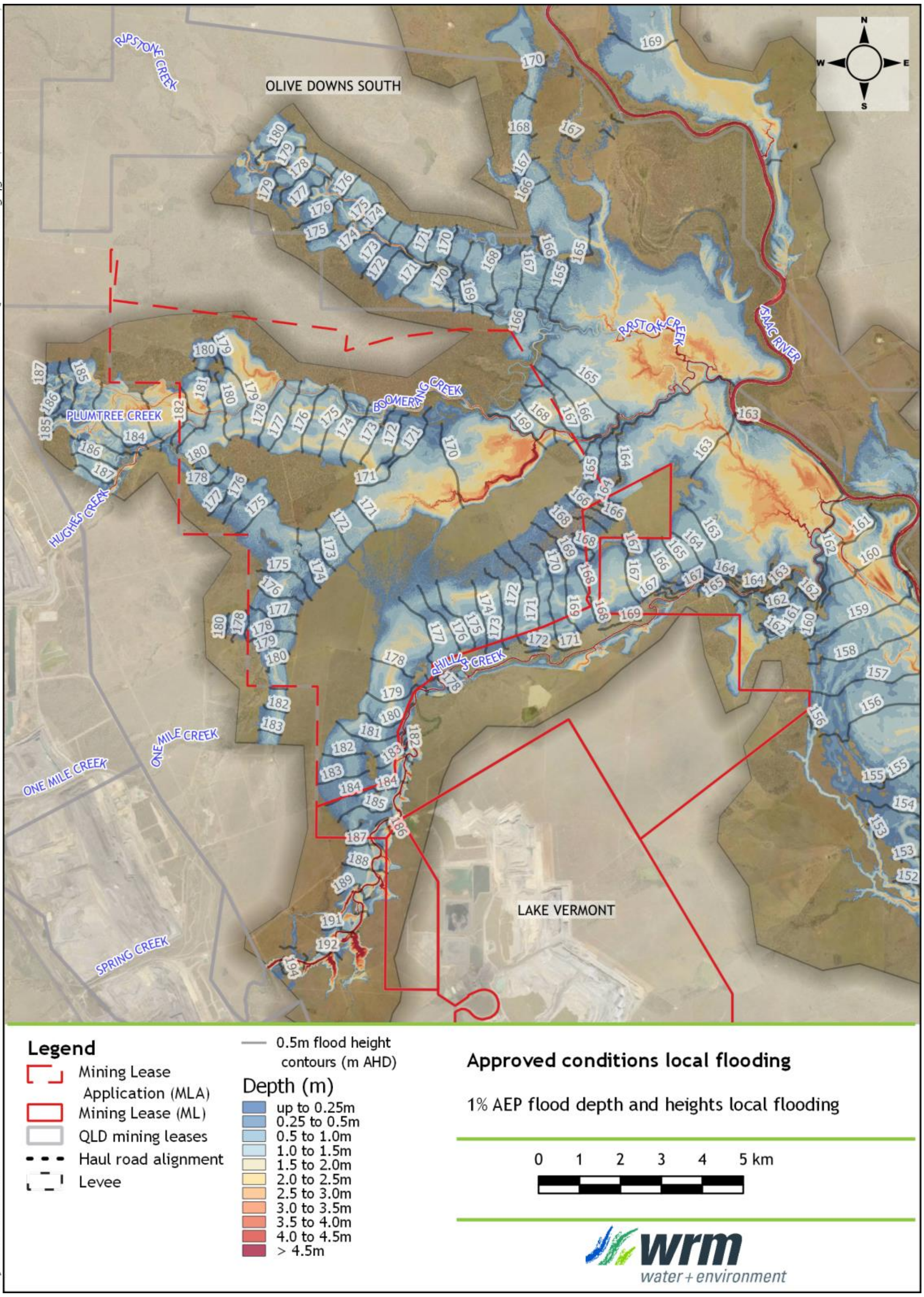
Figure 4.15 and Figure 4.16 shows the extent, depth and velocity of flood flows across the project area. Modelling of smaller flood events was also used to understand flood behaviour over a range of conditions. Modelling of the 50% AEP flood depths and flood velocities across the Project area showed that:

- The upper reach of Boomerang Creek has a low channel capacity. Floodwater from this frequent event would flow over the southern bank of Boomerang Creek (and Hughes Creek) at several locations near the western lease boundary and flow in a southeasterly direction via two main shallow floodplain flow paths to One Mile Creek.
- Boomerang Creek downstream of the overflow path to the One Mile Creek confluence drains independently of the floodplain flows with the remaining 50% AEP flows contained in bank.
- One Mile Creek also has low channel capacity with the 50% AEP flows draining along several channels and as shallow overbank flows.
- One Mile Creek receives Hughes Creek overflows and then Boomerang Creek overflows to effectively become the primary flow path during flood flows.
- Boomerang Creek downstream of the One Mile Creek confluence is also perched with a significant proportion of the One Mile Creek flood flows bypassing the main channel and flowing independently along the southern floodplain eventually draining to Phillips Creek.
- Flows would be contained in-bank in Phillips Creek, with local catchment runoff contributing all flow in its northern floodplain.
- Flows are confined within Ripstone Creek upstream of the Project but then lose definition with a low carrying capacity downstream of the Project area.
- Apart from some localised areas where overbank flows are concentrated, floodplain flow velocities are relatively low (less than 0.5 m/s).

Modelling of the 2% AEP flood depths and flood velocities across the Project area showed that:

- With the exception specific locations along remnant channels, floodplain flow velocities are relatively low (less than 1.0 m/s).
- The southeast-flowing overflow paths from Boomerang Creek to One Mile Creek are significantly wider and deeper, but the perched Boomerang Creek channel downstream of the overflow paths continues to drain independently of the floodplain.
- Along the southern margin of the larger eastern flood overflow path, depths exceed 2 m and velocities exceed 2 m/s.
- Flooding along One Mile Creek becomes wider. Downstream of the flow path from Boomerang Creek, flow depths increase beyond 4 m, but with the exception of relatively short sections of the main channel, velocities are less than 1 m/s.
- Flows escape the channel of Phillips Creek just upstream of the Project area, and flow north along a drainage path on the left Phillips Creek floodplain before turning east. The Phillips Creek channel is perched, with a wide levee of naturally deposited material separating the independently flowing channel from its floodplain.

- Very shallow minor overflow paths begin to establish in parts of the Project between Phillips Creek and One Mile Creek in this event.
- In their lower reaches, the Ripstone Creek, Boomerang Creek, One Mile Creek and Phillips Creek floodplains combine and merge with the Isaac River floodplain.



J:\0622-27 Meadowbrook EIS\WI\QGIS\TUFLOW config.qgz (Issued: 24 November 2022)

Projection: EPSG:20355

Figure 4.15 – Flood depth and height – 1% AEP design flood - existing (approved) conditions

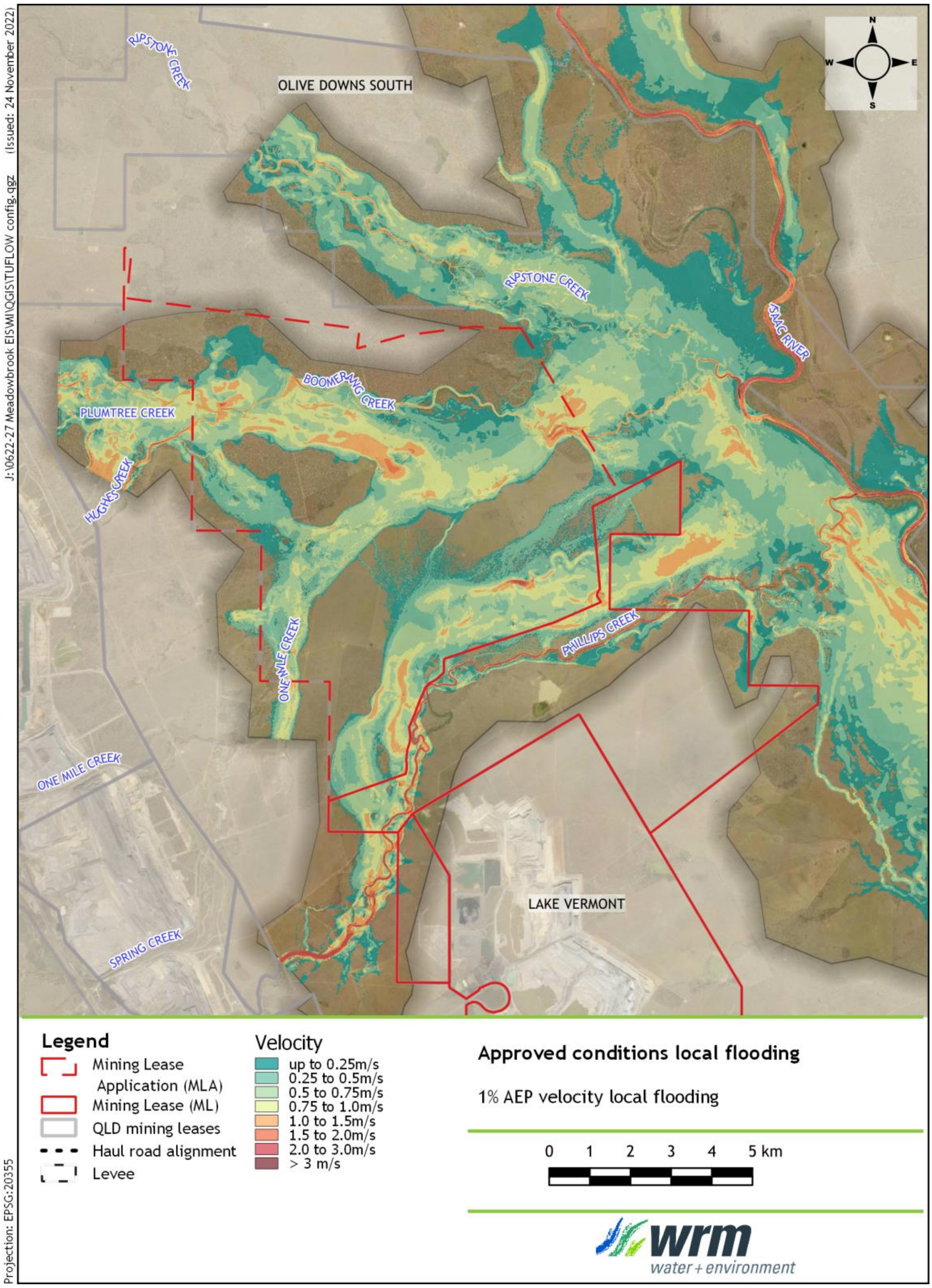


Figure 4.16 – Flood velocity – 1% AEP design flood - existing (approved) conditions

4.8 GEOMORPHOLOGY

The proposed longwall panels underly and will cause subsidence in Boomerang Creek, One Mile Creek and their floodplains, was well as part of the Phillips Creek floodplain to the south. Queensland Government mapping has defined Boomerang Creek and One Mile Creek as a watercourse under the Water Act 2000.

In the proposed subsidence area, Boomerang Creek meanders across a broad floodplain. The channel is typically 1.5 m to 2.5 m deep with a sandy bed.

The channel capacity is relatively low, with floodwater flowing over the southern bank at several locations for the 50% AEP flood via two shallow southeasterly flow paths to One Mile Creek. Floodwater ponds in existing gilgai, meander cutoffs and remnant channels in the very flat floodplain between the two waterways.

One Mile Creek is a Boomerang Creek tributary. In the downstream parts of the proposed subsidence area, One Mile Creek and Boomerang Creek share the same floodplain. However, their geomorphic characteristics are quite different, with the bed material of One Mile Creek being significantly finer, and its channel being smaller and narrower.

Parts of the One Mile Creek channel appear to be sediment-limited – with the roots of much of the riparian vegetation being exposed following recent flow events (refer Figure 4.17). One Mile Creek is typically 0.75 m to 1.5 m deep, with a top width of approximately 15 m.

The One Mile Creek bank vegetation comprised mostly small trees and shrubs, whereas Boomerang Creek is lined with large paperbacks and casuarina, and lomandra and other grasses on the banks (refer Figure 4.18). The northern Phillips Creek floodplain and much of the One Mile Creek floodplain has been extensively cleared for grazing, with large areas of pasture and low shrubby regrowth (refer Figure 4.19).

While localised thick deposits of sand were encountered at various locations, compared to the deep uniform drape of sand in the channel of Boomerang Creek, the bed material of One Mile Creek is comparatively fine, comprising fine sands, silts and clay (consistent with particle size distributions of the bed sediment samples). Along much of One Mile Creek, the roots of the woody bank vegetation were exposed, and the channel was devoid of in-channel vegetation. Farm dams constructed on the channel of One Mile Creek upstream of the Project area were full and were likely impacting the movement of water and sediment through the Project area.

Figure 4.17 – Photograph of One Mile Creek channel

Figure 4.18 – Photograph of Boomerang Creek channel

Figure 4.19 – Photograph of Phillips Creek northern floodplain channel

The hydraulic models were also used to define the hydraulic characteristics of relevance to the floodplain morphology:

- Stream velocity has been used as an indicator of stream impacts, where increases in velocities would suggest some change in the stream characteristics may occur. Note there is not a direct relationship between velocity and the force exerted on soil particles at the boundary and thus stream power and shear stress are used as more reliable indicators of erosion potential.
- Shear stress provides a measure of the tractive force acting on sediment particles at the boundary of the stream and is used to determine the threshold of motion for bed material. It provides an indication of the potential for erosion of cohesive sediments or movement of non-cohesive sediments at the channel boundary.
- Stream power is a function of discharge, hydraulic gradient and flow width. It represents the energy that is available to do work in and on the channel. High stream powers are indicative of elevated erosion potential.

The modelling included:

- An assessment of the 50% AEP design flood to represent the behaviour of the creek channels at bank full flow conditions. The bank full flow is the maximum flow that the channel can carry before it overflows onto the adjacent floodplain. In geomorphologic studies, the bank full flow is often considered to be the stream forming flow, because it often exerts the greatest influence on channel geometry.
- An assessment of the 2% AEP design flood to represent the behaviour of the creeks and associated floodplains during large floods. It can be used to identify whether the changed out of bank flood behaviour could inadvertently cause an avulsion of the channel.

5 Site water management system

5.1 OVERVIEW

The water management system for the proposed operations is described in detail the Site Water Balance and Water Management System Report (WRM, 2022c). The system will centre on the Project MIA, which is proposed to be located to the southwest of the underground operations.

The MIA will include mine administration and operations buildings, bathhouse facilities, a warehouse, equipment hardstand and laydown area, maintenance workshops and service bays, diesel storage and refuelling facilities, access to the portals to underground drifts, mustering areas, a water treatment plant, a sewage treatment plant and associated water management infrastructure. The infrastructure corridor linking the new MIA to the existing operation will include sealed access and coal haulage roads, electricity transmission lines and water pipelines. The proposed MIA layout is shown in Figure 5.1.

The underground operations are planned to operate for 23 years (from Year 1 to Year 23). Open cut mining would take place in the 11 years from Project Year 20 to Project Year 30.

A site water balance model was developed to assess the performance of the proposed system under historical climate conditions. The model dynamically simulates the operation of the water management system on a daily time step, using the GoldSim software to keep account of water volumes and representative water quality.

The water balance model represents the key hydrological inputs including groundwater inflows, rainfall, evaporation, pump transfers and overflows. Runoff was simulated on a daily timestep using the Australian Water Balance Model (AWBM), and a simple conservative solute balance was configured to use total dissolved salts (TDS) as an indicator of water quality. Each runoff type or water source was assigned a representative TDS concentration based on observations of changes in stored water quality following inflows to the water storages at the existing Lake Vermont operations. The site water types and management system are described in the following sections. Further details of the water and salt balance are provided in the Site Water Balance and Water Management System report (WRM, 2022c).

5.2 SITE WATER TYPES

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. In addition, runoff from active mining areas (including coal stockpiles, etc.) may have increased concentrations of salts and other pollutants when compared to natural runoff.

The site water management system separates water into segregated management systems:

- Mine affected water system - which will manage runoff and groundwater inflows from the underground, open cut pit, ROM stockpile and MIA. This closed system is designed to prevent releases of mine affected water to the environment.

  The principal component of inflows to the mine affected water system would be groundwater seepage to the underground and open cut pit. The groundwater assessment states the median electrical conductivity (EC) of groundwater samples taken from the Rewan Group sediments was 26,290 μS/cm, whereas the median EC of samples from the tertiary sediments was 20,716 μS/cm. For the surface water model, groundwater inflows were assigned an approximately equivalent representative total dissolved salts (TDS) concentration of 17,000 mg/L (based on a conversion factor from EC to TDS of 0.65).

- Sediment water system - the open cut mining activities would see overburden material placed in out-of-pit and in-pit waste rock dumps adjacent to the proposed open cut pit.

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

Previous waste characterisation assessments (AARC, 2013 and AARC, 2014, RGS 2021) described the Lake Vermont overburden as being typical of that overlying the Rangal coal measures. The waste rock predominantly comprises weathered and unweathered Permo-Triassic sediments, containing approximately equal proportions of greyish-green sandstones, siltstones and mudstones. The Rewan Formation was deposited in an upper fluvial environment, with no marine influence. Sulphide is rarely detected, and while the coal seams do contain minor pyrite nodules, this material is not associated with the mine waste, so the risk of acid forming has been assessed as low, with no acid rock drainage issues having been reported during the ~13 years of Lake Vermont Mine operations so far.

The Geochemical Assessment of Mining Waste Materials Project (RGS, 2021) indicates waste rock at the Meadowbrook Project would have similar characteristics to the existing operation, with:

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

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

Runoff from the open cut waste rock dumps will be managed under an erosion and sediment control plan which is to be implemented throughout the Project, such that sediment generated and transported by runoff will be settled in a sediment dam.

As overburden runoff quality is expected to be relatively benign, sediment dams could potentially discharge directly into the environment (after the settlement of suspended sediment) with minimal impact to downstream water quality. However, sediment dams have been sized to achieve a relatively high level of containment, and stored water will be returned to the MIA dam for blending with mine affected water before reuse.

- Clean water - from undisturbed areas is generally diverted around the areas of disturbance by levees and drainage systems, including at the proposed MIA and open cut pit.
- Raw water – a pipeline will be constructed within the infrastructure corridor to extend the existing raw water supply pipeline at the Lake Vermont Mine that sources water from the Eungella Water Pipeline Southern Extension. Raw water would be delivered to a dedicated raw water dam at the Meadowbrook MIA for supply to the underground operations and potable water treatment plant.

Bowen Basin Coal holds a water supply agreement with Sunwater's Eungella Water Pipeline Pty Ltd for the supply of up to 1,500 ML of water per annum to the Lake Vermont Mine and an on-supply contract with Peabody to transfer Peabody's 1,000 ML per year water allocation to the Lake Vermont Mine.

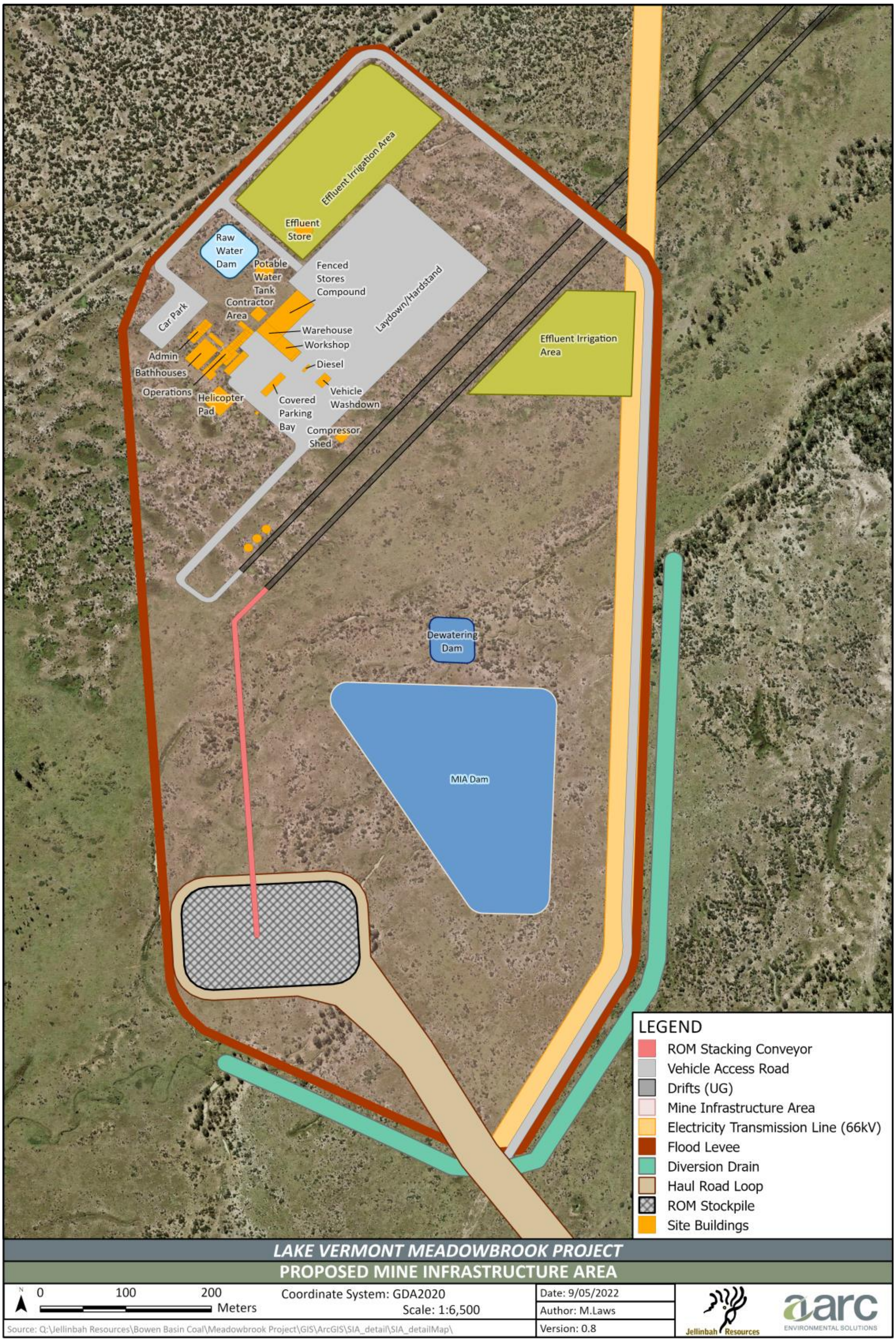


Figure 5.1 – MIA Layout

5.3 WATER MANAGEMENT SYSTEM COMPONENTS

The major components of the proposed Lake Vermont Meadowbrook water management system are described in the following sections. The locations of the main components within the MIA are shown in Figure 5.1.

5.3.1 MIA and open cut pit levees

The MIA and open cut pit would be protected by levees and associated minor drainage systems to exclude clean water runoff from Phillips Creek and One Mile Creek and their minor tributaries in the 0.1% AEP design flood. The levees would be 'regulated structures' and would be designed, constructed, operated and decommissioned in accordance with the '*Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)*' and '*Structures which are dams or levees constructed as part of environmentally relevant activities (ESR/2016/1934)*'.

The MIA levee structures would be developed during the initial Project construction phase, remaining in place until mine closure, at which point they would be removed and the areas rehabilitated. The open cut pit levee structures would also be temporary, required only once open cut mining commences in Project Year 20 until the final overburden profile is achieved and the associated permanent landform established.

5.3.2 Raw water supply pipeline

A raw water supply pipeline will be constructed within the infrastructure corridor to connect to the existing raw water supply pipeline at the Lake Vermont Mine that sources water from the Eungella Water Pipeline Southern Extension. The proposed 12 km raw water supply pipeline will transfer raw water to a Raw Water Dam at the MIA.

5.3.3 Underground mine dewatering system

Water accumulating within the underground workings (groundwater inflows, excess dust suppression and washdown water) would be pumped to the surface to a turkey's nest dam (the Dewatering Dam) located within the MIA. Underground dewatering is anticipated to cease in Project Year 23 at the completion of underground operations.

5.3.4 Open cut mining dewatering

Local runoff and groundwater seepage accumulating within in-pit sumps in the open cut mining pit will be pumped to the Dewatering Dam.

5.3.5 Return water pipeline

Inflows to the underground operations and associated water management system are expected to exceed demands for mine water within the Meadowbrook operation. The return water pipeline will be used to transfer excess mine affected water via the infrastructure corridor to environmental dams at the existing Lake Vermont Mine. The return water pipeline will be located within the proposed infrastructure corridor for the Project.

5.3.6 Potable water supply

The water treatment plant will be located within the MIA and have the capacity to treat raw water from the Raw Water Dam and pipeline at a rate of up to approximately 10 ML/year. Treated water will be stored in 180 kL capacity potable water tanks adjacent to the plant.

Effluent from the water treatment plant will be captured and stored within the mine affected water system and used for dust suppression.

5.3.7 Sewage treatment

Sewage generated at the MIA will be pumped to a package STP. The STP will have secondary treatment capability and the ability to produce Class C effluent for irrigation as defined in the

Queensland Public Health Regulation 2018. It is conservatively estimated that effluent will be produced at a rate of approximately 40 kL/day (based on 200 workers each generating 200 L/day of effluent on site each day). Wet weather storage will be located adjacent to the plant. Irrigation of treated effluent is proposed to occur with the MIA. Details of the proposed effluent treatment and disposal system are provided in the Land-Based Effluent Disposal Assessment Report (Cardno, 2022).

5.3.8 Raw water dam

The Raw Water Dam is located within the MIA and would temporarily store raw water for use where relatively high quality water is required – for example within the underground operations, in equipment requiring clean water for cooling, and feed water for the potable water treatment plant. The Raw Water Dam would be sized to provide continuation of supply in the event of reasonably foreseeable equipment failure (e.g. pump or pipeline failure).

5.3.9 Mine infrastructure area dam

Runoff from disturbed areas within the MIA would be contained within the levee system and directed via a series of drains to the Mine Infrastructure Area Dam (MIA Dam) which is proposed for the low area to the east of the ROM stockpile. Runoff captured in the MIA Dam could include runoff from the ROM stockpile, laydown areas, workshop areas. For this assessment, it has been conservatively assumed that the MIA Dam would capture runoff from the entire area within the MIA levee. In detailed design, the site drainage system may be configured to minimise the area captured and to direct clean runoff from undisturbed parts of the MIA away from the dam.

The MIA Dam will be sized and operated to contain runoff under all historical events - with a maximum operating level chosen such that pumped inflows would cease when the remaining capacity is equivalent to the 1 in 10 AEP 24 hour rainfall volume.

5.3.10 Dewatering dam

The Dewatering Dam would be located within the MIA and store water transferred from the underground and open cut mining operations. Water stored in the Dewatering Dam would be reused for dust suppression in the surface and underground operations.

Excess water would be transferred via the return water pipeline to the existing Lake Vermont Mine, for reuse within the site water management system – and to offset water otherwise imported via the raw water pipeline.

The Dewatering Dam would be operated to avoid any overflows, however, emergency overflows via the spillway would be captured within the MIA Dam.

5.3.11 Sediment dams

During open cut mining operations, catchment runoff from overburden dumps will be captured in three sediment dams (referred to as Southern Sediment Dam, Northern Sediment Dam 1 and Northern Sediment Dam 2 as shown in Figure 5.2). Sediment dams will be designed and operated in accordance with the Department of Environment and Heritage Protection Guideline - Stormwater and environmentally relevant activities (DEHP, 2017). This guideline states that:

"For events up to and including a 24 hour storm event with an ARI of 1 in 10 years, the following must be achieved:

1. *a sediment basin must be designed, constructed and operated to retain the runoff at the site(s) approved as part of the ERA application;*
2. *the release stormwater from these sediment basins must achieve a total suspended solids (TSS) concentration of no more than 50mg/L for events up to and including those mentioned above. For events larger than those stated above, all reasonable and practical measures must be taken to minimise the release of prescribed contaminants."*

The Northern Sediment Dam 1 would be initially constructed by pre-excavating overburden material near the northern corner of the open cut pit levee. Once the existing ground surface is mined out, sediment dams would be formed into localised depressions north and south of the open cut pit.

The capacities of the proposed water storage dams and their associated maximum catchment areas are summarised in Table 5.1.

Sediment dams were sized to capture runoff from the 1 in 10 AEP 24 hour design rainfall event. The MIA dam was sized through trial and error to that there would be no modelled discharges under historical climate conditions.

Water captured in the sediment dams would be regularly monitored as described in section 6 to confirm the water quality is consistent with the design assumptions.

Table 5.1 - Proposed Lake Vermont Meadowbrook storage details

Storage name	Storage type	Maximum catchment area (ha)	Water Storage capacity (ML)	Overflows to
Raw Water Dam	Raw water	0.4	20	One Mile Creek
Dewatering dam	Mine affected water	0.4	20	One Mile Creek
MIA Dam	Mine affected water	73	440	One Mile Creek
North Sed Dam 1	Sediment dam	327	240	One Mile Creek
North Sed Dam 2	Sediment dam	223	155	One Mile Creek
South Sed Dam	Sediment dam	256	180	Phillips Creek Northern floodplain tributary

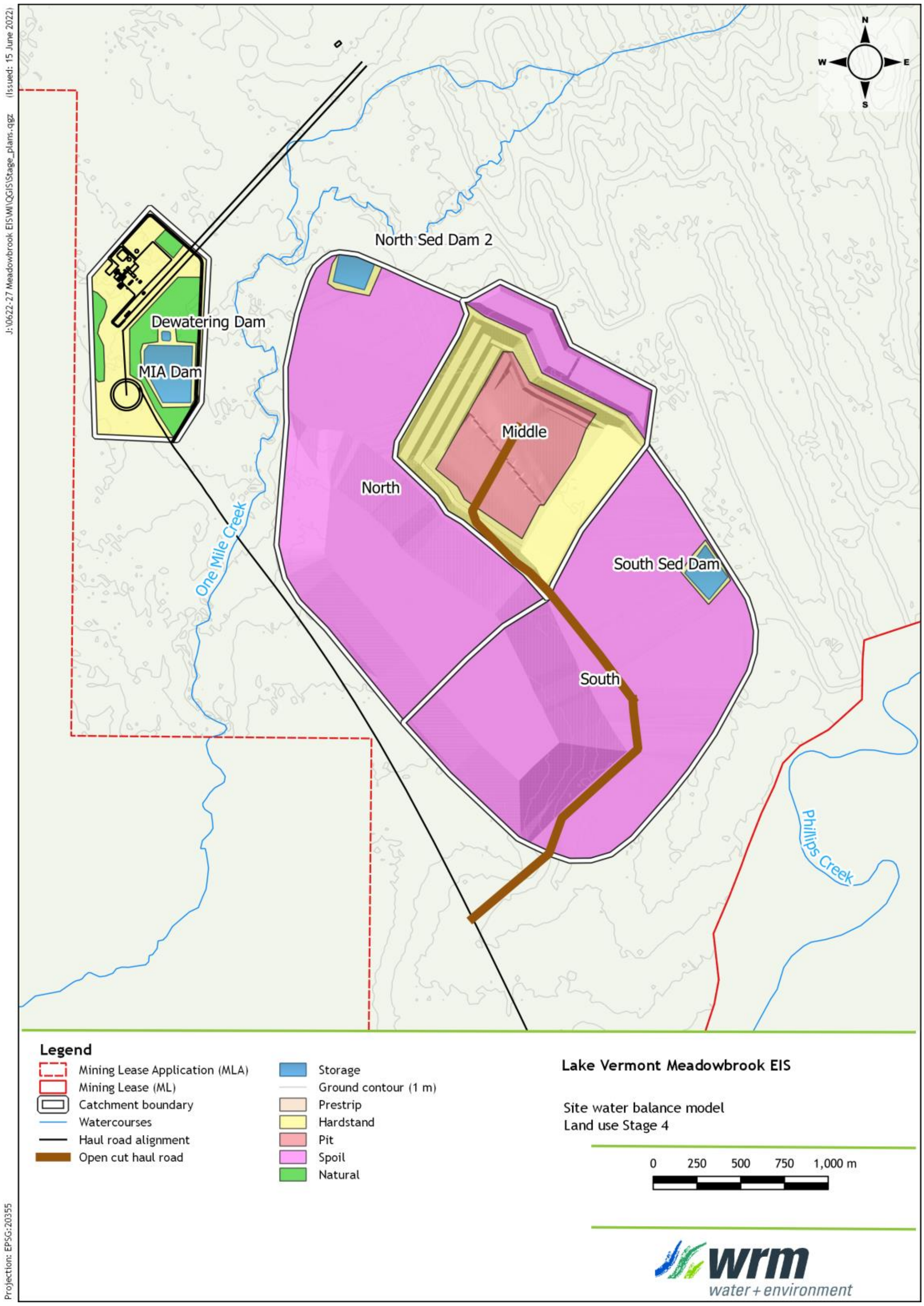


Figure 5.2 – Proposed catchment and land use boundaries Year 29-30

5.4 CONSEQUENCE ASSESSMENT

A consequence assessment has been completed for the dams making up the proposed water management system, in accordance with the Manual for assessing consequence categories and hydraulic performance of structures (DES, 2016) (the Manual).

The Manual sets out the requirements of the administering authority, for consequence category assessment and certification of the design of 'regulated structures', constructed as part of environmentally relevant activities (ERAs) under the Environmental Protection Act 1994 (EP Act).

Each dam is assigned a Consequence Category of High, Significant or Low depending on its potential to cause harm. A structure categorised as a Significant or High consequence, is referred to as a regulated structure. Such structures must comply with hydraulic performance objectives set out in the Manual.

5.4.1 Assessment protocols

The manual requires an assessment of the potential for harm under the following failure event scenarios:

(a) **'Failure to contain - seepage'** - spills or releases to ground and/or groundwater via seepage from the floor and/or sides of the structure;

(b) **'Failure to contain - overtopping'** - spills or releases from the structure that result from loss of containment due to overtopping of the structure; and

(c) **'Dam break'** - collapse of the structure due to any possible cause.

5.4.2 Assessment criteria

For each failure event scenario, a consequence category is assigned depending on the potential to cause:

- Harm to Humans;
- General Economic Loss; or
- General Environmental Harm.

The potential for harm at the Meadowbrook Project is described in general terms in the following section, and the adopted Consequence Categories are summarised in Table 5.2.

5.4.2.1 Harm to humans

Consumption of contaminated water

The nearest known surface town water supply systems are on the Fitzroy River and would not be materially affected by discharge of the contents of any of the dams at the Project (due to the total stored volume being less than 500 ML, and the very large dilution potential during wet season flows).

Due to the ephemeral nature of the nearby streams, surface water is generally not used as a source of potable water in the region. All dams at the Project are located such that human consumption of any contaminated waters is very unlikely and would not meet the 'Significant' threshold of potentially affecting the health of 10 or more people. ***Consequence Category: Low***

Dam Break

For the purposes of the Manual, the assessment excludes site personnel engaged by the resource operation and located on the tenements. Due to the sparse population in the region, there are no workplaces or dwellings in the potential failure impact zone of the site water dams. All dams are located such that people are not routinely present in the potential failure path if an embankment was to fail. ***Consequence Category: Low***

5.4.2.2 General Economic Loss

There are no significant commercial operations in the immediate downstream reaches of Isaac River or its tributaries likely to be affected by contamination under any of the potential failure impact scenarios.

The potential damage caused by dam-break of the MIA Dam embankment is likely limited due to its limited height (planned to be less than 5 m) and storage capacity. ***Consequence Category: Low***

5.4.2.3 Environmental Harm

Stored water quality in the Dewatering Dam, and MIA Dam, are likely to be similar to mine water dams at other Central Queensland mine sites, with elevated salinity, and pH, and some dissolved metals. As there are no High Ecological Value (HEV) Zones identified in the downstream receiving environment, there is limited potential to cause harm to Significant Environmental Values. ***Consequence Category: Low***

5.4.3 Failure to contain - seepage

Localised impacts of seepage to the ecology of the on-site reaches of One Mile Creek and its tributaries is possible, but any significant impact would be limited in extent. The MIA Dam and Dewatering Dam have therefore been assigned a Low Consequence Category; however, a detailed groundwater assessment should be carried out to further inform the detailed design of seepage management measures or reclassification of structures if appropriate. ***Consequence Category: Low (to be confirmed through seepage assessment)***

5.4.3.1 Failure to Contain - Dam Break and Overtopping

The manual states that a dam is to have a Significant Consequence Category if it meets the following criteria:

> *Location such that contaminants may be released so that adverse effects …would be likely to be caused to Significant Values – and 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*

Given the relatively small volume and concentrations of contaminants, it is unlikely that remedial measures would meet these criteria. Therefore, a Significant Consequence Category is not justified for the Environmental Harm trigger for the MIA dam. Given the very small catchment of the Dewatering Dam, a Significant Consequence Category is not justified for this dam. ***Consequence Category: Low***

Table 5.2 - Summary of consequence assessment - dams

Failure to contain - seepage	Dewatering Dam	MIA Dam	Raw Water Dam	Sediment Dams
Harm to humans	L	L	L	L
General environmental harm	L	L	L	L
General economic loss/damages	L	L	L	L
Failure to contain - overtopping				
Harm to humans	L	L	L	L
General environmental harm	L	L	L	L
General economic loss/damages	L	L	L	L
Dam break				
Harm to humans	L	L	L	L
General environmental harm	L	L	L	L
General economic loss/damages	L	L	L	L
OVERALL CCA RATING	L	L	L	L
Requires DSA/MRL	N	N	N	N
Requires engineered spillway	Y	Y	Y	Y
Requires lining (unless detailed groundwater investigation indicates risks are low)	Y	Y	N	N

L = Low consequence

S = Significant consequence

6 Surface water monitoring

6.1 OVERVIEW

Monitoring of surface water quality both within and external to the Project would form a key component of the surface water management system. Monitoring of upstream, on-site and downstream water quality would assist in demonstrating that the site water management system is effective in meeting its objective of minimal impact on receiving water quality and would allow for early detection of any impacts and appropriate corrective action.

The surface water monitoring protocols would:

- ensure compliance with the EA for the Project;
- provide valuable information on the performance of the water management system; and
- facilitate adaptive management of water resources on-site.

6.2 WATER QUALITY MONITORING LOCATIONS

Bowen Basin Coal has previously monitored a number of surface water locations (as detailed in Section 4.6). The Surface Water Monitoring Program would include the continued monitoring of these sites to monitor surface water flows and quality upstream and downstream of the Project.

The water quality monitoring program would also include monitoring of all dams at least quarterly.

Surface runoff and seepage from waste rock emplacements, including any rehabilitated areas during operations, would be monitored for 'standard' water quality parameters including, but not limited to pH, EC, major anions (sulfate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), TDS, TSS, turbidity and a broad suite of soluble metals/metalloids.

The sediment dam monitoring would be used to validate the anticipated quality of water runoff reporting to sediment dams. Initially, the sediment dam monitoring would occur on a regular (e.g. monthly) basis to demonstrate the water quality of stored waters is consistent with the relevant operating parameters. Bowen Basin Coal would also undertake event-based sampling of the relevant sediment dam as soon as practicable after a sediment dam overflow.

If water quality sampling of sediment dam water shows contaminant concentrations materially higher than those predicted by the geochemical characterisation study, the sizing and operation of the dams would be reviewed to ensure on-site containment.

7 Summary of impacts

7.1 OVERVIEW

Coal reserves in the underground mining area will be mined over approximately 23 years. The primary underground target seam is the Vermont Lower Seam, which extends across the whole underground mining footprint. The overlying Leichardt Lower Seam, which is a secondary underground target seam is only present across the northern half of the underground footprint.

The provisional mine schedule and sequence is based on maintaining a total Lake Vermont Mine Complex product coal output of approximately 9 Mtpa. The timing may however vary to consider factors such as localised geological features, market conditions or mining economics.

Underground mining will commence in the Vermont Lower Seam in Project Year 1 (indicatively 2026). Approximately 22 months of initial in-seam development with continuous miners is planned before the longwall commences operation. It is planned to extract the southern longwall panels in the Vermont Lower seam first, progressing from west to east. Upon completing extraction of the southern Vermont Lower seam panels, the longwall will commence mining the northern Leichardt Lower seam panels. Once the northern Leichardt Lower seam panels have been extracted, mining will commence in the Vermont Lower Seam. Coal reserves in the open cut pit will be mined for approximately 11 years starting in Project Year 20 (indicatively 2045).

Longwall mining typically results in subsidence which leads to progressive development of shallow, trough-like depressions on the surface above each extracted longwall panel. These trough-like depressions have gentle grades and develop relative to the natural surface.

The depressions on the surface develop as the roof strata above the coal seam progressively collapse to fill the void created by the extraction of coal in the area behind the longwall. As the roof collapses into the mined area (referred to as the 'goaf'), the fracturing and settlement of rocks progresses upwards through the overlying strata and results in sagging and bending of the near surface layers.

The predicted depth and extent of mine induced subsidence was estimated by Gordon Geotechniques (GG, 2022) and is shown in Figure 7.1. The maximum depth of predicted subsidence varies with location around the proposed operation, depending on whether two seams are being mined in an area. The map in Figure 3.1 shows:

- The channel of Phillips Creek would not be directly affected by subsidence. Maximum subsidence depths on Phillips Creek northern floodplain would be up to 2.5 m to 3.0 m.
- Maximum subsidence depths on the One Mile Creek channel and southern floodplain would be up to 2.5 m to 3.0 m.
- Maximum subsidence depths in the floodplain between One Mile Creek and Boomerang would be over 4.5 m in localised areas.
- The channel and floodplain of Boomerang Creek would see maximum subsidence depths of up to 4.0 m.

Subsidence would occur gradually over time, as the longwall progresses. The total surface area predicted to be affected by subsidence within the Project area is approximately 2,195 ha. The post-mining surface topography was developed by subtracting subsidence contour profiles for the Project from the base topographic surface. Changes to the local topography induced by subsidence are illustrated in the ground elevation contour map in Figure 7.2.

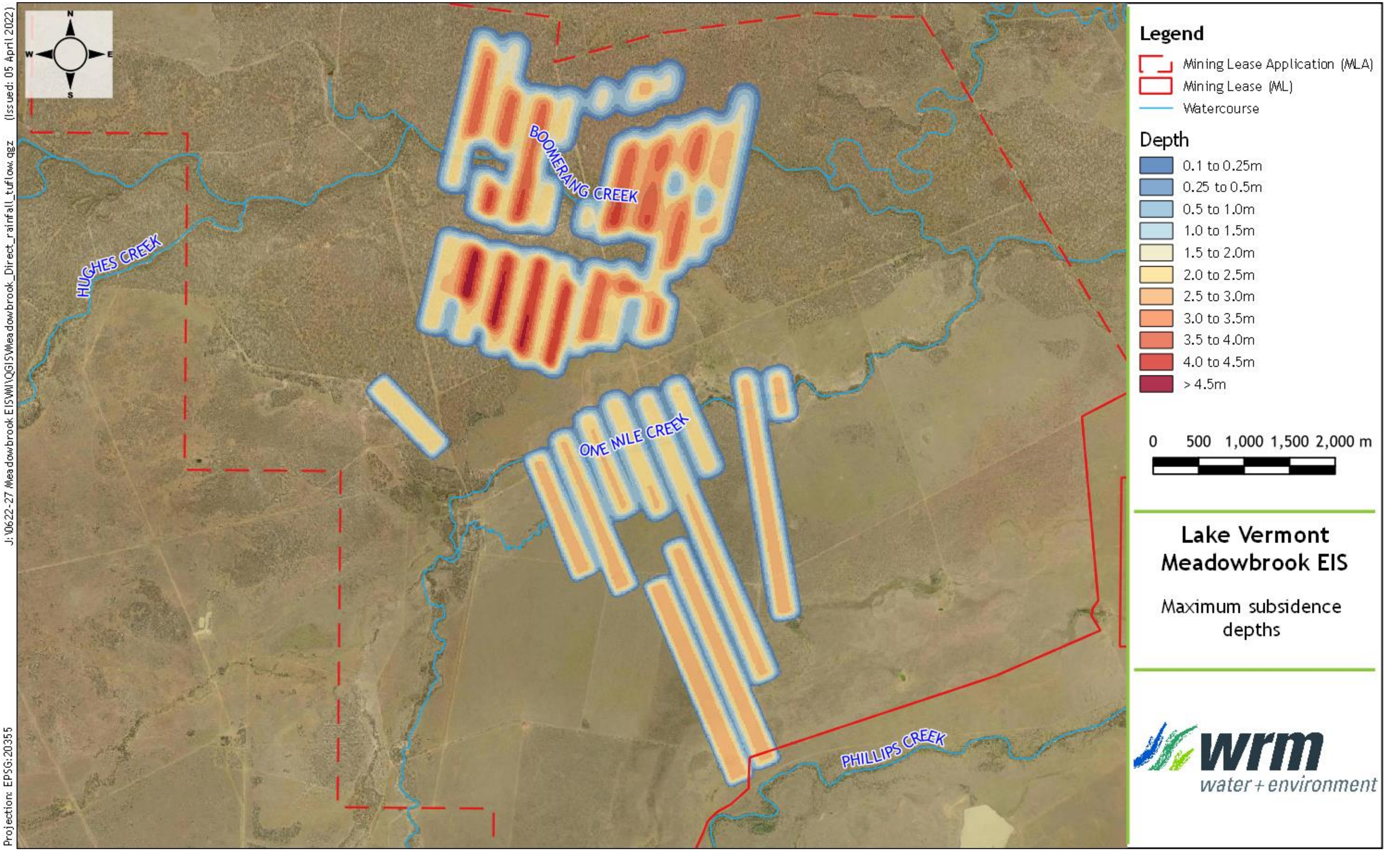


Figure 7.1 – Maximum depth and extent of predicted mining-induced subsidence

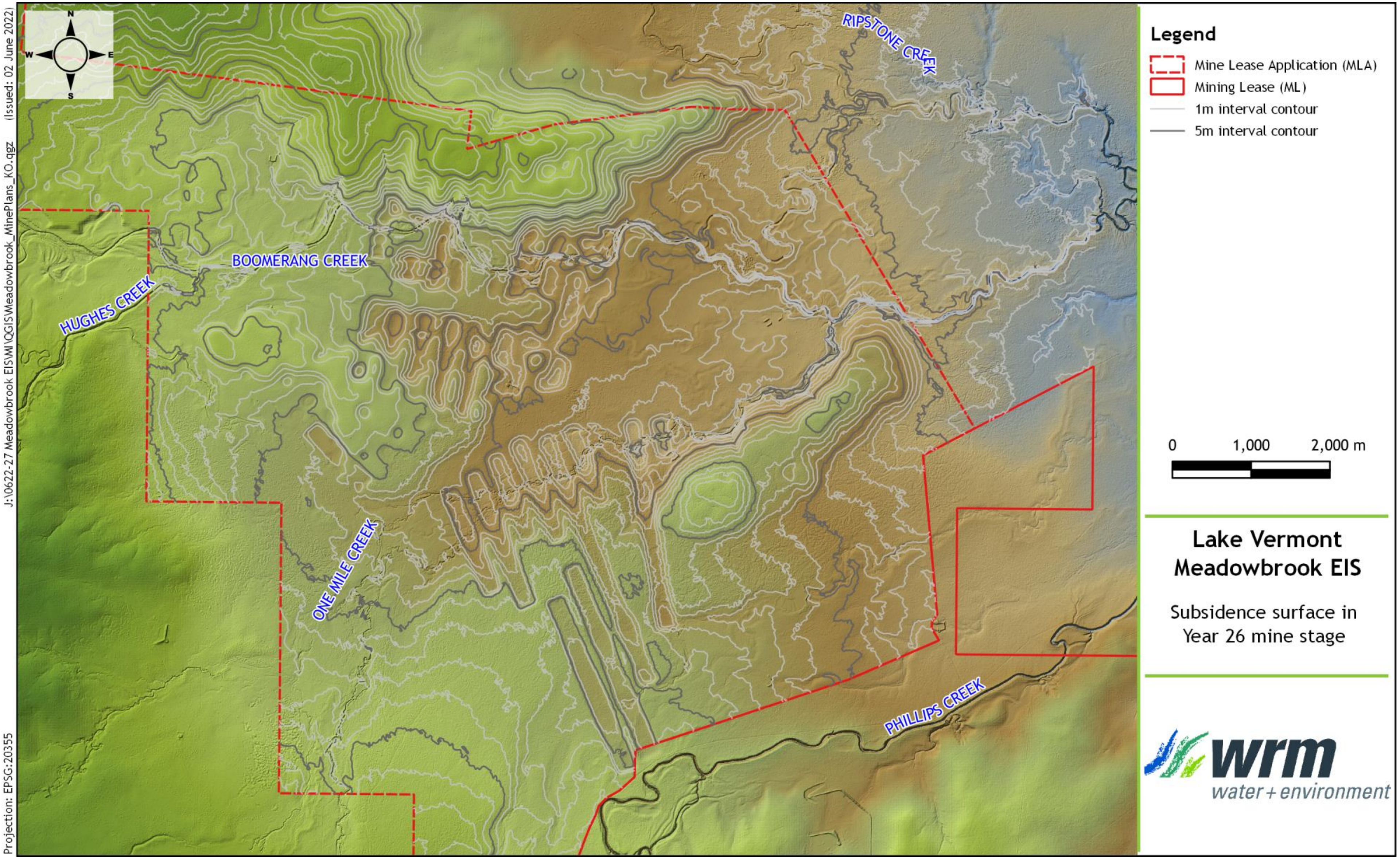


Figure 7.2 – Subsided ground surface – Year 26

7.2 MODELLING APPROACHES ASSUMPTIONS, LIMITATIONS AND RISK

The following sections outline the impacts of the project on flooding, geomorphology and downstream conditions based on the proposed water management strategy and the results of the detailed surface water modelling studies. The detailed technical reports outline the assumptions and approaches to surface water modelling, which can be divided into two main categories, with specific risks and limitations:

Flood modelling – Flood models were used to establish design flood levels and velocities across the project area, and to assess the change in flood conditions which would be caused by the project. The models were also used to inform the geomorphology assessment.

The flood models were developed in accordance with the procedures set out in Australian Rainfall and Runoff. Joint calibration of the hydrological and hydraulic models was undertaken to reproduce the recorded flood hydrograph recorded in a recent Phillips Creek flood event. This gives a high level of confidence in the flood model results, but there are some uncertainties in the selection of hydrologic (determining the response of the catchment to rainfall) and hydraulic (determining the flow conditions for a catchment runoff) parameters.

Flood levels and velocities are dependent on the selection of hydraulic roughness parameters across the project area. These values were selected based on the Phillips Creek calibration and experience with calibrating similar flood models in the region. Further measured water level data would allow these parameters to be selected with a higher level of confidence, however, the consequences of the plausible range of parametric uncertainty on the findings of this EIS would be minimal, because:

- The assessment is largely based on a comparison of post-development conditions against baseline conditions (for example changes to flood level and velocity). As consistent parameter sets were adopted for pre- and post-development scenarios, potential errors in the change in flood conditions are significantly less than absolute errors in the design water levels or velocities (as the errors cancel each other out).
- During later phases of design, the flood models will be rerun using the final details to confirm the design flood levels and quantify model uncertainties. Where absolute estimates (as opposed to changes in conditions) are important (e.g. for establishing the risk of inundation of the final landform and establishing the height of the MIA flood levee) a suitable design freeboard will be adopted to account for uncertainties in the design flood levels.

Water balance modelling - water balance models were used to assess the potential accumulation of water in the rehabilitated open cut mine landform, to assess the ability of the water management system to contain runoff, and to quantify the magnitude of sediment dam spill and their dilution.

While the site water balance model is based on the best currently available information and is expected to reasonably represent future mine water management system performance, actual system behaviour will differ from the model predictions for a variety of reasons, including:

- differences in the climate compared to the adopted climatic sequence;
- variations in operating procedures due to equipment failure or operational error;
- differences between the adopted groundwater inflows and actual inflows;
- differences in catchment characteristics and behaviour compared to the assumptions behind the parameterisation of the runoff model.

However, the site water balance model parameterisation was informed by several years of observed water management system behaviour at the Lake Vermont Operation. Uncertainties in the key parameters were the subject of sensitivity analysis, and it is therefore very unlikely the system would behave outside the reported bounds over the historical climate set.

As part of detailed design, Bowen Basin Coal would review and rerun the site water balance model to ensure the adopted design capacities achieve the proposed containment outcomes. Once operational site monitoring data becomes available, the model would be validated against historical performance, and periodically updated along with the Lake Vermont operational water balance model. Confirmation of inflows to the underground and open cut operations will be a key parameter for confirmation.

Estimates of the dilution potential of streamflow co-incident with sediment dam overflows are based on a simple model of One Mile Creek/Boomerang Creek catchment runoff. There are no streamflow data available for calibration of the runoff model and catchment behaviour is potentially affected by activities in the upstream catchment, and the spatial variability of upstream rainfall. The runoff estimates are the best possible with the available information

7.3 FLOODING

The hydraulic model was used to simulate flood conditions under approved site conditions (base case), operational conditions (with full longwall mining subsidence), post-closure conditions and cumulative impact scenarios. Full details are provided in the flood modelling assessment report (WRM, 2022a).

Figure 7.3 and Figure 7.4 show the impacts of the project on the extent and depth of the 1% AEP design flood at Year 26 (the time of maximum disturbance). Full details of the analysis can be found in the flood modelling assessment in the flood modelling assessment report (WRM, 2022a).

The results show the Project would alter local flood conditions via a number of mechanisms:

- underground mine subsidence would locally reduce flood levels but increase the depth and extent of flooding;
- underground mining would redirect floodplain flow along subsidence panels – however, the effects will be mitigated by bunding across the panels to reduce the potential for this to occur;
- subsidence would increase floodplain storage, which has the effect of reducing downstream flood flows, levels and extents;
- the haul road embankment would cause some obstruction to floodplain and channel flows – locally increasing upstream flood levels. However, the vertical alignment design and cross-drainage structures limit the upstream impacts and preserve the downstream flow distribution;
- levees around the open cut operation and MIA would locally reduce floodplain conveyance and storage – this would have the effect of locally increasing upstream flood levels and redistributing downstream flow to the opposite floodplains until the levees were decommissioned and the floodplain landform returned to pre-mining levels. The modelled flood heights in the 0.1% AEP design flood were used as the basis of protection works around the surface operations (at the open cut pit and mine infrastructure area).

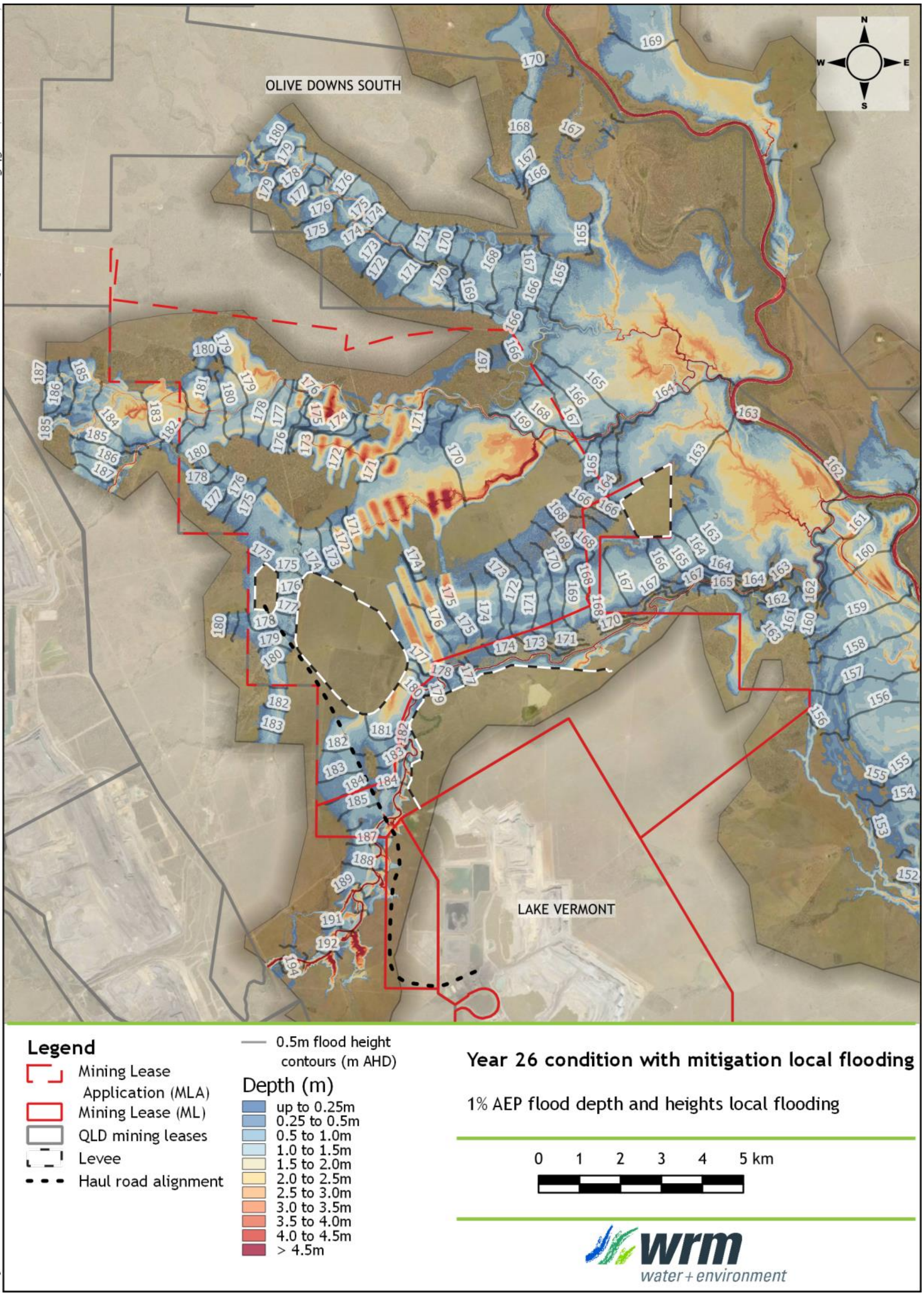
The results of the investigation for local creek flooding and regional Isaac River flooding through the Project area are summarised as follows:

- Changes in flood level and velocity would largely be confined to the lease area. In events greater 50% AEP, the proposed haul road would increase upstream off-lease flood levels within the Phillips Creek channel by less than 60 mm. Elsewhere, water level increases are predicted to be largely confined to the lease area. The depth and extent of any off-lease impacts would be minimal in events up to the 0.1% AEP.

- For the 2% AEP and greater floods, northern Phillips Creek floodplain flow could be diverted along the subsidence panels towards One Mile Creek. This effect would be mitigated by the construction of bunds across the subsidence panels - limiting afflux in the One Mile and Boomerang Creek floodplains to 50 to 100 mm. The subsidence would result in a small reduction in flood levels downstream of the subsidence zone.
- Velocity impacts on the subsidence areas are complex, with velocities increasing over chain pillars and reducing in subsidence panels. Velocity increases in the vicinity of the southeastern corner of the open cut mine range from 0.8 m/s in the 10% AEP event to 2 m/s increases in the PMF.
- Off-lease velocity impacts are predicted to be minimal.
- The surrounding final landform surface will be shaped to ensure that flood events up to the 0.1 % AEP flood will not extend into the in-pit emplacement area.

The loss in floodplain storage caused by other upstream developments in the regions will be offset to some degree by the increase in flood storage induced by subsidence at the Meadowbrook Project. The cumulative impact of all known proposed floodplain developments in the nearby reaches of the Isaac River floodplain is to increase water levels in the vicinity of the Project by 60 mm in the post-closure cumulative impact scenario.

J:\0622-27 Meadowbrook EIS\WM\QGIS\TUFLOW config.qgz (Issued: 01 June 2022)



Projection: EPSG:20355

Figure 7.3 – 1% AEP flood depth and heights – Year 26

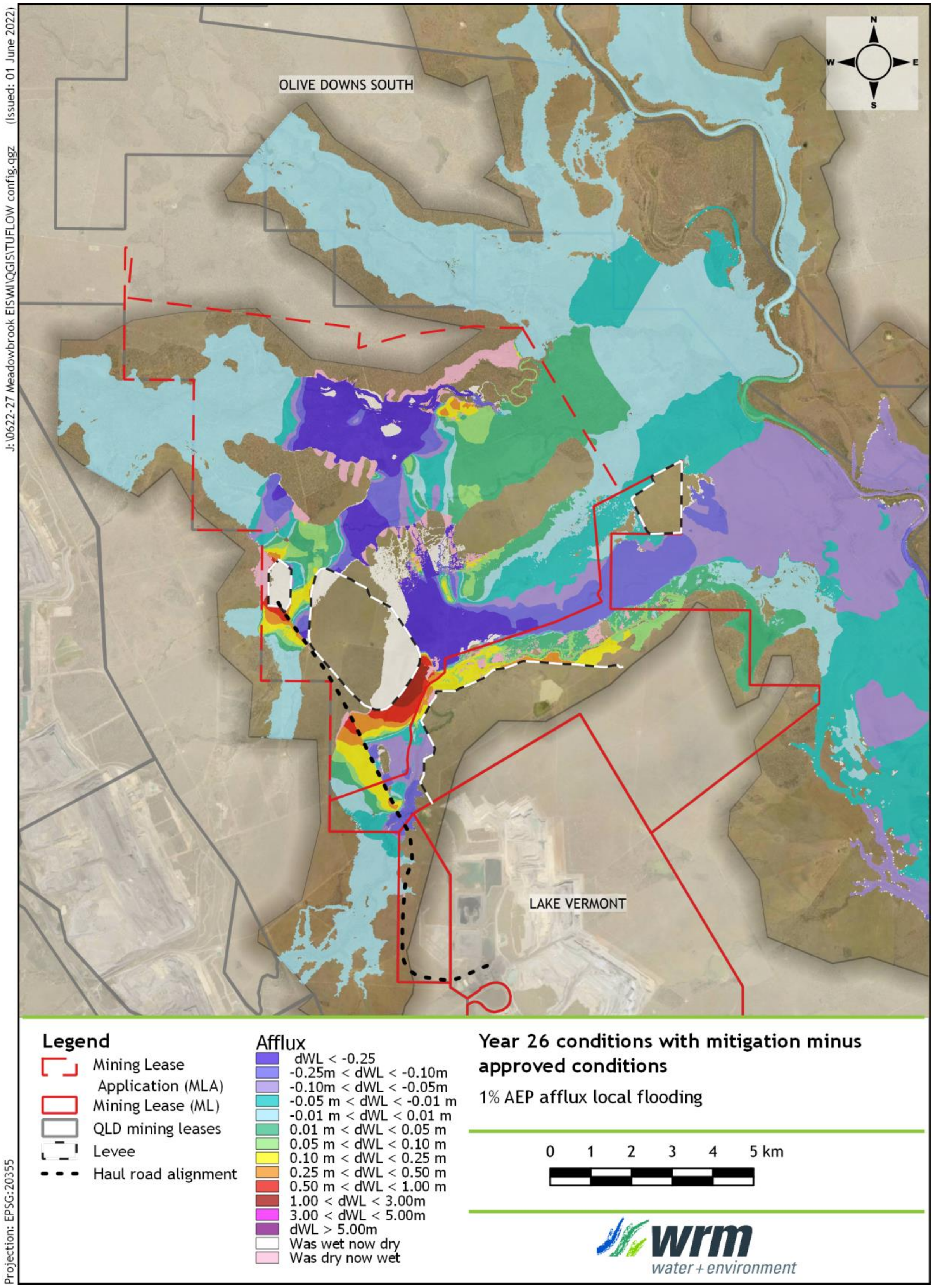


Figure 7.4 – 1% AEP increase in flood depth – Year 26

7.4 GEOMORPHOLOGY

Full details of the assessment of the impacts of subsidence on the geomorphology of the streams crossing the project area are provided in the geomorphological assessment report (WRM, 2022b). The following sections outline the main findings.

Subsidence would occur gradually as the Project progressively develops over the planned life of the underground mine of 22 years to 2048. The total surface area predicted to be affected by subsidence within the Project area is approximately 2,195 ha.

The channel and floodplain of Boomerang Creek would see a maximum subsidence depth of up to 4.0 m. Maximum subsidence depths in the floodplain between One Mile Creek and Boomerang would be over 4.5 m in localised areas. Maximum subsidence depths on the One Mile Creek channel and southern floodplain would be up to 3.0 m. Maximum subsidence depths on the Phillips Creek northern floodplain would be up to 3.0 m. The channel of Phillips Creek would not be directly affected by subsidence.

Hydraulic models were used to assess the potential flood and geomorphic impacts of the Project. Models were developed for pre-mining conditions, which assume all approved works on the Lake Vermont lease have been implemented, and post mining conditions, which assume that the additional longwall panels within the Project area have also been subsided and that works associated with the open cut pit (temporary levees around the mining area and mine infrastructure area, haul road/access road and earthworks to mitigate some of the Project impacts) are in place. Full details of the analysis are provided in the geomorphology assessment in the geomorphological assessment report (WRM, 2022b), the main finding of which are summarised below.

7.4.1 Boomerang Creek

Due to the relatively flat natural ground slopes and the depth of the proposed subsidence, the extent and depth of undrained depressions in the floodplain would significantly increase. These depressions would partially fill with local rainfall and runoff and slowly evaporate or seep into the local soils. The duration of ponding in these depressions would depend on the depth and duration of rainfall, but based on water balance modelling, they would be unlikely to fill completely, and would be expected to store more than 1 m of water less than 10% of the time. However, based on modelling of the 50% AEP flood, the depressions would be expected to fill with Boomerang Creek floodwater at least every few years. The ponded water would then persist until it evaporated or seeped into the underlying soil. In the absence of seepage, depending on their depth, the ponds could then be expected to persist for several months post filling.

Within the subsidence zone, peak flood levels would be reduced by up to approximately 3.5 m and 3.0 m in the 50% AEP and 2% AEP floods respectively. The extent of inundation would be increased slightly by backwater flowing up the subsidence troughs. During small flood events, additional flood storage would significantly reduce the peak flow rate, and peak flood levels in downstream reaches of Boomerang Creek by as much as 0.3 m to 0.5 m. In floods larger than the 2% AEP event, the impact of subsidence on downstream flows would be minimal.

In small floods, the proposed subsidence would result in an increase in the amount of Boomerang Creek floodwater flowing towards One Mile Creek. Velocity increases of 0.25 m/s to 0.5 m/s are predicted over a broad area where Boomerang Creek floodwater approaches One Mile Creek between Ch 14,000 to Ch 16,000. However, the increased velocities would be insufficient to erode the floodplain except in localised areas as it drains into subsidence troughs. Where vegetation coverage is poor over dispersive soils new flow paths would be likely to establish over time.

The proposed subsidence would result in a series of 4 main troughs in the channel bed due to the interaction of the differential settlement across the nine longwall panels and the intervening unmined pillars in each of the two overlying coal seams. These areas would see decreases in channel velocity, bed shear and stream power, causing reductions in sediment transport capacity in each trough, and promoting further aggradation of the bed (relative to the top of bank level) in these areas.

There would be increased channel velocity, bed shear and stream power as the channel drains into the mine subsidence zone at Ch 9,250. The deep bed sediments in these reaches are expected to erode relatively quickly as the channel morphology changes to reflect the higher bed grade. This may also lead to marginal increases in bank erosion as the channel capacity increases.

Channel velocity, bed shear and stream power would also increase as flow enters the second and fourth subsidence troughs (Ch 10,200, and Ch 11,700 to Ch 12,000). The bed sediments on the downstream side of these localised elevated sections of the stream bed are expected to scour and headward erosion may potentially occur to the extent that this elevated section of stream bed will be eroded down to the upstream and downstream bed levels (which will rise as the bed aggradation occurs). The expected aggradation relative to the bank levels could accelerate the potential abandonment of the existing Boomerang Creek channel. It should be emphasised that given the number of remnant channels and abundant sediment supplies in the catchment, a new Boomerang Creek channel could form in the absence of the proposed subsidence. Hydraulic modelling of earlier stages of underground operations indicated that the avulsion risk would be greatest in Year 17 prior to the development of the easternmost panels.

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

It should be noted that Alluvium (2019) found that depending on the timing of flows and mining and the infilling of subsidence at the proposed Saraji East underground mine through Hughes and Boomerang Creek would potentially cause downstream bedload starvation for a period and this could impact the timing of infilling of the bed at the Meadowbrook Project. Based on estimated average sediment supply rates to the catchment, in the absence of significant depletion of sediment in the reach of Boomerang Creek between the two projects, it is expected to take 15 to 45 years for the Meadowbrook subsidence depressions to refill with sediment post-mining. Complete replenishment of residual sediment loss attributable to the Saraji East project could take a similar time, however large floods occurring after the completion of mining could significantly reduce these timeframes.

7.4.2 One Mile Creek

The proposed subsidence would result in a series of 8 main troughs in the channel bed due to the differential settlement across the longwall panels and the intervening unmined pillars in the one overlying coal seam which are aligned approximately perpendicular to the channel.

All troughs associated with the One Mile Creek floodplain would be directly connected to the main channel – and during flood flows, water would flow laterally into the subsidence areas. The north-flowing reaches of the One Mile Creek floodplain would also experience minor impact from the construction of the temporary levee proposed around the northern end of the open cut pit mining area. At the completion of open cut mining, the levee would be decommissioned, and the One Mile Creek floodplain would be restored to pre-mining levels through the placement of in-pit overburden in the final landform.

Within the subsidence zone, peak flood levels would be reduced by up to approximately 1.3 m and 1.5 m in the 50% AEP and 2% AEP floods respectively. In floods larger than the 2% AEP event, the impact of subsidence on downstream flows would be minimal.

Parts of the channel within subsidence troughs would see decreases in channel velocity, bed shear and stream power, causing reductions in sediment transport capacity in each trough, and promoting further aggradation of the bed (relative to the top of bank level) in these areas.

There would be increased channel velocity, bed shear and stream power as the channel drains into the mine subsidence zone at Ch 9,750. Velocities in this area would remain less than guidelines values but given the relatively fine sediment in this area and the apparent limitation in sediment supply, these reaches are expected to erode as the channel morphology changes to reflect the higher bed grade. This may also lead to increases in bank erosion as the channel capacity increases.

Channel velocity, bed shear and stream power also increase as flow enters the second to fifth subsidence troughs (Ch 10,600, and Ch 11,200 to Ch 11,750 and Ch 12,250). The bed sediments on the downstream side of these localised elevated sections of the stream bed are expected to scour and headward erosion would occur through this elevated section of stream bed.

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

To promote the movement of water and sediment through this reach, Bowen Basin Coal will consider decommissioning the existing farm dam on One Mile Creek prior to the commencement of mining.

Where practical, minor drainage channels are proposed to drain the subsidence panels, however as this is not possible in all areas, ponding of runoff captured in the floodplain between Boomerang and One Mile Creeks would effectively reduce the local catchment draining to One Mile Creek by approximately 9 km^2 (6.9%).

During open cut operations, water which would normally flow to One Mile Creek would be intercepted by the proposed mine water management system within the levees protecting the mine pit and sediment dams. During the period of peak open cut mining disturbance, the temporary maximum additional reduction in catchment area to One Mile Creek would be approximately 3 km^2 (i.e. a total of 12 km^2). At the completion of mining and rehabilitation of the final landform, this would reduce to approximately 1.5 km^2 (i.e. a total catchment loss of 10.5 km^2 – 8%).

This catchment loss would impact the downstream 4 km to 6 km reach of One Mile Creek in minor runoff events, (which has been impacted by historical mining activities in the upper catchment) but would not significantly further alter the flow regime. The impacts of the catchment loss would be minimal downstream of the confluence, where it would make up 1.8% of the 489 km^2 total catchment.

Water balance modelling of the overland flow into the One Mile Creek depressions shows their median stored volume would total only 20 ML, but they could intercept approximately 283 ML/a of catchment runoff on average (median 96 ML/a).

7.4.3 Phillips Creek floodplain

The main channel of Phillips Creek will not be impacted by the proposed subsidence. However, four underground panels crossing the northern Phillips Creek floodplain would impact flooding and drainage. The proposed temporary levee around the southeastern end of the open cut mining area would also impact flood flows until it was decommissioned, and pre-mining ground levels restored at the end of mining.

A minor drainage channel would be constructed around the toe of the levee to ensure the floodplain is free draining. Drainage channels would be cut through the pillars separating the subsidence troughs to allow free drainage of catchment runoff through the subsidence zone. Small embankments are also proposed across the subsidence panels to restrict the flow of water from Phillips Creek to One Mile Creek. The remaining small depression would intercept a portion of the overland flow from the local catchment of 1,436 ha (about 2.8% of the total Phillips Creek catchment). The average annual volume captured by the pond is estimated to be 167 ML/a (about 0.8% of the average annual flow in Phillips Creek at the project).

7.4.4 Ongoing monitoring and mitigation measures

A subsidence monitoring plan will be developed to assess the changes in bed levels and the impact of increased localised sedimentation. Bank protection measures will be considered if monitoring indicates that the increase in erosion is having a demonstrable impact on the channel form.

Overland flow from local catchments captured in subsidence depressions may be pumped downstream if required to manage impacts on downstream flow paths.

7.5 SITE WATER BALANCE

During underground operations, the average annual demand for water is estimated to be up to approximately 1,390 ML/year. The principal water demand would be for raw water for underground operations. This water is not consumed in the process of use – however would become mine affected water after use in the underground operation. Minor quantities of water captured in the water management system would be used for washdown and dust suppression in the surface operations.

During open cut operations (and after the cessation of underground mining), the average annual water demand would be significantly reduced (to approximately 180 ML/year). While the infrastructure corridor linking the new MIA to the existing operation will include sealed access and coal haulage roads (which will not require watering for dust suppression during operations), water would be used for dust suppression on haul roads in the active mining area.

If on-site supplies are insufficient during dry periods, they would be supplemented with additional imported raw water. However, there will generally be an excess of water on-site – particularly during underground operations, and excess water would be returned to the existing Lake Vermont Mine for reuse within the site water management system via a pipeline along the infrastructure corridor.

The results of the water balance model show:

- The need for imported water from the raw water supply pipeline is expected to decrease from a peak of nearly 1,500 ML/a around Year 5 to less than 200 ML/a in the last 5 years of open cut operations. The available pipeline water allocation is sufficient to maintain supplies.
- The adopted MIA Dam storage capacity is sufficient to contain inflows throughout the Project life without overflow. The likelihood of nearing the available capacity increases once open cut operations commence in Project Year 20.
- In-pit water volumes would generally be maintained at relatively low volumes which would not interrupt mining operations. The 90th percentile in-pit inventory is always less than 380 ML. In very wet years, up to 1,091 ML of water could be stored in the open cut at the 1% confidence level. Pumping to the Dewatering Dam would ensure the pit is empty prior to the following wet season.
- During underground operations, the average annual quantity of water returned to the existing Lake Vermont operation would be approximately 1,000 ML/year (ranging from 518 ML/year to 1595 ML/year). During open cut operations, the average would reduce to approximately 404 ML/year (but could range from 0 ML/year to 3,078 ML/year depending on the prevailing weather conditions). Water delivered from Meadowbrook would offset Lake Vermont mine’s use of pipeline water. The Lake Vermont Mine water management system has significant potential storage capacity available (with careful planning, as much as 15 GL could be stored in part of the mine pits while maintaining mining in some areas). Water transferred from Meadowbrook following wet periods could be accommodated within the existing capacity.
- The model results show sediment dam overflows would only be expected in the wettest 10% of historical climate periods The largest modelled total sediment dam release during open cut operations was 1,038 ML from North Sediment Dam under very wet climate conditions. Median total project releases are expected to be much smaller – less than 140 ML from each dam over the total project life. The maximum modelled salinity of sediment dam releases was 691 mg/L at the North Sediment Dam. Dilution by flows in the receiving waters would further reduce salinities.
- Dissolved Inorganic Nitrogen (DIN) is occasionally measured within the existing Lake Vermont water management system. Recent samples indicated nitrite concentrations below the default aquatic ecosystem guideline. Ammonia levels were below the limit of reporting except in all dams tested except Environmental Dam 5 (0.22 mg/L), which stores water decanted from the CDAs and pumped from the mine pits. Total nitrate

levels were also below the limit of reporting in all dams except ED3, where the concentration was 1.93 mg/L. These results indicate overflows from the water management system would be unlikely to elevate DIN concentrations above background levels. Compared to other point and diffuse sources of DIN in the Great Barrier Reef catchments, the contribution of dam overflows to total nutrient loads in the Great Barrier Reef lagoon would be minimal and will not have a residual impact on DIN concentrations in the Great Barrier Reef catchment waters.

The average annual site water balance through both underground and open cut phases of the operation are shown in Table 7.1.

Table 7.1 - Average annual site water balance

Component	Process	Volume (ML/year)	
		Underground operations Project Years 1-23	Open cut operations Project Years 20-30
Inflows	Rainfall and runoff	127.0	527.5
	Net groundwater inflow	197.4	193.3
	External supply pipeline	1,051.0	310.5
	Total	**1,375.5**	**1031.2**
Outflows	Dam evaporation	7.3	16.7
	Haul road dust suppression	10.8	158.1
	ROM coal moisture	144.7	24.6
	Vent shaft losses	113.5	26.6
	Miscellaneous surface demands	98.8	94.1
	Return to Lake Vermont	997.3	693.6
	Spill from MIA Dam	0.0	0.0
	Spill from Sediment Dams	2.0	16.1
	Total	**1,374.3**	**1,029.9**
Change in Site Water Inventory		**1.2**	**1.3**

*Includes inflow to underground during start of open cut operations

7.6 REDUCTION IN DOWNSTREAM FLOW

The project could potentially reduce in downstream streamflow via the mechanisms outlined in the following sections.

7.6.1 Residual post-subsidence depressions

Where practical, minor drainage channels are proposed to drain the subsidence panels, however as this is not possible in all areas, ponding of runoff captured in the floodplain between Boomerang and One Mile Creeks would effectively reduce the local catchment draining to One Mile Creek by approximately 9 km^2 (6.9%). The potential catchment loss is indicated in Figure 7.5. This catchment loss would impact the downstream 4 km reach of One Mile Creek in minor runoff events (which has been impacted by historical mining activities in the upper catchment) but would not significantly further alter the flow regime. The impact of the catchment loss would be minimal downstream of the confluence, where it would make up 1.8% of the 489 km^2 total catchment.

7.6.2 Potential loss in the open cut mining area

During open cut operations, water which would normally flow to One Mile Creek and Phillips Creek would be intercepted by the proposed mine water management system within the levees protecting the mine pit and sediment dams. The construction of the sediment dams would be staged, and in large rainfall events they could overflow. However during the period of peak open cut mining disturbance, the temporary maximum additional reduction in catchment area draining to the downstream 6 km reach of One Mile Creek would be approximately 3 km^2. At the completion of mining and rehabilitation of the final landform, this would reduce to approximately 1.5 km^2 (i.e. a total catchment loss of 10.5 km^2 – 8%).

At Phillips Creek, there would be a corresponding 0.3 km^2 temporary loss of catchment during operations and a loss of 0.03 km^2 after rehabilitation of the final landform. These losses are insignificant in terms of impacts to the flow regime of Phillips Creek and its floodplain.

The areas of potential surface runoff catchment loss are indicated in Figure 7.5 for the final landform scenario.

7.6.3 Potential loss to underground workings

Based on field measurements and observations at similar operations Gordon Geotechniques (GG, 2022) predicted the maximum depth of continuous subsurface subsidence cracking above the workings would be:

- up to 120 m in the single seam extraction areas;
- up to 180 m in areas where both the Leichhardt Lower and Vermont Lower Seam are to be extracted.

Gordon Geotechniques (GG, 2022) predicted the maximum depth of continuous subsurface subsidence cracking above the workings would not extend to the ground surface at Boomerang, One Mile and Phillips Creeks.

7.6.4 Potential loss to surface cracking

Surface subsidence cracks will develop in the proposed longwall mining areas. The areas with the highest potential for cracking are those located at the panel edges where the maximum tensile strain occurs. Gordon Geotechniques concluded the widest of these cracks would extend to no more than 10 to 15 m below ground level, with the majority less than 1 m deep. Maximum surface crack widths up to 200 mm could be expected in the shallower parts of the area, decreasing to less than 50 mm at greater depths. Some reworking and widening of existing cracks are predicted where both seams are extracted. Cracks of this depth would not result in the loss of water from the alluvium associated with the watercourses overlying the underground workings.

7.6.5 Impacts on downstream water resources

The maximum total catchment loss of 10.5 km^2 makes up less than 0.26% of the total Isaac River catchment downstream of the Project of 4,100 km^2. The impacts of the project on downstream water users will therefore be minimal.

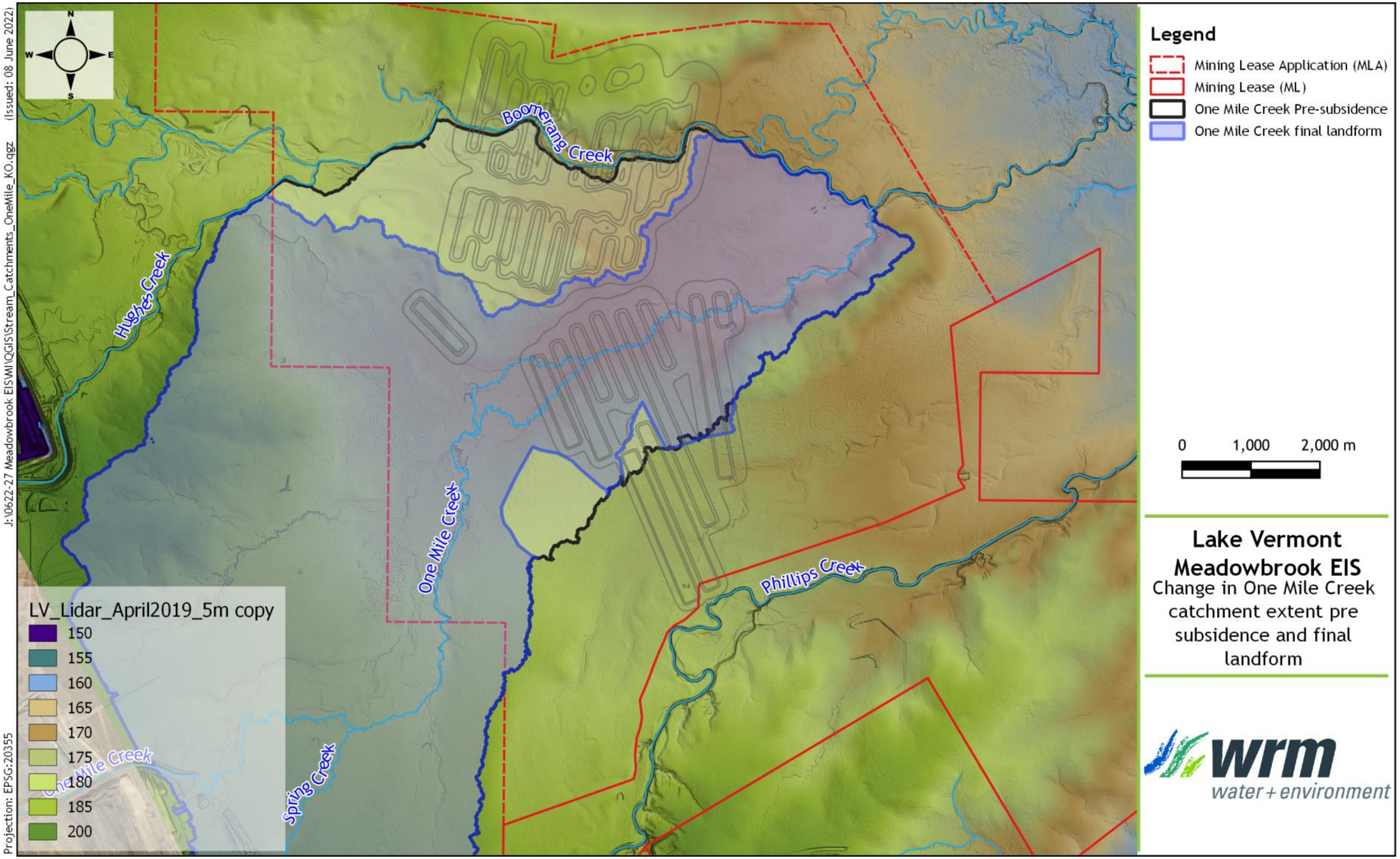


Figure 7.5 – Changes in flow paths – with mitigation works – One Mile Creek – final landform

7.7 CUMULATIVE IMPACTS – SURFACE WATER

7.7.1 Overview

The objective of a cumulative impact assessment is to identify the potential for impacts from the Project that may have compounding interactions with similar impacts from other projects within a suitable region of influence of the Project. The cumulative impact assessment considers projects that are proposed, under development or already in operation.

There are two levels at which cumulative impacts may be relevant for surface water:

- *Localised cumulative impacts* – These are the impacts that may result from multiple existing or proposed mining operations in the immediate vicinity of the Project. Localised cumulative impacts include the effect from concurrent operations that are close enough to potentially cause an additive effect on the receiving environment. This assessment has considered all existing and proposed projects located adjacent to or upstream of the Project within the upper Isaac River catchment.
- *Regional cumulative impacts* – These include the Project's contribution to impacts that are caused by mining operations throughout the Bowen Basin region or at a catchment level. Each coal mining operation in itself may not represent a substantial impact at a regional level; however, the cumulative effect on the receiving environment may warrant consideration.

7.7.2 Relevant projects

7.7.2.1 Existing projects

Projects that are currently operating within the Isaac River catchment upstream or adjacent to the Project have been included in the localised cumulative impact assessment for the Project and are listed in Table 7.2.

7.7.2.2 New or developing projects

Relevant projects that have been considered include:

- Projects within the predicted area of influence of the Project, as listed on the Department of State Development, Infrastructure and Planning (DSDIP) website that are undergoing assessment under the SDPWO Act for which an Initial Advice Statement (IAS) or an EIS are available;
- Projects within the predicted area of influence of the Project, which are listed on the website of the DES that are undergoing assessment under the EP Act for which an IAS or an EIS are available; and
- Projects within the predicted area of influence of the Project, which are listed on the website of the Department of Infrastructure, Local Government and Planning (DILGP) that are undergoing assessment under the *Regional Planning Interests Act 2014* for which an Assessment Application is available.

Projects currently undergoing assessment or having recently completed assessment under these processes and included in the cumulative impact assessment for the Project are listed in Table 7.3.

7.7.3 Cumulative impacts – surface water resources

7.7.3.1 Water quality

The Project is located in the Isaac River catchment, which is a major tributary within the Fitzroy basin. The Fitzroy basin is the largest catchment in Queensland draining into the Pacific Ocean and also the largest catchment that drains to the Great Barrier Reef, although it does not contribute significant freshwater flows to the coastal environment when compared to river systems further north.

In 2008, the Queensland Government undertook an investigation into the cumulative effects of coal mining in the Fitzroy River basin on water quality (EPA, 2009). The investigation found that:

- There were inconsistencies in discharge quality limits and operating requirements for coal mine water discharges as imposed through EAs.
- In some cases, discharge limits and operating conditions of coal mines were not adequately protecting downstream EVs.

These conclusions led to a number of inter-related actions by Queensland Government and other stakeholders:

- Water quality objectives were developed for the Fitzroy Basin and added to Schedule 1 of the EPP (Water) in October 2011.
- Model water conditions were developed for coal mines in the Fitzroy basin (DERM February 2012). These model water conditions are designed to manage water discharges to meet the water quality objectives set out in the EPP (Water) and to provide consistency between mining operations in the Fitzroy basin.
- EAs for a number of mining operations were amended to introduce conditions consistent with the model water conditions.
- A number of mining operations entered into Transitional Environmental Programs (TEP) under the EP Act. These TEPs were focussed on actions that would allow mines to achieve compliance with new environmental authority conditions and upgrade operating conditions.

Table 7.2 – Existing projects considered in the localised cumulative impact assessment

Project	Proponent	Description	Operational status	Relationship to the Project area	
				Timing	Location
Burton Mine	Peabody Energy Australia (PEA)	Open cut coal mine	Ceased production	May have overlapping operational phases with the construction and operations of the Project, although unlikely given the current operational status.	52 km to the north of the Project area. Located within Isaac River catchment (upstream).
Moorvale Mine	PEA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	39 km to the north of the Project area. Located within Isaac River catchment (upstream).
Eaglefield Mine	PEA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	85 km to the northwest of the Project area. Located within Isaac River catchment (upstream).
North Goonyella Mine	PEA	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	85 km to the northwest of the Project area. Located within Isaac River catchment (upstream).
Millennium Mine	PEA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	35 km to the north of the Project area. Located within Isaac River catchment (upstream).
Goonyella Riverside Mine	BHP	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	75 km to the northwest of the Project area. Located within Isaac River catchment (upstream).
Moranbah North Mine	Anglo American	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	65 km to the northwest of the Project area. Located within Isaac River catchment (upstream).
Grosvenor Mine	Anglo American	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	55 km to the northwest of the Project area. Located within Isaac River catchment (upstream).
Carborough Downs Mine	Fitzroy Queensland Resources	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	44 km to the north-northwest of the Project area. Located within Isaac River catchment (upstream).
Isaac Plains Complex	Stanmore Coal	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	45 km to the northwest of the Project area. Located within Isaac River catchment (upstream).
Poitrel Mine	BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	25 km to the north of the Project area. Located within Isaac River catchment (upstream).
Daunia Mine	BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	25 km to the north of the Project area. Located within Isaac River catchment (upstream).
Caval Ridge Mine	BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	20 km to the northwest of the Project area. Located within Isaac River catchment (upstream).
Peak Downs Mine	BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	15 km to the northwest of the Project area. Located within Isaac River catchment (upstream).

Project	Proponent	Description	Operational status	Relationship to the Project area	
				Timing	Location
Saraji Mine	BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	4 km to the west of the Project area. Located within Isaac River catchment (upstream).
Norwich Park Mine	BMA	Open cut coal mine	Ceased production	May have overlapping operational phases with the construction and operations of the Project, although unlikely given the current operational status.	15 km to the south of the Project area. Located within Isaac River catchment (downstream).
Lake Vermont Mine	Jellinbah Group	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project.	2 km to the south of the Project area. Located within Isaac River catchment (downstream).

Table 7.3 – New or developing projects considered in the cumulative impact assessment

Project	Proponent	Description	Status	Relationship to the Project area	
				Timing	Location
Eagle Downs Mine	South32	Underground coal mine	Construction on hold - site under care and maintenance	May have overlapping operational phases with the construction and operations of the Project.	17 km to the northwest of the Project area. Located within Isaac River catchment (upstream).
Winchester South Project	Whitehaven Coal Limited	Open cut coal mine	EIS active	May have overlapping operational phases with the construction and operations of the Project	15 km to the northwest of the Project area. Located within Isaac River catchment.
Red Hill Mining Project	BMA	Underground coal mine	Approved project (on hold)	May have overlapping operational phases with the construction and operations of the Project.	70 km to the north-northwest of the Project area. Located within Isaac River catchment.
Moorvale South Project	PEA	Open cut coal mine	Approved project	May have overlapping operational phases with the construction and operations of the Project	20 km to the north of the Project area. Located within Isaac River catchment.
Olive Downs Project	Pembroke	Open cut coal mine	Approved project	May have overlapping operational phases with the construction and operations of the Project	7 km to the north of the Project area. Located within Isaac River catchment.
Isaac Downs Project	Stanmore Coal	Open cut coal mine	EIS active	May have overlapping operational phases with the construction and operations of the Project	36 km to the north-northwest of the Project area. Located within Isaac River catchment.
New Lenton Coal Project	New Hope Corporation	Open cut coal mine	EIS lapsed	May have overlapping operational phases with the construction and operations of the Project	90 km to the north of the Project area. Located within Isaac River catchment.
Saraji East Mining Lease Project	BMA	Underground coal mine	EIS active	May have overlapping operational phases with the construction and operations of the Project	Immediately to the west of the Project area. Located within Isaac River catchment.
Bowen Gas Project	Arrow Energy	CSG field and production facilities	Approved project	May have overlapping operational phases with the construction and operations of the Project	The Project lies within the Bowen EIS Study Area.
Ironbark No. 1 (Ellensfield)	Fitzroy Resources	Underground Coal Mine	Approved project	May have overlapping operational phases with the construction and operations of the Project	65 km to the north-northwest of the Project area.

With these measures in place, a strong and strategic policy framework is now in place for management of cumulative water quality impacts from mining activities. This framework allows for management of individual mining activities in such a way that overarching water quality objectives can be achieved.

Mine-affected water from the Project would be managed through a water management system which is designed to operate in accordance with typical EA conditions and the model water conditions. That is, it will have discharge conditions and in-stream trigger levels aligned with the WQOs in the EPP (Water).

A review of the release conditions at other coal mines in the vicinity of the Project has been undertaken. A summary of these release conditions is provided in Table 7.4 and the locations of the release points at nearby mines is shown in Figure 7.6. Table 7.4 shows the following:

- The receiving water contaminant trigger levels for:
  - EC range between 864 and 2,000 µS/cm;
  - pH ranges vary between 6.5 to 9.0; and
  - suspended solids range between 258 to 1,500 mg/L (with many to be determined).
- The mine-affected water release during flow events varies significantly. The mines closest to the Project (Peak Downs Mine, Saraji Mine) have maximum EC release limits of up to 10,000 µS/cm.

The Queensland Government commissioned an assessment of mine-affected water releases in the Fitzroy River basin during the 2012–2013 wet season (known as the Pilot Scheme). The report, prepared by consultants Gilbert and Sutherland (G&S, 2016), concluded that the Fitzroy as a whole is not currently ‘at capacity’ in terms of salt load at a catchment or sub-catchment scale.

The operational policy of the Pilot Scheme aims to manage the cumulative impact of mine-affected water releases across the Fitzroy Basin. To achieve this, trigger values have been derived for six monitoring locations across the basin. If in-stream EC triggers are exceeded during times when mine-affected water releases are being undertaken upstream, the regulator has the ability to issue a “cease release” notification to all coal mines in the Fitzroy Basin with conditions that authorise the release of mine-affected water.

Given that the Project mine-affected water releases are being managed within an overarching strategic framework for management of cumulative impacts of mining activities, the proposed management approach for mine-affected water from the Project is expected to have negligible cumulative impact on surface water quality and associated environmental values.

Table 7.4 – Environmental Authority Release conditions at coal mines in the vicinity of the Project

Mine	EA	Location	Receiving water contaminant trigger levels	Mine affected water quality limits	Conditions relating to receiving waters
Isaac Plains Coal Mine	EPML00932713	Isaac River U/S of the Project area	• EC: 1,000 µS/cm • pH: 6.5 - 8.0 • Suspended Solids: TBD • Sulphate: 1,000 mg/L	• EC: 720-8,000 µS/cm • pH: 6.5 - 9.0 • Turbidity: No limit • Suspended Solids: No limit • Sulphate: 250-400 (flow dependent)	Releases allowed when minimum flow in the receiving water (Isaac River) is greater than 4 m^3/s
Millennium Coal Mine	EPML00819213	Isaac River U/S of the Project area	• EC: 1,000 µS/cm • pH: 6.5 - 8.0 • Suspended Solids: TBD • Sulphate: 1,000 mg/L	• EC: 1,400 µS/cm • pH: 6.5 - 9.0 • Turbidity: N/A • Suspended Solids: 258 mg/L • Sulphate: 1,000 mg/L	Release calculated as percentage of flow in receiving waters (1% in Isaac River and 20% in New Chum Creek)
Poitrel Coal Mine	EPML00963013	Isaac River U/S of the Project area	• EC: 1,000 µS/cm • pH: 6.5 - 8.0 • Turbidity: 750 NTU • Suspended Solids: TBD • Sulphate: 250 mg/L	• EC: 720-7,200 µS/cm • pH: 6.5 - 8.5 • Turbidity: 500 NTU • Suspended Solids: N/A • Sulphate: 250-1,000 mg/L	Releases allowed when minimum flow in the receiving water (Isaac River) is greater than 14 m^3/s
Daunia Coal Mine	EPML00561913	Isaac River U/S of the Project area	• EC: 864 µS/cm - cease release • pH: 6.5 - 8.5 • Sulphate: 1,000 mg/L	• EC: 5,000 µS/cm • pH: 6.5 - 9.0 • Sulphate: 1,000 mg/L	Releases allowed when minimum flow in the receiving water (Isaac River via New Chum Creek) is greater than 3 m^3/s
Caval Ridge Coal Mine	EPML00562013	Isaac River U/S of the Project area	• EC: 2,000 µS/cm • pH: 6.5 - 9.0 • Sulphate: 1,000 mg/L	• EC: 10,000 µS/cm • pH: 6.5 - 9.5 • Sulphate: N/A	Releases allowed when minimum flow in the receiving water (3 m^3/s in Isaac River and 0.5 m^3/s in Cherwell Creek
Eagle Downs Coal Mine	EPML00586713	Isaac River U/S of the Project area	• EC: 1,000 µS/cm • pH: 6.5 - 8.0 • Turbidity: N/A • Suspended Solids: TBD • Sulphate: 100 mg/L	• EC: 1,200 µS/cm • pH: 6.5 - 9.0 • Turbidity: N/A • Suspended Solids: 80th percentile of background of u/s sites • Sulphate: 1,000 mg/L	
Moorvale Coal Mine	EPML00802813	Isaac River U/S of the Project area	• EC: 1,000 µS/cm • pH: 6.5 - 9.0 • Turbidity: 4,000 NTU	• EC: 2,500 µS/cm • pH: 6.5 - 9.0 • Turbidity: 4000 NTU • Suspended Solids: N/A • Sulphate: 1,000 mg/L	Releases allowed when minimum flow in the receiving water (0.02 m^3/s in North Creek)

Mine	EA	Location	Receiving water contaminant trigger levels	Mine affected water quality limits	Conditions relating to receiving waters
Lake Vermont Mine	EPML00659513	Isaac River D/S of the Project area	• EC: 1,000 µS/cm • pH: 6.5 - 8.0 • Suspended Solids: 1,500 mg/L • Sulphate: 300 mg/L	*Isaac River RP's* • EC: 1,500 µS/cm • Sulphate: 300 mg/L *Phillips Creek RP's* • EC: 720-5,500 µS/cm (flow dependant) • Sulphate: 300-1,500 µS/cm (flow dependant)	Releases allowed when minimum flow in the receiving water (Isaac River) is greater than 7.5 m^3/s
Peak Downs Coal Mine	EPML00318213	Isaac River U/S of the Project area	• EC: 2,000 µS/cm • pH: 6.5 - 9.0	• EC: 10,000 µS/cm • pH: 6.5 - 9.5 • Sulphate: N/A (correlated with EC)	Releases allowed when minimum flow in the receiving water (3 m^3/s in Isaac River and 0.1 m^3/s in Boomerang Creek)
Saraji Coal Mine	EPML00862313	Isaac River U/S of the Project area	• EC: 2,000 µS/cm • pH: 6.5 - 9.0	• EC: 10,000 µS/cm • pH: 6.5 - 9.5	Releases allowed when minimum flow in the receiving water (3 m^3/s in Isaac River, 0.1 m^3/s in Hughes Creek/One Mile Creek/Spring Creek/Phillips Creek)
Norwich Park Coal Mine	EPML00865013	Isaac River D/S of the Project area	• EC: 2,000 µS/cm • pH: 6.5 - 9.0 • Sulphate: 1,000 mg/L	• EC: 10,000 µS/cm • pH: 6.5 - 9.5 • Sulphate: N/A (correlated with EC)	Releases allowed when minimum flow in the receiving water (Scotts Creek/Stephens Creek/Rolf Creek) is greater than 1 m^3/s
Olive Downs Project	EA0001976	Isaac River adjacent to the Project area	• EC: 2,000 µS/cm • pH: 6.5 - 9.0 • TSS: TBA • Turbidity: TBA • Sulphate: 545 mg/L	• EC: 1,000-7,200 µS/cm • pH: 6.5 - 9.0 • Turbidity: 300 NTU • Sulphate: 1,000 mg/L	Releases allowed when minimum flow in the receiving water (Isaac River) is greater than 4 m^3/s

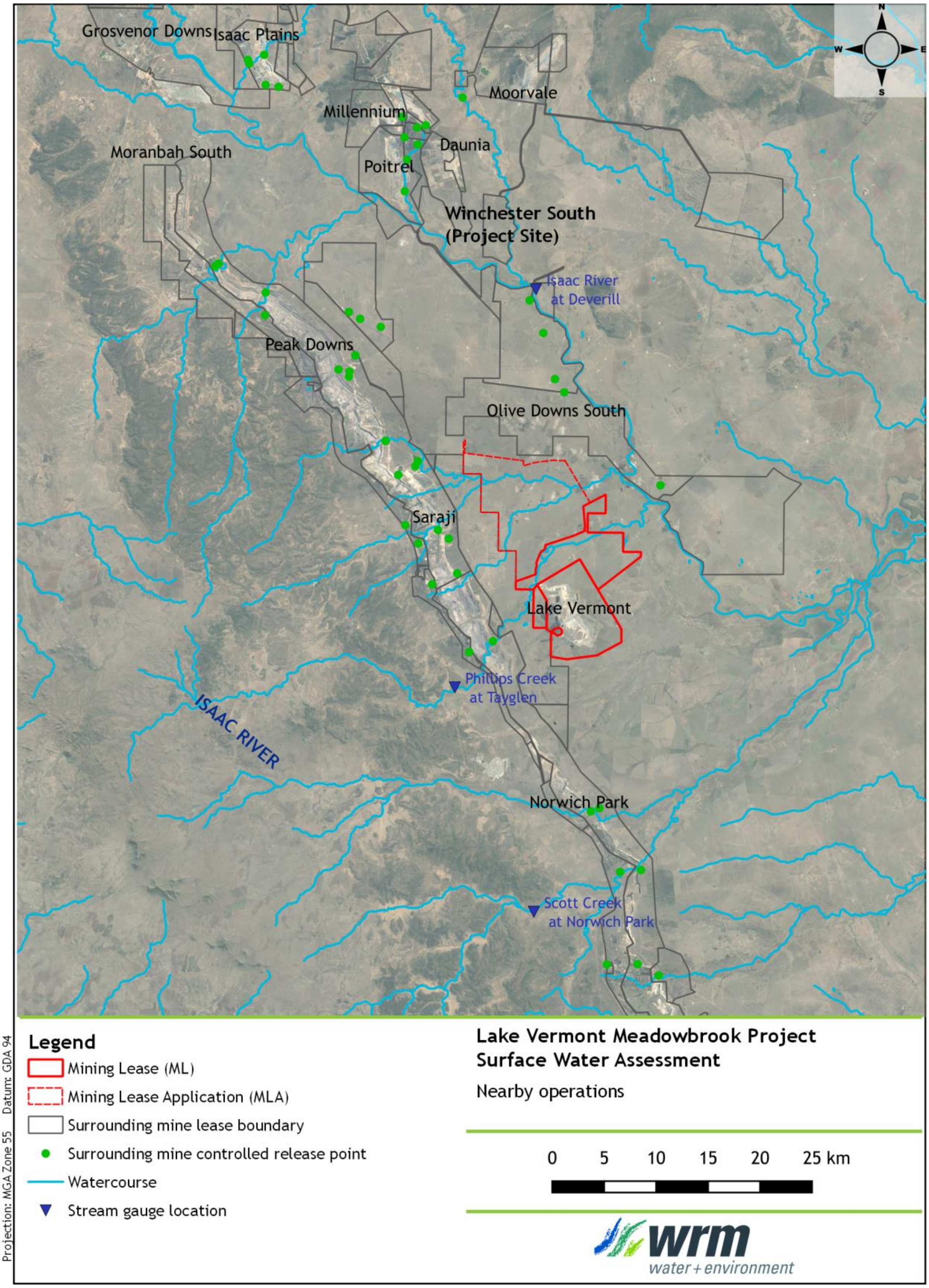


Figure 7.6 – Cumulative impact assessment – location of nearby release points

ACARP Project C18033 Extension

A study was undertaken in 2012 with the aim of gathering information on the tolerances of freshwater macroinvertebrates from the Fitzroy Catchment to saline mine water, that could potentially be utilized for developing guidelines for mine-affected water discharge. Part of this study involved developing ecosystem protection toxicant trigger values calculated from species sensitivity distribution derived from commercial tests. A 95% ecosystem protection trigger value of 2,000 µS/cm and a 99% ecosystem protection trigger value of 900 µS/cm were developed.

These trigger levels are significantly higher than the WQO's for the Upper Isaac River catchments water, particularly for 95% ecosystem protection. These trigger values were consistent with the lower range of previously published toxicological and other effects data on relevant aquatic species. These toxicant trigger values derived from the study could be used to inform the regulation of mine-affected water releases were aquatic ecosystem toxicity from salinity is the primary issue of concern.

Bowen Gas Project EIS

The Project lies within the study area of the Bowen Gas Project (BGP), and there are two water treatment facilities proposed as part of the BGP development. The indicative locations of the water treatment facilities discharge points are as follows:

- A section of the upper Isaac River, located downstream of Burton Mine; and
- A section of the Isaac River adjacent to the Olive Downs Project.

The impact assessments for the BGP indicated that surface water resources within the BGP area had been impacted by different historic and current land uses such as agriculture, mining and urban development. The impact assessments determined that through the implementation of appropriate mitigation measures, the potential impacts on surface water quality could be minimized. In addition, the set of principles for CSG water discharges developed in the impact assessments would allow for CSG water to be discharged without having any significant impact to the receiving environment.

Given that the proposed water treatment facilities for the BGP have a design capacity of up to 20 ML/d and water would only be discharged the prescribed limit of an environmental authority, the impact of BGP discharges on the receiving environment are expected to be insignificant from a cumulative impact perspective.

7.7.3.2 Loss of Catchment and Stream Flows in the Isaac River

As detailed in Section 7.6, the Project would result in a loss of catchment to the Isaac River during operations and post-mining. The surface runoff volume lost from the catchment would generally be in proportion to the excision of the catchment area. The Project area is less than 0.26% of the catchment area of the Isaac River to the project area.

The cumulative impact assessment includes mining operations within the Isaac River that are adjacent or downstream of the Project.

There are approximately 17 existing coal mines upstream of the Project that also capture runoff from the Isaac River catchment. The total estimated captured area of all these projects (including the Project) combined represents around of 9.5% of the Isaac River catchment to the Isaac River/ Stephens Creek confluence. Assuming 30% of the total area would be captured within the site water management systems, around 3% of the Isaac River catchment to the Isaac River/ Stephens Creek confluence could be captured in mine water managements systems. The impacts on the surface water resources of the Isaac River would be reduced by licensed discharges of captured surface water.

A comparison of the captured catchment areas of the existing mining projects considered in the cumulative impact assessment with the Isaac River catchment to the Isaac River/ Stephens Creek confluence is provided in Table 7.5. The overall loss of catchment area and associated stream flow is relatively small.

Table 7.5 – Catchments areas of existing projects considered in the cumulative impact assessment

Catchment	Total catchment area (km^2)	Estimated mine-affected catchment area (km^2)
Project area	70	11
Other mining operations (estimated)	669	221
Combined (estimated)	739	232
Isaac River	**7,782**	

7.8 FINAL LANDFORM

The proposed open cut mining method would involve initially developing a pit in the southeastern corner of the mining area on the northern Phillips Creek floodplain. Initially, waste-rock would be placed in an out-of-pit stockpile to the southwest of the pit. Mining would then proceed in a northwesterly direction, with waste rock then being placed in-pit to re-establish pre-mining ground levels in the Phillips Creek floodplain. Mining would later commence at the northwestern end of the mining area on the edge of the One Mile Creek floodplain and proceed southeast so that the final mine pit would be located in the high ground between the two floodplains.

Groundwater modelling undertaken for the groundwater impact assessment (JBT, 2022) predicts that groundwater levels will be temporarily reduced in the project areas during underground and open cut operations. The modelling predicts it will take over one hundred years for the local groundwater levels within the final pit landform to return to regional groundwater levels.

The proposed rehabilitated final landform in Figure 7.7 shows the pit shell would be partially backfilled, leaving a surface depression at the final location of the open cut pit.

The final landform design was developed to ensure that even after the underlying groundwater level recovers to the maximum predicted level, the depression would remain a source of groundwater recharge, and would not receive seepage from the regional groundwater. This ensures the accumulating volumes of water and concentrations of salts are minimised.

The floor of the backfilled depression is designed at approximately 160 mAHD. It would have a total depth of approximately 15 m to the overflow point at around 175 mAHD near the eastern corner.

The total potential water storage capacity is significant, with up to approximately 9 GL of surface water storage (excluding the interstitial pore space in the adjoining waste rock) available above the backfilled surface to the overflow level.

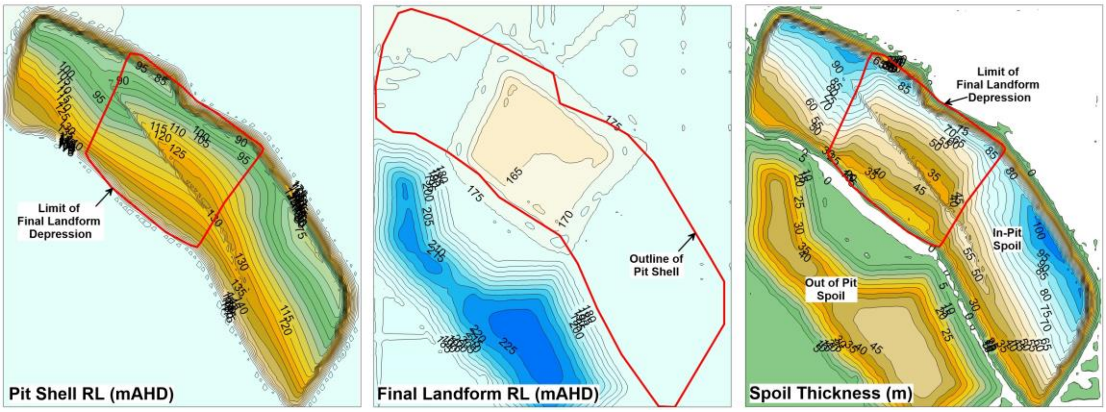


Figure 7.7 – Final landform depression catchments and land use (source: JBT, 2022)

The waste rock placed in the pit shell will be relatively pervious and provide a preferential source of groundwater recharge. After mining, rainfall and runoff would seep into the in-pit spoil within the pit shell.

Following prolonged rainfall, water would occasionally accumulate in the lowest parts of the landform before seeping through the spoil forming the floor of the depression. The seepage water would fill the interstitial pore space in the underlying waste rock and recharge the regional groundwater.

The results of the rehabilitated landform water balance show that due to the limited surface catchment and seepage through the base of the depression, intermittently accumulated water volumes would be relatively small. The mean modelled surface water volume was 8 ML, ranging up to 80 ML following periods of the highest recorded rainfall. Significantly more water would be stored in the interstitial pore space in the adjacent waste rock.

With the proposed landform design, the intermittent stored water depth would be very shallow (of the order of up to 1.2 m above the floor level). Under all climate change scenarios modelled, the long-term water levels would remain around 15 m below the spill level and would not overflow.

Catchment runoff is likely to provide a diminishing source of dissolved salts, and as there will be no groundwater inflows, seepage to the underlying spoil would prevent the accumulation of dissolved salts in the final landform depression.

The salinity of surface water within the rehabilitated landform depression will fluctuate over a relatively moderate range, such that the modelled median TDS under low and high runoff salinity scenarios was 270 mg/L and 465 mg/L respectively (ranging up to 553 mg/L and 950 mg/L).

The final landform would be shaped to ensure floodwaters are excluded from the residual depression of the rehabilitated pit.

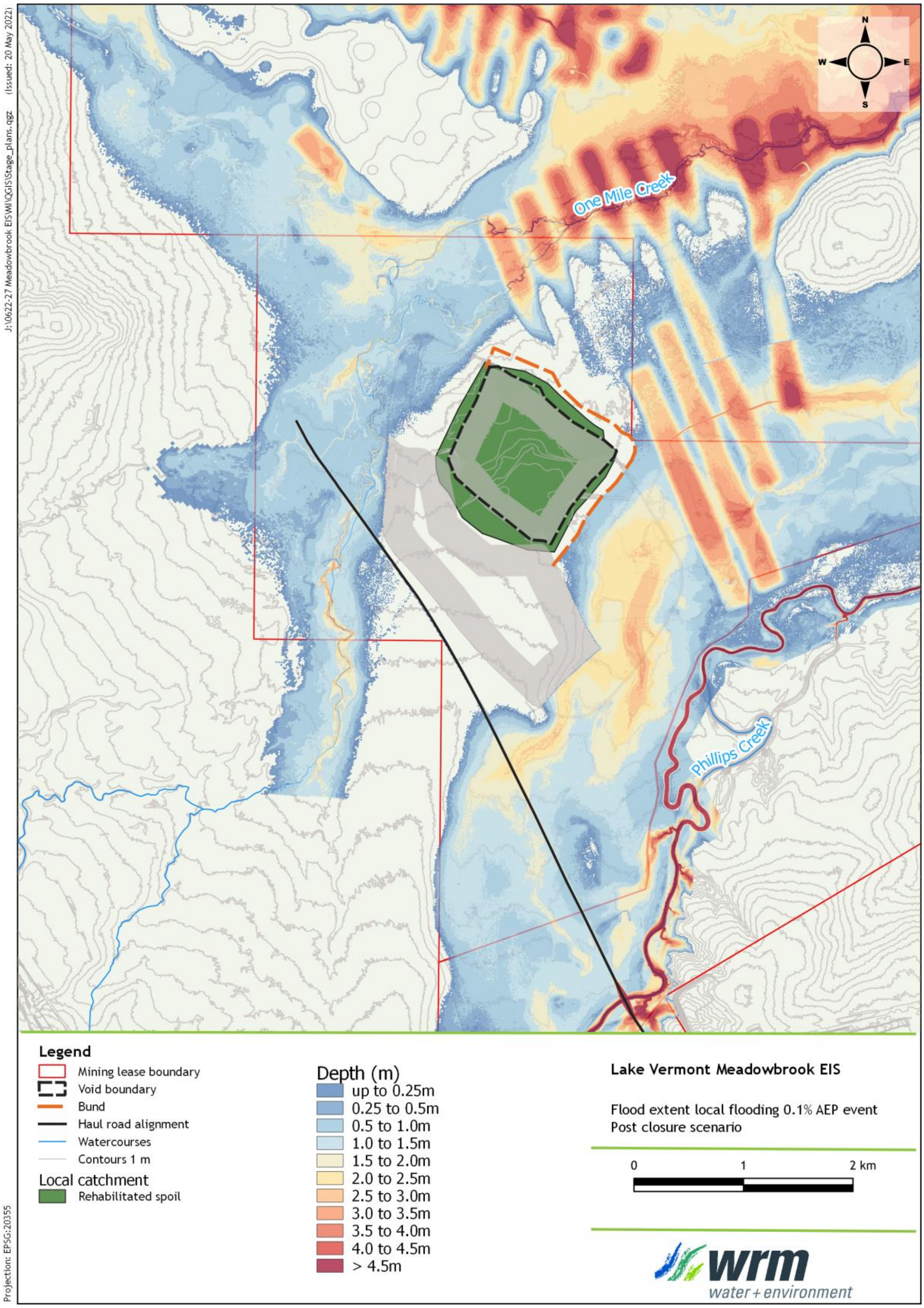


Figure 7.8 – Final landform depression and extent of 0.1% AEP flood

8 References

AARC, 2013	Lake Vermont Progressive Waste Characterisation Assessment, AustralAsian Resource Consultants, 2013
AARC, 2014	Lake Vermont Northern Extension Geochemical Waste Rock Characterisation, AustralAsian Resource Consultants, June 2014
AARC, 2022	Lake Vermont Meadowbrook Coal Mine Project Aquatic Ecology Assessment, Prepared for Bowen Basin Coal Pty Ltd, AARC Environmental Solutions, April 2022.
Alluvium, 2009	Isaac River Flood Study – Isaac River Cumulative Impact Assessment of Mine Developments
Alluvium, 2019	Technical Report: hydrology, hydraulics and geomorphology. Saraji East Mining Lease Project by Alluvium Consulting Australia for AECOM, QLD 4006
ANZG, 2020	Australian and New Zealand Governments (2020). Toxicant default guideline values for aquatic ecosystem protection: Total iron in marine water.
Ball et al., 2019	*'Australian Rainfall and Runoff – A Guide to Flood Estimation'*, Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) © Commonwealth of Australia (Geoscience Australia), 2019.
BMT, 2017	TUFLOW FLIKE (software), BMT, version 5.0.251.0, 2017.
BMT, 2018	*'TUFLOW Classic/HPC User Manual - Build 2019-03-AD'*, BMT Pty Ltd, 2018.
BMT, 2021	TUFLOW (software), BMT, version 2020-10-AB, 2021.
BoM, 2003	*'The Estimation of Probable Maximum Precipitation in Australia, Generalised Short Duration Method'*, Hydrometeorological Advisory Service, Commonwealth Bureau of Meteorology, June 2003.
BoM, 2005	*'Guidebook to the Estimation of Probable Maximum Precipitation: Generalised Tropical Storm Method'*, Hydrometeorological Advisory Service, Commonwealth Bureau of Meteorology, September 2005.
BoM, 2016	*2016 Rainfall IFD Data System, Bureau of Meteorology, http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016*
Boughton & Chiew, 2003	Calibrations of the AWBM for Use on Ungauged Catchments, Technical Report 03/15, Cooperative Research Centre for Catchment Hydrology, December 2003
Cardno, 2022	M31991 Lake Vermont Meadowbrook Project Land-Based Effluent Disposal Assessment Report, Cardno (Qld) Pty Ltd, 16 March 2022
Chow, 1959	*Open Channel Hydraulics,* written by V.T. Chow, McGraw-Hill Book Company, NY, 1959.

DEHP, 2011	*Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), September 2011*
DEHP, 2013	*'Manual for Assessing Consequence Categories and Hydraulic Performance of Structures'* Version 4, Queensland Government Department of Environment and Heritage Protection, November 2013.
DEHP, 2017	*Department of Environment and Science (DES) (2017). Model mining conditions.*
DEHP, 2013	*Department of Environment and Heritage Protection (DEHP) (2013). Model water conditions for coal mines in the Fitzroy Basin.*
DNRME, 2016	*'Isaac River at Deverill – Rating table'*, Queensland Department of Natural Resources, Mining and Energy, February 2016.
DNRM, 2019	Guideline: Works that interfere with water in a watercourse for a resource activity—watercourse diversions authorised under the Water Act 2000, The Department of Natural Resources, Mines and Energy OSW/2019/4599 Version 2.00 05/02/2019
DSITIA, 2015	Consistent Climate Change Scenarios project user guide, The State of Queensland (Department of Science, Information Technology and Innovation), 2015.
EPA, 2009	Queensland Government Environmental Protection Agency (2009). A study of the cumulative impacts on water quality of mining activities in the Fitzroy River Basin.
C. Dougall, C. Carroll, M. Herring, R. Trevithick, S. Neilsen and P. Burger, 2009	Enhanced sediment and nutrient modelling and target setting in the Fitzroy Basin, Technical Report, Department of Environment and Resource Management, 2009
FS, 2018	Pembroke Olive Downs Coking Coal Project (ODCCP) EIS study, Fluvial Systems 2018
Garcia, J. 2015	River Sinuosity Index: geomorphological characterisation (Technical Note) 2015/01/24
Geoscience Australia, 2019	ARR Data Hub (software), Geoscience Australia, Version 2019_v1, April 2019, <http://data.arr-software.org/>
G&S, 2016	Gilbert and Sutherland / Marsden Jacob Associates, Improving Mine Water Management for the Fitzroy Basin: Final Report on the Effectiveness of the 2012-13 Pilot Mine Water Release & Evaluation of Market Based Mechanisms
IESC, 2018	Information Guidelines for Independent Expert Scientific Committee advice (IESC, 2018) on coal seam gas and large coal mining development proposals
Jordan, *et al.*, 2005	Jordan, P., Nathan, R., Mittiga, L., and Taylor, B. (2005). Growth curves and temporal patterns of short duration design storms for extreme events.
GG, 2022	Subsidence prediction report for the Meadowbrook Underground Project, Gordon Geotechniques Pty Ltd 2022
Hjulstrom, 1935	"Studies of the morphological activity of rivers as illustrated by the River Fyris, Bulletin. Geological Institute Upsalsa, 25, 221-527

Innovyze, 2019	*XPRafts (software), Innoyvze, Version 2018.1.2, 2019.*
JBT, 2022	Meadowbrook Project Groundwater Impact Assessment, JBT Consulting Pty Ltd, July 2022
Minserve, 2017	'ML7052//MDL303/MDL429/MDL3001 (Lake Vermont Northwest) - Statement of Coal Resources North of ML70331 and West of the Isaac Fault', prepared for Bowen Basin Coal Pty Ltd by Minserve Group Pty Ltd, January 2017
Queensland Government, 2020	Terms of reference for an environmental impact statement under the Environmental Protection Act 1994 - Lake Vermont Meadowbrook Project proposed by Bowen Basin Coal Pty Ltd April 2020
RGS, 2021	Geochemical Assessment of Mining Waste Materials Lake Vermont Meadowbrook Project, RGS Environmental Pty Ltd, June 2021
WRM, 2022a	Meadowbrook Project Flood Modelling Assessment, WRM Water and Environment Pty Ltd, October 2022
WRM, 2022b	Meadowbrook Project Geomorphological Assessment, WRM Water and Environment Pty Ltd, October 2022
WRM, 2022c	Meadowbrook Project Site Water Balance and Water Management System, WRM Water and Environment Pty Ltd, October 2022
WRM, 2022d	Meadowbrook Project Rehabilitated Landform Water Balance, WRM Water and Environment Pty Ltd, October 2022