MACHEnergy

Mount Pleasant Operation

A JOINT VENTURE WITH JCDA Japan Coal Development Australia

Appendix D

Surface Water Assessment

REPORT

Mount Pleasant Optimisation Project Surface Water Assessment

Prepared for: MACH Energy Australia Pty Ltd

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Revision	Description	Author	Reviewer	Approved	Date
k	Final Report	CAW	TSM / Client	TSM	16-12-20

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1.0 INTRODUCTION

1.1 BACKGROUND AND OVERVIEW

The Mount Pleasant Operation (MPO) Development Consent DA 92/97 was granted on 22 December 1999. The MPO was also approved under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2012 (EPBC 2011/5795).

MACH Energy Australia Pty Ltd (MACH Energy) acquired the MPO from Coal and Allied Operations Pty Ltd on 4 August 2016. MACH Energy commenced construction activities at the MPO in November 2016 and commenced mining operations in October 2017, in accordance with Development Consent DA 92/97 and EPBC 2011/5795.

MACH Mount Pleasant Operations Pty Ltd manages the MPO as agent for and on behalf of the unincorporated Mount Pleasant Joint Venture between MACH Energy (95% owner) and JCD Australia Pty Ltd (5% owner).

The approved MPO includes the construction and operation of an open cut coal mine and associated rail spur and product coal loading infrastructure located approximately three kilometres (km) north-west of Muswellbrook in the Upper Hunter Valley of New South Wales (NSW) (refer Figures 1 and 2).

The mine is approved to produce up to 10.5 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal. Up to approximately nine trains per day of thermal coal products from the MPO are transported by rail to the Port of Newcastle for export or to domestic customers for use in electricity generation.

1.2 PROJECT OVERVIEW

MACH Energy is preparing an Environmental Impact Statement (EIS) to support a State Significant Development (SSD) Application for the Mount Pleasant Optimisation Project (the Project). The proposed key Project activities comprise:

- increased open cut coal extraction within MPO Mining Leases by mining of additional coal reserves, including lower coal seams in the North Pit;
- staged increase in extraction, handling and processing of ROM coal at a rate of up to 21 Mtpa (i.e. progressive increase in ROM coal mining rate from 10.5 Mtpa over the Project life);
- staged upgrades to the existing Coal Handling and Preparation Plant (CHPP) and coal handling infrastructure to facilitate the handling and processing of additional coal;
- rail transport of up to approximately 17 Mtpa of product coal to domestic and export customers;
- upgrades to workshops, electricity distribution and other ancillary infrastructure;
- existing infrastructure relocations to facilitate mining extensions (e.g. local roads, powerlines and water pipelines);
- construction and operation of new water management and water storage infrastructure in support of the Project;
- additional reject dewatering facilities to allow co-disposal of fine rejects with waste rock as part of ROM waste rock operations;
- development of an integrated waste rock emplacement landform that incorporates geomorphic drainage design principles for hydrological stability and varying topographic relief to be more natural in appearance;
- construction and operation of new ancillary infrastructure in support of Project operations;
- extension to the time limit on operations to 22 December 2048;

- an average operational workforce of approximately 600 people, with a peak of approximately 830 people;
- ongoing exploration activities and other associated infrastructure, plant, equipment and activities.

The proposed general arrangement of the Project is shown in Figure 2.

Hydro Engineering & Consulting Pty Ltd (HEC) has been commissioned by MACH Energy to prepare a Surface Water Assessment which will form a component of the EIS being prepared in support of the SSD Application.

Figure 1 Site Locality

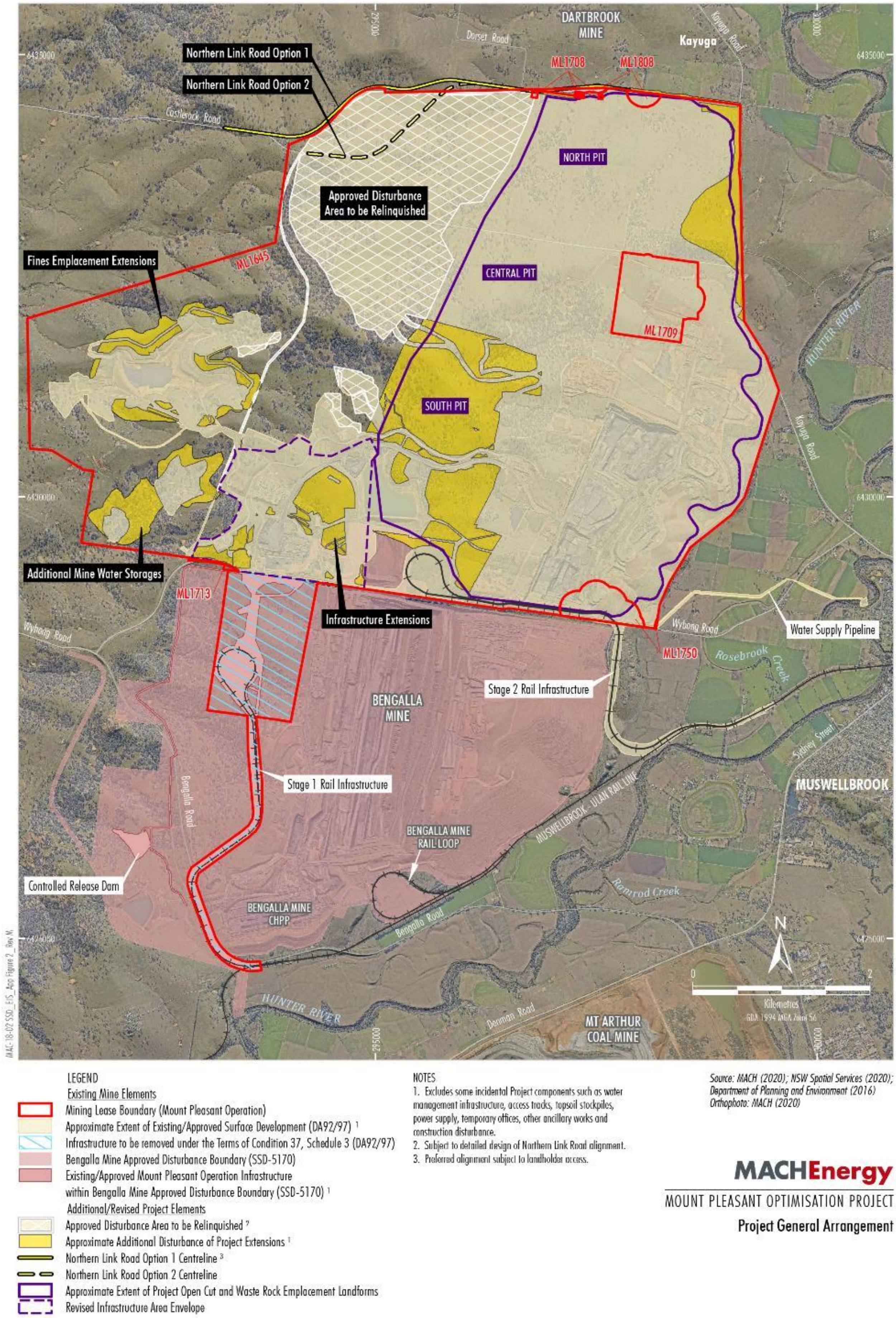


Figure 2 Project General Arrangement

2.0 REGULATORY FRAMEWORK

2.1 OVERVIEW

The following legislation, plans, policies and regulations have been considered in the preparation of this Surface Water Assessment:

- *Environmental Planning Assessment Act 1979* and the Secretary's Environmental Assessment Requirements (SEARs);
- *Water Management Act 2000, Water Management (General) Regulation 2018* and associated water sharing plans;
- *Protection of the Environment Operations Act 1997* and *Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002* (HRSTS);
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- Strategic Regional Land Use Policy, which considers potential impacts on agricultural land;
- *National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality* (Australian and New Zealand Environment Conservation Council [ANZECC] and the Agriculture and Resource Management Council of Australia and New Zealand [ARMCANZ], 2000), the *Australian and New Zealand Water Quality Guidelines* (ANZG, 2018) and the NSW Government Water Quality and River Flow Objectives;
- *Dams Safety Act 2015*;
- *Managing Urban Stormwater Soils and Construction – Volume 2E Mines and Quarries* (NSW Department of Environment and Climate Change [DECC], 2008) and *Managing Urban Stormwater, Soils and Construction* (Landcom, 2004) (collectively referred to as the 'Blue Book');
- NSW Flood Prone Land Policy; and
- *Significant impact guidelines 1.3: Coal seam gas and large coal mining developments—impacts on water resources* (Significant Impact Guidelines) (Commonwealth of Australia, 2013).

The design of infrastructure for the Project has considered the requirements of the above legislation, plans, policies and regulations. Further discussion on the regulatory framework with respect to surface water is provided in the following sections.

2.2 SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

This assessment has been prepared in accordance with the SEARs for the Project dated 17 February 2020, the supplementary SEARs dated 3 October 2020, and the letter from the delegate of the Planning Secretary to MACH Energy dated 2 October 2020. Table 1 provides a summary of the SEARs (including requirements provided by relevant agencies) related to surface water and reference to the relevant section of the report which addresses the requirement.

Table 1 Summary of SEARs and Relevant Sections

Reference	Requirements	Report Section
SEARS – Key Issues	**Water** – including:	
	• a detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures;	Section 4.0, 5.0 and 6.0
	• identification of any licensing requirements or other approvals under the *Water Act 1912* and/or *Water Management Act 2000*;	Section 2.3.2 and 2.3.3 and the EIS
	• demonstration that water for the construction and operation of the proposed development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP) or water source embargo;	Section 4.3.3
	• an assessment of any likely flooding impacts of the development;	Section 3.4.2
	• the measures which would be put in place to control sediment run-off and avoid erosion;	Section 9.0
	• an assessment of the likely impacts of the development on the quantity and quality of existing surface and groundwater resources including a detailed assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives; and	Section 8.0
	• an assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users.	Section 8.0
	Cumulative Impacts – including a detailed assessment of the cumulative impacts of the development, in combination with other existing and approved mining projects in the locality, with a particular focus on air quality, noise, traffic and social impacts, as well as impacts on water resources.	Section 8.3
BCD*	The EIS must describe background conditions for any water resource likely to be affected by the development, including:	
	a. Existing surface and groundwater.	Section 3.0
	b. Hydrology, including volume, frequency and quality of discharges at proposed intake and discharge locations.	Section 5.2 and 8.2
	c. Water Quality Objectives including groundwater as appropriate that represent the community's uses and values for the receiving waters.	Section 3.3.2
	d. Indicators and trigger values/criteria for the environmental values identified at (c) in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government.	Section 5.2.10
	The EIS must assess the impacts of the development on water quality, including:	Section 8.2
	a. the nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the development protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction.	

* Biodiversity and Conservation Division of the NSW Department of Planning Industry & Environment

Table 1 (Cont.) Summary of SEARs and Relevant Sections

Document	Requirements	Report Section
BCD	b. Identification of proposed monitoring of water quality.	Section 3.3, 3.4, 3.5 and 3.6
	The EIS must assess the impact of the development on hydrology, including:	
	c. Water balance including quantity, quality and source.	Section 4.1, 5.2.1, 5.2.6 and 6.2
	d. Effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas.	8.0
	e. Effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems.	Section 8.0
	f. Impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (e.g. river benches).	Section 8.0
	g. Changes to environmental water availability, both regulated/licensed and unregulated/rules-based sources of such water.	Section 8.4.3
	h. Mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options.	Section 2.9
	i. Identification of proposed monitoring of hydrological attributes.	Section 8.4
EPA*	**Water**	
	• Identify the condition of the local catchment and those immediate areas on and around the proposed development e.g. soils, erosion potential, vegetation cover, etc;	Section 3.2, 4.2 and 4.3
	• Identify nearby water resources, the background water conditions (including river flow data, water flow/direction and quality data, the depth to groundwater, groundwater flow/gradient and quality data, reliance on water resources by surrounding users and by the environment) and relevant water quality objectives in line with relevant guidance/standards; and	Section 3.0
	• Identify existing impacts to water resources (including other industrial discharges);	Section 8.3
	• Identify any water intakes, intake frequency and volumes related to the proposed development;	N/A
	• Identify any expected discharges (including stormwater), discharge quality, discharge frequency and volumes related to the proposed development;	Section 4.3, 5.2.3, 5.2.7, 6.6, 8.2 and 9.1
	• Identify all practical measures that can be taken to prevent any expected discharges or an explanation of why any specific discharges cannot be prevented;	Section 9.1
	• Identify potential impacts to surface and groundwater during both construction and operational stages and identify best practice mitigation measures (pollution control) and strategies to protect surface and groundwater resources, particularly erosion and sediment controls during the construction stage and the rehabilitation stage and the inclusion of permanent erosion and sediment controls where required and applicable;	Section 9.1

* NSW Environmental Protection Authority

Table 1 (Cont.) Summary of SEARs and Relevant Sections

Document	Requirements	Report Section
EPA	• Include a detailed water balance and discharge inventory; and • Include an assessment of any mixing zones; and • Include any proposed discharge limits. Note: this will require a detailed Water Quality Assessment to be completed.	Section 2.4, 4.3 and 5.2
Muswellbrook Council	Water 1. Provide an assessment of the likely impacts of the development on the quantity and quality of existing surface water resources including a detailed assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives; 2. Provide an assessment of the likely impacts of the development on groundwater resources, 3. Provide an assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users, including cumulative impacts of water licences issued to the Project, other mines, and power stations that will permanently remove water from the catchment. Each mine says they hold sufficient water licences to cover “loss of water”. But the loss is permanent, and if the water sharing regime needs to change in the broader catchment for societal, ecological, or climate change reasons, or to satisfy the requirements for emerging industries, the water loss due to mines will place limitations on the ability to change the water sharing regime.	Section 8.0
NSW Government Resources Regulator	Where a void is proposed to remain as part of the final landform, include: ... outcomes of the surface and groundwater assessments in relation to the likely final water level in the void. This should include an assessment of the potential for fill and spill along with measures required be implemented to minimise associated impacts to the environment and downstream water users.	Section 7.0
DPIE* and NRAR†	The SEARS should include: • The identification of an adequate and secure water supply for the life of the project. This includes confirmation that water can be sourced from an appropriately authorised and reliable supply. This is also to include an assessment of the current market depth where water entitlement is required to be purchased. • A detailed and consolidated site water balance. • Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts. • Proposed surface and groundwater monitoring activities and methodologies. • Consideration of relevant legislation, policies and guidelines, including the NSW Aquifer Interference Policy (2012), the Guidelines for Controlled Activities on Waterfront Land (2018) and the relevant Water Sharing Plans.	Section 2.2, 3.0 Section 4.3.3 and the EIS Section 6.2 Section 8.0 Section 5.2.5 Section 2.1 and the EIS

* NSW Department of Planning Industry & Environment

† NSW Government Natural Resources Access Regulator

2.3 WATER MANAGEMENT ACT 2000

The objects of the *Water Management Act 2000* are to provide for the sustainable and integrated management of the water sources of the State for the benefit of both present and future generations.

2.3.1 Water Sharing Plans

Surface water in the vicinity of the Project is regulated by the following water sharing plans released under the *Water Management Act 2000* (Figure 3):

- *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009*.
- *Water Sharing Plan for the Hunter Regulated River Water Source 2016*.

Subclause 4(2) of the *Water Sharing Plan for the Hunter Regulated River Water Source 2016* provides that the plan applies to:

- all water between the bed and banks of all rivers, from the Glenbawn Dam water storage downstream to the Hunter River, and from Glennies Creek Dam water storage downstream to the junction with the Hunter River, which have been declared by the Minister to be regulated rivers; and
- all water contained within the unconsolidated alluvial sediments underlying the waterfront land of all rivers referred to above.

The Hunter River Management Zone 1A (Hunter River from Glenbawn Dam to Goulburn River Junction) is located to the east and south of the Project.

The *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009* applies to all other surface water and alluvial groundwater occurring in the vicinity of the Project. The Project Mining Leases are located wholly within the Muswellbrook Water Source, directly south of the Dart Brook Water Source (Figure 3).

2.3.2 Water Licensing

Under the *Water Management Act 2000*, it is an offence to "take" water without a water licence unless an exemption applies.

MACH Energy holds the following surface water entitlements for the Project:

- 961 units of Hunter Regulated River (High Security); and
- 589 units of Hunter Regulated River (General Security) (MACH Energy also holds 2,348 units currently assigned to MACH Energy-owned agricultural properties around the Project; these entitlements could be assigned to the Project if and when required).

In addition to the above, MACH also holds 41 units of Muswellbrook Water Source (aquifer) water allocation licence (WAL), currently assigned to a MACH Energy-owned agricultural property. This WAL (or part thereof) could be assigned to the Project if and when required.

2.3.3 Excluded Works under the Water Management (General) Regulation 2018

The Project would involve the use of the existing/approved water management infrastructure with augmentations and extensions, including the progressive development of pumps, pipelines, water storage dams and other water management infrastructure.

Item 12 of Schedule 4 of the *Water Management (General) Regulation 2018* provides access licence exemptions in relation to water take from or by means of certain works specified in Schedule 1, known as 'excluded works'.

Items of relevance to the Project in Schedule 1 of the *Water Management (General) Regulation 2018* are as follows:

1 Dams solely for the control or prevention of soil erosion:

(a) from which no water is reticulated (unless, if the dam is fenced off for erosion control purposes, to a stock drinking trough in an adjoining paddock) or pumped, and

(b) the structural size of which is the minimum necessary to fulfil the erosion control function, and

(c) that are located on a minor stream.

…

3 Dams solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice or required by a public authority (other than Landcom or the Superannuation Administration Corporation or any of their subsidiaries) to prevent the contamination of a water source, that are located on a minor stream.

2.3.4 Harvestable Rights

Harvestable rights orders under the *Water Management Act 2000* allow owners or occupiers of a landholding to collect, without the need for a water access licence, a proportion of the average regional rainfall runoff on their land by means of one or more dams.

More specifically, the Harvestable Rights Order for the Eastern and Central Division of NSW made under section 54 of the *Water Management Act 2000* (NSW Government Gazette No. 40 of 31 March 2006, p 1628) allows the capture of up to 10% of the average regional rainfall runoff on a landholding by a dam or dams up to a certain capacity, which are located on minor streams.

The maximum harvestable rights dam capacity (MHRDC) for MACH Energy was calculated using the WaterNSW online harvestable rights calculator. An assumed total contiguous property area of 5,110 hectares resulted in a maximum harvestable rights capacity of 358 ML based on an average annual rainfall runoff of 0.7 ML/ha specified by the WaterNSW harvestable rights calculator.

There are currently 66 farm dams on MACH Energy's landholdings. The total combined surface area of these dams is 6.1 ha. Based on an average assumed depth of 1.5 m, the total capacity of these existing farm dams has been conservatively estimated to be approximately 92 ML. Accordingly, the residual harvestable rights dam capacity available for the Project is 266 ML.

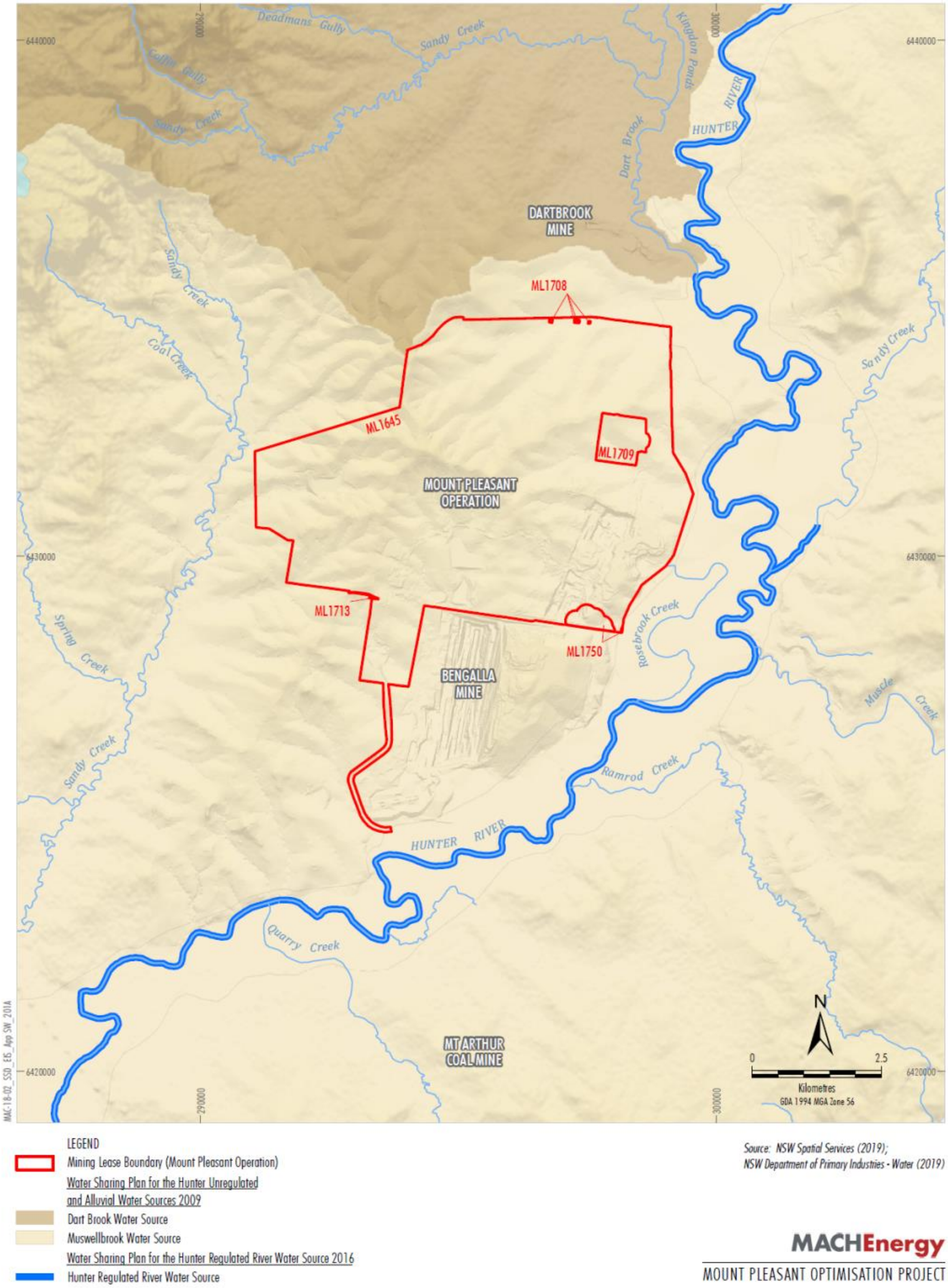


Figure 3 Relevant Surface Water Sources

2.4 PROTECTION OF THE ENVIRONMENT OPERATIONS ACT 1997

The *Protection of the Environmental Operations Act 1997* and the *Protection of the Environment Operations (General) Regulation 2009* set out the general obligations for environmental protection in NSW.

Under section 48 of the *Protection of the Environmental Operations Act 1997*, it is an offence to carry out a "scheduled activity" (including coal mining above a certain capacity or disturbance area) without an Environment Protection Licence (EPL).

The MPO operates in accordance with EPL 20850.

The HRSTS was originally established by the then Department of Land and Water Conservation and Hunter River Trust in 1995 as a pilot trial to manage salinity discharges to the Hunter River, such that salt concentrations would be held below irrigation and environmental standards. The HRSTS is now managed by the NSW Environment Protection Authority (EPA) under the *Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002*.

The HRSTS prohibits the release of saline water during periods of low flow in the Hunter River and controls releases of saline water during periods of high flow in the Hunter River such that specific salinity targets at various points in the river are not exceeded.

Participants in the HRSTS are issued with tradeable discharge credits. Each credit entitles the holder to a share of the available salt discharge capacity announced by WaterNSW during high flow periods. MACH Energy currently holds 41 HRSTS discharge credits.

Discharges at the MPO would be undertaken in accordance with the HRSTS and EPL 20850.

The approved discharge dam (DW1) will be located to the west of Bengalla Road and is planned to be commissioned in early 2022 (refer Section 4.0).

2.5 ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

On 29 February 2012, the Mount Pleasant Project was granted approval, subject to conditions, by the Commonwealth Minister's delegate, under sections 130(1) and 133 of the EPBC Act (EPBC 2011/5795). The conditions attached to the EPBC Act approval have since been varied on a number of occasions.

The proposed action to increase open cut coal extraction to allow mining of additional coal reserves and increase processing operations at the MPO not already authorised by the Approval Decision EPBC 2011/5795 was referred to the Commonwealth Minister for the Environment and Energy in July 2020 (EPBC 2020/8735) (the proposed action).

A delegate of the Commonwealth Minister determined on 26 August 2020 that the proposed action is a "controlled action" and therefore the action requires approval under the EPBC Act due to potential impacts on the following Matters of National Environmental Significance (MNES) under Part 3 of Chapter 2 of the EPBC Act:

- threatened species and communities; and
- a water resource, in relation to large coal mining development.

The delegate of the Commonwealth Minister also determined, pursuant to section 87 of the EPBC Act, that the proposed action is to be assessed by the accredited assessment process under Part 4 of the *Environmental Planning and Assessment Act, 1979* (EP&A Act). Accordingly, this assessment considers potential impacts of the proposed action in Section 8.4.

2.6 STRATEGIC REGIONAL LAND USE POLICY

The Strategic Regional Land Use Policy aims to identify, map and protect valuable residential and agricultural land from the impacts of mining. Implementation of the policy includes the Gateway process to closely examine the potential impacts of new mining proposals on strategic agricultural land and equine and viticulture critical industry clusters.

The Project does not require a Gateway Certificate or Site Verification Certificate as it does not require a new Mining Lease.

2.7 NATIONAL WATER QUALITY MANAGEMENT STRATEGY

The *NSW Water Quality and River Flow Objectives* (Office of Environment and Heritage [OEH], 2006) have been developed to guide plans and actions to achieve healthy waterways in NSW.

Each objective is based on providing the right water quality for the environment and the different beneficial uses of the water. They are based on measurable environmental values, which are those values or uses of water that the community believes are important for a healthy ecosystem for public benefit, welfare, safety or health.

The target concentrations for each water quality objective are based on *National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ, 2000). The *Australian New Zealand Water Quality Guidelines* (ANZG, 2018) have been developed to progressively supersede the ANZECC & ARMCANZ (2000) Guidelines, with revisions provided for aquatic ecosystem default guideline values. Where updated default guideline values are yet to be published under the ANZG (2018) Guidelines, adoption of the ANZECC & ARMCANZ (2000) Guideline default values is recommended.

2.8 DAMS SAFETY ACT 2015

The following existing dams at the MPO are declared dams under section 5 of the *Dams Safety Act 2015*:

- Mount Pleasant ED3 (Environmental Dam 3);
- Mount Pleasant MWD (Mine Water Dam); and
- Mount Pleasant TD (Tailings Dam - Fines Emplacement Area).

These dams would continue to be used for the Project.

Bengalla CW1 and the Bengalla Discharge Dam are Bengalla Mine dams located in the vicinity of the Project. They are also declared dams under the *Dams Safety Act 2015*.

Under section 48 of the *Dams Safety Act 2015*, the area of land surrounding, or in the vicinity of, a declared dam can be deemed a notification area. Before granting development consent for any mining operations in a notification area, a consent authority must refer the application for development consent to Dams Safety NSW and take into consideration any matters that are raised by Dams Safety NSW in relation to the application.

2.9 MANAGING URBAN STORMWATER SOILS AND CONSTRUCTION

Managing Urban Stormwater: Soils and Construction (Landcom, *2004*) provides guidance on best practice management measures for erosion and sediment control during construction and other land disturbance activities. *Managing Urban Stormwater Soils and Construction – Volume 2E – Mines and*

Quarries (DECC, 2008) provides specific advice on appropriate measures and design standards for mining operations.

The design of erosion and sediment control measures for the Project has been based on the recommended approaches and design criteria from these documents.

2.10 NSW FLOOD PRONE LAND POLICY

The NSW Government's Flood Prone Land Policy is directed at providing solutions to existing flooding problems in developed areas, and ensuring that new developments are compatible with the flood hazard and do not create additional flooding problems in other areas. Under the Flood Prone Land Policy, the management of flood prone land remains the responsibility of local government. To facilitate this, the NSW Government has published the *Floodplain Development Manual: The Management of Flood Liable Land* (Department of Infrastructure, Planning and Natural Resources [DIPNR], 2005), to provide guidance to councils in the implementation of the Flood Prone Land Policy, and provide funding in support of floodplain management programs.

Muswellbrook Shire Council commissioned Royal HaskoningDHV (RHDHV) to produce the Hunter River (Muswellbrook to Denman) Floodplain Risk Management Study. The Floodplain Risk Management Study builds on the Hunter River Flood Study (Muswellbrook to Denman) that was prepared by Worley Parsons for Muswellbrook Shire Council in 2014.

3.0 BASELINE SURFACE WATER RESOURCES

The Project is located within the Hunter River catchment, which covers an area of approximately 21,500 square kilometres (km^2), and includes the major towns of Newcastle, Singleton and Muswellbrook (refer Figure 1). The Hunter River flows in a south-westerly direction approximately 1 km to the east of the MPO and is regulated by two major storages operated by WaterNSW: the Glenbawn and the Glennies Creek Dams. The Glenbawn Dam is located approximately 16 km upstream of the MPO mining lease boundary, while the Glennies Creek Dam is located on a tributary of the Hunter River approximately 37 km east of the MPO mining lease boundary. Glenbawn Dam has an operating capacity of 750,000 ML with water supplied to the surrounding region for agricultural and industrial purposes. Glenbawn Dam also serves a flood mitigation function with an additional 120,000 ML available for flood storage. Glennies Creek Dam has a capacity of 283,000 ML and provides water supply for irrigation, environmental flows, stock, industry and household needs in the Hunter Valley.

3.1 RAINFALL AND EVAPORATION

The long-term average monthly rainfall recorded at regional Bureau of Meteorology (BoM) stations is summarised in Table 2 in comparison with Scientific Information for Land Owners (SILO) Point Data[1] average monthly rainfall. The locations of the stations and SILO data point are shown in Figure 4.

Table 2 Summary of Average Regional Rainfall (mm)

BoM Station Number	**61053**	**61192**	**61374**	**61168**	**61000**	**SILO Point Data**
BoM Station Name	**Muswellbrook (Lower Hill St)**	**Muswellbrook (Spring Creek)**	**Muswellbrook (St.Heliers)**	**Muswellbrook (Lindisfarne)**	**Aberdeen (Main Rd)**	
Latitude	**-32.26**	**-32.21**	**-32.22**	**-32.31**	**-32.17**	**-32.25**
Longitude	**150.88**	**150.74**	**150.92**	**150.76**	**150.89**	**150.85**
Data Period	Sep 1870 – Dec 2012	Dec 1960 – Jan 2020	Nov 1992 – Jun 2020	Nov 1960 – Apr 2020	Jun 1894 – May 2020	Jan 1889 – Jun 2020
January	69.8	86.2	59.7	77.9	73.5	73.3
February	66.6	66.8	63.8	61.1	62.2	63.2
March	52.8	73.0	61.7	60.1	51.6	56.7
April	43.2	45.1	37.4	37.0	40.2	42.0
May	41.5	47.2	41.9	40.7	41.5	39.5
June	51.3	43.5	50.1	37.8	44.5	48.2
July	44.2	32.8	35.9	29.6	40.6	41.3
August	38.6	36.2	38.9	30.1	36.5	37.6
September	40.5	37.1	45.9	38.9	39.1	40.2
October	48.6	52.9	43.3	49.8	49.3	48.3
November	56.1	64.8	71.8	57.2	50.9	53.6
December	67.0	74.5	60.8	63.3	66.1	63.8
Annual	**620**	**653**	**580**	**593**	**601**	**608**

[1] The SILO Point Data is a system which provides synthetic daily climate data sets for a specified point by interpolation between surrounding point records held by BoM – Queensland Department of Environment and Science (2020).

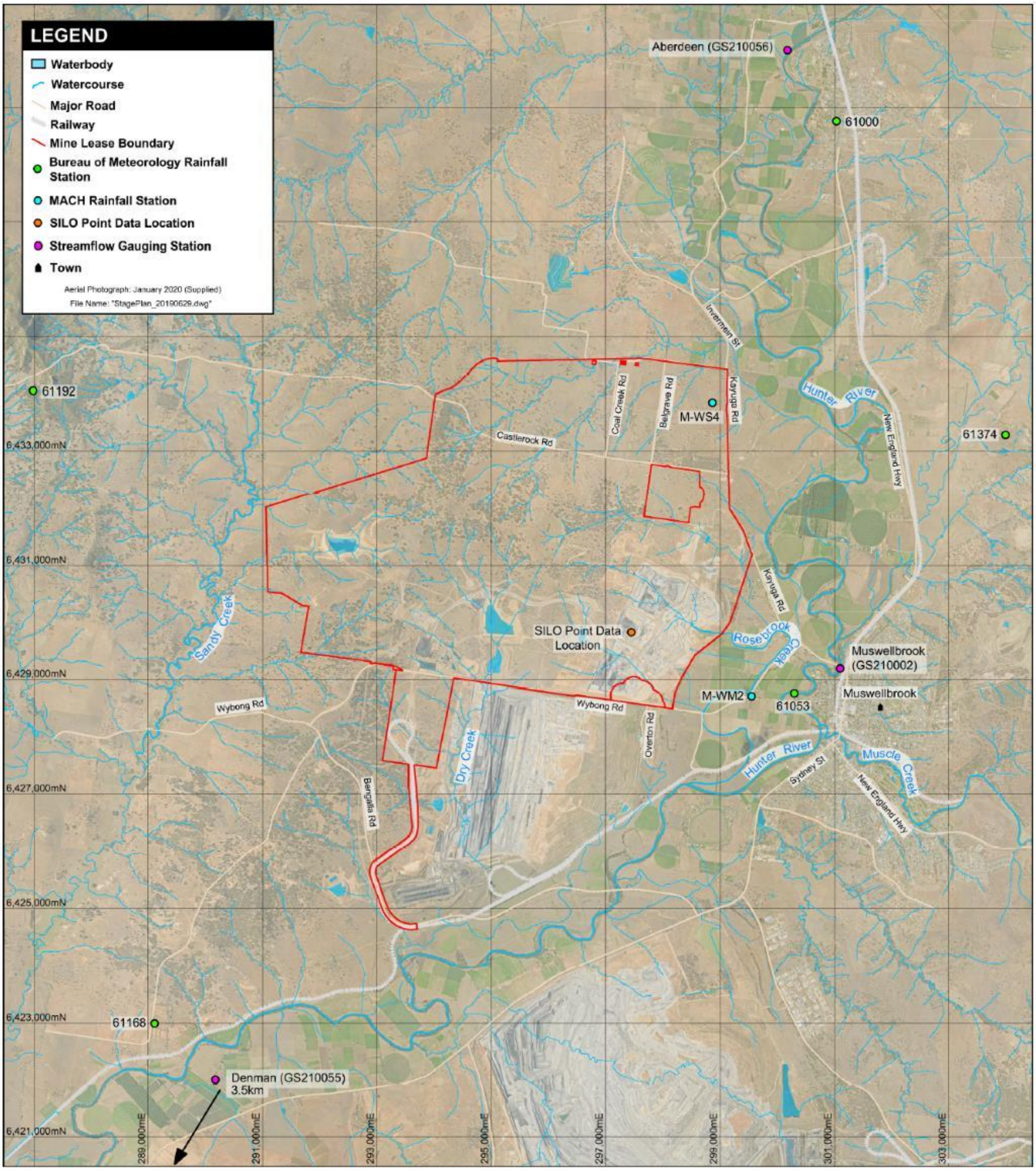


Figure 4 Surface Water Systems and Regional Monitoring Sites

Table 2 illustrates that rainfall is typically spread throughout the year but tends to be higher in the summer months. The average long-term annual rainfall for stations with corresponding periods of record varies between 593 millimetres (mm) at Muswellbrook (Lindisfarne) and 653 mm at Muswellbrook (Spring Creek).

MACH Energy also operates meteorological stations at Kayuga Road (M-WS4) and Wybong Road (M-WS2) which measure rainfall, wind speed and direction, temperature, solar radiation, relative humidity and atmospheric pressure (refer Figure 4 for locations). Data has been recorded at M-WS4 since January 2019 and at M-WS2 since July 2019. The total monthly rainfall recorded at each station is presented in Table 3 for the period July 2019 to June 2020.

Table 3 Total Monthly Rainfall at On-site Meteorological Stations

Year	Month	Total Monthly Rainfall (mm)	
		Kayuga Road (M-WS4)	Wybong Road (M-WS2)
2019	July	6.1	8.8
	August	18.0	20.2
	September	39.4	29.2
	October	11.4	18.0
	November	31.2	40.2
	December	18.2	3.2
2020	January	74.2	88.2
	February	131.4	138.6
	March	55.5	55.0
	April	101.1	106.4
	May	21.6	24.6
	June	27.8	31.6
Total		536	564

The data in Table 3 illustrates that an average total rainfall of 550 mm was recorded at the MPO between July 2019 and June 2020.

Average monthly pan evaporation, calculated from long-term synthetic data obtained from the SILO Point Data for the MPO is provided in Table 4. A comparison of Table 2 and Table 4 illustrates that average annual pan evaporation is approximately 2.5 times greater than average annual rainfall in the vicinity of the MPO (SILO Point Data), with average pan evaporation exceeding average rainfall in all months.

Table 4 Average Monthly Pan Evaporation

Month	Pan Evaporation (mm)
January	209
February	164
March	146
April	101
May	70
June	52
July	61
August	87
September	116
October	154
November	181
December	210
Annual Average	1,551

Number of years of data = 131.5.

3.2 CATCHMENTS AND SURFACE WATER RESOURCES

3.2.1 Surface Water Drainage

The drainage network in the vicinity of the MPO is generally characterised by steep gullies which emanate from areas of higher topography in the surrounding hills to the alluvial floodplains adjacent to the Hunter River (refer Figure 4).

Rosebrook Creek and two unnamed tributaries of Rosebrook Creek traverse the eastern portion of the MPO and join the Hunter River approximately 3 km downstream of the south-eastern MPO boundary. Multiple unnamed headwater drainage lines traverse the central portion of the site, which is part of the catchment of Dry Creek (this is an unnamed tributary of the Hunter River however its colloquial name of Dry Creek has been used throughout this report). The western portion of the site lies within the catchment of Sandy Creek. Both Dry Creek and Sandy Creek are tributaries of the Hunter River.

The Dry Creek Project, implemented by Bengalla Mine, was designed to divert Dry Creek around the Bengalla Mine. The Dry Creek Project comprises a dam north of Wybong Road, a pump station and pipeline and a protective contour levee to release water from the pipeline into an unnamed tributary of the Hunter River. The Bengalla Mining Company (BMC) monitors water quality at sites on unnamed drainage lines and the Hunter River, downstream of the MPO. Mangoola Coal Operations Pty Limited (MCO) also undertakes surface water and stream health monitoring in Sandy Creek downstream of the MPO.

3.2.2 Licensed Discharge Points

Discharges at the Project would continue to be undertaken in accordance with the HRSTS and EPL 20850. MACH Energy currently holds 41 discharge credits with no discharges undertaken to date (MACH Energy, 2019a).

The approved discharge dam (DW1) will be located to the west of Bengalla Road and is planned to be commissioned in early 2022.

3.3 SURFACE WATER MONITORING PROGRAM

3.3.1 Program Description

Surface water quality monitoring has been undertaken in the vicinity of the MPO from January 1993 to December 1994 and from July 2000 to present at sites shown in Figure 5.

The water quality monitoring results for the period January 1993 to December 1994 are presented in ERM Mitchell McCotter (ERMMM) (1997) and results summarised in Section 3.5.

The water quality monitoring results for the period July 2000 to May 2020 are summarised in this report. Water quality monitoring is undertaken for two suites of parameters as follows:

- Suite 1: pH, electrical conductivity (EC), total suspended solids (TSS) and total dissolved solids (TDS)
- Suite 2: pH, EC, TSS, total metals, turbidity, dissolved oxygen, total phosphorus and total nitrogen.

MACH Energy's surface water monitoring sites are shown on Figure 5 and listed in Table 5 along with a summary of the type of monitoring undertaken at each site, the frequency of monitoring and the period of record available for the Surface Water Assessment (this report).

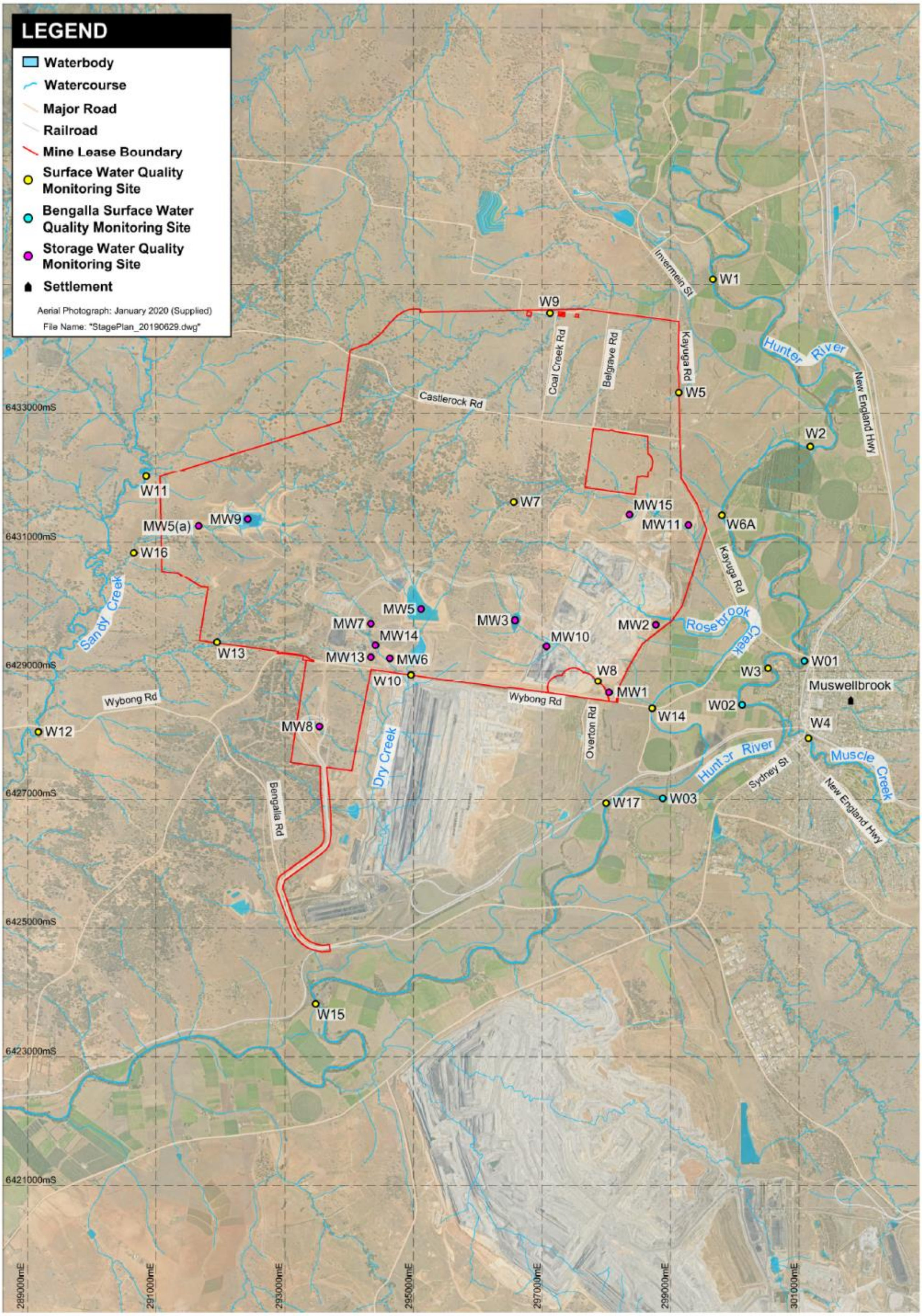


Figure 5 MPO Water Quality Monitoring Sites

Table 5 Surface Water Monitoring Program

Site	Watercourse & Location	Period of Record	Type of Monitoring
W1	Hunter River (upstream)	Jul 2000 – May 2020	Monthly & event based† (Suite 1) Special Frequency^ (Suite 2)
W2	Hunter River (central)	Jul 2000 – May 2020	Baseline – monthly (Suite 1) Operational - monthly & event based (Suite 1) Special Frequency (Suite 2)
W3	Hunter River (Muswellbrook)	Oct 2011 – May 2020	Baseline – monthly (Suite 1) Operational - monthly & event based (Suite 1) Special Frequency (Suite 2)
W4	Muscle Creek (east of the MPO site, outside of influence)	Jul 2000 – May 2020	Event based (Suite 1)
W5	Unnamed drainage line north-east of the MPO site	Nov 2005 – May 2020	Operational - monthly & event based (Suite 1) Special Frequency (Suite 2)
W6A‡	Hunter River (central)	Jul 2000 – May 2020	Baseline – monthly (Suite 1) Operational - monthly & event based (Suite 1) Special Frequency (Suite 2)
W7	Unnamed drainage line within the MPO site	Jul 2010 – May 2020	Baseline – monthly (Suite 1) Operational - monthly & event based (Suite 1) Special Frequency (Suite 2)
W8	Unnamed drainage line south-east of the MPO site	Feb 2005 – May 2017	Discontinued
W9	Unnamed drainage line north of the MPO site	Jun 2007 – May 2020	Operational - monthly & event based (Suite 1) Special Frequency (Suite 2)
W10	Dry Creek	Feb 2005	Discontinued
W11	Sandy Creek (upstream)	Oct 2017 – May 2020	Monthly & event based (Suite 1) Special Frequency (Suite 2)
W12	Sandy Creek (downstream)	Oct 2017 – May 2020	Baseline – monthly (Suite 1) Operational - monthly & event based (Suite 1) Special Frequency (Suite 2)
W13	Unnamed drainage line south-west of the MPO site	Feb 2018 – May 2020	Baseline – monthly (Suite 1) Operational - monthly & event based (Suite 1) Special Frequency (Suite 2)
W14	Rosebrook Creek	No data*	Monthly & event based (Suite 1) Special Frequency (Suite 2)
W15	Hunter River (downstream)	Oct 2017 – May 2020	Monthly & event based (Suite 1) Special Frequency (Suite 2)
W16	Unnamed drainage line west of the MPO site	Jan 2020 – May 2020	Baseline – monthly (Suite 1) Operational - monthly & event based (Suite 1) Special Frequency (Suite 2)
W17	Hunter River (downstream)	Jan 2020 – May 2020	Monthly & event based (Suite 1) Special Frequency (Suite 2)

* Dry or insufficient water for sampling; † Event based frequency occurs no more than once per month; ^ Special Frequency = quarterly until the end of 2018 and annually thereafter; ‡ Monitoring site W6 was replaced by site 6A (located approximately 500 metres downstream of site W6) in 2011.

Water quality monitoring is also undertaken by WaterNSW at three gauging stations on the Hunter River in the vicinity of the MPO (refer Figure 4). Near continuous records of EC are available from March 1998 for GS 210056, February 1992 at GS 210002 and February 1993 at GS 210055. Grab samples have also been collected with records available for physicochemical properties, nutrients, minerals and some metals. The water quality records for each site are summarised in Section 3.5.

3.3.2 Water Quality Objectives

As documented in the MPO Surface Water Management Plan (SWMP; MACH Energy, 2019b), surface water quality site specific trigger values have been developed for the site in accordance with the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ, 2000). Site specific trigger values based on the 20th and 80th percentile[2] of the site specific monitoring data were derived from datasets collected over two years of monthly sampling (i.e. 24 data points) for the baseline monitoring period. The period of July 2000 to July 2016 (inclusive) was adopted as the baseline monitoring period as this represents the period prior to commencement of construction at the MPO (MACH Energy, 2019b).

Site specific trigger values were derived for water quality at sites W2 and W6A on the Hunter River, although there was insufficient data to develop site specific trigger values for TDS. Site W17 also on the Hunter River was assigned site specific trigger values as defined in the Bengalla Water Management Plan (BMC, 2016). The site specific trigger values were derived in accordance with ANZECC & ARMCANZ (2000), with the 80th percentile for each constituent calculated from the baseline dataset for the Bengalla monitored Hunter River sites W01, W02 and W03 (refer Figure 5). Sufficient monitoring data (over two years of monthly monitoring) has now been recorded for two sites which are not currently influenced by the MPO, namely W3 on the Hunter River and W12 on Sandy Creek. As such, site specific trigger values have been derived for these sites and are summarised in Section 3.5.

Sites W1 and W4 are located upstream or outside of the influence of the MPO and act as reference sites for comparison with potential impact sites. As such, site specific trigger values have not been derived for these sites. Sites W5, W7 and W9 are located on ephemeral drainage lines which are frequently dry and as such insufficient data was available to develop site specific trigger values for inclusion in the SWMP (MACH Energy, 2019b). Site specific trigger values for newly established (post 2017) surface water monitoring sites (W11 – W16) were also not included in the SWMP due to insufficient data points, although the SWMP states that site specific trigger values will be developed for these sites once sufficient monitoring data has been collected (MACH Energy, 2019b).

The site specific trigger values specified in the SWMP (MACH Energy, 2019b) are presented in Table 6.

Table 6 Surface Water Quality Site Specific Trigger Values

Site	pH	EC (µS/cm)	TSS (mg/L)
	20th / 80th Percentile Trigger Values	80th Percentile Trigger Value	80th Percentile Trigger Value
W2	6.5 – 8.3	539	18
W6A	6.5 – 8.4	496	19
W17	6.5 - 8.1	650	40

µS/cm = micro Siemens per centimetre; TSS = Total Suspended Solids; mg/L = milligrams per litre.

[2] 20th percentile for pH only.

The revised Water Quality Management Framework detailed in the ANZG (2018) Guidelines states that where locally relevant water quality guideline values are not yet available, the default guideline values should be adopted. However, updated default guideline values are yet to be published under the ANZG (2018) Guidelines for physicochemical constituents and, as such, adoption of the ANZECC & ARMCANZ (2000) Guideline default values are recommended. Updated default guideline values for toxicants have been published by ANZG (2018) and are adopted in the assessment of baseline water quality data presented in the following sections.

In NSW, the level of protection applied to most waterways is that for 'slightly to moderately disturbed' ecosystems, for which ANZG (2018) recommends adoption of the default guideline values for aquatic ecosystems at the 95% protection level. The baseline water quality data for physicochemical constituents has been assessed against the ANZECC & ARMCANZ (2000) default guideline values for the protection of slightly disturbed aquatic ecosystems in south-east Australian Upland and Lowland Rivers. Upland streams are defined as those above 150 metres (m) altitude. The default guideline values listed in Table 7 have been used as a basis for interpretation of the water quality data in Section 3.5, in addition to the site specific trigger values for sites W2, W3, W6A, W12 and W17.

Table 7 Water Quality Default Guideline Values

Parameter	Aquatic Ecosystems (95% level of species protection)†	Aquatic Ecosystems (Upland Rivers in NSW)‡	Aquatic Ecosystems (Lowland Rivers in NSW)‡	Primary Industries (Short Term Irrigation and Livestock Drinking)*
pH (pH units)	-	6.5 - 8	6.5 – 8.5	-
EC (µS/cm)	-	350	300	-
Turbidity (NTU)	-	2 - 25	6 - 50	-
TDS (mg/L)	-	-	-	2,000
Aluminium (pH > 6.5)	0.055	-	-	-
Arsenic - As III (mg/L)	0.024	-	-	-
Boron (mg/L)	0.37	-	-	-
Beryllium (mg/L)	-	-	-	0.5
Cadmium (mg/L)	0.0002	-	-	-
Chromium (mg/L)	0.001	-	-	-
Cobalt (mg/L)	-	-	-	0.1
Copper (mg/L)	0.0014	-	-	-
Iron (mg/L)	-	-	-	10
Lead (mg/L)	0.0034	-	-	-
Lithium (mg/L)	-	-	-	2.5
Manganese (mg/L)	1.9	-	-	-
Mercury (mg/L)	0.0006	-	-	-
Nickel (mg/L)	0.011	-	-	-
Selenium (mg/L)	0.011	-	-	-
Sodium (mg/L)	-	-	-	115
Sulphate (mg/L)	-	-	-	1,000
Zinc (mg/L)	0.008	-	-	-
Ammonia as N (mg/L)	0.9	-	-	-
Nitrate as N (mg/L)	2.4°	-	-	-
Total Phosphorus (mg/L)	-	0.02	0.05	-

NTU = Nephelometric Turbidity Units; TDS = Total Dissolved Solids.

† ANZG (2018)

‡ ANZECC & ARMCANZ (2000)

° As recommended by ANZG (2018), value obtained from NIWA (2013) which was used to inform the current New Zealand nitrate toxicity attribute.

* Note that guideline values for primary industries were not tabulated where default guideline values for protection of aquatic ecosystems were available because the latter provide lower values.

3.4 SURFACE WATER FLOW REGIME

3.4.1 Streamflow Monitoring

Local unnamed surface water drainage systems within and adjacent to the MPO are predominately ephemeral, with the sites being dry the majority of the time during which monitoring was undertaken. A summary of sampling frequency of local drainages in the MPO area is presented in Table 8.

Table 8 Sampling Frequency of Local Drainages

Site	Number of Samples	Number of Dry Samples	Frequency of Samples with Water Present
W5	235	231	1.7%
W7	233	231	0.9%
W8*	204	171	16.2%
W9	238	225	5.5%
W10*	201	200	0.5%
W13	36	30	16.7%
W14	36	36	0.0%
W16	7	1	85.7%

* Monitoring sites W8 and W10 have been discontinued due to disturbance by mining activities.

Table 8 illustrates that, excepting site W16, the local surface water drainage systems were dry between 83% (site W13) and 100% (site W14) of time that monitoring was undertaken. Site W16 was dry for one of seven sampling events undertaken.

Streamflow monitoring in the vicinity of the MPO is undertaken by WaterNSW at three gauging stations on the Hunter River (refer Figure 4). The monitoring sites and streamflow records for the period of monitoring to April 2020 are summarised in Table 9. Flow duration curves for each monitoring site are presented in Figure 6.

Table 9 Hunter River Streamflow Summary

Monitoring Site	Monitoring Commenced	Percentage of Days with Data	Catchment Area (km^2)	Daily Flow (ML/day)*		
				Minimum	Median	Maximum
Aberdeen (GS 210056)	1959	67%	3,090	13.3	358.7	99,042
Muswellbrook (GS 210002)	1913	69%	4,220	0.0	343.1	175,831
Denman (GS 210055)	1959	82%	4,530	0.0	335.6	109,287

* Data source: https://realtimedata.waternsw.com.au/ - accessed 3 December 2020

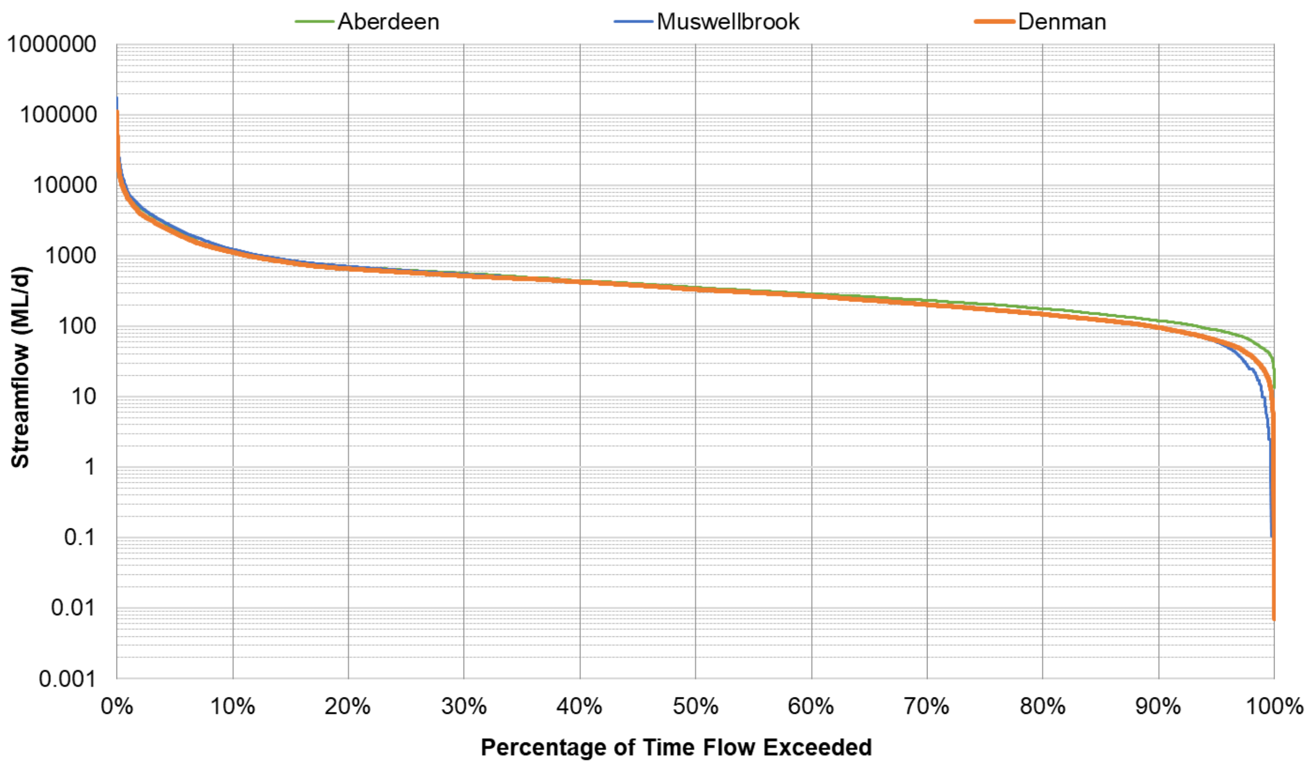


Figure 6 Hunter River Flow Duration Curves

The streamflow records in Table 9 and the flow duration curves in Figure 6 illustrate that the Hunter River is near perennial in the vicinity of the MPO due to regulated releases from Glenbawn Dam. A non-negligible streamflow rate (greater than 1 ML/d) has been recorded approximately 99% of the time. Figure 6 illustrates that the streamflow rates upstream (Aberdeen) and downstream (Denman) of the MPO are fairly consistent with little variability between the sites, as would be expected given the highly regulated nature of the river flow.

3.4.2 Flooding

The easternmost extent of the MPO mine landform is located outside of the 1% Annual Exceedance Probability (AEP) flood extent for the Hunter River. The potential for the MPO mine landform to result in changes to flood depth, extent or velocity in the vicinity of the MPO is considered to be negligible (MACH Energy, 2019a).

Once constructed, the approved MPO MOD 4 rail spur will cross the Hunter River floodplain, within the 1% AEP flood extent (MACH Energy, 2019a). The MOD 4 rail infrastructure has been designed to meet a range of flood risk management performance criteria, as defined in the MPO Water Management Plan (MACH Energy, 2019a).

3.5 SURFACE WATER QUALITY

3.5.1 Regional Water Quality

Table 10 summarises the recorded EC on the Hunter River at Aberdeen (GS 210056), Muswellbrook (GS 210002) and Denman (GS 210055). The calculated statistics are based on daily average values.

Table 10 Summary of Hunter River EC Records

Data/Statistic	Aberdeen (GS 210056)	Muswellbrook (GS 210002)	Denman (GS 210055)
ANZECC (2000) default guideline value (µS/cm)	350	300	300
No. of days	7,912	9,951	9,597
Minimum (µS/cm)	5	93	119
20th percentile (µS/cm)	338	373	413
Median (µS/cm)	380	441	520
80th percentile (µS/cm)	476	590	674
Maximum (µS/cm)	774	1,011	1,178
No. of exceedance days	5,547	9,733	9,466
% Days exceeded	70%	98%	99%

Table 10 illustrates that daily average EC values recorded on the Hunter River upstream of the MPO (GS 210056) have ranged between 5 and 774 µS/cm, with 70% of the recorded data exceeding the default guideline value of 350 µS/cm for upland rivers in NSW. The recorded EC levels increase with distance downstream on the Hunter River, ranging between 119 and 1,178 µS/cm at Denman (GS 210055).

The grab sample records for each site are summarised in Table 11. Where the value was below the laboratory limit of detection, the limit of detection has conservatively been adopted in the statistical analysis. The percentage of samples which exceeded the default guideline value (refer Table 7) are presented (% exceedances).

The data presented in Table 11 indicates that the water quality in the Hunter River is predominately neutral to alkaline, although slightly acidic conditions have been recorded previously at Muswellbrook (GS 210002) with a minimum value of pH 6.3 recorded. The EC values presented in Table 11 are consistent with Table 10, with the median EC value increasing with distance downstream on the Hunter River.

A maximum total iron concentration of 98 mg/L was recorded at Muswellbrook (GS 210002) in 1989, with 3% of all samples exceeding the total iron default guideline value for primary industries (10 mg/L). The median and maximum total zinc concentrations recorded at Muswellbrook (GS 210002) and the maximum concentration recorded at Denman (GS 210055) exceeded the default guideline value for aquatic ecosystems while the median and maximum concentrations of phosphorus recorded at all sites exceeded the aquatic ecosystems default guideline value.

Table 11 Hunter River Water Quality Summary – WaterNSW Grab Samples

Parameter (mg/L unless otherwise stated)	Default Guideline Value	Aberdeen (GS 210056)^					Muswellbrook (GS 210002)¥					Denman (GS 210055)¥				
		No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances
pH	6.5 – 8‡; 6.5 – 8.5#	28	7.5	8.2	9.2	64%	820	6.3	8.1	8.9	7%	48	7.6	8.2	9.2	15%
EC (µS/cm)	350‡; 300#	50	110	360	4630	50%	1069	1	439	3350	95%	108	186	485	824	97%
TSS	-	-	-	-	-	-	221	0.02	10	884	-	1	3	-	-	-
Turbidity (NTU)	25‡; 50#	26	0.6	2	39	4%	940	0.2	4	1754	4%	48	1	5	76	2%
TDS	2,000*	-	-	-	-	-	33	133	162	215	0%	-	-	-	-	-
Total Hardness	-	-	-	-	-	-	73	17	160	287	-	-	-	-	-	-
Sulphate	1,000*	8	14	27	38	0%	203	2	29	140	0%	11	22	30	62	0%
Chloride	-	19	14	28	54	-	215	12	41	115	-	23	29	59	102	-
Calcium	-	8	25	33	59	-	187	19	37	69	-	12	27	38	54	-
Magnesium	-	8	15	20	29	-	187	12	26	45	-	12	19	25	37	-
Sodium	115*	19	19	29	48	0%	-	-	-	-	-	-	-	-	-	-
Potassium	-	8	0.8	0.9	1.7	-	-	-	-	-	-	-	-	-	-	-
Total Boron	0.37†	1	0.14	-	-	0%	68	0.01	0.1	740	13%	1	0.21	-	-	0%
Total Iron	10*	1	0.014	-	-	0%	117	0.019	0.17	98	3%	4	0.026	0.11	0.47	0%
Total Manganese	1.9†	-	-	-	-	-	65	0.01	0.05	0.24	0%	-	-	-	-	-
Total Strontium	-	-	-	-	-	-	75	11	40	5013	-	1	88	-	-	-
Total Zinc	0.008†	1	0.006	-	-	0%	23	0.003	0.03	0.15	87%	2	0.002	-	0.018	50%
Ammonia as N	0.9†	102	<0.01	0.01	0.06	0%	184	<0.01	0.01	0.35	0%	131	<0.01	0.01	0.13	0%
Nitrate	2.4†	3	0.06	-	0.184	0%	213	0.01	0.3	7	2%	3	0.42	-	0.52	0%
Phosphorus	0.02‡; 0.05#	16	0.02	0.04	0.06	88%	649	0.01	0.07	4.5	71%	46	0.02	0.08	0.29	76%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems); ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; # ANZECC (2000) default guideline value for Lowland Rivers in NSW; * ANZECC (2000) default guideline value for primary industries; ^ Upland River; ¥ Lowland River.

3.5.2 Site Specific Water Quality

January 1993 to December 1994

The water quality monitoring results for the period January 1993 to December 1994, presented in ERMMM (1997), are consistent with that presented in Table 10 for the Hunter River, with the median EC values ranging between 359 to 544 µS/cm and increasing gradually with distance downstream. The pH values recorded at the Hunter River monitoring sites (ERMMM, 1997) indicated slightly alkaline conditions with median values in the range of pH 8.1 to 8.4. Concentrations of TSS ranged between 1 – 139 mg/L at the upstream monitoring site on the Hunter River (W1) (Table 12) and between 1 – 363 mg/L at the downstream monitoring site (between current monitoring sites W3 and W17).

For sampling sites within or adjacent to the MPO, data was only available for January to December 1994 due to the prevailing low rainfall conditions in 1993. On unnamed drainage lines at monitoring sites W5 and W6, the EC values ranged between 445 – 1,300 µS/cm and between 221 – 450 µS/cm, respectively. The pH values indicated near neutral conditions at site W5, ranging between pH 7.3 and 7.9, and slightly acidic to slightly alkaline conditions at site W6, ranging between pH 6.6 – 8.3. TSS concentrations ranged between 8 – 515 mg/L at site W5 and between 41 – 347 mg/L at site W6.

July 2000 to May 2020

Results of the water quality monitoring for sites on the Hunter River and tributaries of the Hunter River, namely Muscle Creek and Sandy Creek, are summarised in Table 12 to Table 14 below. Where the value was below the laboratory limit of detection, the limit of detection has conservatively been adopted in the statistical analysis. The percentage of samples which exceeded the default guideline value or surface water quality trigger value are presented (% exceedances).

The data in Table 12 and Table 13 show that the pH along the reach of the Hunter River from monitoring site W1 (upstream) to monitoring site W15 (downstream) ranges from slightly acidic to alkaline. The maximum pH value recorded at the upstream and central Hunter River monitoring sites exceeded the default guideline value (site W1 and site W3) and the site specific trigger values (site W2 and site W6A). The maximum pH values recorded at site W2 and W6A were recorded prior to commencement of operations at the MPO. The median and maximum EC values recorded at site W1 (upstream), W3 (central) and W15 (downstream) on the Hunter River exceeded the default guideline values, while the maximum EC value recorded at site W2 (upstream) and W6A (central) exceeded the trigger value and there were no exceedances of the trigger value for EC at the downstream site on the Hunter River (W17). The maximum EC values recorded at site W2, W3 and W6A were recorded prior to commencement of operations at the MPO.

The total aluminium concentrations recorded at site W1 (three records), W2 (six records), W6A (two records), W15 (two records) and W17 (two records) exceeded the default guideline value. The median and maximum concentrations recorded at site W3 exceeded the default guideline value for total aluminium.

The maximum concentrations of total zinc and total copper recorded at all sites exceeded the default guideline value. The maximum concentration of total lead recorded at site W2 exceeded the default guideline value and was recorded prior to the commencement of operations at the MPO.

Table 12 Hunter River Water Quality Summary (W1, W3 and W15) – MACH Energy Sampling Program July 2000 to May 2020

Parameter (mg/L unless otherwise stated)	Default Guideline Value	Hunter River Upstream (W1)^					Hunter River Central (W3)^					Hunter River Downstream (W15)¥				
		No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances
Field pH	6.5 – 8‡ 6.5 – 8.5#	167	6.1	8.1	8.6	51%	40	7.5	8.0	8.2	30%	36	7.4	7.9	8.2	0%
Field EC (µS/cm)	350‡ 300#	167	231	390	880	81%	40	279	393	715	85%	36	278	414	778	97%
TSS	-	167	1.0	7	363	-	40	3.0	10	3010	-	36	4	16	3550	-
Turbidity (NTU)	25‡ 50#	9	1.3	7	272	22%	8	4	9	247	13%	8	3	10	276	13%
TDS	2,000*	39	5	240	310	0%	39	31	237	468	0%	36	33	261	483	0%
Total Hardness	-	1	201	-	201	-	4	158	-	237	-	-	-	-	-	-
Total Alkalinity	-	1	183	-	183	-	4	151	-	210	-	-	-	-	-	-
Sulphate	1,000*	1	29	-	29	0%	4	20	-	33	0%	-	-	-	-	-
Chloride	-	1	30	-	30	-	4	38	-	74	-	-	-	-	-	-
Calcium	-	1	41	-	41	-	4	32	-	47	-	-	-	-	-	-
Magnesium	-	1	24	-	24	-	4	19	-	29	-	-	-	-	-	-
Sodium	115*	1	32	-	32	0%	4	31	-	48	0%	-	-	-	-	-
Potassium	-	1	1	-	1	-	4	2	-	2	-	-	-	-	-	-
Total Aluminium	0.055†	3	0.13	-	1.16	-	6	0.02	0.37	0.91	83%	2	0.29	-	1.04	100%
Total Antimony	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Arsenic	0.024†	9	<0.001	<0.001	<0.001	0%	12	<0.001	<0.001	<0.001	0%	8	<0.001	<0.001	<0.001	0%
Total Barium	-	9	0.01	0.013	0.016	-	12	0.01	0.014	0.021	-	8	0.012	0.016	0.021	-
Total Beryllium	0.5*	1	<0.001	-	<0.001	0%	4	<0.001	-	<0.001	0%	-	-	-	-	-
Total Boron	0.37†	3	<0.05	-	0.06	0%	6	<0.05	<0.05	0.06	0%	2	<0.05	-	<0.05	0%
Total Cadmium	0.0002†	9	<0.0001	<0.0001	<0.0001	0%	12	<0.0001	<0.0001	<0.0001	0%	8	<0.0001	<0.0001	<0.0001	0%
Total Chromium	0.001†	8	<0.001	<0.001	<0.001	0%	9	<0.001	<0.001	<0.001	0%	8	<0.001	<0.001	<0.001	0%
Total Cobalt	0.1*	1	<0.001	-	<0.001	0%	4	<0.001	<0.001	<0.001	0%	-	-	-	-	-

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems); ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; # ANZECC (2000) default guideline value for Lowland Rivers in NSW; * ANZECC (2000) default guideline value for primary industries; ^ Upland River; ¥ Lowland River.

Table 12 (Cont.) Hunter River Water Quality Summary (W1, W3 and W15) – MACH Energy Sampling Program July 2000 to May 2020

Parameter (mg/L unless otherwise stated)	Default Guideline Value	Hunter River Upstream (W1)^					Hunter River Central (W3)^					Hunter River Downstream (W15)¥				
		No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances
Total Copper	0.0014†	9	<0.001	<0.001	0.005	22%	12	<0.001	<0.001	0.005	42%	8	<0.001	<0.001	0.006	38%
Total Iron	10*	8	<0.005	0.26	1.36	0%	8	0.012	0.34	1.12	0%	8	0.016	0.51	1.23	0%
Total Lead	0.0034†	9	<0.001	<0.001	<0.001	0%	11	<0.001	<0.001	<0.001	0%	8	<0.001	<0.001	<0.001	0%
Total Lithium	2.5*	9	<0.001	<0.005	<0.005	0%	12	<0.001	0.004	0.005	0%	8	<0.001	<0.005	<0.005	0%
Total Manganese	1.9†	9	<0.001	0.02	0.08	0%	12	<0.001	0.025	0.06	0%	8	<0.001	0.03	0.07	0%
Total Mercury	0.0006†	4	<0.0001	<0.0001	<0.0001	0%	7	<0.0001	<0.0001	<0.0001	0%	3	<0.0001	-	<0.0001	0%
Total Nickel	0.011†	9	<0.001	<0.001	<0.001	0%	12	<0.001	<0.001	0.002	0%	8	<0.001	<0.001	<0.001	0%
Total Selenium	0.011†	9	<0.001	<0.001	0.01	0%	12	<0.001	0.006	0.01	0%	8	<0.001	<0.001	<0.01	0%
Total Strontium	-	9	0.22	0.24	0.33	-	12	0.006	0.25	0.45	-	8	0.23	0.27	0.29	-
Total Zinc	0.008†	9	<0.005	<0.005	0.19	11%	12	<0.005	<0.005	0.011	17%	8	<0.005	<0.005	0.015	13%
Ammonia as N	0.9†	1	0.03	-	0.03	0%	4	<0.01	0.03	0.07	0%	-	-	-	-	-
Nitrate	2.4†	7	<0.005	0.009	0.15	0%	10	0.015	0.11	0.44	0%	6	0.028	0.15	0.19	0%
Phosphorus	0.02‡ 0.05#	9	<0.02	0.03	0.1	56%	12	<0.02	0.055	0.11	92%	8	<0.020	0.06	0.11	63%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems); ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; # ANZECC (2000) default guideline value for Lowland Rivers in NSW; * ANZECC (2000) default guideline value for primary industries; ^ Upland River; ¥ Lowland River.

Table 13 Hunter River Water Quality Summary (W2, W6A and W17) – MACH Energy Sampling Program July 2000 to May 2020

Parameter (mg/L unless otherwise stated)	Trigger Value or Default Guideline Value	Hunter River Upstream (W2)^					Hunter River Central (W6A)≠					Hunter River Downstream (W17)±				
		No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances
Field pH	7.8 – 8.3^ 7.8 – 8.4≠ 6.5 – 8.1±	223	6.5	8.1	8.8	26%	154	6.9	8.1	8.7	23%	5	7.3	7.7	7.9	0%
Field EC (µS/cm)	539^ 496≠ 650±	223	229	400	790	20%	154	280	390	860	16%	5	293	520	620	0%
TSS	18^ 19≠ 4±	223	1	7	211	16%	154	1	7	2210	16%	5	16	89	3260	80%
Turbidity (NTU)	25^ 25≠ 50±	8	1	6	274	25%	7	2	6	216	14%	2	13	-	304	50%
TDS	2,000*	41	8	240	440	0%	35	18	223	322	0%	5	85	254	382	0%
Total Hardness	-	5	145	182	221	-	-	-	-	-	-	-	-	-	-	-
Total Alkalinity	-	5	144	182	192	-	-	-	-	-	-	-	-	-	-	-
Sulphate	1,000*	5	17	26	28	0%	-	-	-	-	-	-	-	-	-	-
Chloride	-	5	26	45	50	-	-	-	-	-	-	-	-	-	-	-
Calcium	-	5	30	35	44	-	-	-	-	-	-	-	-	-	-	-
Magnesium	-	5	17	23	27	-	-	-	-	-	-	-	-	-	-	-
Sodium	115*	5	26	34	41	0%	-	-	-	-	-	-	-	-	-	-
Potassium	-	5	1	2	2	-	-	-	-	-	-	-	-	-	-	-
Total Aluminium	0.055†	6	0.14	0.32	0.41	100%	2	0.38	-	0.52	100%	2	0.42	-	4.6	100%
Total Antimony	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Arsenic	0.024†	12	<0.001	<0.001	<0.001	0%	7	<0.001	<0.001	<0.001	0%	2	<0.001	-	<0.001	0%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems); ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; # ANZECC (2000) default guideline value for Lowland Rivers in NSW; * ANZECC (2000) default guideline value for primary industries; ^ W2 (upland river); ≠ W6A (upland river); ± W17 (lowland river).

Table 13 (Cont.) Hunter River Water Quality (W2, W6A and W17) – MACH Energy Sampling Program July 2000 to May 2020

Parameter (mg/L unless otherwise stated)	Trigger Value or Default Guideline Value	Hunter River Upstream (W2)^					Hunter River Central (W6A)≠					Hunter River Downstream (W17)±				
		No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances
Total Barium	-	12	0.01	0.014	0.016	-	7	0.010	0.013	0.017	0%	2	0.019	-	0.036	-
Total Beryllium	0.5*	5	<0.001	<0.001	<0.001	0%	-	-	-	-	-	-	-	-	-	-
Total Boron	0.37†	5	<0.05	<0.05	<0.05	0%	2	<0.05	-	<0.05	0%	2	<0.05	-	<0.05	0%
Total Cadmium	0.0002†	12	<0.0001	<0.0001	<0.0001	0%	7	<0.0001	<0.0001	<0.0001	0%	2	<0.0001	-	<0.0001	0%
Total Chromium	0.001†	7	<0.001	<0.001	<0.001	0%	7	<0.001	<0.001	<0.001	0%	2	<0.001	-	0.004	50%
Total Cobalt	0.1*	5	<0.001	<0.001	<0.001	0%	-	-	-	-	-	-	-	-	-	-
Total Copper	0.0014†	12	<0.001	<0.001	0.002	8%	7	<0.001	<0.001	0.002	14%	2	<0.001	-	0.005	50%
Total Iron	10*	7	0.007	0.18	0.53	0%	7	0.007	0.37	0.66	0%	2	0.59	-	6.48	0%
Total Lead	0.0034†	12	<0.001	<0.001	0.01	9%	7	<0.001	<0.001	<0.001	0%	2	<0.001	-	0.001	0%
Total Lithium	2.5*	12	<0.001	0.003	0.005	0%	7	<0.001	<0.005	<0.005	0%	2	<0.001	-	0.003	0%
Total Manganese	1.9†	12	<0.001	0.021	0.042	0%	7	<0.001	0.019	0.044	0%	2	0.041	-	0.15	0%
Total Mercury	0.0006†	7	<0.0001	<0.0001	<0.0001	0%	3	<0.0001	-	<0.0001	0%	2	<0.0001	-	<0.0001	0%
Total Nickel	0.011†	12	<0.001	<0.001	<0.001	0%	7	<0.001	0.001	0.002	0%	2	<0.001	-	0.005	0%
Total Selenium	0.011†	12	<0.001	0.006	0.010	0%	7	<0.001	<0.001	<0.01	0%	2	<0.01	-	<0.01	0%
Total Strontium	-	12	0.23	0.25	0.38	-	7	0.23	0.24	0.25	-	2	0.26	-	0.30	-
Total Zinc	0.008†	12	<0.005	<0.005	0.009	9%	7	<0.005	<0.005	0.01	29%	2	<0.005	-	0.014	50%
Ammonia as N	0.9†	5	0.02	0.02	0.03	0%	-	-	-	-	-	-	-	-	-	-
Nitrate	2.4†	11	<0.005	0.032	0.16	0%	5	<0.005	0.017	0.03	0%	-	-	-	-	-
Phosphorus	0.02‡ 0.05#	12	<0.01	0.03	0.06	58%	7	<0.020	0.03	0.08	57%	2	0.05	-	0.2	50%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems); ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; # ANZECC (2000) default guideline value for Lowland Rivers in NSW; * ANZECC (2000) default guideline value for primary industries; ^ W2 (upland river); ≠ W6A (upland river); ± W17 (lowland river).

Table 14 Muscle Creek and Sandy Creek Water Quality Summary

Parameter (mg/L unless otherwise stated)	Default Guideline Value	Muscle Creek (W4)¥					Sandy Creek Upstream (W11)¥					Sandy Creek Upstream (W12)^				
		No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances
Field pH	6.5 – 8‡ 6.5 – 8.5#	235	6.5	7.6	8.3	0%	19	7.2	7.8	8.3	0%	36	7.5	8.0	8.4	39%
Field EC (µS/cm)	350‡ 300#	235	383	1930	5580	100%	19	2090	6320	8410	100%	36	897	4970	7890	100%
TSS	-	235	1	5	232	0%	19	1	8	18	0%	36	1	9	172	0%
Turbidity (NTU)	25‡ 50#	9	2	10	1010	22%	4	2	-	8	0%	8	2	9	1800	13%
TDS	2,000*	49	5	896	1850	0%	19	1120	3660	4650	95%	36	4	2905	4730	86%
Total Hardness	-	4	392	-	882	-	-	-	-	-	-	-	-	-	-	-
Total Alkalinity	-	4	189	-	320	-	-	-	-	-	-	-	-	-	-	-
Sulphate	1,000*	4	212	-	490	0%	-	-	-	-	-	-	-	-	-	-
Chloride	-	4	321	-	489	-	-	-	-	-	-	-	-	-	-	-
Calcium	-	4	81	-	195	-	-	-	-	-	-	-	-	-	-	-
Magnesium	-	4	46	-	96	-	-	-	-	-	-	-	-	-	-	-
Sodium	115*	4	214	-	364	100%	-	-	-	-	-	-	-	-	-	-
Potassium	-	4	3	-	5	-	-	-	-	-	-	-	-	-	-	-
Total Aluminium	0.055†	6	0.13	0.16	0.82	100%	-	-	-	-	-	2	0.04	-	0.21	50%
Total Antimony	-	6	<0.001	<0.001	<0.001	-	-	-	-	-	-	2	<0.001	-	<0.001	0%
Total Arsenic	0.024†	12	<0.001	<0.001	0.002	0%	4	<0.001	-	0.002	0%	8	<0.001	<0.001	0.003	0%
Total Barium	-	12	0.04	0.06	0.08	-	4	0.1	-	0.23	0%	8	0.18	0.22	0.37	0%
Total Beryllium	0.5*	4	<0.001	-	<0.001	0%	-	-	-	-	-	-	-	-	-	-
Total Boron	0.37†	6	0.06	0.11	0.14	0%	-	-	-	-	-	2	0.13	-	0.28	0%
Total Cadmium	0.0002†	12	<0.0001	<0.0001	0.0002	0%	4	<0.0001	-	<0.0001	0%	8	<0.0001	<0.0001	<0.0001	0%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems); ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; # ANZECC (2000) default guideline value for Lowland Rivers in NSW; * ANZECC (2000) default guideline value for primary industries; ^ Upland River; ¥ Lowland River.

Table 14 (Cont.) Muscle Creek and Sandy Creek Water Quality Summary

Parameter (mg/L unless otherwise stated)	Default Guideline Value	Muscle Creek (W4)¥					Sandy Creek Upstream (W11)¥					Sandy Creek Upstream (W12)^				
		No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances
Total Chromium	0.001†	8	<0.001	<0.001	0.002	13%	4	<0.001	-	<0.001	0%	8	<0.001	<0.001	<0.001	0%
Total Cobalt	0.1*	4	<0.001	-	<0.001	0%	-	-	-	-	-	-	-	-	-	-
Total Copper	0.0014†	12	<0.001	<0.001	0.03	25%	4	<0.001	-	0.002	25%	8	0.001	0.001	0.003	25%
Total Iron	10*	8	0.006	0.22	1.10	0%	4	0.21	-	0.71	0%	8	0.01	0.18	0.25	0%
Total Lead	0.0034†	12	<0.001	<0.001	0.002	0%	4	<0.001	-	<0.001	0%	8	<0.001	<0.001	<0.001	0%
Total Lithium	2.5*	12	0.006	0.012	0.017	0%	4	0.024	-	0.037	0%	8	0.005	0.011	0.016	0%
Total Manganese	1.9†	12	0.002	0.13	0.26	0%	4	0.08	-	0.86	0%	8	<0.001	0.26	1.7	0%
Total Mercury	0.0006†	7	<0.0001	<0.0001	<0.0001	0%	-	-	-	-	-	3	<0.0001	-	<0.0001	0%
Total Nickel	0.011†	12	<0.001	<0.001	0.003	0%	4	<0.001	-	0.002	0%	8	<0.001	<0.001	0.002	0%
Total Selenium	0.011†	12	<0.001	0.006	0.01	0%	4	<0.001	-	0.001	0%	8	<0.001	<0.001	0.01	0%
Total Strontium	-	12	0.52	0.94	1.44	0%	4	2.8	-	3.2	0%	8	1.1	1.6	2.1	0%
Total Zinc	0.008†	12	<0.005	0.007	0.037	33%	4	<0.005	-	0.011	25%	8	<0.005	<0.005	0.011	13%
Ammonia as N	0.9†	4	0.01	-	0.05	0%	-	-	-	-	-	-	-	-	-	-
Nitrate	2.4†	10	<0.005	0.024	0.24	0%	4	<0.025	-	0.025	0%	6	0.025	0.025	0.05	0%
Phosphorus	0.02‡ 0.05#	12	0.01	0.08	0.11	58%	4	<0.02	-	0.14	50%	8	0.02	0.03	0.12	50%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems); ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; # ANZECC (2000) default guideline value for Lowland Rivers in NSW; * ANZECC (2000) default guideline value for primary industries; ^ Upland River; ¥ Lowland River.

The data in Table 14 shows that the pH in tributaries of the Hunter River, namely Muscle Creek and Sandy Creek, ranged from slightly acidic to alkaline. Higher EC values were recorded in Muscle Creek and Sandy Creek compared with sites in the Hunter River, with a maximum EC value of 8,410 µS/cm recorded at site W11. The EC values recorded at sites on Muscle Creek and Sandy Creek exceeded the default guideline values.

All records of total aluminium at site W4 on Muscle Creek (six samples) and the maximum concentration recorded at site W12 on Sandy Creek exceeded the default guideline value. The maximum concentration of total chromium recorded at site W4 on Muscle Creek and the maximum concentration of total zinc and total copper recorded at all sites on Muscle Creek and Sandy Creek exceeded the default guideline value.

Results of the water quality monitoring for the unnamed tributaries which traverse the MPO are summarised in Table 15 and Table 16 below. Where the value was below the laboratory limit of detection, the limit of detection has been adopted in the statistical analysis. The percentage of samples which exceeded the default guideline value are presented (as % exceedances).

The monitoring data summarised in Table 15 and Table 16 show that the pH recorded in unnamed tributaries which traverse the MPO ranges from slightly acidic to slightly alkaline. The minimum pH value recorded at site W5 and W9 was lower than the default guideline value and the upper default guideline pH value was exceeded at site W8 based on the maximum recorded pH value. The maximum EC value recorded at site W5, W8 and W9 exceeded the default guideline value while the EC values recorded at sites W7, W13 and W16 were within the range of default guideline values.

The total aluminium concentrations recorded at site W8 (one record) and W16 (two records) exceeded the default guideline value. The total aluminium concentration at site W8 was recorded prior to commencement of mining at the MPO while the total aluminium concentrations at site W16 were recorded in 2020 post commencement of mining at the MPO. Site W16 was dry prior to the recorded maximum total aluminium concentration of 87.7 mg/L and as such the high concentration of total aluminium is likely reflective of a first flush response to episodic rainfall following an extended low rainfall period. It should be noted that the Fines Emplacement Area and an associated sediment dam (Environmental Dam 2 [ED2]) are located upstream of site W16, however, the concentrations of total aluminium recorded in these storages during the corresponding period were substantially less and inconsistent with the concentration recorded at site W16 (refer Section 3.6).

The total chromium concentrations recorded at site W13 (one record) and W16 (two records) exceeded the default guideline value and the total iron concentrations recorded at site W16 (two records) exceeded the default guideline value. The concentration of total iron recorded in the storages upstream of site W16 during the corresponding period were substantially less and inconsistent with the concentration recorded at site W16 (refer Section 3.6). The maximum total iron concentration of 85 mg/L recorded at site W16 was less than the maximum total iron concentration recorded in the Hunter River at Muswellbrook (GS 210002) in 1989 (98 mg/L, refer Table 11).

The total lead, nickel and zinc concentrations recorded at site W8 (one record) and W16 (two records) exceeded the default guideline value. The total copper concentrations recorded at site W8 (one record), W13 (one record) and W16 (two records) exceeded the default guideline value. The concentrations of total copper, lead, nickel and zinc at site W8 were recorded prior to commencement of mining at the MPO.

The water quality monitoring results indicate that the concentrations of total aluminium, chromium, copper, iron, lead, nickel and zinc are, at times, naturally elevated above the relevant guideline values in regional and local surface water systems.

Table 15 Unnamed Tributary Water Quality Summary (W8, W13 and W16)

Parameter (mg/L unless otherwise stated)	Default Guideline Value	W8^					W13^					W16^				
		No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances
Field pH	6.5 – 8‡	33	6.1	7.3	8.5	15%	6	6.6	7.3	7.8	0%	6	7.5	7.6	7.8	0%
Field EC (µS/cm)	350‡	33	60	238	930	15%	6	93	151	204	0%	6	134	193	327	0%
TSS	-	33	7	326	2060	0%	6	64	184	6830	0%	6	64	470	2190	0%
Turbidity (NTU)	25‡	-	-	-	-	-	1	350	-	350	100%	2	416	2718	5020	100%
TDS	2,000*	4	65	-	1560	0%	6	80	204	720	0%	6	107	180	549	0%
Total Hardness	-	1	111	-	111	-	-	-	-	-	-	-	-	-	-	-
Total Alkalinity	-	1	128	-	128	-	-	-	-	-	-	-	-	-	-	-
Sulphate	1,000*	1	16	-	16	0%	-	-	-	-	-	-	-	-	-	-
Chloride	-	1	58	-	58	-	-	-	-	-	-	-	-	-	-	-
Calcium	-	1	18	-	18	-	-	-	-	-	-	-	-	-	-	-
Magnesium	-	1	16	-	16	-	-	-	-	-	-	-	-	-	-	-
Sodium	115*	1	38	-	38	0%	-	-	-	-	-	-	-	-	-	-
Potassium	-	1	15	-	15	-	-	-	-	-	-	-	-	-	-	-
Total Aluminium	0.055†	1	48.2	-	48.2	100%	-	-	-	-	-	2	12.2	-	87.7	100%
Total Antimony	-	1	<0.001	-	<0.001	-	-	-	-	-	-	2	<0.001	-	<0.001	-
Total Arsenic	0.024†	1	0.008	-	0.008	0%	1	<0.001	-	<0.001	0%	2	0.002	-	0.006	0%
Total Barium	-	1	0.37	-	0.37	-	1	0.02	-	0.02	-	2	0.07	-	0.44	-
Total Beryllium	0.5*	1	0.002	-	0.002	0%	-	-	-	-	-	-	-	-	-	-
Total Boron	0.37†	1	0.07	-	0.07	0%	-	-	-	-	-	2	0.05	-	0.06	0%
Total Cadmium	0.0002†	1	<0.0001	-	<0.0001	0%	1	<0.0001	-	<0.0001	0%	2	<0.0001	-	<0.0001	0%
Total Chromium	0.001†	-	-	-	-	-	1	0.003	-	0.003	100%	2	0.017	-	0.134	100%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems); ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) default guideline value for primary industries; ^ Upland River.

Table 15 (Cont.) Unnamed Tributary Water Quality Summary (W8, W13 and W16)

Parameter (mg/L unless otherwise stated)	Default Guideline Value	W8^					W13^					W16^				
		No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances	No. of Samples	Min	Median	Max	% Exceedances
Total Cobalt	0.1*	1	0.019	-	0.019	0%	-	-	-	-	-	-	-	-	-	-
Total Copper	0.0014†	1	0.024	-	0.024	100%	1	0.003	-	0.003	100%	2	0.009	-	0.06	100%
Total Iron	10*	-	-	-	-	-	1	1.4	-	1.4	0%	2	13	-	85	100%
Total Lead	0.0034†	1	0.022	-	0.022	100%	1	<0.001	-	<0.001	0%	2	0.004	-	0.04	100%
Total Lithium	2.5*	1	0.019	-	0.019	0%	1	<0.005	-	<0.005	0%	2	0.007	-	0.05	0%
Total Manganese	1.9†	1	0.49	-	0.49	0%	1	0.009	-	0.009	0%	2	0.14	-	1.3	0%
Total Mercury	0.0006†	1	<0.0001	-	<0.0001	0%	-	-	-	-	-	2	<0.0001	-	<0.0001	0%
Total Nickel	0.011†	1	0.035	-	0.035	100%	1	0.006	-	0.006	0%	2	0.02	-	0.15	100%
Total Selenium	0.011†	1	<0.01	-	<0.01	0%	1	<0.001	-	<0.001	0%	2	<0.01	-	<0.01	0%
Total Strontium	-	1	0.49	-	0.49	0%	1	0.045	-	0.045	0%	2	0.11	-	0.24	0%
Total Zinc	0.008†	1	0.069	-	0.069	100%	1	<0.005	-	<0.005	0%	2	0.022	-	0.18	100%
Ammonia as N	0.9†	1	2.5	-	2.5	100%	-	-	-	-	-	-	-	-	-	-
Nitrate	2.4†	1	0.07	-	0.07	0%	1	1.9	-	1.9	100%	-	-	-	-	-
Phosphorus	0.02‡	1	0.65	-	0.65	100%	1	1.3	-	1.3	100%	2	0.19	-	0.21	100%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems); ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) default guideline value for primary industries; ^ Upland River.

Table 16 Unnamed Tributary Water Quality Summary (W5, W7 and W9)

Parameter		Field pH	Field EC (µS/cm)	TSS (mg/L)	TDS (mg/L)
Default Guideline Value	Upland Rivers‡	6.5 - 8	350	-	2000*
	Lowland Rivers#	6.5 – 8.5	300	-	-
Site W5^	Count	4	4	4	-
	Minimum	6.1	80	8.0	-
	Median	-	-	-	-
	Maximum	7.0	1,558	20	-
	% Exceedances	75%	25%	-	-
Site W7^	Count	2	2	2	-
	Minimum	6.8	145	20	-
	Median	-	-	-	-
	Maximum	7.8	310	71	-
	% Exceedances	0%	0%	-	-
Site W9¥	Count	13	13	13	1
	Minimum	6.4	50	28	80
	Median	7.0	206	111	-
	Maximum	7.4	537	784	80
	% Exceedances	8%	38%	-	0%

‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; # ANZECC (2000) default guideline value for Lowland Rivers in NSW; * ANZECC (2000) default guideline value for primary industries; ^ Upland River; ¥ Lowland River.

Surface Water Quality Site Specific Trigger Values – W3 and W12

Sufficient monitoring data for calculation of site specific trigger values for water quality (over two years of monthly monitoring data) has been recorded at sites W3 and W12. As these sites are not currently influenced by mining activities, site specific trigger values have been derived and are summarised in Table 17.

Table 17 Site Specific Trigger Values – W3 and W12

Site	pH	EC (µS/cm)	TSS (mg/L)	TDS (mg/L)
	20th / 80th Percentile Trigger Values	80th Percentile Trigger Value	80th Percentile Trigger Value	80th Percentile Trigger Value
W3	6.5 – 8.1	446	22	271
W12	6.5 – 8.1	6420	18	3890

3.6 SITE STORAGES WATER QUALITY

Water quality is monitored in site water management storages in accordance with a site sampling program, with monthly sampling undertaken where sufficient water volume permits. The locations of the monitoring sites are shown in Figure 5. The available data from this program, which is summarised in Table 18 and Table 19 below, illustrates the characteristics of mine site water quality.

Table 18 Site Storages Water Quality Summary – Physicochemical

Monitoring Site (Storage)	Variable	Field pH	Field EC (µS/cm)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	Oil & Grease (mg/L)
MW1 (SD1)	No of Samples	29	29	29	29	29	29
	Min	7.5	296	<5	260	25	<1
	Median	8.6	571	99	400	140	2
	Max	9.2	1988	1230	1190	2000	5
MW2 (SD3)	No of Samples	20	20	20	20	20	20
	Min	7.8	368	9	288	60	<1
	Median	8.8	640	161	386	280	2
	Max	9.2	1422	1340	888	2500	5
MW11 (SD4)	No of Samples	2	2	2	2	2	2
	Min	8.6	540	<5	457	100	<1
	Max	9.6	730	518	612	800	7
MW3 (HWD)	No of Samples	31	31	29	29	29	29
	Min	7.2	359	<5	191	2	<1
	Median	8.5	1308	8	744	14	2
	Max	8.8	2700	30	1550	40	5
MW5 (MWD)	No of Samples	12	12	12	12	12	12
	Min	8.5	385	<5	214	2	<1
	Median	8.7	541	<5	313	6	2
	Max	8.9	1076	36	703	55	5
MW5(a) (ED2)	No of Samples	17	17	17	17	17	17
	Min	8.1	410	<5	388	4	<1
	Median	8.9	3090	15	1670	15	2
	Max	9.3	4560	125	2480	550	5
MW6 (ED3)	No of Samples	25	25	25	25	25	25
	Min	8.1	304	1	174	2	<1
	Median	8.6	375	21	330	36	5
	Max	9.3	1170	307	718	1000	5

SD = Sediment Dam. HWD = Highwall Dam. MWD = Mine Water Dam. ED = Environmental Dam.

Table 18 (Cont.) Site Storages Water Quality Summary – Physicochemical

Monitoring Site (Storage)	Variable	Field pH	Field EC (µS/cm)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	Oil & Grease (mg/L)
MW7 (EDMIA)	No of Samples	17	17	17	17	17	17
	Min	7.3	189	<5	203	11	<1
	Median	8.4	385	23	296	120	2
	Max	8.8	1707	157	935	380	5
MW8 (RLD)	No of Samples	17	17	17	17	17	17
	Min	6.5	302	<5	157	15	<1
	Median	8.4	468	18	231	50	2
	Max	9.2	998	54	536	140	5
MW13 (CHPP Dam)	No of Samples	13	13	13	13	13	13
	Min	8.3	683	<5	407	9	<1
	Mean	8.5	973	16	562	22	2
	Max	8.8	1471	54	951	85	2
MW14 (EFD6)	No of Samples	13	13	13	13	13	13
	Min	8.1	381	10	222	26	<1
	Median	8.5	975	47	557	44	2
	Max	9.2	1248	111	791	200	2
MW9 (FEA)	No of Samples	16	16	16	16	16	16
	Min	8.1	374	<5	170	2	<1
	Median	8.4	1031	15	609	26	2
	Max	9.2	1820	108	1230	180	5
MW10 (In-Pit A)	No of Samples	12	12	12	12	12	12
	Min	8.5	385	<5	214	2	<1
	Median	8.7	541	<5	313	6	2
	Max	8.9	1076	36	703	55	5
MW15 (In-Pit D)	No of Samples	6	6	6	6	6	6
	Min	3.6	3230	<5	2650	1	<1
	Median	6.7	5830	8	4205	33	2
	Max	8.0	6750	78	5870	160	2

FEA = Fines Emplacement Area. EDMIA = Environmental Dam Mine Infrastructure Area. RLD = Rail Loop Dam. EFD = Environmental Farm Dam (note EFD6 is a small farm dam with a small external catchment area, and as such, has been included in the catchment of ED3 for the purposes of the site water balance model – refer Section 5.0).

Table 19 Site Storages Water Quality Summary – Total Metals

Monitoring Site (Storage)	Variable	Total Metals (mg/L)														
		Aluminium	Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Lithium	Manganese	Mercury	Nickel	Selenium	Silver	Zinc
MW1 (SD1)	Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min	1.0	<0.001	0.05	<0.0001	<0.001	0.003	0.7	<0.001	<0.001	0.008	<0.0001	0.002	<0.01	<0.001	<0.005
	Max	2.6	<0.001	0.05	<0.0001	0.002	0.006	1.9	0.002	0.003	0.049	<0.0001	0.004	<0.01	<0.001	0.006
MW2 (SD3)	Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min	1.1	<0.001	0.05	<0.0001	<0.001	0.003	0.8	<0.001	<0.001	0.019	<0.0001	0.002	<0.01	<0.001	<0.005
	Max	15.9	0.004	0.05	<0.0001	0.01	0.014	9.3	0.007	0.007	0.082	<0.0001	0.011	<0.01	<0.001	0.025
MW11 (SD4)	Samples	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Value	10.8	0.005	0.13	<0.0001	0.008	0.016	9.7	0.007	0.003	0.306	<0.0001	0.014	<0.01	<0.001	0.033
MW3 (HWD)	Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min	0.1	<0.001	0.05	<0.0001	<0.001	<0.001	<0.05	<0.001	0.018	0.113	<0.0001	0.007	<0.01	<0.001	<0.005
	Max	0.1	0.005	0.08	<0.0001	0.002	<0.001	0.6	<0.001	0.038	0.244	<0.0001	0.01	<0.01	<0.001	0.009
MW5 (MWD)	Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min	0.02	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.05	<0.001	0.002	0.007	<0.0001	<0.001	<0.01	<0.001	<0.005
	Max	0.2	0.002	<0.05	<0.0001	<0.001	<0.001	0.2	<0.001	0.009	0.016	<0.0001	0.004	<0.01	<0.001	<0.005
MW5(a) (ED2)	Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min	0.1	<0.001	0.1	<0.0001	<0.001	<0.001	0.1	<0.001	0.03	0.006	<0.0001	0.004	<0.01	<0.001	<0.005
	Max	0.8	0.002	0.14	<0.0001	0.002	<0.001	0.7	<0.001	0.039	0.018	<0.0001	0.006	<0.01	<0.001	<0.005
MW6 (ED3)	Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min	0.1	<0.001	0.06	<0.0001	<0.001	<0.001	0.1	<0.001	0.004	0.018	<0.0001	0.002	<0.01	<0.001	<0.005
	Max	0.4	<0.001	0.08	<0.0001	<0.001	0.002	0.3	<0.001	0.009	0.059	<0.0001	0.003	<0.01	<0.001	0.01
MW7 (EDMIA)	Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min	4.6	<0.001	0.05	<0.0001	0.004	0.002	4.1	<0.001	<0.001	0.025	<0.0001	0.005	<0.01	<0.001	0.01
	Max	5.5	0.003	0.08	<0.0001	0.006	0.003	4.3	0.002	0.003	0.353	<0.0001	0.013	<0.01	<0.001	0.012

Table 19 (Cont.) Site Storages Water Quality Summary – Total Metals

Monitoring Site (Storage)	Variable	Total Metals (mg/L)														
		Aluminium	Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Lithium	Manganese	Mercury	Nickel	Selenium	Silver	Zinc
MW8 (RLD)	Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min	0.6	<0.001	0.05	<0.0001	<0.001	<0.001	0.3	<0.001	<0.001	0.003	<0.0001	<0.001	<0.01	<0.001	<0.001
	Max	1.5	<0.001	0.1	<0.0001	0.002	<0.001	0.9	<0.001	<0.001	0.013	<0.0001	0.002	<0.01	<0.001	<0.001
MW13 (CHPP Dam)	Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min	0.1	<0.001	0.05	<0.0001	<0.001	<0.001	0.1	<0.001	0.01	0.008	<0.0001	0.002	<0.01	<0.001	<0.001
	Max	0.3	<0.001	0.09	<0.0001	<0.001	0.002	0.3	<0.001	0.019	0.076	<0.0001	0.004	<0.01	<0.001	<0.001
MW14 (EFD6)	Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min	0.5	<0.001	0.05	<0.0001	<0.001	<0.001	0.3	<0.001	0.01	0.023	<0.0001	0.002	<0.01	<0.001	<0.001
	Max	1.0	0.002	0.1	<0.0001	0.002	<0.001	0.8	<0.001	0.018	0.046	<0.0001	0.003	<0.01	<0.001	<0.001
MW9 (FEA)	Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min	0.1	<0.001	0.06	<0.0001	<0.001	<0.001	0.1	<0.001	0.003	0.007	<0.0001	0.005	<0.01	<0.001	<0.001
	Max	0.3	0.002	0.08	<0.0001	0.002	<0.001	0.3	<0.001	0.031	0.237	<0.0001	0.006	<0.01	<0.001	<0.001
MW10 (In-Pit A)	Samples	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min	0.02	<0.001	0.05	<0.0001	<0.001	<0.001	<0.05	<0.001	0.002	0.007	<0.0001	<0.001	<0.01	<0.001	<0.005
	Max	0.2	0.002	0.05	<0.0001	<0.001	<0.001	0.2	<0.001	0.009	0.016	<0.0001	0.004	<0.01	<0.001	<0.005
MW15 (In-Pit D)	Samples	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Min	<0.01	0.009	0.11	<0.0001	<0.001	<0.001	<0.05	<0.001	0.057	0.141	<0.0001	0.015	<0.01	<0.001	<0.005
	Max	0.3	0.012	0.16	<0.0001	<0.001	<0.001	0.3	<0.001	0.096	3.26	<0.0001	0.024	<0.01	<0.001	0.026

FEA = Fines Emplacement Area.

The data in Table 18 indicates that the pH of the site storages ranges between acidic and alkaline with the median value indicating alkaline conditions in all site storages except MW15 (In-pit D). At MW15 (In-pit D), a minimum value of pH 3.6 was recorded and is likely reflective of temporary, localised acid generating conditions (e.g. exposure of the Wynn Seam in the open cut pit, which is identified as potentially acid forming in the *Mount Pleasant Optimisation Project Geochemistry Assessment* [RGS Environmental, 2020]). The EC values ranged between 189 µS/cm at MW7 (Environmental Dam Mine Infrastructure Area [EDMIA]) and 6,750 µS/cm at MW15 (In-pit D). TSS ranged between less than 5 mg/L to 1,340 mg/L, while oil and grease concentrations were low in the majority of storages (5 mg/L or less), except for MW11 (SD4) where a maximum of 7 mg/L was recorded.

The data in Table 19 shows that the concentrations of total cadmium, total mercury, total selenium and total silver were at or below the limited of detection in all site storages. A maximum concentration of 0.012 mg/L total arsenic was recorded at MW15 (In-Pit D) while the remainder of site storages recorded a total arsenic concentration at or below the limit of detection.

Total aluminium concentrations ranged from less than 0.01 mg/L (MW15) and 15.9 mg/L (MW2), total iron between less than 0.05 mg/L and 9.7 mg/L (MW11), total manganese between 0.003 mg/L (MW8) and 3.3 mg/L (MW15) and total zinc ranged from below the limit of detection and 0.033 mg/L (MW11). The remainder of total metals were generally recorded at low concentrations in all storages.

To date, there have been no licensed discharges from storages at the MPO.

4.0 SURFACE WATER MANAGEMENT SYSTEM

4.1 OVERVIEW

Surface water management and monitoring at the MPO is currently undertaken in accordance with the Site Water Balance, Erosion and Sediment Control Plan, Surface Water Management Plan and Surface and Groundwater Response Plan, which are components of the Water Management Plan (MACH, 2019a).

The Site Water Balance describes the water management system at the MPO, tracks site water storage requirements through current water balance model predictions and outlines the on-site responsibilities with regard to the site water balance (e.g. monitoring of site water usage).

The Erosion and Sediment Control Plan outlines the erosion and sediment control strategy for the MPO including erosion and sediment control measures, design criteria and provisions for reporting on the effectiveness and performance of the system.

The Surface Water Management Plan outlines (MACH, 2019b):

- the existing surface water conditions and baseline data relevant to the MPO;
- surface water impact assessment criteria and triggers;
- surface water management measures; and
- surface water monitoring.

The Surface and Groundwater Response Plan includes:

- trigger action response plans for downstream impacts to flow, water quality and stream health;
- processes to deal with complaints related to surface water;
- the surface water impact investigation protocol; and
- a response plan, in the event that an investigation conclusively attributes an adverse impact on an existing surface water supply user to the MPO.

The existing water management system would be updated to incorporate the Project. The objectives and design criteria of the Project site water management system would be to:

- protect the integrity of local and regional water resources;
- separate runoff from undisturbed, rehabilitated and mining-affected areas;
- design and manage the system to operate reliably throughout the life of the Project in all seasonal conditions, including both extended wet and dry periods;
- provide water for use in mining operations that is of sufficient volume and quality;
- prioritise the re-use of water on-site (including the adoption of belt press filters for new coal processing modules); and
- manage groundwater inflows and CHPP process water on-site.

4.2 EXISTING OPERATIONAL WATER MANAGEMENT SYSTEM

The existing MPO water management system is comprised of a number of dams, the south and central open cut pits and the Fines Emplacement Area, together with a system of pumped transfers and drains. The locations of the site water storages and associated sub-catchment boundaries as of June 2019[3] are shown in Figure 7. Figure 8 shows a schematic representation of the existing water management system storages and inter-linkages.

The MWD is the main water storage on site and supplies makeup water requirements to the CHPP. Thickened fine reject slurry produced by the CHPP is pumped to the Fines Emplacement Area and fine reject bleed water[4] and Fines Emplacement Area rainfall runoff are recovered via pumping to the MWD. The water management system allows water in all dams to ultimately report to the MWD. Inflows to the MWD also include water pumped from the Hunter River extracted via WALs during periods of reduced on-site water inventory. Outflows include water supply for the CHPP, vehicle washdown, stockpile dust suppression, construction and haul road dust suppression.

ED2 is located downstream of the Fines Emplacement Area and served as a sediment dam during construction of the Fines Emplacement Area embankment. Any seepage from the Fines Emplacement Area is captured in a subsurface seepage collection system located at the toe of the Fines Emplacement Area embankment and pumped back to the Fines Emplacement Area (ATC Williams, 2017).

Environmental Dam 3 (ED3), the CHPP Dam, Sediment Dam 1 (SD1), Sediment Dam 3 (SD3) and Sediment Dam 4 (SD4) form part of the existing water management system, with water ultimately pumped back to the MWD. Water from SD4 is pumped to SD3 and water from SD3 is pumped to SD1 which in turn transfers water to the MWD.

Groundwater inflow to the South and Central open cut pits is dewatered and directed to the High Wall Dam 1 (HWD1). A truckfill point at HWD1 is used to supply water for haul road dust suppression with transfer from HWD1 to the MWD available during periods of high in-pit water inventory.

EDMIA is a sediment dam with a partly disturbed catchment and can supplement site water supply via pumping to the MWD during periods of low water inventory. Rail Loop Dam 1 (RLD1) is located adjacent to the rail loop to capture potentially mine affected runoff from this area with water pumped back to ED3.

Sediment dams SD1, SD3, SD4 and EDMIA were designed in accordance with Landcom (2004) and DECC (2008) with spill from these dams allowed to occur in accordance with the design guidelines (refer Section 5.2.8).

The MPO sources water from the Hunter River via the approved water supply pipeline. In November 2018, MACH Energy obtained approval to duplicate the Hunter River water supply pump station, water pipeline and associated services (Stage 2 water supply pipeline) and demolish and remove the redundant approved infrastructure. The Project would source water from the Hunter River via the Stage 2 water supply pipeline.

[3] Contour data provided by MACH Energy for June 2019.

[4] Fine reject bleed water is water liberated from fine reject slurry as it settles within the Fines Emplacement Area. This water reports to the fine reject surface, ponds and is available for reclaim pumping.

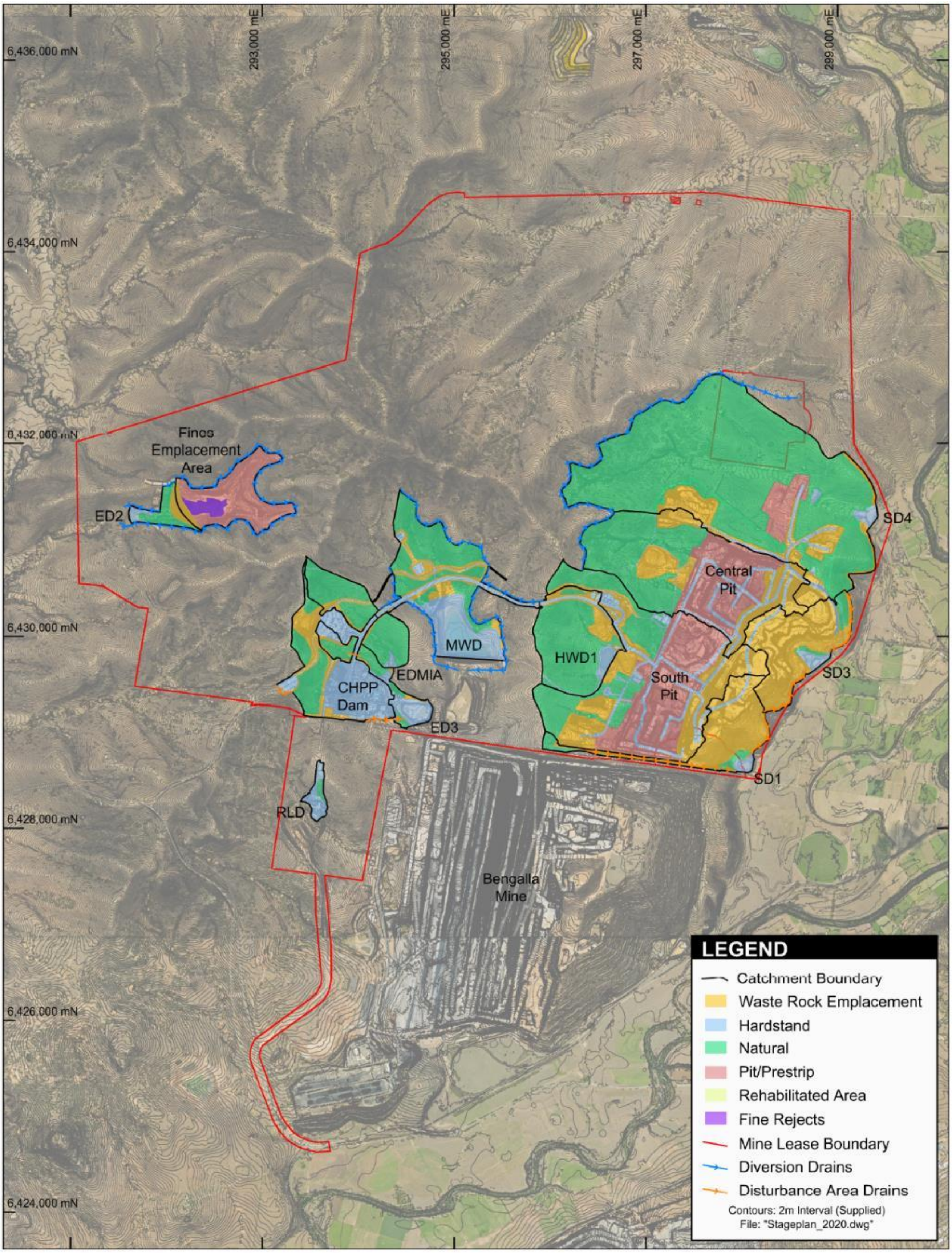


Figure 7 Existing Surface Water Management System and Sub-Catchment Boundaries

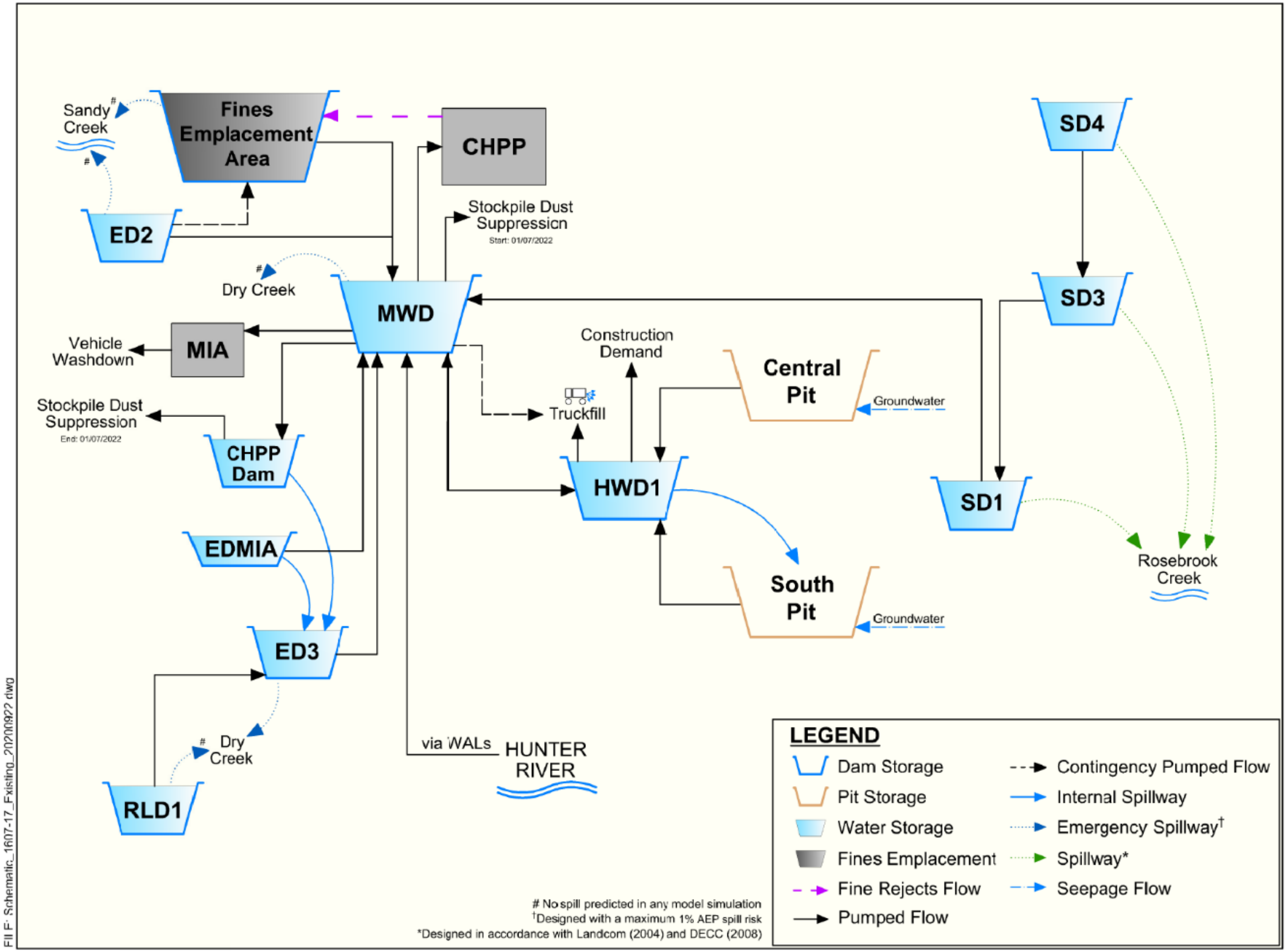


Figure 8 Existing Water Management System Schematic

4.3 PROPOSED OPERATIONAL WATER MANAGEMENT SYSTEM

The proposed operational water management system will comprise a combination of existing storages and additional storages as necessary to manage runoff from mine disturbed areas and divert runoff away from the open cut pit areas. The proposed operational water management system and sub-catchment boundaries at Year 2026, Year 2028, Year 2031, Year 2041 and Year 2047 are shown in Figure 9 to Figure 13. Figure 14 shows a schematic representation of the proposed water management system storages and inter-linkages. Table 20 lists the existing and proposed operational water management system storages and their primary function.

As the south open cut pit expands, HWD1 will be decommissioned and HWD2 will be constructed upstream of the central open cut pit to provide interim storage for pumped flow from the open cut pits to the MWD and to provide water supply for truckfill demand. A second RLD (RLD2) is planned to be commissioned in 2021 to capture runoff from the relocated rail loop with RLD1 to be decommissioned following decommissioning of the current rail loop. An additional mine water dam (MWD2) will be constructed to the south of the Fines Emplacement Area to provide for additional water storage and supply requirements from 2026.

The approved discharge dam (DW1) is planned to be constructed to facilitate controlled releases to the Hunter River under the conditions of the HRSTS. The dam will be located to the west of Bengalla Road and is planned to be commissioned in early 2022.

Additional sediment dams will be constructed at intervals along the eastern Project boundary to manage runoff from the expanded open cut pit and waste rock emplacement disturbance areas. The sediment dams have been conceptually designed as detailed in Section 4.3.1. As the catchment area directed to SD4 increases, the storage capacity of SD4 will need to be increased as indicated in Section 4.3.1. Diversion drains will be constructed to convey runoff from upstream areas disturbed by mining to the sediment dams and from the sediment dams to offsite. As the open cut pit area expands to the north and west, progressive rehabilitation of waste rock emplacement areas will be undertaken which will reduce disturbed area runoff to the sediment dams along the eastern boundary of the site.

As the south open cut pit progresses to the west, MWD1 will be decommissioned and replaced by an additional mine water dam (MWD3) by 2041. Diversion drains will be constructed around the perimeter of the dams to divert runoff from undisturbed areas around the dams and off-site.

HWD2 will be replaced by HWD3 further to the north to provide interim storage for pumped flow from the open cut pits to the MWDs and to provide water supply for haul road dust suppression. Progressive rehabilitation of the waste rock emplacement areas would continue to be undertaken.

To facilitate the handling and processing of additional coal, various CHPP upgrades would be implemented, including two additional coal processing modules. The new coal processing modules would be generally similar in design to the existing coal processing modules. One key difference is that reject dewatering facilities (such as belt press filters or alternative technologies) would be constructed for the new coal processing modules to improve water recovery and allow co-disposal of fine rejects with coarse rejects and waste rock as part of ROM waste rock emplacement operations.

Table 20 Proposed Operational Water Management System Storages

Storage†	Status	Classification	Primary function
ED2	Existing	Sediment dam	Management of site runoff
ED3	Existing	Sediment dam	Management of site runoff
RLD1	Existing	Sediment dam	Management of site runoff
EDMIA	Existing	Sediment dam	Management of site runoff
CHPPSD	Existing	Sediment dam	Management of site runoff
HWD1	Existing	Highwall dam	Management of site runoff
HWD2	Approved	Highwall dam	Management of site runoff
HWD3	Proposed	Highwall dam	Management of site runoff
MWD1	Existing	Mine Water Storage	Primary storage of operational water (including recirculated mine water and licensed river water)
MWD2	Proposed	Mine Water Storage	Primary storage of operational water (including licensed river water and recirculated mine water)
MWD3	Proposed	Mine Water Storage	Primary storage of operational water (including licensed river water and recirculated mine water)
SD1	Existing	Sediment dam	Management of site runoff
SD3	Existing	Sediment dam	Management of site runoff
SD4	Existing	Sediment dam	Management of site runoff
SD5	Proposed	Sediment dam	Management of site runoff
SD6	Proposed	Sediment dam	Management of site runoff
SD7	Proposed	Sediment dam	Management of site runoff
RLD2	Approved	Sediment dam	Management of site runoff
DW1	Approved	Discharge dam	Storage and management of operational water for controlled release

† In addition to these operational water storages, operational water will also be managed within the Open Cut Pit(s) and within the Fines Emplacement Area.

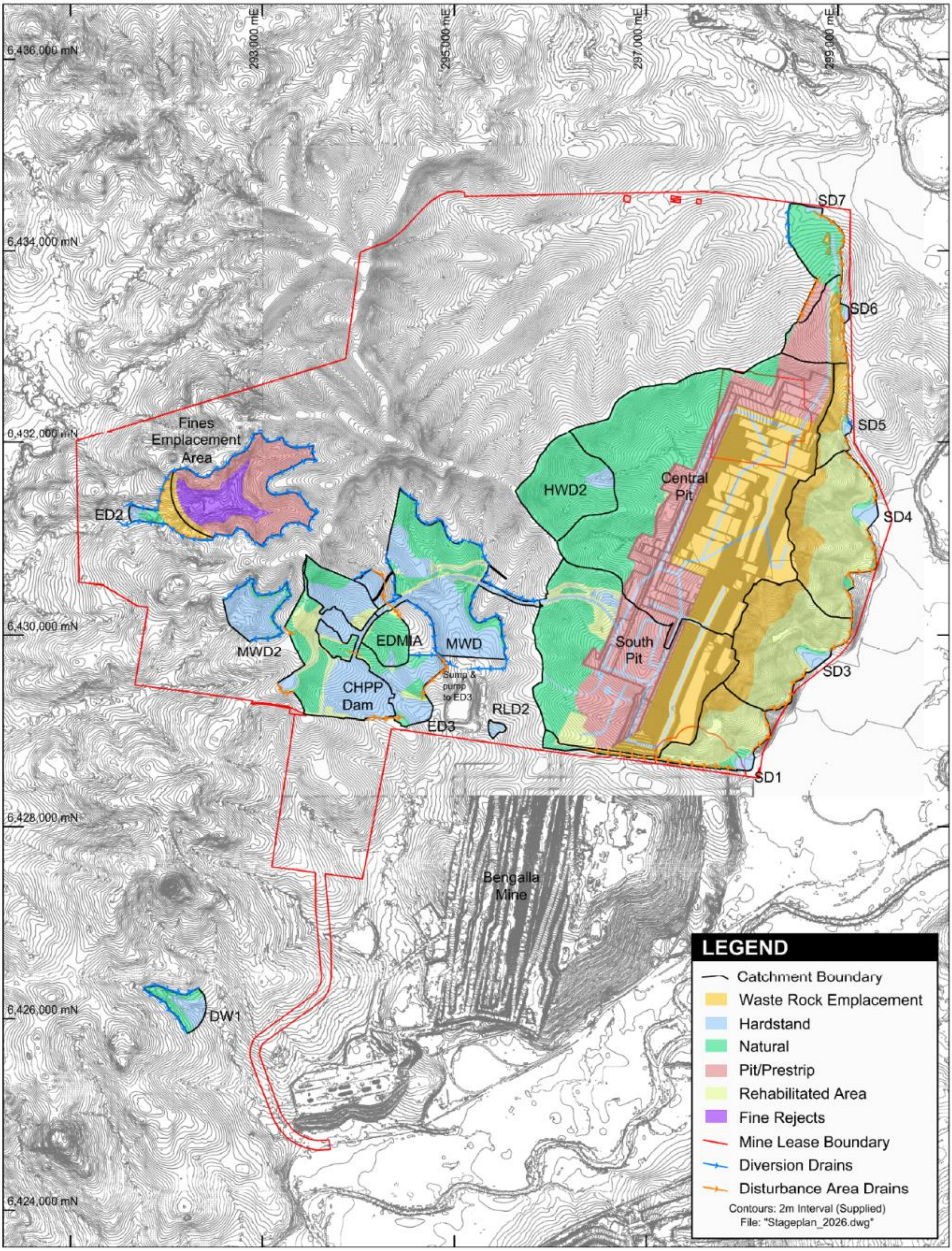


Figure 9 Year 2026 Proposed Water Management Layout and Sub-Catchment Boundaries

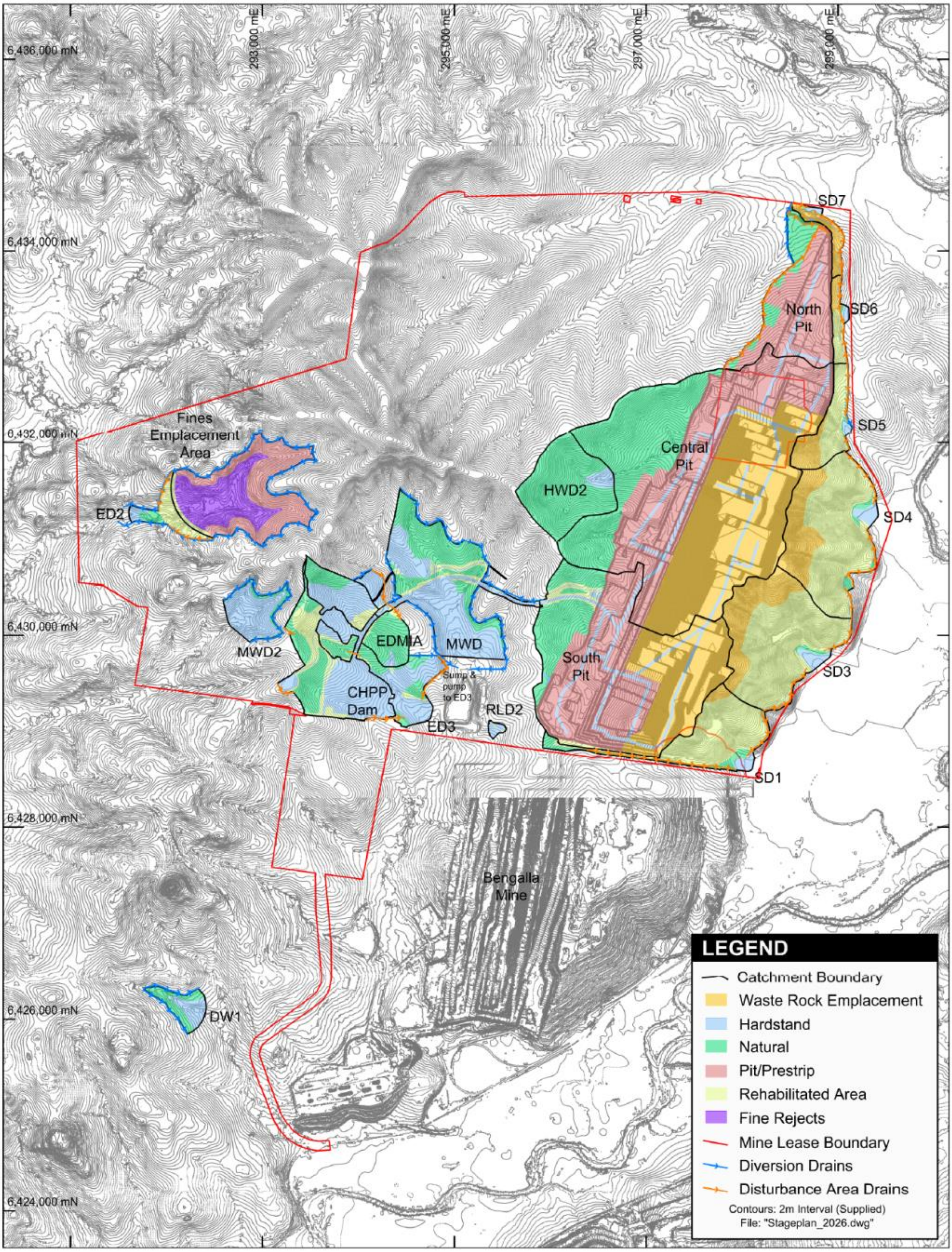


Figure 10 Year 2028 Proposed Water Management Layout and Sub-Catchment Boundaries

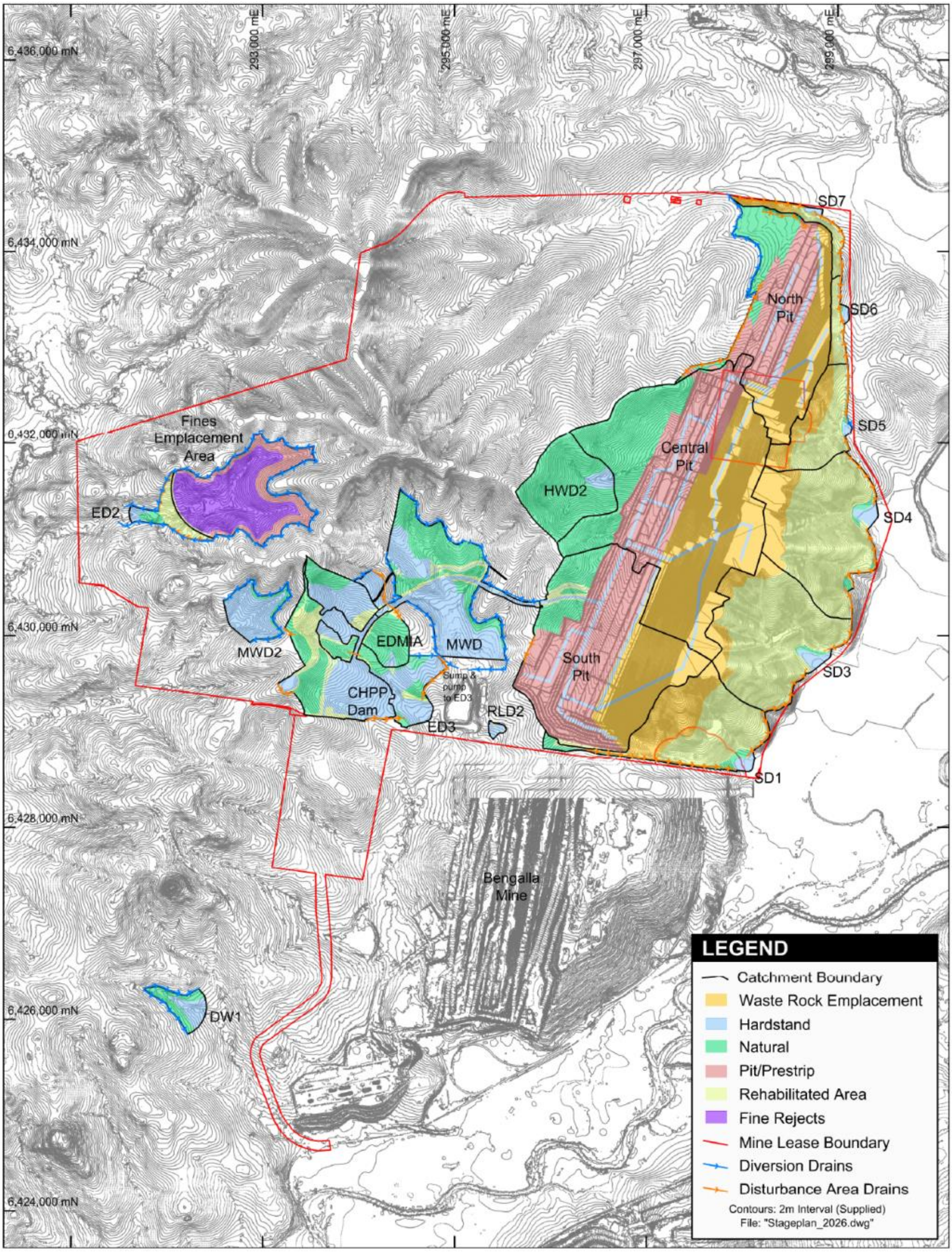


Figure 11 Year 2031 Proposed Water Management Layout and Sub-Catchment Boundaries

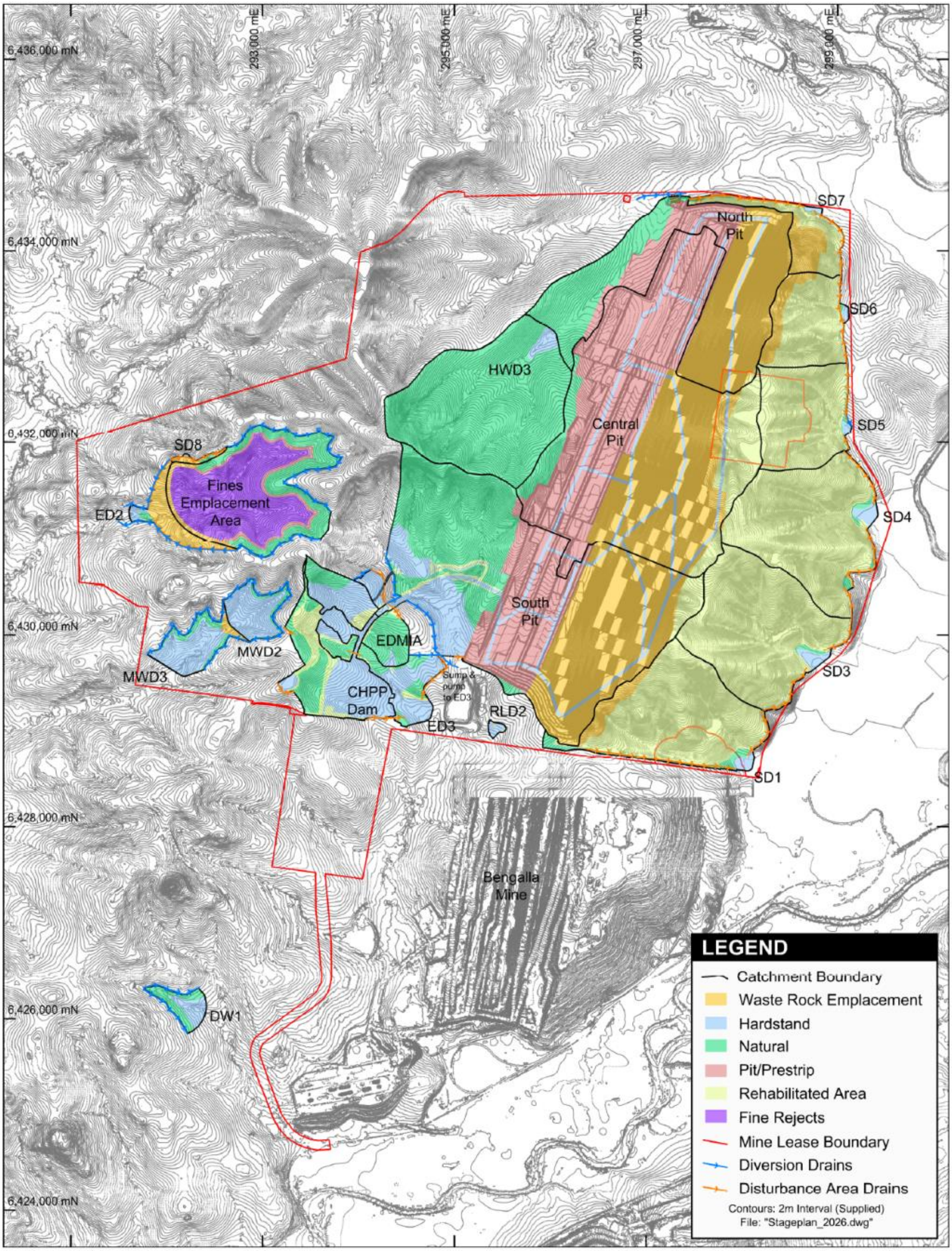


Figure 12 Year 2041 Proposed Water Management Layout and Sub-Catchment Boundaries

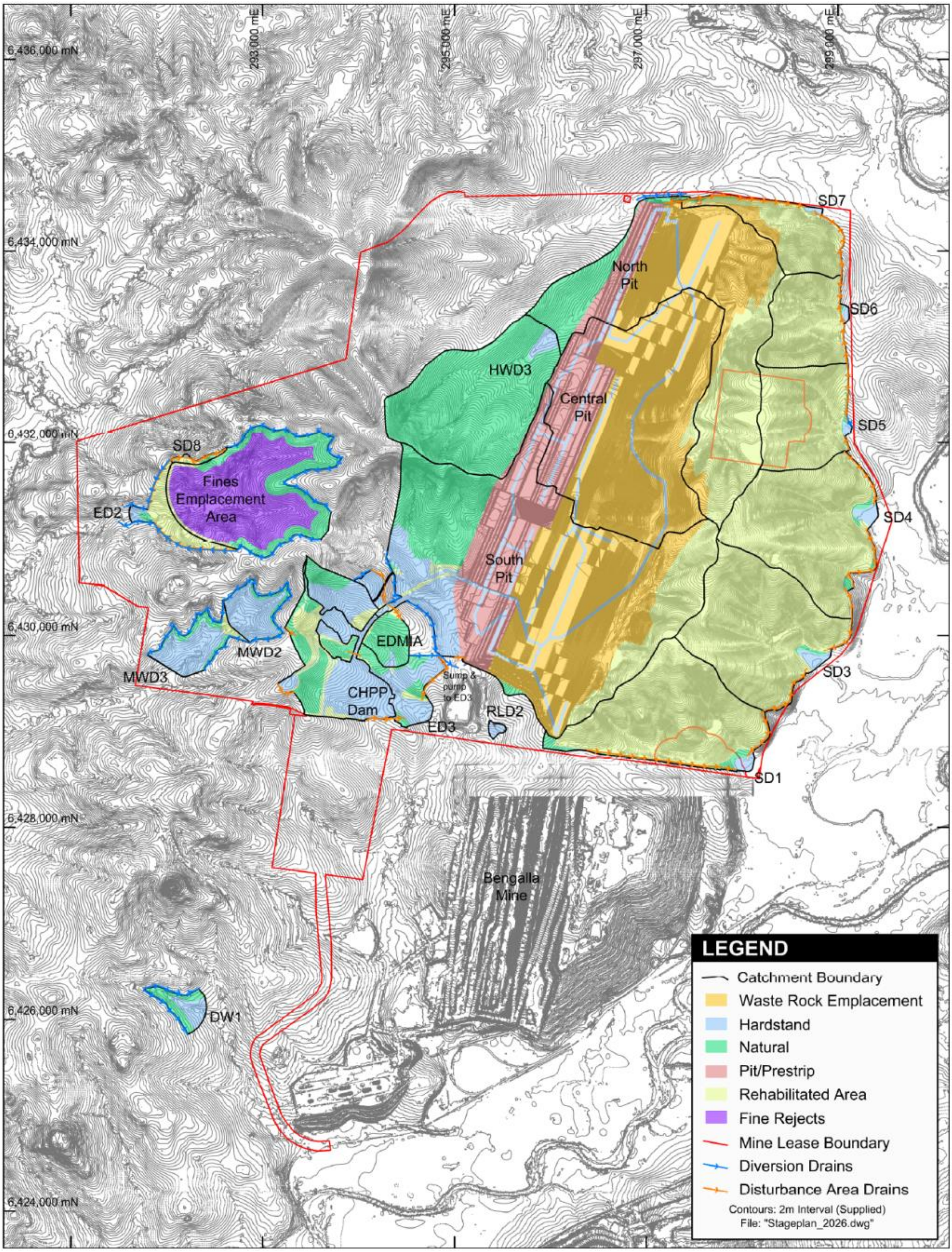


Figure 13 Year 2047 Proposed Water Management Layout and Sub-Catchment Boundaries

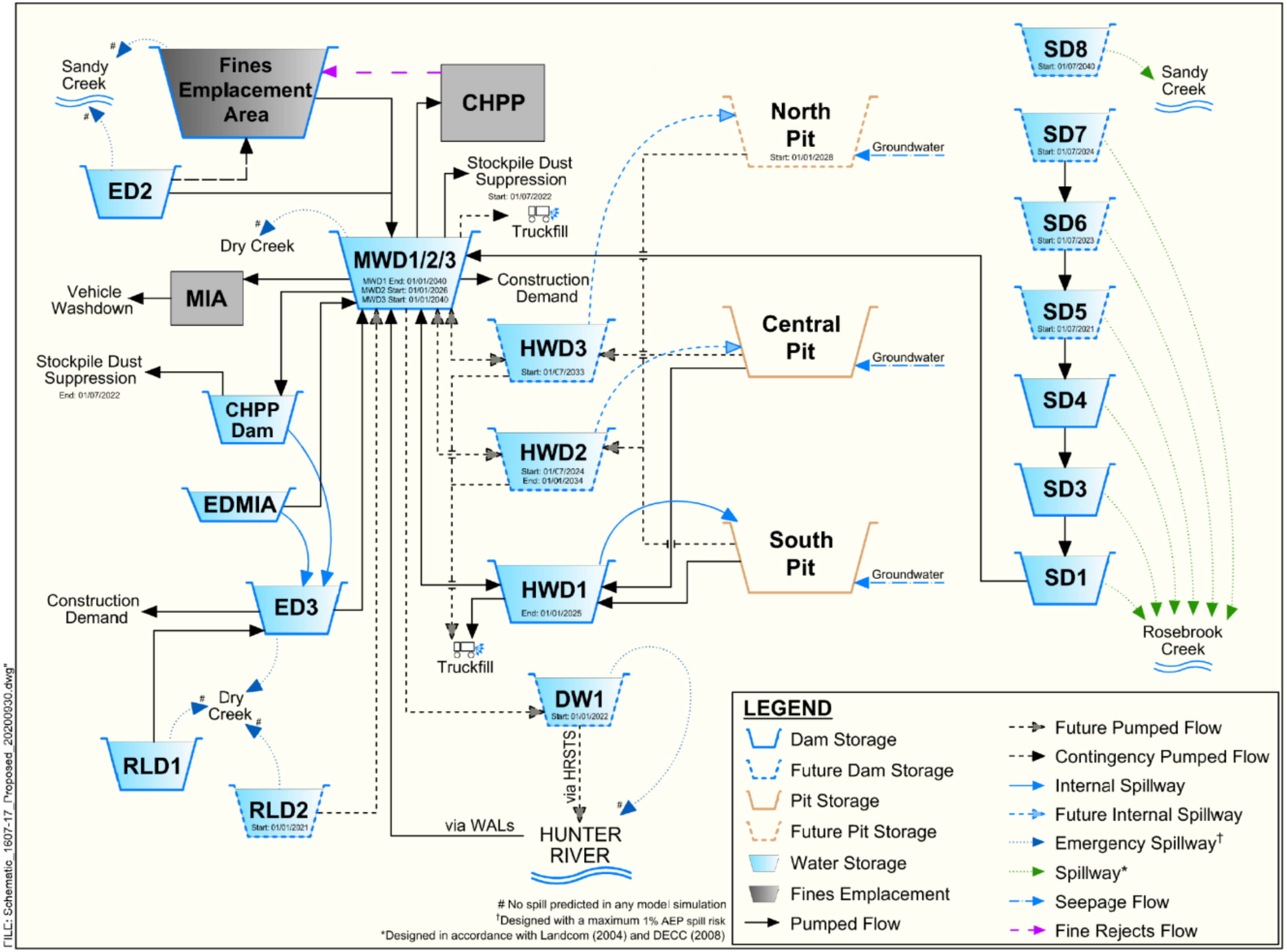


Figure 14 Proposed Water Management System Schematic

4.3.1 Sediment Dams

The conceptual design of the proposed sediment dams has been undertaken in accordance with the Landcom (2004) and DECC (2008) guidelines, assuming the following design criteria:

- Type D sediment retention basin (10% or more of the soil materials are dispersible);
- sediment dams to be in place for more than three years;
- adequate capacity to capture runoff from a 90th percentile 5-day duration rainfall event (DECC, 2008) of 39.4 mm (average of Cessnock and Scone 5-day rainfall depths in Table 6.3a of Landcom, 2004);
- a volumetric runoff coefficient of 0.51 assuming soil hydrologic group C – Table F2 of Landcom (2004); and
- allowance for sediment storage zone capacity equal to 50% of the above calculated settling zone capacity.

A summary of estimated maximum catchment areas, required capacity and required pump rate of the sediment dams is provided in Table 21. The pump rate has been calculated based on the requirement that the sediment dams can be emptied within five days of filling, as recommended by Landcom (2004). Note that as transfer occurs sequentially between each dam, the pump rate is increased from SD7 to SD1 (refer Section 5.2.10).

Table 21 Conceptual Design of SD4 Upgrade and Additional Sediment Dams

Sediment Basin	Estimated Commissioning Date	Estimated Maximum Catchment Area (ha)	Settling Zone Volume (ML)	Sediment Zone Volume (ML)	Minimum Required Capacity (ML)	Minimum Required Pump Rate (L/s)
SD4 (Upgrade)	1/8/2027	173.6	34.8	17.4	52.2	81
SD5	1/7/2021	95.3	19.1	9.6	28.7	44
SD6	1/7/2023	73.9	14.8	7.4	22.3	34
SD7	1/7/2024	65.1	13.1	6.5	19.6	30
SD8*	1/7/2040	3.0	0.6	0.3	0.9	1

* Not explicitly modelled, included in ED2 catchment.
ha = hectares, L/s = litres per second, ML = megalitres.

4.3.2 Water Demand

The site water demand, comprising haul road dust suppression, stockpile dust suppression, vehicle washdown, construction and CHPP make-up requirements, will be required for the Project life. Stockpile dust suppression requirements will increase in proportion with the increase in stockpile area while the haul road dust suppression and vehicle washdown will increase in proportion with the increase in total haul road length and CHPP feed rate. Construction water will also be required for RLD2, MWD2, MWD3, HWD2, HWD3, upgrade of SD4 and the additional sediment dams.

4.3.3 Water Supply

Water will be supplied for site purposes from a number of sources during the life of the Project, including (as available):

- open cut pit dewatering;
- internal runoff collection at the mine site;
- return water from the Fines Emplacement Area;
- water reclaimed from the belt press filters on new coal processing modules; and

- Hunter River supply.

In addition, in order to reduce make-up water demand from the Hunter River over the life of the MPO, MACH Energy may also source water from other external sources, such as excess mine water from the adjoining mines (i.e. Dartbrook and Bengalla Mines). Should this water sharing be undertaken, it would be subject to MACH Energy and other relevant parties obtaining all necessary secondary approvals.

4.4 PROPOSED FINAL LANDFORM

The proposed final landform is illustrated in Figure 15. Post-mining, all mining areas, except for the western pit face, will be regraded to a stable landform and revegetated. Permanent diversion drains will be constructed adjacent to the south-eastern, south-western and north-western edges of the final void catchment to convey runoff from upstream areas away from the final void and divert runoff to existing surface water drainages.

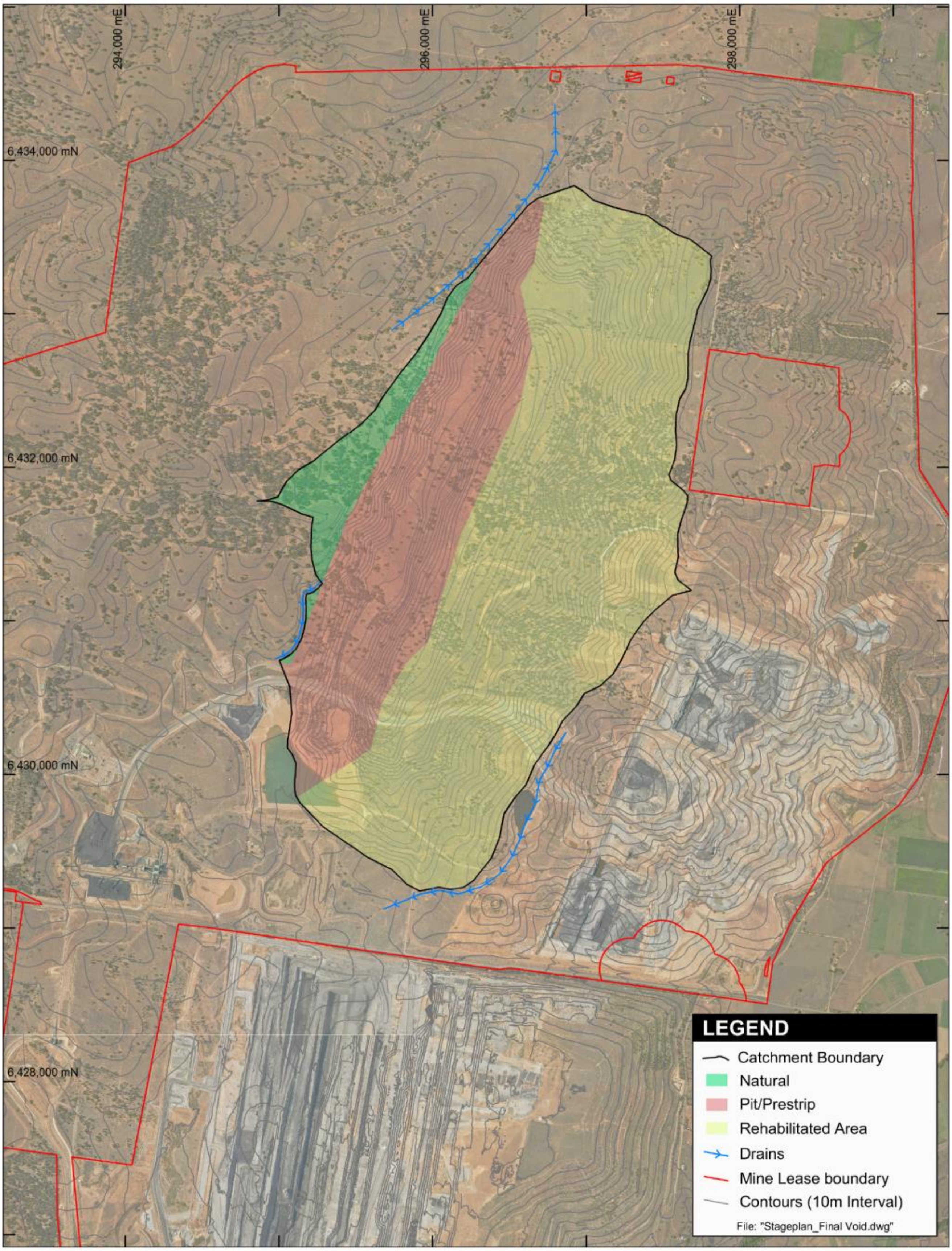


Figure 15 Final Void Water Management Layout and Sub-Catchment Boundaries

5.0 OPERATIONAL WATER AND SALT BALANCE MODELLING

5.1 MODEL DESCRIPTION

The water balance model has been developed to simulate the storages and linkages shown in schematic form in Figure 8 and Figure 14. The model has been developed using the GoldSim® simulation package. The model simulates the behaviour of water held in and pumped between all simulated water storages. For each storage the model simulates:

Change in Storage = Inflow – Outflow

Where:

Inflow includes rainfall runoff, groundwater inflow (for the open cut pit), fine rejects bleed water (for the Fines Emplacement Area), water sourced from the Hunter River (for the MWDs) and all pumped inflows from other storages.

Outflow includes evaporation, spill, all pumped outflows to other storages or to a demand sink (e.g. the CHPP) and controlled release via the HRSTS (for DW1).

The model operates on an 8-hourly time step. Model simulations begin on 1st July 2020 and finish on 31st December 2048. The model simulates 121 “realizations” derived using the historical daily climatic record[5] from 1892 to 2012. This period aligns with the Hunter River Integrated Quantity-Quality Model (IQQM) simulations which have been undertaken using climatic data from 1892 to 2012 to simulate available water determinations in the Hunter Valley as well as other key water supply parameters (refer Section 5.2.6). Although the period of climatic data from 2012 to 2020 is not simulated in the water balance model, due to the need to align with the IQQM simulations, the period of climatic data from 1892 to 2012 comprises a wide range of climatic events including high, low and median rainfall periods.

Realization 1 uses climatic data from 1892 to 1897, realization 2 uses data from 1893 to 1898, realization 3 uses data from 1894 to 1899 and so on. The results from all realizations are used to generate estimates of supply reliability, spill and open cut pit water inventory.

5.2 MODEL DATA AND ASSUMPTIONS

A summary of the data and key assumptions underpinning the model are provided in the sub-sections that follow.

5.2.1 Rainfall Runoff Simulation and Catchment Areas

Rainfall runoff in the water balance model is simulated using the Australian Water Balance Model (AWBM) (Boughton, 2004). The AWBM is a nationally-recognised catchment-scale water balance model that estimates catchment yield (flow) from rainfall and evaporation.

AWBM simulation of flow from six different sub-catchment types was undertaken, namely: undisturbed (natural) areas, hardstand (for example, roads and infrastructure areas), open cut pit, active waste rock emplacement, rehabilitated areas and fines reject emplacement. AWBM simulation of flow from each of the sub-catchment types was undertaken. Model AWBM parameters are summarised in Table 22 below. Evaporation pan factors were set to 1 for fine rejects and hardstand areas and 0.85 for all other sub-catchment types based on experience with similar projects. The fine rejects sub-catchment was split into two sub-areas; wet beach (20% of the area) and dry beach (80% of the area) to allow for the different runoff characteristics expected.

[5] Data was sourced from SILO Point Data generated climatic data for the mine location – refer Section 3.1.

Table 22 Model AWBM Parameters

Parameter	Sub-catchment Type					
	Natural (Undisturbed)	Hardstand	Open Cut Pit	Waste Rock	Rehabilitated	Fine Rejects
C_1 (mm)	7.5	2	5	15	7.5	0
C_2 (mm)	76.2	10	70	50	76.2	5
C_3 (mm)	152.4	30	90	110	152.4	5
A_1	0.134	0.333	0.2	0.1	0.134	0.2
A_2	0.433	0.334	0.6	0.3	0.433	0.8
A_3	0.433	0.333	0.2	0.6	0.433	-
K_s (d^{-1})	0.2	0	0.1	0.5	0.3	0
BFI	0.22	0	0	0	0.22	0
K_b (d^{-1})	0.861	-	-	-	0.861	-

For water surface areas, rainfall was assumed to add directly to the storage volume with no losses.

Each modelled storage catchment area was divided into sub-catchment areas corresponding with the sub-catchment types in Table 22. Catchment and sub-catchment areas for the modelled storages were calculated from the supplied stage plans (refer Section 4.0).

Figure 16 summarises the total catchment area reporting to the water management system over the simulation period. The catchment area is calculated in the model by linearly interpolating between the values derived from the stage plans. The total catchment area was approximately 1,415 ha as of July 2020 and is expected to increase to approximately 2,700 ha over the life of the Project.

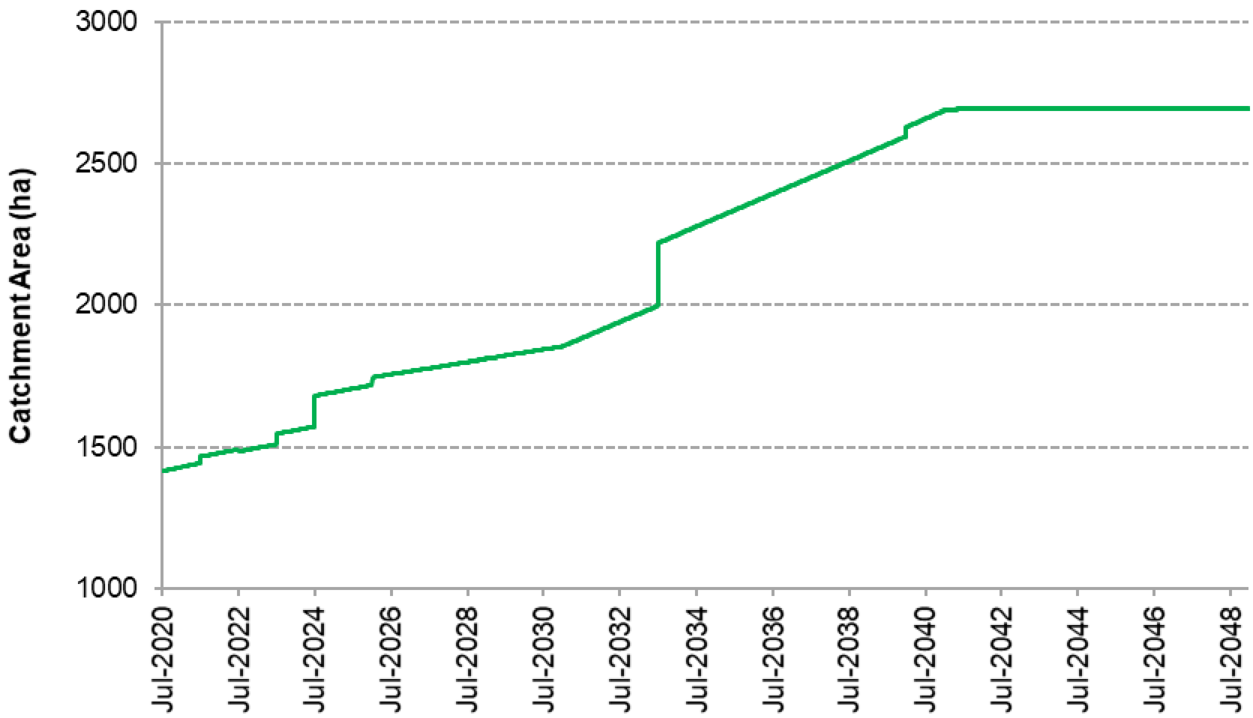


Figure 16 Modelled Total Catchment Area Versus Time

5.2.2 Evaporation from Storage Surfaces

Storage volumes simulated by the model are used to calculate storage surface area (i.e. water area) based on storage level-volume-area relationships for each water storage.

The following pan factors were assumed in the estimation of evaporation from various water storage areas (as a multiplier on daily pan evaporation):

- Fines Emplacement Area 1.1; due to the darker reject surface;
- Open Cut Pits 0.8; due to shading effects and lower wind speed at depth; and
- All other storages: monthly values varying from 0.84 to 0.95 on the basis of values in McMahon et al. (2013) for Scone.

5.2.3 CHPP Demand and Fine Rejects Disposal

The Stage 1 CHPP would process ROM coal at a rate of up to 10.2 Mtpa until the first of the Stage 2 CHPP modules are constructed. At that time, the Stage 1 CHPP would continue to process ROM coal at a rate of approximately 7.9 Mtpa producing conventional fine rejects. The Stage 2 CHPP will include belt press filters for dewatering fine rejects and will process additional coal when the production rate is above 7.9 Mtpa.

Forecast annual tonnes of ROM CHPP feed, product, fine and coarse rejects are shown in Figure 17.

The CHPP demand was calculated by simulating the moisture balance across the CHPP, using the following data:

- Coarse reject yield: 70% of total reject
- Fine reject yield: 30% of total reject
- ROM coal moisture: 9%
- Product moisture: 11%
- Coarse reject moisture: 18.5%
- Thickened fine rejects underflow solids content: 25%
- Belt press filter fine rejects solids content: 65%

Fine rejects from the Stage 1 CHPP were modelled as discharged to the Fines Emplacement Area from commencement of processing. Fine rejects were modelled as settling to 60% solids content. Figure 17 shows the daily resulting calculated fine rejects bleed rate (i.e. water reporting to the surface as the fine rejects settle).

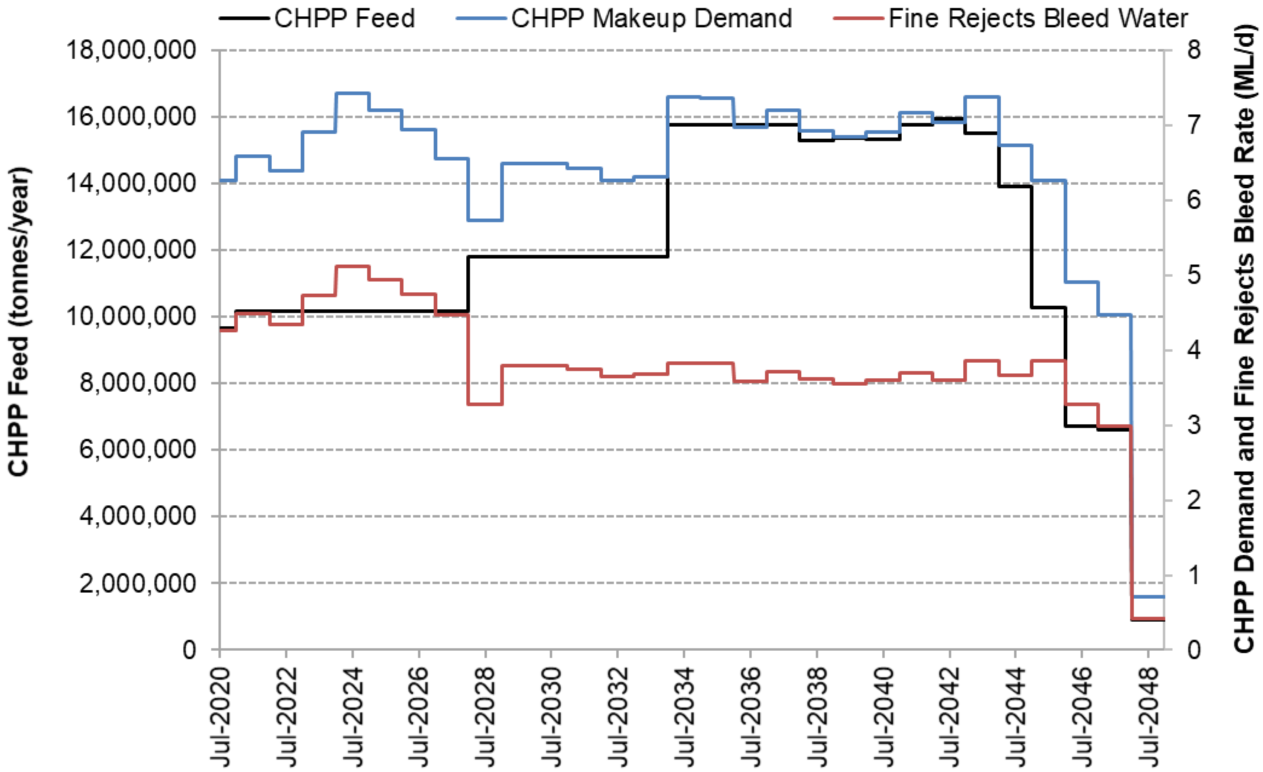


Figure 17 Modelled CHPP Feed, Water Demand and Fine Rejects Reclaim

5.2.4 Other Water Demands

Haul road dust suppression demand was calculated based on haul road lengths derived from supplied stage plans (refer Section 4.0). Daily demand was calculated based on the following assumptions:

- 30 m average watering width for the primary haul road;
- 25 m average watering width for the in-pit and waste emplacement haul roads;
- 80% of the total length of the in-pit and waste emplacement haul roads would be active and require watering at any one time;
- evaporation factor of 1.1 to allow for the darker, trafficked haul road surfaces; and
- on days where rainfall exceeded evaporation, zero demand was simulated.

The water truck fleet is assumed to be increased as necessary over the duration of the Project in order to meet haul road dust suppression demand requirements. The simulated haul road dust suppression demand is illustrated in Figure 18. Calculated haul road dust suppression demand averaged approximately 2.1 ML/d for the simulation period.

Existing vehicle washdown demand was estimated at 36.5 ML/year. To account for an increase in truck fleet associated with an increase in coal tonnage over the life of the Project, the vehicle washdown demand was factored based on the CHPP feed rate. Dust suppression of stockpiles was calculated based on an initial stockpile area of 32,780 square metres (m^2) increasing by 29,180 m^2 from the start of 2022, with stockpile dust suppression demand calculated in the same way as for haul road dust suppression demand.

Construction water will be required for the proposed upgrades to the CHPP and for construction of the proposed water storages.

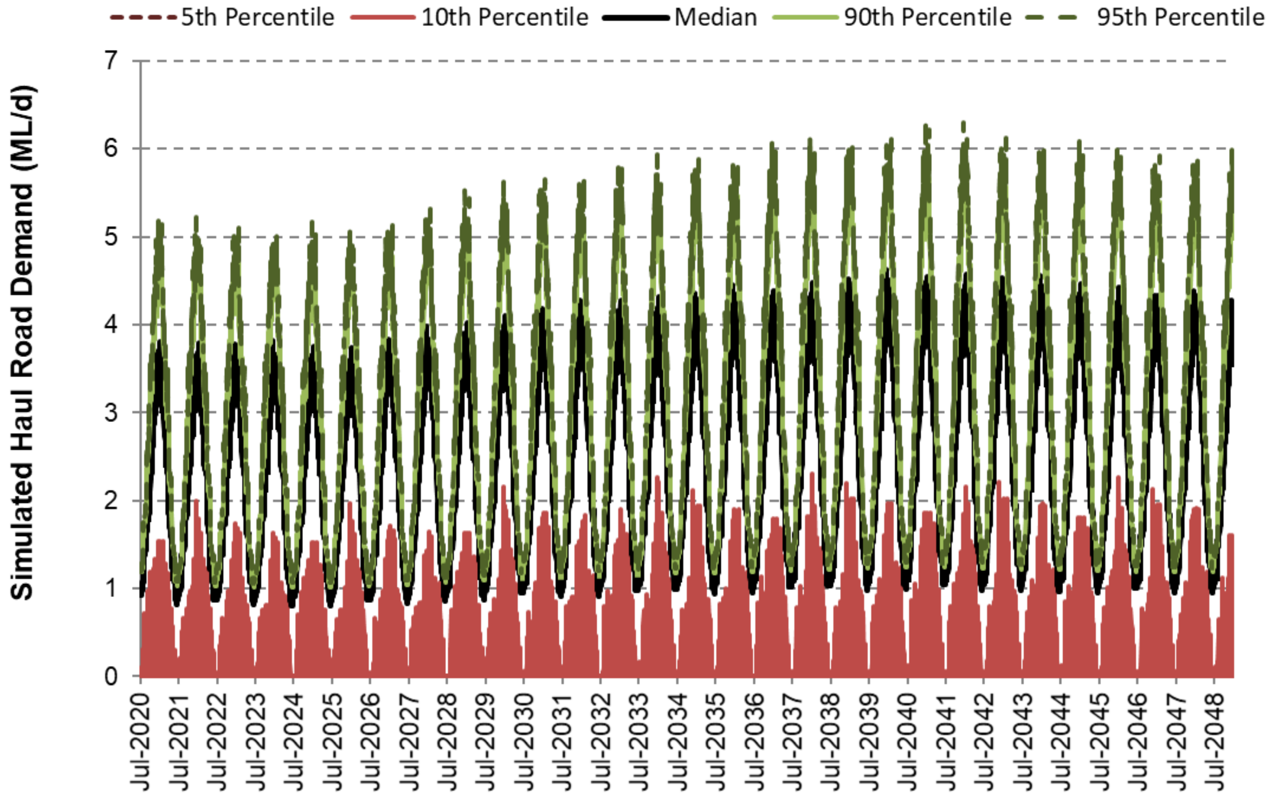


Figure 18 Simulated Haul Road Demand

5.2.5 Groundwater Inflow

Predicted annual groundwater inflow rates to the Open Cut Pits over the simulation period are shown in Figure 19 (AGE, 2020). The annual volume is presented for the July to June period (financial year).

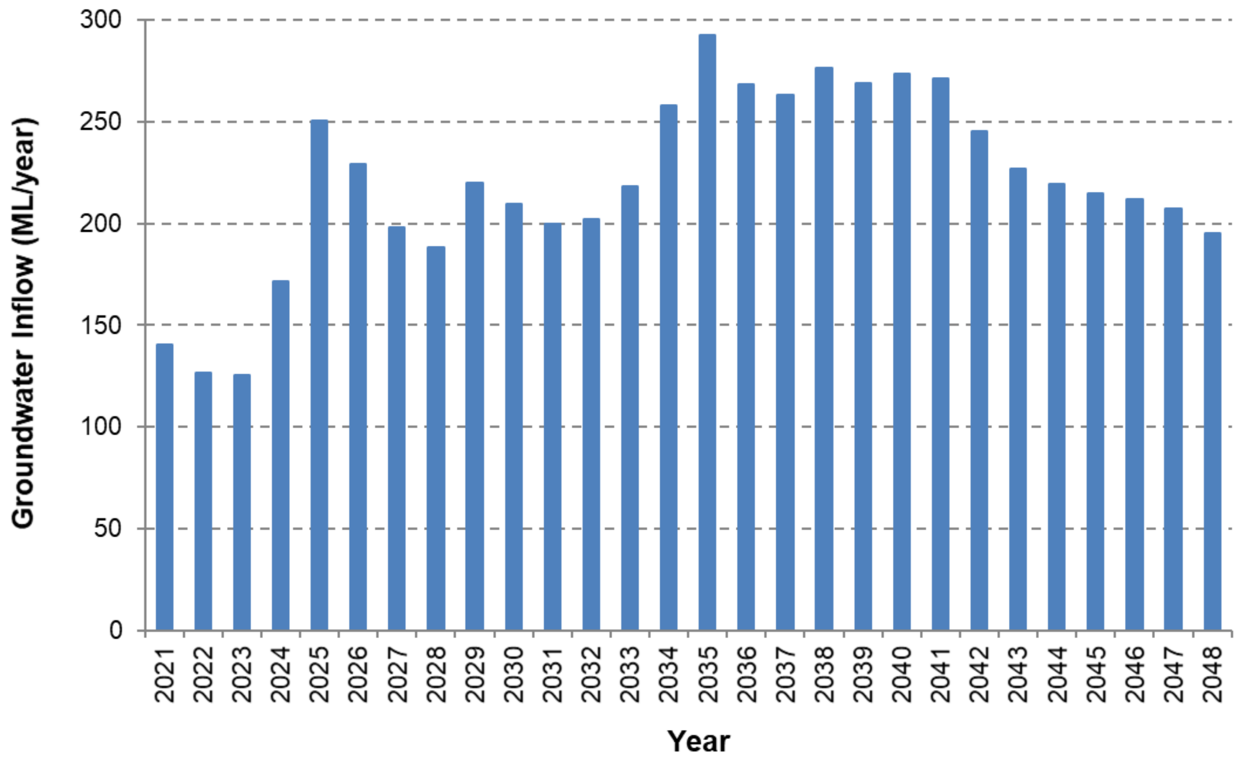


Figure 19 Predicted Annual Total Open Cut Groundwater Inflow

The groundwater inflow rates were apportioned to each open cut pit based on the coal seam strike length. The estimated strike length for each open cut pit over the life of the Project is presented in Table 23.

Table 23 Estimated Open Cut Pit Strike Lengths

Date	South Pit Strike Length (km)	Central Pit Strike Length (km)	North Pit Strike Length (km)	Total Strike Length (km)
1-1-2020	1.55	0.89	0.00	2.44
1-1-2026	0.75	2.80	0.00	3.55
1-1-2028	1.31	3.07	1.37	5.75
1-1-2031	1.85	2.25	1.53	5.63
1-1-2041	1.55	3.40	0.29	5.24
1-1-2047	2.00	1.82	1.38	5.20

The groundwater inflow rates were reduced to allow for evaporation from the exposed coal seam (recognising that the coal seam is the principal aquifer). Calculations allowed for average coal seam thickness of 55.9 m (AGE, 2020) and strike length versus time multiplied by a pan factor for the open cut of 0.8. The simulated total annual groundwater inflow rate net of evaporation is shown in Figure 20. The annual volume is presented for the July to June period (financial year).

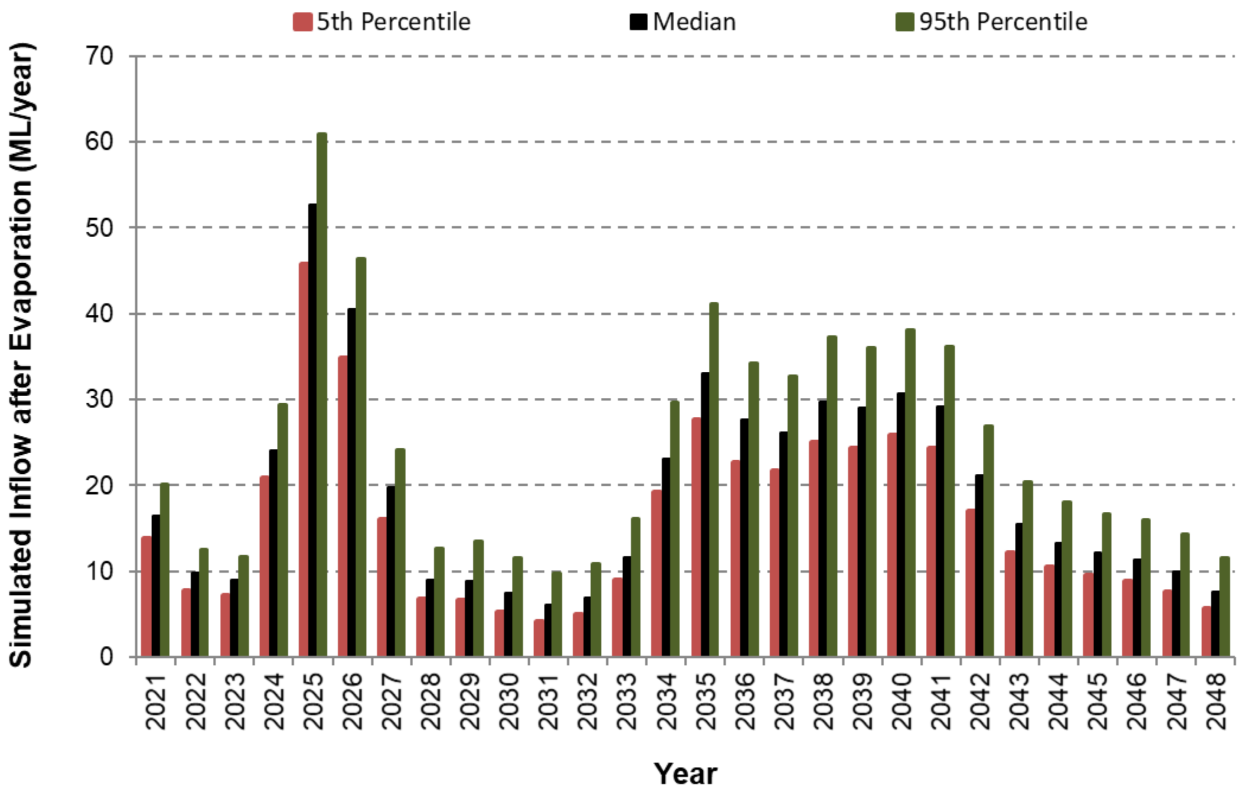


Figure 20 Groundwater Inflow After Evaporation

5.2.6 Hunter River Supply

The IQQM is the model used by the Department of Planning, Industry and Environment - Water (DPIE - Water) to make available water determinations in the Hunter Valley, in accordance and in conjunction with the *Water Sharing Plan for the Hunter Regulated River Water Source 2003*. IQQM simulations have previously been undertaken using climatic data from 1892 to 2012 (the same period of data as used in the water balance model) to generate predictions of general security WAL available water determinations (AWDs), periods of off-allocation flow and volume of water stored in Glenbawn Dam and Glennies Creek Dam (the two Hunter River major regulating storages), used to estimate AWD for High Security (HS) WALs.

A total of 858 ML/year Hunter River HS WALs and 2,577 ML/year Hunter River General Security (GS) WALs were modelled for the Project (noting that MACH Energy has subsequently purchased additional entitlement as summarised in Section 2.3). The simulation starts at the commencement of the current water year. A pumping rate of 200 L/s was used to simulate extractions from the Hunter River. Sourcing of water from the Hunter River was only simulated when certain ‘trigger’ volumes in the MWDs occurred (refer Section 5.2.10). Carry over of GS WALs has been included per clause 53(6)(b) of the *Water Sharing Plan for the Hunter Regulated River Water Source 2003* although no carry over has been assumed for the first modelled water year (2020/21).

5.2.7 Licensed HRSTS Discharge

DW1 will comprise a catchment area of 15 ha and a capacity of 363 ML with commissioning at the start of 2022. In the event of excess water stored in the MWDs, governed by ‘trigger’ volumes in the MWDs (refer Section 5.2.8), water would be transferred from the MWDs to DW1. Release via the HRSTS from DW1 has been simulated to occur at the next river release opportunity at a maximum release rate of 125 ML/d.

Simulating periods available for licensed release involved firstly developing a relationship between river flow rate and river registers for declared “high” flow events. This was carried out using historical river registers sourced online, correlated against recorded Hunter River daily flows. This correlation was extended to “flood” flow events in the Hunter River (during which no daily discharge restriction applies). Hunter River flow rates at Denman were simulated by the IQQM for the same period of historical climate data as used in the water balance model and these flows used with the above correlation relationship to simulate river registers. A total of 41 HRSTS credits were simulated, with the rate of release dependent on the modelled salinity in DW1 (refer Section 6.6).

5.2.8 Storage Capacities and Design Criteria

A summary of the required capacity to meet the associated design criteria for each simulated storage are shown in Table 24. Also tabulated is the modelled capacity which was provided by MACH Energy and is understood to be derived from as-built survey or the latest civil design information. Note that the modelled capacity is greater than or equal to the required capacity for all storages.

The open cut pits were excluded from Table 24 because their capacity was not based on design criteria. For modelling purposes, the open cut pit storages were assumed to comprise an excavated sump throughout the Project life and the volume of water stored was tracked within the model and reported to assess risk of disruption to mining (refer Section 6.3).

The Fines Emplacement Area was excluded from Table 24 because its capacity varies with time. Storage characteristics for the Fines Emplacement Area were developed at different times over the Project life based on the fine rejects beach profile generated from the indicative mine schedule for the Project and an assumed 2% sloping fine rejects beach. The Fines Emplacement Area reclaim pumping rate and MWDs trigger level were set so that no spills were simulated from this area.

Table 24 Modelled Storage Capacities and Design Criteria

Storage	Initial Estimated Required Capacity (ML)	Design Criterion	Modelled Capacity (ML)
ED2	6.9	Sized to mitigate spill risk	25.5*
ED3	289.7	1% AEP spill risk	331.7*
RLD1	2.5	1% AEP spill risk	16.3*
EDMIA	-	Nominal size – spills to ED3	17.1*
CHPPSD	-	Nominal size – spills to ED3	8.2*
HWD1	106.5	Nominal size – spills to South open cut pit	110^
HWD2	110	Nominal size – spills to Central open cut pit	110^
HWD3	110	Nominal size – spills to North open cut pit	165.3
MWD1	2,018.2	Allow for buffer to supply site demands	2,077*
MWD2	1,850.6	Allow for buffer to supply site demands – simulated as commencing Jan 2039	1,850.6
MWD3	1,799	Allow for buffer to supply site demands	1,799
SD1	23.1	Landcom (2004) & DECC (2008)	51.6*
SD3	32.3	Landcom (2004) & DECC (2008)	40.2*
SD4	22.5	Landcom (2004) & DECC (2008) – storage will expand from Sep 2027	36.6 / 56.2
SD5	28.7	Landcom (2004) & DECC (2008)	28.7
SD6	22.3	Landcom (2004) & DECC (2008)	22.3
SD7	19.6	Landcom (2004) & DECC (2008)	19.6
RLD2	9.5	1% AEP spill risk	9.5
DW1	363	1% AEP spill risk	363

* Based on as-built survey; ^ design capacity. Note: The catchment reporting to each of these storages is shown in Figure 9 to Figure 13.

5.2.9 Initial Stored Water Volumes

A summary of the initial recorded stored water volumes in each simulated storage just prior to the start of the simulation (values recorded on 24th June 2020) are provided in Table 25.

Table 25 Modelled Initial Stored Water Volumes

Storage	Initial Stored Water Volume (ML)
ED2	9.7
ED3	53.2
RLD1	3.7
EDMIA	5.9
CHPPSD	3.9
HWD1	83.4
MWD1	1,561.3
SD1	9.2
SD3	3.5
SD4	-

5.2.10 Pumping Rates and Triggers

Simulated pumped transfer rates between storages and the triggers which dictate when pumps are activated and deactivated are summarised in Table 26. Triggers were adjusted based on iterative simulations to achieve desired water management outcomes.

Table 26 Modelled Pump Rates and Triggers

Source	Destination	Pump Rate (L/s)	Condition 1 - To Start Pump	Condition 2 - To Start Pump	Condition 3 - To Stop Pump
ED2	MWDs	15	ED2 > 17.9 ML	MWD1 < 1,845 ML MWD2 < 1,647 ML	ED2 < 0.7 ML$^{\Delta}$
	FEA*	100	ED2 > 17.9 ML	FEA < FSL†	ED2 < 0.7 ML$^{\Delta}$
ED3	MWDs	100	ED3 > 120 ML	MWD1 < 1,969 ML MWD2 < 1,758 ML	ED3 < 102.2 ML$^{\Delta}$
EDMIA	MWDs	50	EDMIA > 2.5 ML	MWD1 < 1,642 ML MWD2 < 1,462 ML	EDMIA < 0.7 ML$^{\Delta}$
HWD1	MWD1	300	HWD1 > 85 ML	MWD1 < 1,845 ML	HWD1 < 70 ML
HWD2/3	MWDs	300	HWD2/3 > 10 ML	MWD1 < 1,845 ML MWD2 < 1,647 ML	HWD2/3 < 8 ML
MWD1	HWD1	200	MWD1 > 504 ML	HWD1 < 30 ML	MWD1 < 504 ML or HWD1 > 70 ML
			MWD1 > 1,969 ML	-	MWD1 < 1,969 ML
MWD1	CHPPSD	100	MWD1 > 150 ML	CHPPSD < 4.1 ML	MWD1 < 144 ML
MWD1	DW1	200	MWD1 > 1,836 ML	DW1 < 309 ML	MWD1 < 1,836 ML or DW1 >309 ML
MWD1	HWD2/3	200	MWD1 > 504 ML	HWD2/3 < 4 ML	MWD1 < 504 ML or HWD2/3 > 8 ML
			MWD1 > 1,969 ML	-	MWD1 < 1,969 ML
MWD2	HWD2/3	200	MWD2 > 444 ML	HWD2/3 < 4 ML	MWD2 < 444 ML or HWD2/3 > 8 ML
			MWD2 > 1,758 ML	-	MWD2 < 1,758 ML
MWD2	DW1	200	MWD2 > 1,647 ML	DW1 < 309 ML	MWD2 < 1,647 ML or DW1 > 309 ML
MWD2	CHPPSD	100	MWD2 > 31.5 ML	CHPPSD < 4.1 ML	MWD2 < 16.5 ML
MWD2	MWD3	200	MWD2 > 1,240 ML	MWD3 < 1,710 ML	MWD2 < 1,240 ML or MWD3 > 1,710 ML
MWD3	MWD2	100	MWD3 > 1,710 ML	MWD2 < 1,230 ML	MWD3 < 1,710 ML or MWD2 > 1,230 ML

$^{\Delta}$ Dead storage volume.

† FSL = Full Supply Level - capacity minus 250 ML freeboard.

* FEA = Fines Emplacement Area.

Table 26 (Cont.) Modelled Pump Rates and Triggers

Source	Destination	Pump Rate (L/s)	Condition 1 - To Start Pump	Condition 2 - To Start Pump	Condition 3 - To Stop Pump
DW1	Hunter River	1,447	MWD1 > 1,836 ML or MWD2 > 1,647 ML	DW1 > 7 ML	MWD1 < 1,836 ML or MWD2 < 1,647 ML or cessation of river discharge opportunity
Hunter River	MWD1	200^	MWD < 1,400 ML		MWD1 > 1,634 ML
Hunter River	MWD2	200^	MWD2 < 1,240 ML		MWD2 > 1,455 ML
South Open Cut Pit	HWD1	100	Pit Sump > 10 ML	HWD1 < 89.3 ML	Pit Sump < 5 ML
		300	Pit Sump > 40 ML	HWD1 < 89.3	Pit Sump < 20 ML
South Open Cut Pit	HWD2_3	100	Pit Sump > 10 ML	HWD2_3 < 15 ML	Pit Sump < 5 ML
		300	Pit Sump > 40 ML	HWD2_3 < 15 ML	Pit Sump < 20 ML
Central Open Cut Pit	HWD1	100	Pit Sump > 10 ML	HWD1 < 89.3 ML	Pit Sump < 5 ML
		300	Pit Sump > 40 ML	HWD1 < 89.3 ML	Pit Sump < 20 ML
Central Open Cut Pit	HWD2_3	100	Pit Sump > 10 ML	HWD2_3 < 15 ML	Pit Sump < 5 ML
		300	Pit Sump > 40 ML	HWD2_3 < 15 ML	Pit Sump < 20 ML
North Open Cut Pit	HWD2_3	200	Pit Sump > 10 ML	HWD2_3 < 15 ML	Pit Sump < 5 ML
		400	Pit Sump > 40 ML	HWD2_3 < 15 ML	Pit Sump < 20 ML
RLD1	ED3	50	Pit Sump > 5 ML	ED3 < 219.8 ML	Pit Sump < 0.2 ML
RLD2	MWDs	50	Pit Sump > 7 ML	MWD1 < 1,969 ML or MWD2 < 1,758 ML	Pit Sump < 2.95 ML
SD1	MWDs	414	SD1 > 28.6 ML	MWD1 < 1,845 ML or MWD2 < 1,647 ML	SD1 < 0.8 ML[Δ]
SD3	SD1	294	SD3 > 7.9 ML	SD1 < 46 ML	SD3 < 0.5 ML
SD4	SD3	194	SD4 > 9.5 ML	SD3 < 33 ML	SD4 < 5 ML
SD5	SD4	113	SD5 > 11.5 ML	SD4 < 33 ML	SD5 < 7 ML
SD6	SD5	68	SD6 > 7.7 ML	SD5 < 21 ML	SD6 < 4.7 ML
SD7	SD6	34	SD7 > 8 ML	SD6 < 15.6 ML	SD7 < 5 ML
FEA*	MWDs	124	FEA > 65.5 ML	MWD1 < 1,969ML or MWD2 < 1,758ML	FEA < 55.5 ML

[Δ] Dead storage volume.

* FEA = Fines Emplacement Area.

^ MACH may target a higher pump rate for the Stage 2 water supply pipeline as part of detailed design.

5.2.11 Salinity Estimates

Catchment runoff salinity (EC values) were estimated from surface water monitoring data for the Hunter River, local surface water monitoring sites, existing site water storages, the Fines Emplacement Area and the existing open cut pit/s (refer Section 3.5). An EC to TDS conversion factor of 0.64 mg/L was adopted (Abrol et al., 1988). Data from the most recent year of salinity monitoring for site storages was used to estimate sub-catchment runoff EC (to maintain consistency with the current catchment and site water management characteristics), whereas Section 3.5

presents summaries of the full record of water quality data. A summary of the modelled inflow salinities is provided in Table 27.

Table 27 Modelled Inflow Salinity

Component		EC (µS/cm)	Basis
Hunter River supply		414	Median recorded EC for Hunter River site W15
Groundwater		5,522	Estimated based on the average EC of the open cut pits
Sub-catchment Runoff	Undisturbed	197	Average EC for monitoring sites W5, W7, W9 and W13
	Hardstand	639	Estimated from the water quality records for RLD1 accounting for the area of hardstand sub-catchment
	Open Cut Pit/Pre-Strip	2,000	Estimated based on the average EC in the open cut pit sumps
	Active Waste Rock	883	Estimated from the water quality records for SD1 and SD3 accounting for the area of active waste rock sub-catchment
	Rehabilitated Areas	312	Adopted 80th percentile EC value from estimates of undisturbed area runoff EC (monitoring sites W5, W7, W9 and W13)
	Fines Emplacement Area	1,292	Average EC based on monitoring records for Fines Emplacement Area

Following model simulation, the predicted salinity concentrations in the site water storages were reviewed against monitored water quality records and found to be consistent.

5.2.12 Initial Electrical Conductivity Estimates

Initial EC was based on values recorded in May 2020 as part of the MPO water monitoring programme, just prior to the commencement of the model simulation period (Table 28).

Table 28 Modelled Initial Storage Salinities

Storage	Initial Stored Water EC (µS/cm)
ED2	3,410
ED3	1,070
RLD1	354
EDMIA	219
CHPPSD	1,471
HWD1	1,593
MWD1	814
SD1	598
SD3	662
Fines Emplacement Area	1,375
South open cut pit	4,210
Central open cut pit	5,680

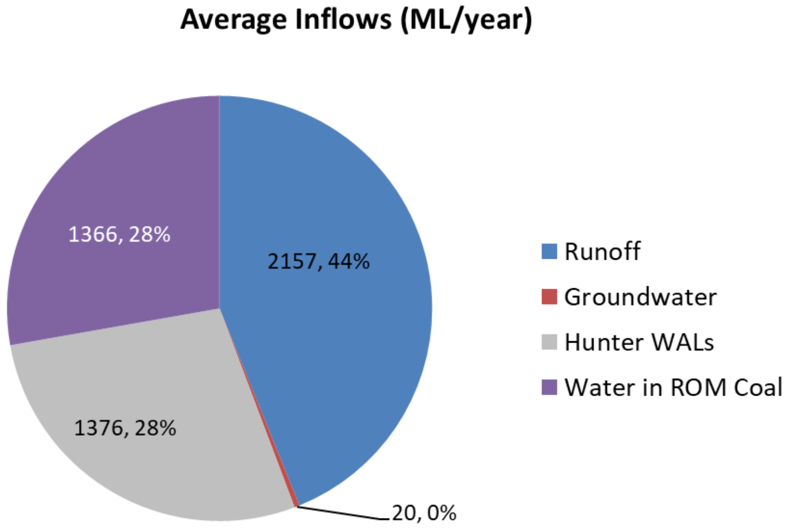
6.0 PROJECT WATER AND SALT BALANCE MODEL RESULTS

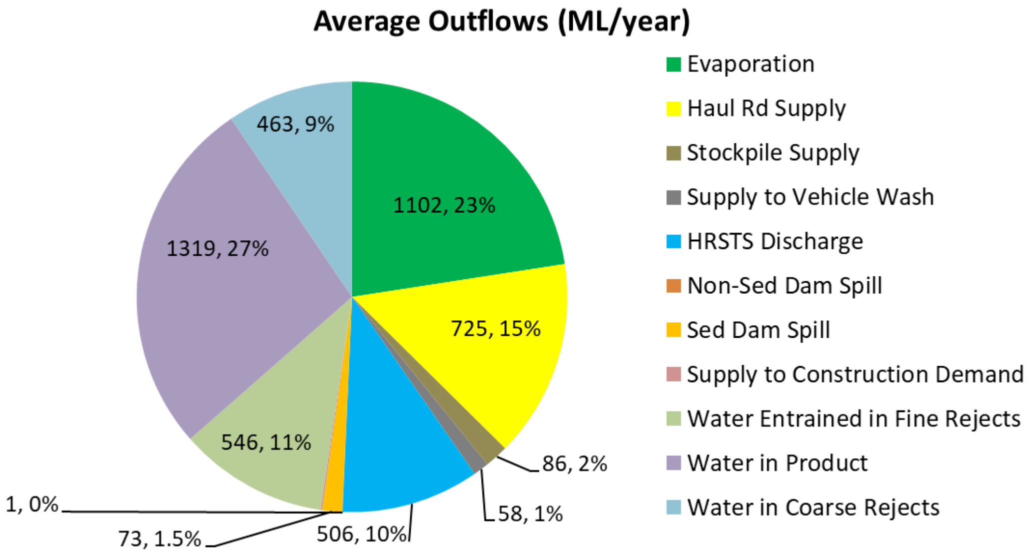
6.1 PROBABILISTIC RESULTS

Probabilistic outputs for key model results are presented in the following sections. The probabilistic outputs present the range of predicted outcomes, with the 5th/95th percentile results representing long-term lower and higher rainfall conditions, respectively. For example, there is a predicted 90% probability that the total water volume will fall in between the 5th/95th percentile volume plots. It is important to note that the plots do not represent a single climatic realization – the probability plots are compiled from all 121 realizations - e.g. the median volume plot does not represent model forecast volume for median climatic conditions.

6.2 OVERALL SITE WATER BALANCE

Model predicted average inflows and outflows, averaged over all 121 realizations and the simulation period, are shown in Figure 21. These results apply with the current water allocation licence volume available for the Project, which can be varied with additional purchases by MACH Energy, if required (refer Section 5.2.6).





Note: All values are given as average ML/year separated by a comma showing percentage of total

Figure 21 Average Modelled System Inflows and Outflows

Rainfall runoff provides the largest input of average modelled system inflow, accounting for 44% of total inflows, followed by licensed extraction (via WALs) at 28% and water entrained in ROM coal at 28%. The volume of water entrained in ROM coal is related to the moisture content of the ROM Coal (9%). Average outflows are dominated by water in the product coal (27%), followed by evaporation (23%) and haul road supply (15%).

6.3 STORED WATER VOLUMES

The predicted total stored water inventory for the MPO is shown in Figure 22 as probability plots over the simulation period.

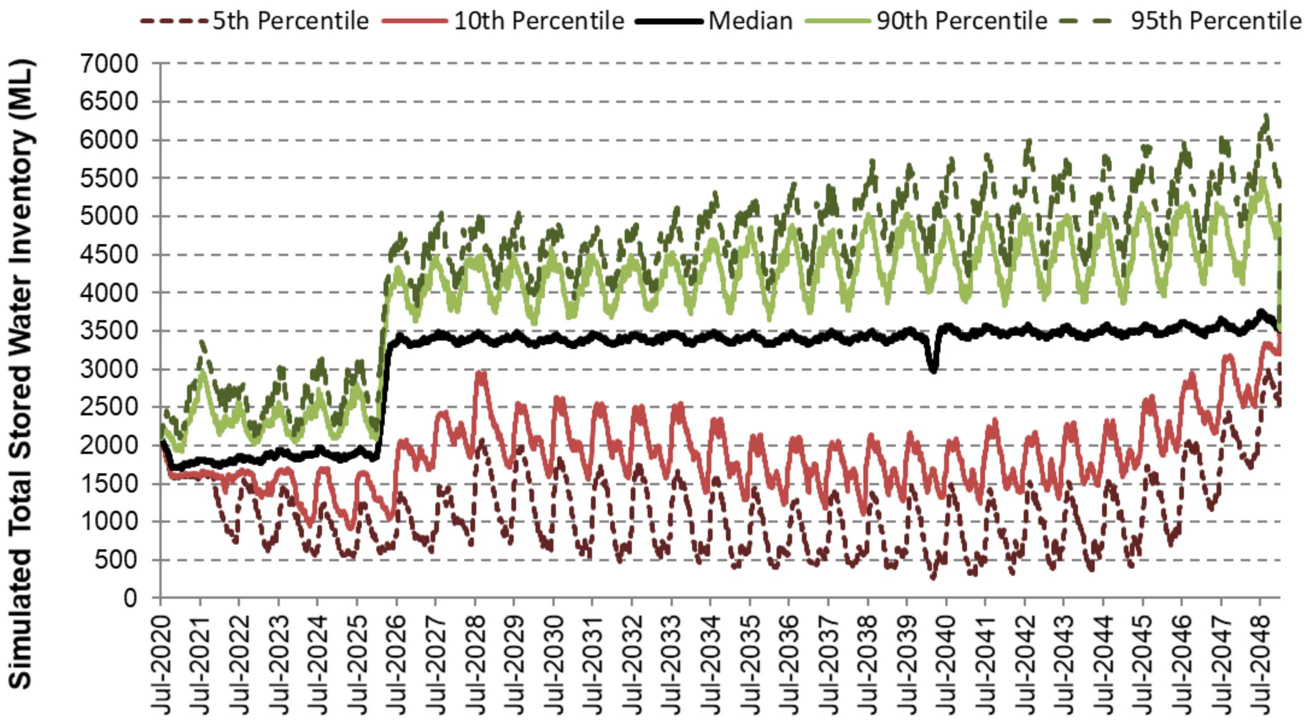


Figure 22 Simulated Total Stored Water Volume

The model results plotted in Figure 22 indicate that median total stored water volume on site oscillates seasonally, falling to lower levels in autumn and peaking in early spring, after the start of the new water year.

The main water storages for the Project are the MWDs. Figure 23, Figure 24 and Figure 25 provide probability plots for the simulated volume in these storages.

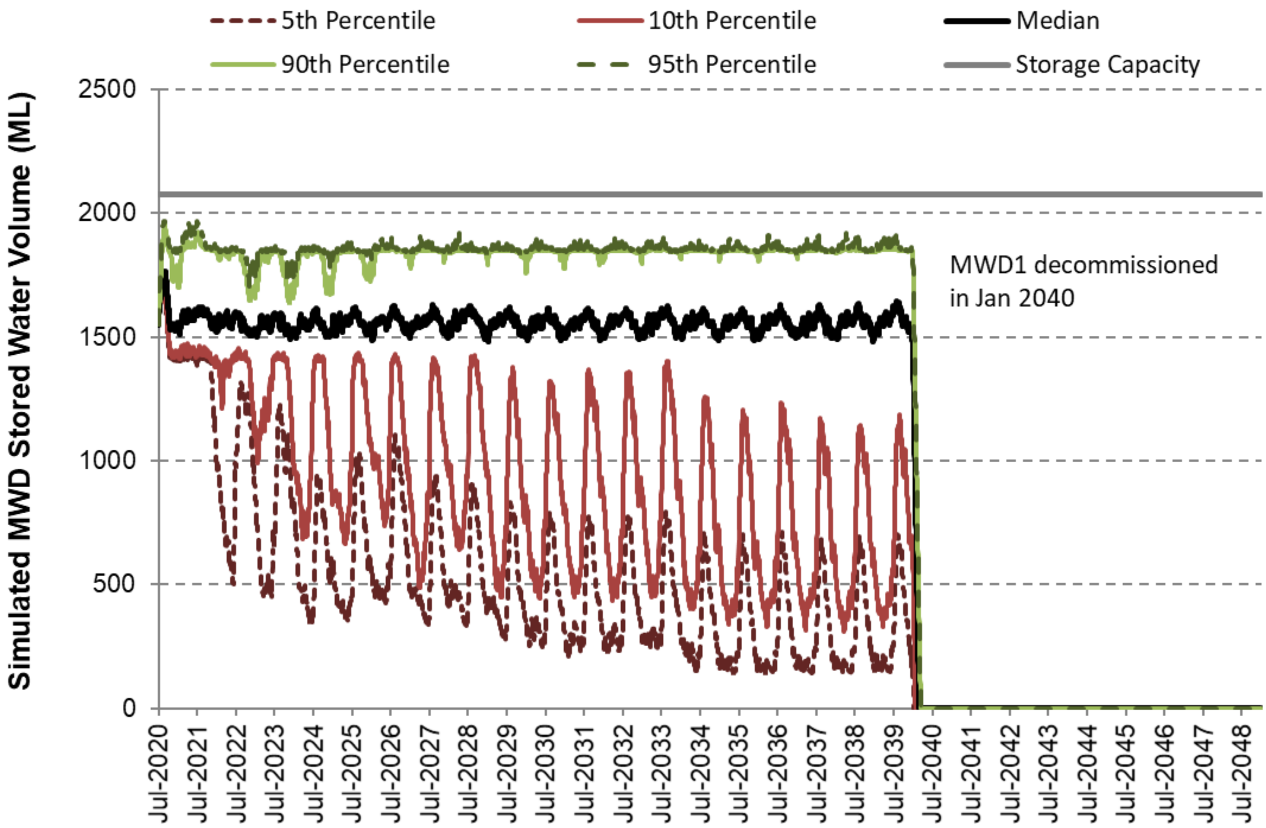


Figure 23 Simulated Stored Water Volume in MWD1

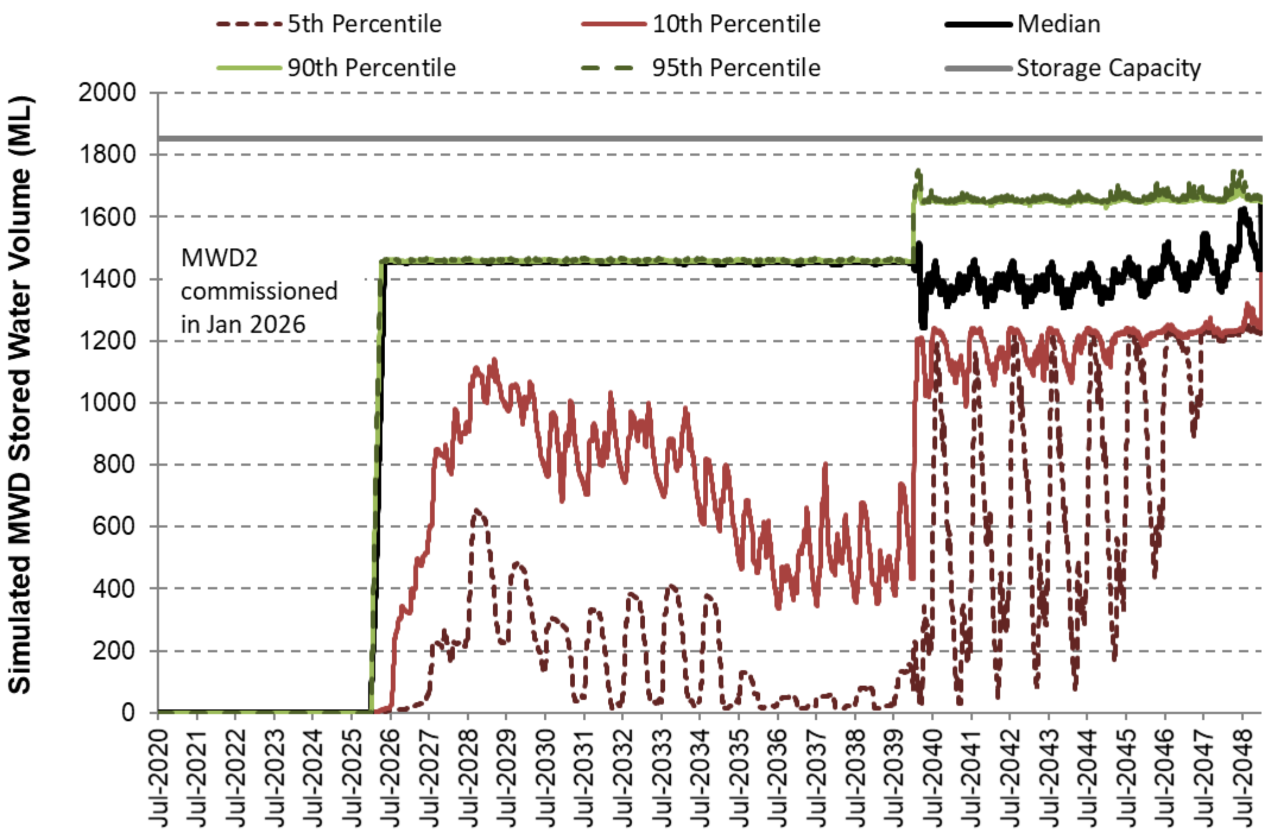


Figure 24 Simulated Stored Water Volume in MWD2

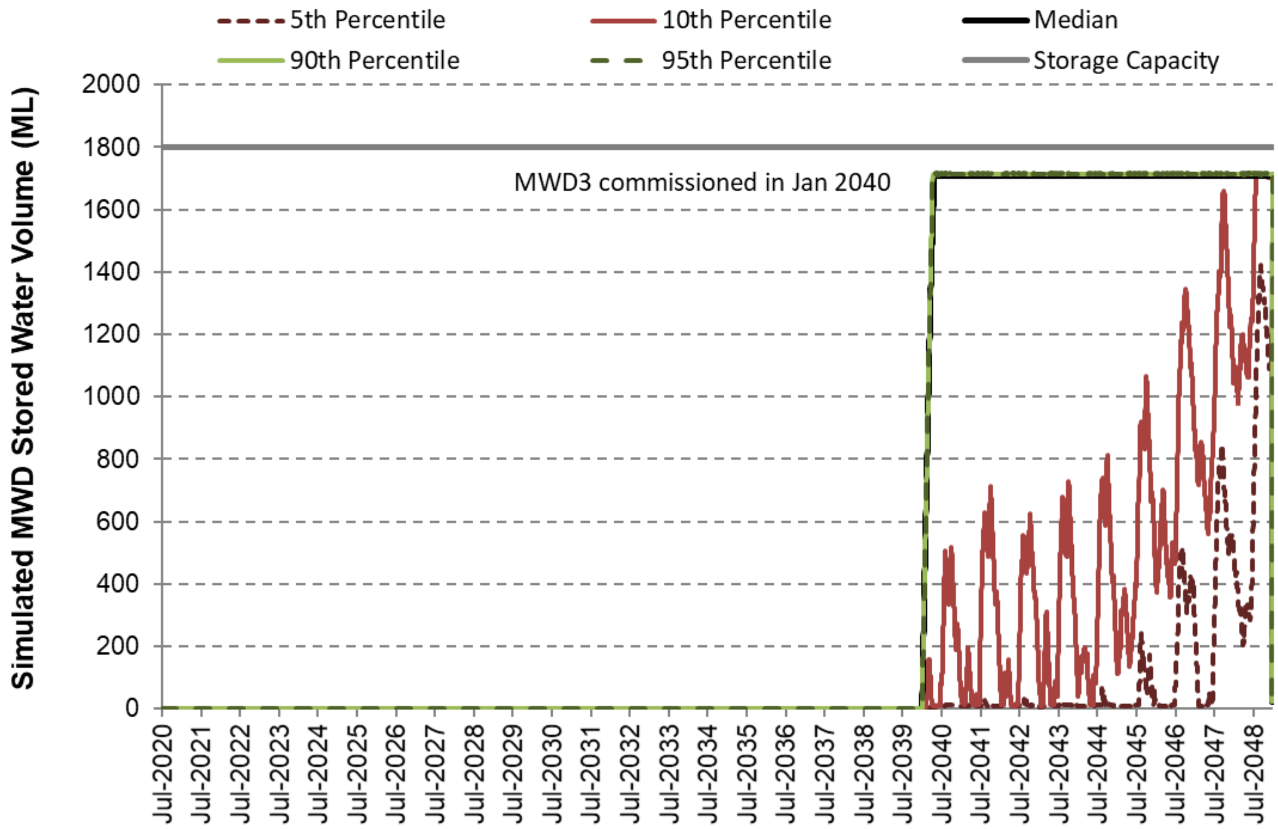


Figure 25 Simulated Stored Water Volume in MWD3

The median results presented in Figure 23, Figure 24 and Figure 25 illustrate that the MWDs have been modelled as maintaining a high and relatively constant water storage volume for the period of operation in order to provide a high reliability of supply (refer Section 6.4).

An excessive volume of water stored in the open cut pits has the potential to disrupt mining. The risk of mining disruption has been assessed by comparing the number of days over the simulation period in which more than 200 ML is predicted to be held in the open cut pits. Table 29 presents the model predictions for the 5th percentile, median and 95th percentile distributions of the percentage of days over the full simulation period in which more than 200 ML is predicted to be held in the open cut pits.

Table 29 Predicted Percentage of Days in Excess of 200 ML Stored in Open Cut Pits

Open Cut Pit	Percentage of Days over the Simulation Period		
	5th Percentile	Median	95th Percentile
South	5.3%	11.7%	16.5%
Central	0.5%	4.2%	7.0%
North	0.0%	2.4%	4.6%

Based on the model results presented in Table 29 there is a 95% probability (5th percentile) that there will be in excess of 200 ML in the South open cut pit more than 5.3% of the time over the life of the Project. There is a 50% probability (median) that there will be in excess of 200 ML in the South open cut pit more than 11.7% of the time over the life of the Project and a 5% probability (95th percentile) that there will be in excess of 200 ML in the South open cut pit more than 16.5% of the time.

During these periods, excess water would be required to be stored in an inactive part of the open cut pits until capacity in the HWDs or MWDs became available. The Project would include three distinct mining areas within the open cut (North, Central and South) which will provide flexibility to store water without impacting mining activities.

6.4 WATER SUPPLY RELIABILITY

Predicted average supply reliability is expressed as total water supplied divided by total demand (i.e. a volumetric reliability) over the simulation period. Average supply reliability over all climatic realizations, as well as the lowest single realization reliability (representing a simulated 'worst case' 28.5 year period), for CHPP supply, haul road dust suppression, stockpile dust suppression, vehicle wash and construction demand are summarised in Table 30.

Table 30 Summary of Modelled Water Supply Reliability

Demand	Average Volumetric Supply Reliability	
	Average	Lowest
CHPP	99.0%	93.2%
Haul Road Dust Suppression	97.2%	85.2%
Stockpile Dust Suppression	99.4%	91.2%
Vehicle Wash	99.6%	92.6%
Construction	99.8%	94.2%

An average 99% CHPP supply reliability is equivalent to 102 days of lost operation over the 28.5 year simulation period, while 93.2% lowest reliability equates to 711 days of lost operation over that period.

Adaptive use of supplementary measures, such as chemical dust suppressants during low rainfall periods and/or additional external water supply, can be adopted for the MPO in order to further reduce potential supply shortfalls. For example, it is estimated that a 40 - 50% reduction in haul road dust suppression water requirements may be achieved through implementation of chemical suppressants during low rainfall periods (Katestone Environmental, 2011).

MACH Energy may also source water from other external sources, such as excess mine water from nearby mines (i.e. Dartbrook and Bengalla Mines). Should this water sharing be undertaken, it would be subject to MACH Energy and other relevant parties obtaining all necessary secondary approvals.

6.5 HUNTER RIVER LICENSED EXTRACTION

A plot of the predicted annual licenced extraction volume from the Hunter River via WALs for the simulation period at different probabilities is shown in Figure 26.

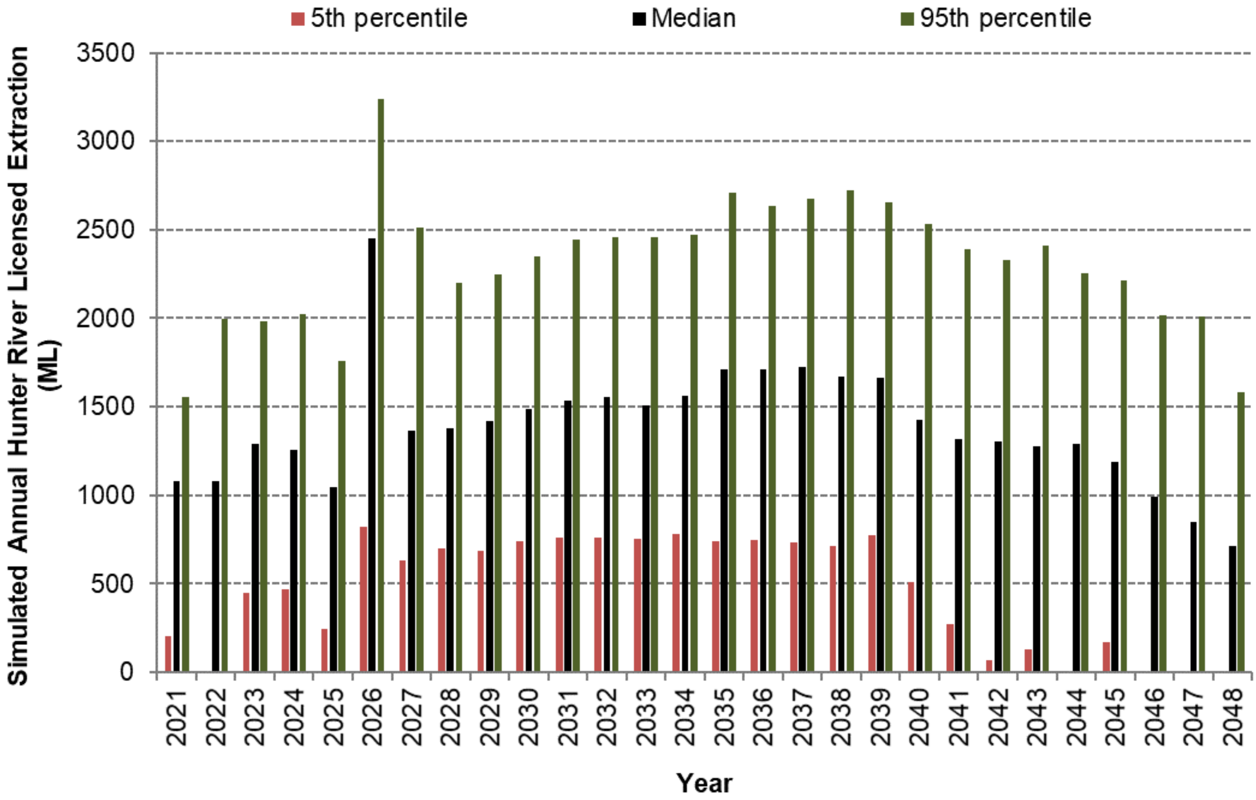


Figure 26 Annual Hunter River Licensed Extraction Volume

The model results provided in Figure 26 indicate that the volume of water sourced from the Hunter River would be lower than the modelled available licensed volume in all years (refer Section 5.2.6) and the recently acquired additional entitlement (refer Section 2.3). Based on the 95th percentile model results, a maximum of 3,241 ML would be required to be sourced from the Hunter River in 2026. This coincides with the commencement of MWD2 and the requirement to fill this new storage in order to boost supply reliability.

6.6 EXTERNAL RELEASE AND OVERFLOW

External release and overflow were simulated as occurring in accordance with the design criteria (refer Table 24) and the HRSTS discharge criteria (refer Section 5.2.7). Figure 27 presents the simulated average annual release from DW1 to the Hunter River and the overflow volume from ED2 to Sandy Creek, ED3 to Dry Creek and sediment dams SD1 to SD7 to Rosebrook Creek.

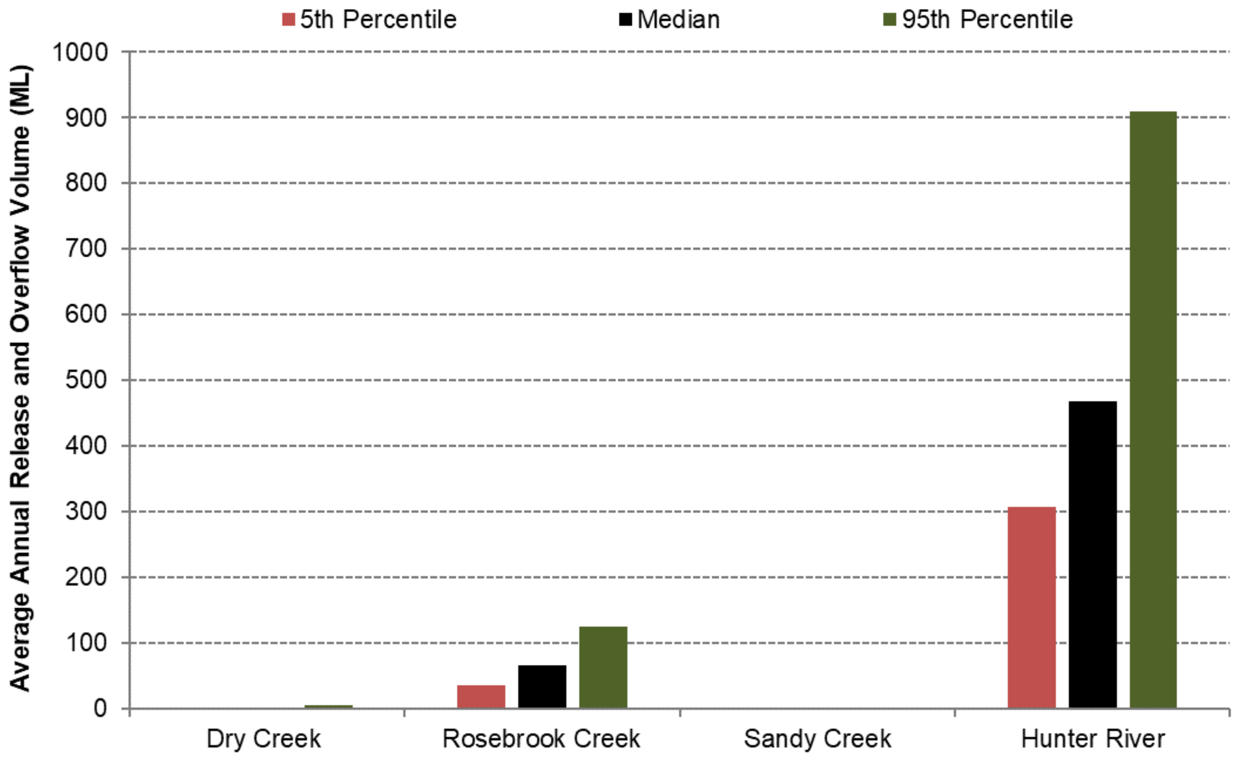


Figure 27 Annual Release and Overflow Volume

Figure 27 illustrates that, on average, an annual volume of 66 ML will overflow to Rosebrook Creek from sediment dams SD1 to SD7 based on the median model results and 125 ML based on the 95th percentile model results. The average Hunter River release volume from DW1 is predicted to be 469 ML based on the median model results and 909 ML based on the 95th percentile model results.

A low risk of overflow from ED3 to Dry Creek is predicted based on all model results. The percentage of annual overflow days from ED3 to Dry Creek is estimated at 1.6% based on all model realizations, which is slightly higher than the 1% AEP spill risk design criterion (i.e. in any simulated year, ED3 has a predicted spill risk of less than 1.6%). In order to achieve the 1% AEP spill risk criterion, it is recommended that the capacity of ED3 is increased prior to the increase in ED3 catchment area, expected to occur by 2026.

No spills were simulated from the Fines Emplacement Area, ED2, the MWDs or DW1.

Figure 28 presents the simulated average annual salt mass release from DW1 to the Hunter River and overflow salt mass from ED3 to Dry Creek and sediment dams SD1 to SD7 to Rosebrook Creek.

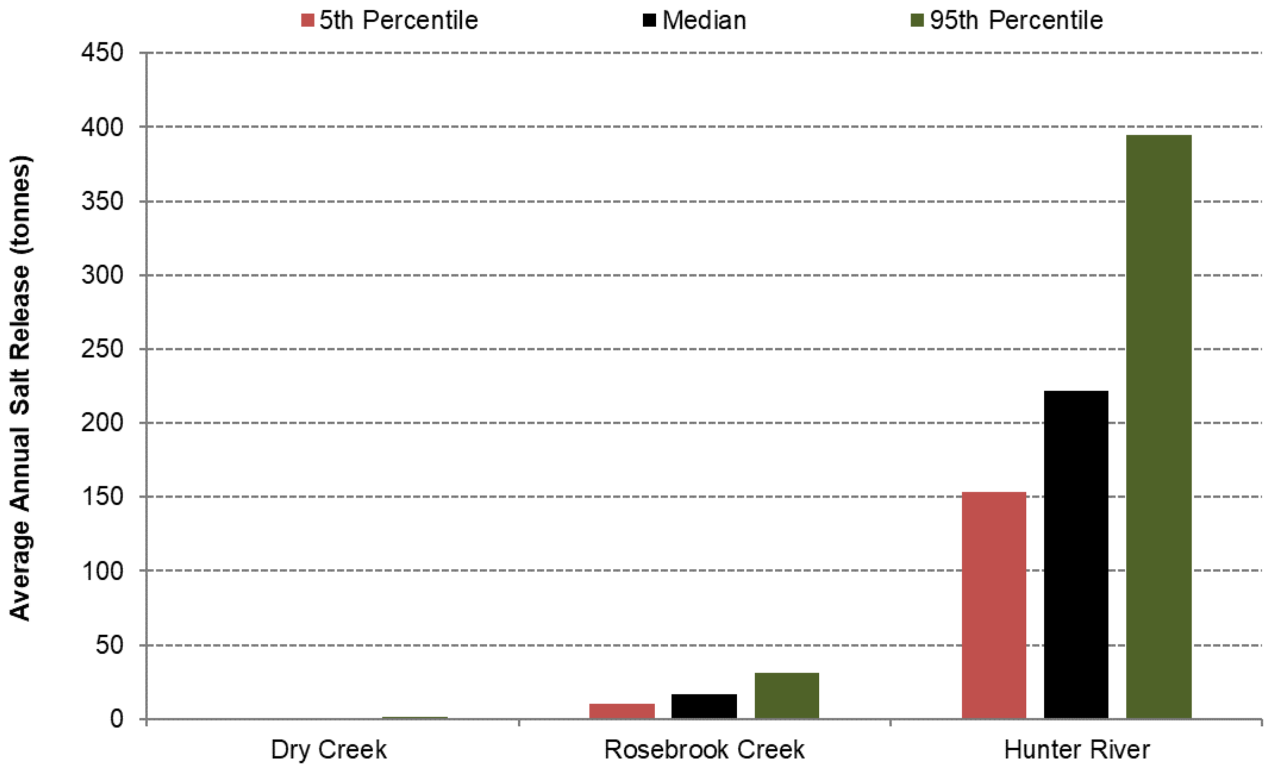


Figure 28 Annual Release and Overflow Salt Mass

Figure 28 illustrates that, on average, an annual mass of 17 tonnes will overflow to Rosebrook Creek from the sediment dams based on the median model results and 31 tonnes based on the 95th percentile model results. The average annual Hunter River release salt mass from DW1 is predicted at 222 tonnes based on the median model results and 395 tonnes based on the 95th percentile model results. For comparison, the long-term records of flow and EC in the Hunter River (refer Section 3.4 and Section 3.5) indicate a median annual salt mass in the Hunter River at Muswellbrook (GS 210002) of 43,111 tonnes and approximately 128,000 tonnes annually under 95th percentile conditions.

Based on the predicted total release volume, the average EC of overflow from the sediment dams to Rosebrook Creek is predicted at 394 µS/cm based on the median model results. This EC value is within the range of baseline EC values recorded for local and regional surface water systems (refer Section 3.5).

The predicted average EC of release waters to the Hunter River from DW1 is predicted at 739 µS/cm based on the median model results. As described in Section 5.2.7, water released from DW1 to the Hunter River was simulated based on 41 HRSTS credits, the modelled salinity concentration of DW1 and the simulated flow in the Hunter River.

7.0 FINAL VOID WATER AND SALT BALANCE MODELLING

7.1 MODEL DESCRIPTION

A daily timestep, final void water and salt balance model has been developed using the GoldSim® simulation package. The model simulates the volume and salinity of the final void water body by simulating the inflows, outflows and resultant volume of water and salt mass:

Change in Storage = Inflow – Outflow

Where:

Inflow includes direct rainfall, runoff and groundwater inflow.

Outflow includes evaporation.

7.2 KEY DATA AND ASSUMPTIONS

The model simulates inflow from remnant final void catchment rainfall runoff (including direct rainfall), groundwater inflow from bedrock as well as outflow due to evaporation on a daily basis. Key model input data include the following:

- A catchment area of 806.2 ha comprising 527.3 ha of rehabilitated waste rock emplacement sub-catchment, 47.6 ha of natural undisturbed sub-catchment and 231.4 ha of remnant open cut pit sub-catchment (refer Section 4.4).
- A 131-year rainfall data set (1889 to 2019) obtained from SILO Point Data and a 131-year evaporation data set for the same period (refer Section 5.2.1). The data set was repeated several times over to generate an extended period of climate data for final void simulation – to ensure equilibrium water levels were reached during the simulation period.
- A constant pan factor of 0.8 was assumed for calculation of evaporation from the final void until the water level reached 10 m below the spill point (if this occurs) at which point monthly pan factors taken from McMahon et al. (2013) were used – refer Section 5.2.2. The lower pan factor used for lower final void levels reflects lower evaporation likely at depth as a result of shading effects.
- Surface rainfall runoff was estimated using the AWBM applied to the final void sub-catchments, in a manner similar to the operational water balance model (refer Section 5.2.1). Direct rainfall was simulated on the contained water surface.
- Catchment runoff salinity (EC) values were estimated from water quality monitoring data as listed in Table 27.
- A groundwater inflow EC of 5,522 µS/cm was adopted based on the average of EC records for the open cut pits (Table 26).
- The rate of evaporation was adjusted based on the simulated final void water salinity (per Morton et al., 1985).

In simulating pit lake salinity, the model assumes conservation of mass and fully mixed conditions.

Groundwater inflow to the final void is expected to occur from the in-pit spoil and hard rock. Predicted rates of groundwater inflow versus water level in the final void were provided by AGE (2020) as shown in Figure 29. Note that this includes estimates of seepage from in-pit spoil and therefore sub-surface seepage from the catchment AWBM ('baseflow' in the AWBM) was not included as input to the final void.

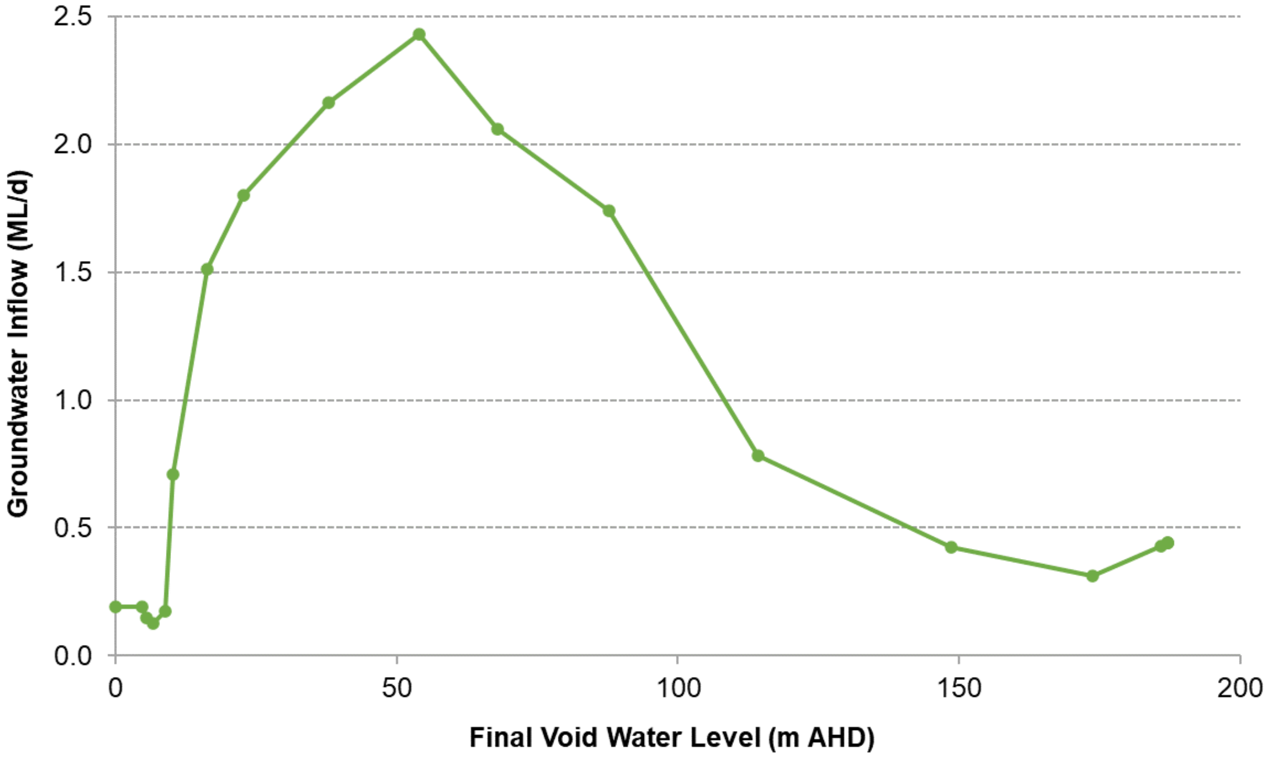


Figure 29 Predicted Final Void Groundwater Inflow Rates

7.3 SIMULATED FUTURE PERFORMANCE

Model-predicted final void water levels and EC values are shown in Figure 30.

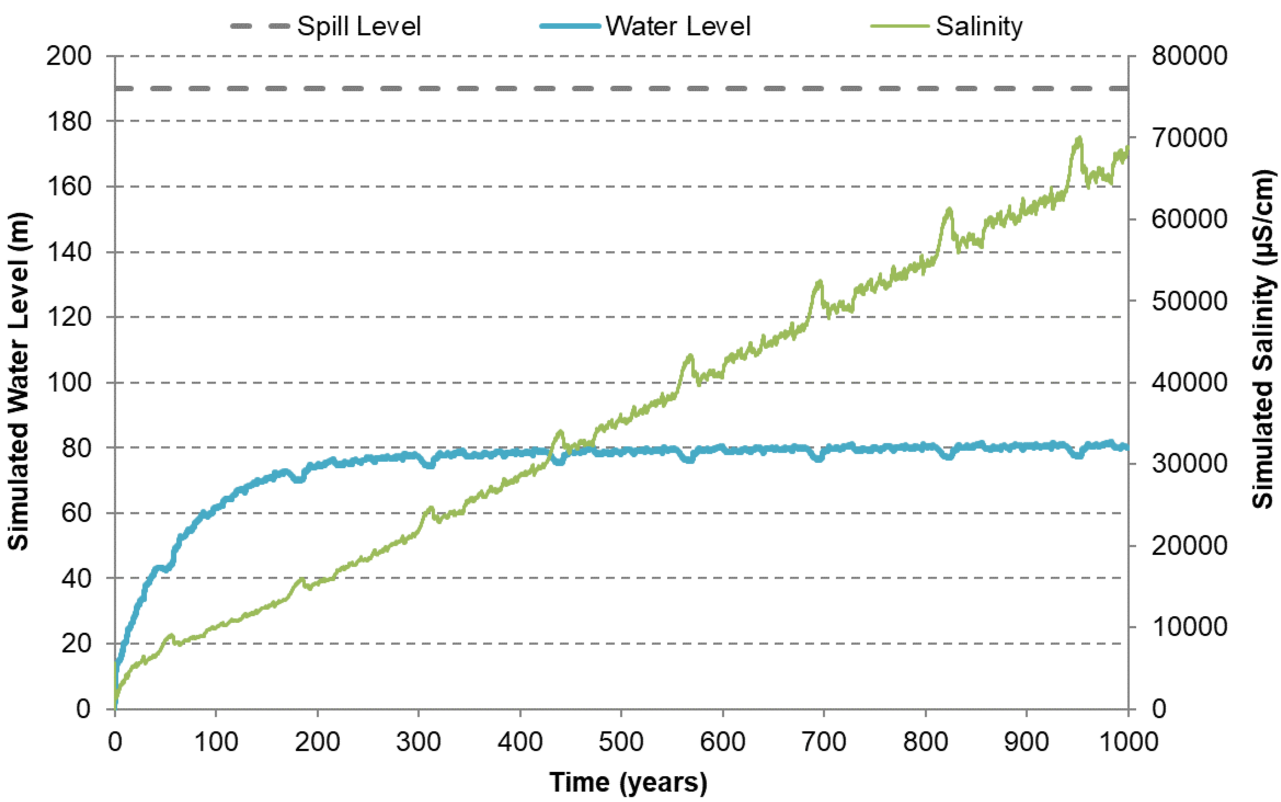


Figure 30 Predicted Final Void Water Level and EC

Results indicate that the final void would reach a peak equilibrium level more than 110 m below the spill level (i.e. the final void is contained). Equilibrium levels would be reached slowly over a period of more than 500 years. Note that, given the water level and groundwater flux relationship provided, groundwater outflow was not simulated to occur – i.e. the final void would remain a groundwater sink. Final void salinity levels would increase slowly as a result of evapo-concentration.

7.4 PMP STORM SURGE ANALYSIS

The probable maximum precipitation (PMP) depth was calculated for the final void in order to assess the maximum potential water level in the final void accounting for such an event. The PMP depth was calculated based on methods published in BoM (2005 and 2006). The Project final void catchment area is located in the Coastal Transition Zone (BoM, 2006) and therefore calculations were based on the Generalised Southeast Australia Method (GSAM) as well as the Generalised Tropical Storm Method (GTSMR). Initial depths were obtained for events between 24 hours and 120 hours for the GTSMR and between 24 hours and 96 hours for the GSAM (the minimum and maximum durations for which estimates are possible using these methods). These initial depths were multiplied by adjustment factors to obtain preliminary PMP depth estimates for each duration and each method. The highest estimated PMP depth for all durations and both methods equated to the GTSMR 120 hour duration storm depth of 1,510 mm.

The PMP depth was applied to the total catchment area of the final void (including the void surface area) equating to a volume of 12,175 ML reporting to the final void in a PMP event, assuming a conservative runoff coefficient of 1 (100% rainfall to runoff). The additional 12,175 ML runoff to the final void during a PMP event would result in an increase in the final void water level of 6.85 m. When added to the final void equilibrium level, this results in a maximum water level of 86.85 m, which remains approximately 103 m below the spill level.

7.5 IMPLICATIONS OF CLIMATE CHANGE OF FINAL VOID WATER LEVEL

The Intergovernmental Panel on Climate Change (IPCC) has, in its fifth assessment report (2013), concluded that:

> *Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, and in global mean sea level rise; and it is extremely likely to have been the dominant cause of the observed warming since the mid-20th century.*

Predicting future climate using global climate models (GCMs) is now undertaken by a large number of research organizations around the world. In Australia, much of this effort has been conducted and co-ordinated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). CSIRO and BoM have recently published a comprehensive assessment of future climate change effects on Australia and future projections (CSIRO and BoM, 2015a). This is based on an understanding of the climate system, historical trends and model simulations of climate response to future global scenarios. Simulations have been drawn from an archive of more than 40 GCMs developed by groups around the world. Modelling has been undertaken for four Representative Concentration Pathways (RCPs) used in the latest IPCC assessment reports, which represent different future scenarios of greenhouse gas and aerosol emission changes and land-use change.

Predictions of future climate from these various models and RCPs have been used to formulate probability distributions for a range of climate variables including temperature, mean and extreme rainfall and potential evapotranspiration. Predictions are made relative to the IPCC reference period 1986 to 2005 for up to 14 future time periods between 2025 and 2090. Predictions for 2025 are relatively insensitive to future emission scenarios because they largely reflect greenhouse gases that have already been emitted. Longer term predictions become increasingly more sensitive to future emission scenarios.

Assessments of likely future concurrent rainfall and evapotranspiration changes have been undertaken using the online Climate Futures Tool (CSIRO and BoM, 2015b). Projected changes from all available climate models are classified into broad categories of future change defined by these two variables, which are the most relevant available parameters affecting rainfall runoff.

For this assessment, the RCP4.5 emissions scenario has been adopted. The year 2090 was selected as the representative year, being approximately 40 years post-mine closure. Climate variable inputs for the 'best case', 'maximum consensus' case and 'worst case' as defined by CSIRO and BoM (2015a) for the RCP4.5 climate change scenarios are provided in Table 31.

The majority of climate models are predicting a decrease in rainfall and an increase in evapotranspiration. This would result in a lower void water level than predicted in Section 7.3. The 'worst case' climate model predicts an increase in annual rainfall of 4.4%, however, this is offset by an increase in evapotranspiration of 7.8%.

Table 31 RCP4.5 Scenario Climate Variable Inputs

Scenario	Climate Model	Annual Change (percent)	
		Rainfall	Evapotranspiration
Best Case (largest reduction in rainfall)	GFDL-ESM2M	-19.8%	+6.9%
Maximum Consensus (highest agreement between different climate models)	NorESM1-M	-10.1%	+5.5%
Worst Case (largest increase in rainfall)	ACCESS1-0	+4.4%	+7.8%

Given the predicted peak equilibrium level is more than 110 m below the void spill level, the potential effects of climate change as reported by CSIRO and BoM are not predicted to increase the risk of spills from the final void as the net impacts of all scenarios would result in negligible change to final void equilibrium levels, which would typically be lower under the climate change scenarios. Accordingly, application of the RCP8.5 emissions scenario, which typically predict lower rainfall and higher evapotranspiration conditions than the RCP4.5 scenario, would result in the final void water level being lower again (i.e. further reducing spill risk).

8.0 POTENTIAL SURFACE WATER IMPACTS

The potential impacts of the Project on local and regional surface water resources comprise:

- Changes to flows in local creeks and the Hunter River due to the progressive extension and subsequent capture and re-use of drainage from active mine catchment areas and the post-mining final landform.
- Potential for export of contaminants (principally sediments and soluble salts) in mine catchment area runoff, controlled releases and overflow from containment storages (principally sediments, soluble salts, oils and greases).
- Potential cumulative impacts to downstream water users associated with licensed extraction and release.

8.1 CATCHMENT YIELD AND FLOW IMPACTS

8.1.1 Catchment Area Reduction and Catchment Yield Effects

During active mining operations, the mine water management system would continue to capture runoff from areas that would have previously flowed to the receiving waters. The potential effects on total flow in the surface water catchments have been assessed on the basis of the reduction in catchment area due to the Project. Table 32 lists the total area of land excised by the Project water management system over the life of the Project from the catchments of Rosebrook Creek, Sandy Creek (at Wybong Road), Dry Creek at Hunter River and the Hunter River (at the confluence of Dry Creek).

Table 32 Total Area Excised by Project from Surface Water Catchments

Year	Sandy Creek at Wybong Road		Rosebrook Creek at Hunter River		Dry Creek at Hunter River		Hunter River at Dry Creek Confluence*	
	Excised Area (km^2)	Percentage of Catchment Area	Excised Area (km^2)	Percentage of Catchment Area	Excised Area (km^2)	Percentage of Catchment Area	Excised Area (km^2)^	Percentage of Catchment Area
2020	0.7	1.4%	10.3	54%	2.8	12%	13.2	0.30%
2026	1.4	3.1%	12.0	63%	3.2	14%	16.0	0.36%
2028	1.4	3.1%	12.0	63%	3.2	14%	16.4	0.37%
2031	1.4	3.1%	12.0	63%	3.3	14%	17.0	0.39%
2041	2.5	5.3%	12.0	63%	5.0	22%	24.3	0.55%
2047	2.5	5.3%	12.0	63%	5.0	22%	24.4	0.55%
Final Landform	0.0	0.0%	3.9	20%	1.6	7%	8.1	0.18%

* Total catchment area of 4,384 km^2.

^ Includes Project components in Rosebrook Creek and Dry Creek catchments.

A summary of the maximum area excised by the Project from the Sandy Creek and Hunter River catchments is provided in Table 33. These areas are compared to the maximum area excised by:

- the approved MPO, as described in the original water management study prepared for the MPO (PPK, 1997); and
- mining up to the currently approved mine life (2026), as listed in Table 32.

Table 33 Comparison of Maximum Area Excised from Key Surface Water Catchments

Development Scenario	Maximum Catchment Excised (km^2)	
	Sandy Creek	Hunter River
Approved MPO (Original EIS)*	4.3	20.1
Approved MPO (2026)	1.4	15.6
Project	2.5	24.4

* Source: PPK (1997).

The maximum area excised by the Project from Sandy Creek catchment is estimated at 2.5 km^2 in 2041, equating to 5.3% of the total catchment area of Sandy Creek at Wybong Road. This is less than the predicted maximum area excised by the original approved MPO, which included two separate staged Fines Emplacement Areas in the Sandy Creek Catchment. MACH Energy's preferred Fines Emplacement Area is a single storage with staged, downstream lifts which reduces the area excised in the water management system relative to the original approved MPO. The establishment of MWD3 post-2026, results in an increase in the area excised from the Sandy Creek catchment relative to the currently approved MPO.

A maximum 5.3% reduction in average total flow volume in Sandy Creek is likely based on the reduction in catchment area associated with the Project (refer Table 32). This reduction in total flow volume is not considered significant given the ephemeral nature of Sandy Creek and is unlikely to be discernible from natural flow variability.

The maximum area excised by the Project from the Rosebrook Creek catchment is estimated at 12 km^2, equating to 63% of the total catchment area of Rosebrook Creek, while the maximum area excised by the Project from the Dry Creek catchment is estimated at 5 km^2, equating to 22% of the total catchment area of Dry Creek. The Project would result in no incremental change to the catchment of Rosebrook Creek relative to the approved MPO (to 2026) as mining is proposed to continue westwards (i.e. the area that would be mined would otherwise drain to the mine water management system). Post-closure, a 20% reduction of the Rosebrook Creek catchment is estimated due to the Project and a 7% reduction of the Dry Creek catchment (Table 31).

As discussed in Section 3.4.1, the local surface water drainage systems within and adjacent to the MPO are predominately ephemeral. A maximum 63% reduction in average total flow volume in Rosebrook Creek is likely based on the reduction in catchment area associated with the Project. This reduction in total flow volume would be significant during high rainfall periods and discernible from natural flow variability. However, this reduction in flow would occur as part of the approved MPO and would be effectively unchanged as a result of the Project.

As discussed in Section 3.2.1, the Dry Creek catchment has been heavily modified by the Bengalla Mine Dry Creek Project and is no longer a natural surface water system. While a moderate reduction in the catchment yield of Dry Creek is predicted based on the reduction in catchment area associated with the Project (maximum 22% reduction), the reduction in total flow volume is not considered material given the heavily modified nature of Dry Creek downstream of the Project.

The maximum area excised by the Project from the Hunter River catchment at the confluence with Dry Creek is estimated at 24.4 km^2 in Year 2047, equating to 0.55% of the total catchment area. This represents a small increase in the total area excised by the originally approved MPO (from 20.1 km^2). With a mean annual flow volume of 287,102 ML in the Hunter River at Muswellbrook (GS 210002), the maximum reduction in mean annual flow due to the Project is estimated at 1,570 ML (0.55%). This represents a small and likely indiscernible impact to flow in the Hunter River at the confluence with Dry Creek.

Post-closure, the area excised from the Hunter River catchment would reduce to 8.1 km^2, which is estimated to equate to a reduction of 0.18% of the mean annual flow (525 ML). This is less than that proposed to be excised by the original approved final landform for the MPO of 20.3 km^2, presented in the 1997 EIS (refer to Figure G6 of PPK [1997], reproduced in Figure 31). Note that much of the original planned MPO final landform was proposed to drain internally, towards the various final voids.

8.1.2 Baseflow Effects

Changes in groundwater-derived baseflow have been predicted by AGE (2020) for the Hunter Regulated River Water Source and the Hunter Unregulated and Alluvial Water Sources and are summarised in Table 34 in comparison with the share components currently held by MACH Energy for the MPO.

Table 34 Maximum Predicted Baseflow Reduction During and Post-Closure

Water Sharing Plan	Water Source	Current MACH Energy Share Components (Units)	During Mining Predicted Baseflow Reduction (ML/year)	Post-Closure Predicted Baseflow Reduction (ML/year)
Hunter Regulated River Water Source, 2016	Hunter Regulated River (Management Zone 1A)	961 (HS) 2,937 (GS)	27	32
Hunter Unregulated and Alluvial Water Sources, 2009	Muswellbrook Water Source (Sandy Creek)	41	2	6
	Dart Brook	Nil	6	13

Table 34 shows that a maximum of 27 ML/year baseflow reduction is predicted during mining for the Hunter Regulated River Water Source and a maximum total of 8 ML/year for Sandy Creek and Dart Brook. The total predicted reduction in baseflow from the Hunter River and its tributaries during mining (35 ML/year) amounts to approximately 0.01% of the 287,102 ML mean annual total flow in the Hunter River at Muswellbrook (GS 210002) (refer Section 8.1.1). Accounting for both the predicted reduction in catchment yield and baseflow, the total reduction (1,604 ML/year) amounts to approximately 0.56% of the mean annual total flow in the Hunter River at Muswellbrook.

Post-closure, the total predicted reduction from the Hunter River water source (51 ML/year) amounts to approximately 0.018% of the 287,102 ML mean annual total flow in the Hunter River at Muswellbrook (GS 210002) (refer Section 8.1.1). Accounting for both the predicted reduction in catchment yield and baseflow, the total reduction (576 ML/year) amounts to approximately 0.2% of the mean annual total flow at this location. These forecast flow reductions represent a small and likely indiscernible impact to flow in the Hunter River at Muswellbrook during the Project and post-closure.

A total of 961 ML/year Hunter River HS WALs and 2,937 ML/year Hunter River GS WALs are available for the Project. As such, MACH Energy hold sufficient WALs to account for the predicted baseflow reduction associated with the Project.

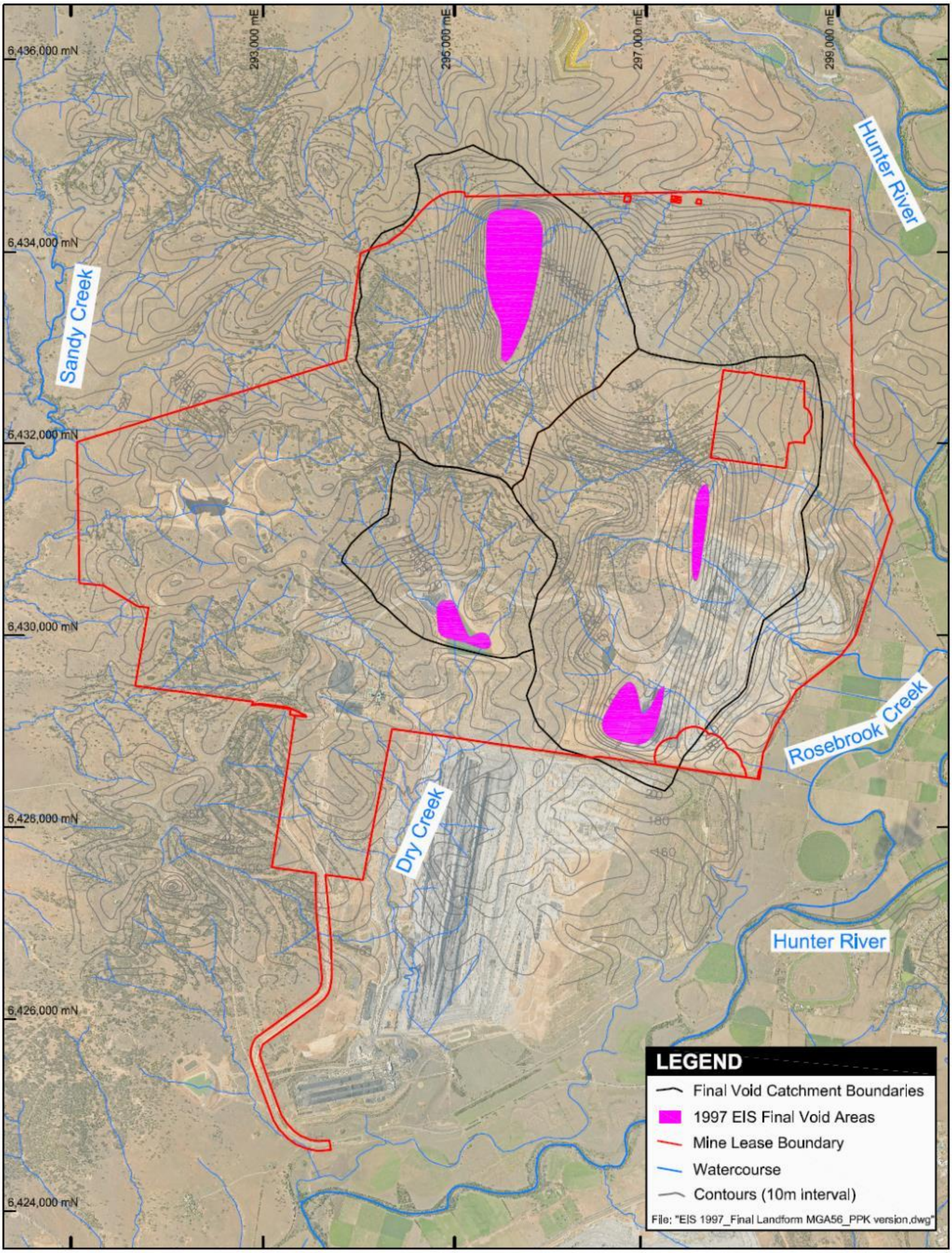


Figure 31 Original Approved Final Landform (Reproduced from Figure G6 of PPK [1997])

8.2 WATER QUALITY IMPACTS

The existing MPO has approval for discharge from the site to the Hunter River under the HRSTS. Additionally, the MPO has Development Consent (DA 92/97) to discharge from sediment dams in accordance with their design criteria.

8.2.1 Storage Overflow

The conceptual design of the proposed sediment dams has been undertaken in accordance with the Landcom (2004) and DECC (2008) guidelines. These guidelines provide for sediment dams to overflow (or discharge) when rainfall exceeds the design criteria of the dams. To date, MACH Energy advise that there have been no overflows from existing sediment dams SD1, SD3 or SD4.

An average annual volume of 66 ML is predicted to overflow to Rosebrook Creek from sediment dams SD1 to SD7 based on the median model results and 125 ML based on the 95th percentile model results. Based on the median predicted total release volume, the average EC of overflow from the sediment dams to Rosebrook Creek is predicted at 394 µS/cm based on the median model results (Section 6.6). This EC value is within the range of baseline EC values recorded for local and regional surface water systems (refer Section 3.5) and is less than the threshold for 'saline water' defined in the HRSTS (400 µS/cm).

Overflow from the sediment dams is predicted to occur during high rainfall events only. During these periods, the concentration of environmentally significant constituents in the sediment dams is likely to be low as inflow from catchment surface runoff will predominate over baseflow (seepage). This is supported by the Groundwater Assessment (AGE, 2020), which states that the majority of seepage from the waste rock emplacement area would report to the Project and Bengalla Mine open cut pits.

An average annual volume of 66 ML overflow from sediment dams SD1 to SD7, based on the median model results, amounts to approximately 0.04% of the 181,000 ML median annual total flow in the Hunter River at Muswellbrook (GS 210002). An average annual volume of 125 ML overflow from sediment dams SD1 to SD7, based on the 95th percentile model results, amounts to approximately 0.02% of the 732,200 ML 95th percentile annual total flow in the Hunter River at Muswellbrook (GS 210002). Plots of water quality constituents recorded in sediment dams SD1 and SD3 are presented in Appendix A in comparison with records for the Hunter River at W15 and W17 and daily rainfall. The water quality records indicate that the level of constituents in SD1 and SD3 following rainfall events is generally within the range of levels recorded in the Hunter River at W15 and W17 during the corresponding period. The concentrations of total manganese, total nickel and total arsenic have also been consistently below the relevant default guideline value (refer Section 3.3.2). The constituents present in the sediment dams during overflow periods are likely to be highly diluted by incident rainfall and flow in the Hunter River and therefore the impact of sediment dam overflow on downstream water quality is expected to be negligible.

The Geochemistry Assessment for the MPO (RGS, 2020) identified that most of the overburden and interburden materials likely to be mined at the MPO are expected to be classified as non-acid forming (NAF) with leachate from these materials likely to be slightly to moderately saline and have low concentrations of soluble metals/metalloids. Overall, the assessment concluded that dissolved metal/metalloid concentrations in surface runoff and seepage from most NAF mining waste materials at the MPO are unlikely to present a significant risk to surface and groundwater resources (RGS, 2020). Material classified as potentially acid forming (PAF) will be appropriately managed in order to reduce the potential for further weathering and oxidation of these materials.

A low risk of overflow from ED3 to Dry Creek is predicted based on all model results. The percentage of annual overflow days from ED3 to Dry Creek is estimated at 1.6% based on all model simulations, which is slightly higher than the 1% AEP spill risk design criterion (i.e. in any simulated year, ED3 has a predicted spill risk of less than 1.6%). As stated in Section 6.6, to achieve the 1% AEP spill risk criterion it is recommended that the capacity of ED3 is increased prior to the increase in ED3 catchment area, expected to occur by 2026. During overflow periods, the constituents present in ED3 would be highly diluted and therefore the impact of overflow from ED3 on downstream water quality is expected to be negligible.

No overflows were predicted from the Fines Emplacement Area, ED2, the MWDs or DW1 in any model simulations.

8.2.2 Hunter River Release

Controlled release from the MWDs and DW1 via the HRSTS will comprise a very small component of the flow in the Hunter River (as governed by the discharge rules of the HRSTS) and dilution will be substantial. The average annual Hunter River release volume from DW1 is predicted to be 469 ML based on the median model results. This compares with the median annual total flow in the Hunter River at Muswellbrook (GS 210002) of approximately 181,000 ML, meaning the forecast maximum median discharge represents 0.26% of the recorded median annual river flow. Similarly, an average annual release volume of 909 ML based on the 95th percentile model results is predicted. This compares with a 95th percentile annual flow recorded in the Hunter River at Muswellbrook (GS 210002) of approximately 732,200 ML, meaning the forecast 95th percentile discharge represents approximately 0.12% of the recorded 95th percentile annual river flow. The 95th percentile annual release volume of 909 ML is comparable to the 95th percentile annual release volume predicted for the approved mine (HEC, 2018).

It is recognised that the above assessment does not account for the fact that controlled release is only predicted to occur at intermittent periods. As such, simulated controlled daily release volumes were used to calculate the percentage of flow in the Hunter River at Muswellbrook that these forecast releases would represent for each release day – i.e. the forecast release dilution. A modelled mine life realization corresponding to the median overall total controlled release volume was selected for illustrative purposes. For each simulated day, the controlled release volume was compared with the flow rate for the Hunter River at Muswellbrook. Release was found to occur on 1.3% of days in total over the 28.5 year simulation. On average, the controlled release volumes equated to 4% of river flow on those (rare) release days.

Plots of water quality constituents recorded in MWD are presented in Appendix A in comparison with records for the Hunter River at W15 and W17 and daily rainfall. The water quality records indicate that the level of constituents recorded in MWD are generally within the range of levels recorded in the Hunter River at W15 and W17 during the corresponding period. The concentrations of total manganese, total lead, total nickel, total arsenic and total chromium have also been consistently below the relevant default water quality guideline value (refer Section 3.3.2). The above assessment illustrates that any contaminants present in the MWDs at the time of controlled release would be highly diluted by flow in the Hunter River and, as such, the impact of controlled release on downstream water quality is expected to be negligible.

8.2.3 Mixing Zone Assessment

The ANZG (2018) guidelines define a mixing zone as an explicitly defined area around a discharge in which some, or all, water quality objectives may not be met. To assess if a mixing zone is required for the Hunter River where discharge from the MPO may occur, the concentration of key constituents in the Hunter River downstream of the discharge were estimated based on the simulated release and overflow volumes for Project.

To assess the influence of release from MWD to the Hunter River (via DW1) on the water quality of the Hunter River, the median and 90th percentile release rate and the median and 10th percentile flow rate in the Hunter River at Muswellbrook (on release days only) were derived from the water balance results. Comparison of the 90th percentile release rate with the 10th percentile flow rate in the Hunter River on the day of release provides a conservative assessment of the potential level of constituents in the Hunter River during periods of high release. The concentrations of key constituents in the Hunter River downstream of the proposed release location were estimated based on the water quality records for the MWD (refer Section 3.6) and the water quality records for the Hunter River at Muswellbrook and Hunter River at monitoring site W15 (refer Section 3.5). As only three records of total metals concentrations were available for the MWD, the maximum concentration was adopted in the assessment for conservatism, while the median concentration was adopted for the Hunter River at Muswellbrook and monitoring site W15. The assessment assumes conservation of mass for all constituents and is therefore conservative.

Table 35 presents the outcomes of the assessment for the estimated water quality in the Hunter River at monitoring site W15 following release from the MPO to the Hunter River. Note that only constituents with a water quality objective and constituents which were recorded above the limit of detection in the MWD have been assessed.

Table 35 Estimated Hunter River Water Quality with Release

Location	Value	Flow Rate (ML/d)	Turbidity (NTU)	Total Aluminium (mg/L)	Total Arsenic (mg/L)	Total Iron (mg/L)	Total Lithium (mg/L)	Total Manganese (mg/L)	Total Nickel (mg/L)
Predicted Rates									
MPO Release to the Hunter River	Median	62							
	90th Percentile	125							
Hunter River at Muswellbrook	Median	1,974							
	10th Percentile	551							
Monitored Water Quality									
MWD	Min		2	0.02	0.001	0.05	0.002	0.007	0.001
	Max		55	0.24	0.002	0.19	0.009	0.016	0.004
Hunter River at Muswellbrook / W15	Median		261	0.67	0.001	0.51	0.005	0.05	0.001
	Max		1,754	1.04	0.001	1.23	0.005	0.24	0.001
Estimated Constituent Levels									
Hunter River at Muswellbrook / W15	Median Flow		254	0.65	0.001	0.5	0.005	0.05	0.001
	10th Percentile Flow		223	0.59	0.001	0.45	0.006	0.04	0.002
Water Quality Objective			50	0.055	0.024	10	2.5	1.9	0.011

The data summarised in Table 35 shows that the median levels of turbidity and total aluminium recorded in the Hunter River at Muswellbrook and monitoring site W15 exceed the water quality objectives under baseline conditions. The maximum levels of turbidity, total iron, total manganese and total aluminium recorded in the MWD are lower than the median levels recorded in the Hunter River at Muswellbrook/W15 and, as such, the level of these constituents is not expected to increase as a result of release from the MPO to the Hunter River. The maximum concentrations of total lithium and total nickel recorded in the MWD were higher than the maximum concentrations recorded in the Hunter River at Muswellbrook/W15 and, as such, a slight increase in the total lithium and total nickel concentrations in the Hunter River at Muswellbrook/W15 may occur under high release conditions. However, the total lithium and total nickel concentrations are expected to remain below the water quality objective. Additionally, the maximum concentrations of total lithium and total nickel recorded in the MWD are consistent with naturally elevated concentrations of total lithium and total nickel recorded in local surface water systems (refer Section 3.5).

The maximum concentration of total arsenic recorded in the MWD was slightly higher than the maximum concentration recorded in the Hunter River at Muswellbrook/W15 though was below the water quality objective for total arsenic. An increase in total arsenic is not expected to be evident in the Hunter River at Muswellbrook/W15 under high release conditions.

Because the assessment is based on three records only for total metals in the MWD, it is recommended that additional data is collected in accordance with the Water Management Plan to continue to monitor the quality of water in on-site water storages.

To assess the influence of sediment dam overflow on the water quality of the Hunter River, the median and 90th percentile overflow rates from the sediment dams and the median and 10th percentile flow rate in the Hunter River at Muswellbrook at the time of overflow were derived from the water balance results. The concentrations of key constituents in the Hunter River downstream of the confluence with Rosebrook Creek were estimated based on the water quality records for sediment dams SD1, SD3 and SD4 and the water quality records for Hunter River at Muswellbrook and Hunter River at monitoring site W17.

Table 36 presents the outcomes of the assessment for the estimated water quality in the Hunter River at monitoring site W17 following overflow from the MPO to the Hunter River. Note that only constituents with a water quality objective and constituents which were recorded above the limit of detection in the sediment dams have been assessed.

The data summarised in Table 36 shows that the median and maximum concentrations of total zinc, total chromium, total copper and total aluminium in the Hunter River at Muswellbrook/W17 exceed the water quality objectives under baseline conditions. The median concentrations of total zinc and total manganese recorded in SD1, SD3 and SD4 were equal to or less than the median concentration recorded in the Hunter River at Muswellbrook/W17 and, as such, the median concentrations of total zinc and total manganese in the Hunter River at Muswellbrook/W17 are not expected to increase as a result of overflow from the MPO to the Hunter River. The EC, turbidity, total lead, total nickel, total manganese and total arsenic levels in the Hunter River are expected to be less than the water quality objective for both median and high overflow conditions.

As overflow from the MPO to the Hunter River is not predicted to result in an exceedance of the baseline water quality levels for total copper, total zinc, total chromium or total aluminium or the water quality objective for the remainder of constituents, a mixing zone is not proposed for overflow from the MPO to the Hunter River. As the assessment is based on seven records only for total metals in SD1, SD3 and SD4, it is recommended that additional data is collected in accordance with the Water Management Plan to continue to monitor the quality of water in on-site water storages.

Table 36 Estimated Hunter River Water Quality with Overflow

Location	Value	Flow Rate (ML/d)	EC (µS/cm)	Turbidity (NTU)	Total Copper (mg/L)	Total Lead (mg/L)	Total Zinc (mg/L)	Total Nickel (mg/L)	Total Manganese (mg/L)	Total Arsenic (mg/L)	Total Chromium (mg/L)	Total Aluminium (mg/L)
Predicted Rates												
MPO Release	Median	2										
	90^{th} Percentile	22										
Hunter River at Muswellbrook	Median	4,662										
	10^{th} Percentile	2,561										
Monitored Water Quality												
SD1, SD3 and SD4	Median		589	200	0.006	0.002	0.006	0.004	0.05	0.001	0.002	2.6
	Max		1,988	2,500	0.016	0.007	0.033	0.014	0.31	0.005	0.01	15.9
Hunter River at Muswellbrook / W17	Median*		439	4	-	-	0.03	-	0.05	-	-	-
	Max		3,350	1,754	0.005	0.001	0.15	0.005	0.24	0.001	0.004	4.6
Estimated Constituent Levels												
Hunter River at Muswellbrook / W17	Median Flow		439	4	0.005	0.001	0.03	0.005	0.05	0.001	0.004	4.6
	10^{th} Percentile Flow		440	6	0.005	0.001	0.03	0.005	0.05	0.001	0.004	4.6
Water Quality Objective			650†	40†	0.0014	0.003	0.008	0.011	1.9	0.024	0.001	0.055

* Only two records were available for some constituents and, as such, only the maximum value has been presented and adopted in the assessment.

† Water quality objective for W17.

8.3 POTENTIAL CUMULATIVE IMPACTS

8.3.1 Overview of Cumulative Impacts

Cumulative impacts have been described in a mining context by Franks, et al (2010) as:

> *"…arise from compounding activities of a single operation or multiple mining and processing operations, as well as the aggregation and interaction of mining impacts with other past, current and future activities that may not be related to mining."*

In the context of surface water resources potentially impacted by the Project there has been significant past development in the upstream, immediate and downstream catchment areas which, if taken from European settlement, include widespread agricultural development and urbanisation. There has also been significant development of the surface water resources themselves - including regulation and extraction of water from local and regional surface water resources. The effects of past development are inevitably incorporated into the baseline descriptions of surface water resources developed for the Project which are based on contemporary monitoring.

8.3.2 Local Cumulative Impacts

The Mangoola Coal mine area is partially located in the Sandy Creek catchment downstream of the MPO. The maximum area of the Sandy Creek catchment to be excised by the Mangoola Coal Operations is estimated at 3.14 km^2 in 2021 which equates to approximately 2.3% of the total catchment area of Sandy Creek (WRM, 2013).

As shown in Table 32, the maximum area of the Sandy Creek catchment to be excised by the Project is 2.5 km^2. This, combined with the maximum reduction of Sandy Creek catchment area (5.3%) as a result of the Mangoola Coal mine development, would see a cumulative maximum reduction of 3.9% of the total catchment area of Sandy Creek to the confluence with the Hunter River, which is less than would otherwise have occurred under the originally approved MPO.

As stated in Section 6.6, no overflow from the MPO to Sandy Creek is predicted to occur. As such, it is highly unlikely that the MPO will result in impacts to the water quality of Sandy Creek.

8.3.3 Regional Cumulative Impacts

The MPO is situated adjacent to the Bengalla Mine and in the vicinity of the Muswellbrook Coal Mine, Dartbrook Mine, Mount Arthur Coal Mine and Mangoola Coal Mine. These mines operate in a highly regulated water system with licensing of water take undertaken in accordance with the *Water Management Act 2000* and release of water undertaken in accordance with the HRSTS, the relevant Development Consent and the EPL for each site. Each of these mines are located downstream of the Glenbawn and Glennies Creek Dams and therefore would not affect the volume of water stored in, or released from, the dams. With the implementation of the various controls under these regulatory systems, the cumulative impacts on downstream water users associated with the proposed Project are expected to be negligible.

8.4 EPBC ACT IMPACT ASSESSMENT

As described in Section 2.4, a delegate of the Commonwealth Minister determined on 26 August 2020 that the proposed action is a "controlled action" and therefore the action requires approval under the EPBC Act.

The elements of the Project which require EPBC Act approval exclude activities that are already approved under the existing EPBC Act approval (which largely mirrors the project approved under the Development Consent DA 92/97). Therefore, the consideration of potential impacts on MNES is focused on the impacts of the proposed action.

8.4.1 Potential Impacts on Hydrological Characteristics

The Significant Impact Guidelines for Water Resources provide the following guidance on potential impacts of an action on hydrological characteristics:

> *A significant impact on the hydrological characteristics of a water resource may occur where there are, as a result of the action:*
>
> *a) changes in the water quantity, including the timing of variations in water quantity*
>
> *b) changes in the integrity of hydrological or hydrogeological connections, including substantial structural damage (e.g. large scale subsidence)*
>
> *c) changes in the area or extent of a water resource where these changes are of sufficient scale or intensity as to significantly reduce the current or future utility of the water resource for third party users, including environmental and other public benefit outcomes.*

As discussed in Section 8.1, the Project would result in:

- A reduction in the area excised from the Sandy Creek catchment relative to the original MPO approval.
- No incremental change in the area excised from the Rosebrook Creek catchment.
- A small increase in the area excised from the Hunter River catchment relative to the original MPO approval.

Water pumped from the Hunter River for water supply would be taken in accordance with MACH Energy's existing water access licences entitlements.

Therefore, the Project is not considered to have a significant impact on surface water hydrology.

8.4.2 Potential Impacts on Water Quality

The Significant Impact Guidelines for Water Resources provide the following guidance on potential impacts of an action on water quality:

> *A significant impact on a water resource may occur where, as a result of the action:*
>
> *a) there is a risk that the ability to achieve relevant local or regional water quality objectives would be materially compromised, and as a result the action:*
>
> *i. creates risks to human or animal health or to the condition of the natural environment as a result of the change in water quality*
>
> *ii. substantially reduces the amount of water available for human consumptive uses or for other uses, including environmental uses, which are dependent on water of the appropriate quality*
>
> *iii. causes persistent organic chemicals, heavy metals, salt or other potentially harmful substances to accumulate in the environment*
>
> *iv. seriously affects the habitat or lifecycle of a native species dependent on a water resource, or*
>
> *v. causes the establishment of an invasive species (or the spread of an existing invasive species) that is harmful*

vi. to the ecosystem function of the water resource, or

b) there is a significant worsening of local water quality (where current local water quality is superior to local or regional water quality objectives), or

c) high quality water is released into an ecosystem which is adapted to a lower quality of water.

Controlled releases of water to the Hunter River would continue to be undertaken in accordance with the HRSTS and relevant EPL conditions.

The Project is not predicted to result in any discernible deterioration in water quality in Sandy Creek, Rosebrook Creek or the Hunter River (Section 8.2). Therefore, the proposed action is not considered to have a significant impact on surface water quality.

8.4.3 Consideration of Cumulative Impacts

The Significant Impact Guidelines for Water Resources require the action to be:

considered with other developments, whether past, present or reasonably foreseeable developments.

Consideration of cumulative impacts is presented in Section 8.3.3, including:

- Consideration of potential cumulative impacts of the Project and Mangoola Coal on the Sandy Creek catchment.
- Consideration of potential cumulative impacts in the Hunter River catchment, which is a highly regulated water system with various regulatory frameworks established to manage cumulative impacts.

The Dry Creek catchment has been heavily modified by the Bengalla Mine Dry Creek Project and is no longer a natural surface water system. While a moderate reduction in the catchment yield of Dry Creek is predicted based on the reduction in catchment area associated with the Project (maximum 22% reduction [Table 31]), the reduction in total flow volume is not considered material given the heavily modified nature of Dry Creek downstream of the Project.

The contribution of the proposed action to any potential cumulative impacts on surface water quality, flow or availability is expected to be negligible.

8.4.4 Consideration of Potential for Significant Impact

Based on the assessment presented above, the proposed action would not result in significant changes to the quantity or quality of water available to third party users or the environment. Accordingly, the proposed action would not have a significant impact on water resources on a local, regional, state or national scale.

9.0 MONITORING, MITIGATION AND MANAGEMENT

9.1 OPERATIONAL MONITORING AND MANAGEMENT

Surface water monitoring and management at the MPO will continue to be undertaken in accordance with the Erosion and Sediment Control Plan, Surface Water Management Plan and Surface and Groundwater Response Plan, which are components of the Water Management Plan. The plans will be updated to include the Project water management system once the Project is approved.

The current water quality monitoring program for the MPO will continue to be undertaken and the outcomes assessed against the surface water quality site specific trigger values, as summarised in Section 3.3, and in accordance with the surface water quality response protocol detailed in the Surface and Groundwater Response Plan. In conjunction with the current water quality monitoring program, it is recommended that additional monitoring is undertaken at the relevant time during the life of the Project as summarised in Table 37.

Table 37 Recommended Additional Water Monitoring

Monitoring Sites/Locations	Parameters	Frequency	Recommendation
DW1 release via Hunter River pipeline	Volume discharged	Daily when discharging	Commence upon commissioning
	pH, EC and TSS	Continuous EC and daily pH and TSS monitoring during discharge	
Sediment Dams - SD5 to SD8	pH, EC, TSS, TDS and occurrence and duration of spillway flow	Daily during discharge and for five days after	Commence upon commissioning
SD5 to SD8 RLD2 HWD2 and HWD3 MWD2 and MWD3	Suite 1^	Monthly	Commence upon commissioning
	Suite 2^	Quarterly	
	Level	Minimum monthly	Installation of level gauge board upon construction
Surface water monitoring sites^	Antimony, beryllium, cobalt, molybdenum, thorium, uranium, alkalinity and major ions‡	Minimum annual	In combination with current water quality monitoring program
Erosion and sediment control structures	Integrity/function, water level and sediment build up	Monthly and immediately following rainfall events with more than 20 mm in 24 hours*	Continue existing and add proposed additional sediment controls

^ Refer Section 3.3.
* In accordance with the MPO Erosion and Sediment Control Plan.
‡ As recommended in RGS (2020).

The results from the monitoring program will continue to be maintained in a database for review and assessment and used to assist in the management of the quality and quantity of surface water within and around the Project. The monitoring report results and any specialist interpretations of trends observed in the monitoring data will be reported annually in the Annual Review.

It is recommended that the site water balance model and numerical groundwater model are updated and verified on a regular basis to maintain the models as reliable tools for assessing the effectiveness of the site water management system. Periodic forecast water balance modelling will inform near term water supply reliability for the Project as it progresses and the need to plan for contingency measures such as the use of dust suppressants in dry periods.

9.2 POST-MINING MONITORING AND MANAGEMENT

Water quality monitoring should continue for two years following cessation of operations, with monitoring data reviewed at annual intervals (as part of the annual review process) over this period. Reviews should involve assessment against long-term performance objectives that are derived from baseline conditions or a justifiable departure from these, with due allowance for climatic variations. If objectives are not substantially met within the two-year period, management measures should be revised and the monitoring period extended.

9.3 POTENTIAL CONTINGENCY MEASURES

Potential contingency measures in the event of unforeseen impacts or impacts in excess of those predicted would include:

- conducting additional monitoring (e.g. increase in monitoring frequency or additional sampling locations) to confirm impacts and inform the proposed contingency measures;
- refinements to the water management system design such as additional containment dams, increases to storage or pumping capacity, installation of new structures as required to address the identified issue.
- the implementation of stream remediation measures and possible additional controls (e.g. rock armouring) to reduce the extent and effect of erosion; and/or
- the implementation of revegetation measures in conjunction with other stabilisation techniques (as required) to remediate impacts of vegetation loss due to erosion.

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APPENDIX A – WATER QUALITY ANALYSIS PLOTS

Sediment Dams[6]

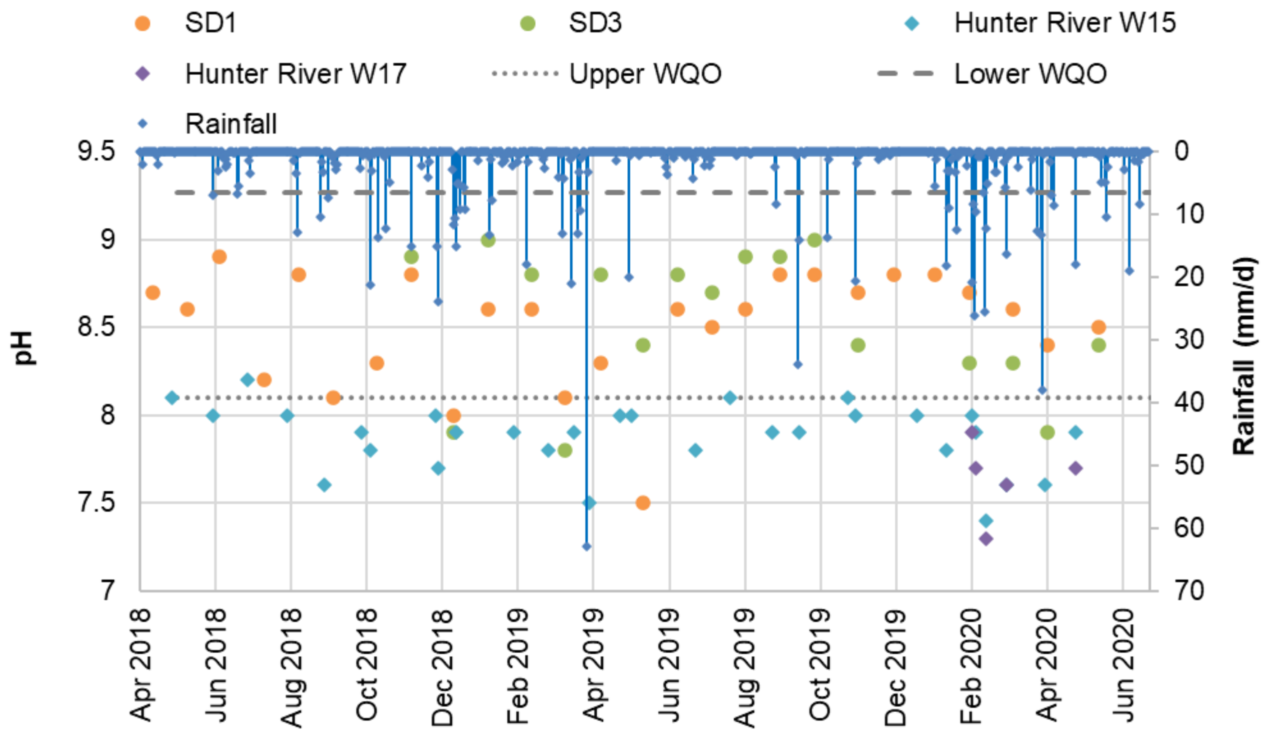

Chart 1 pH Records for Sediment Dams and Hunter River

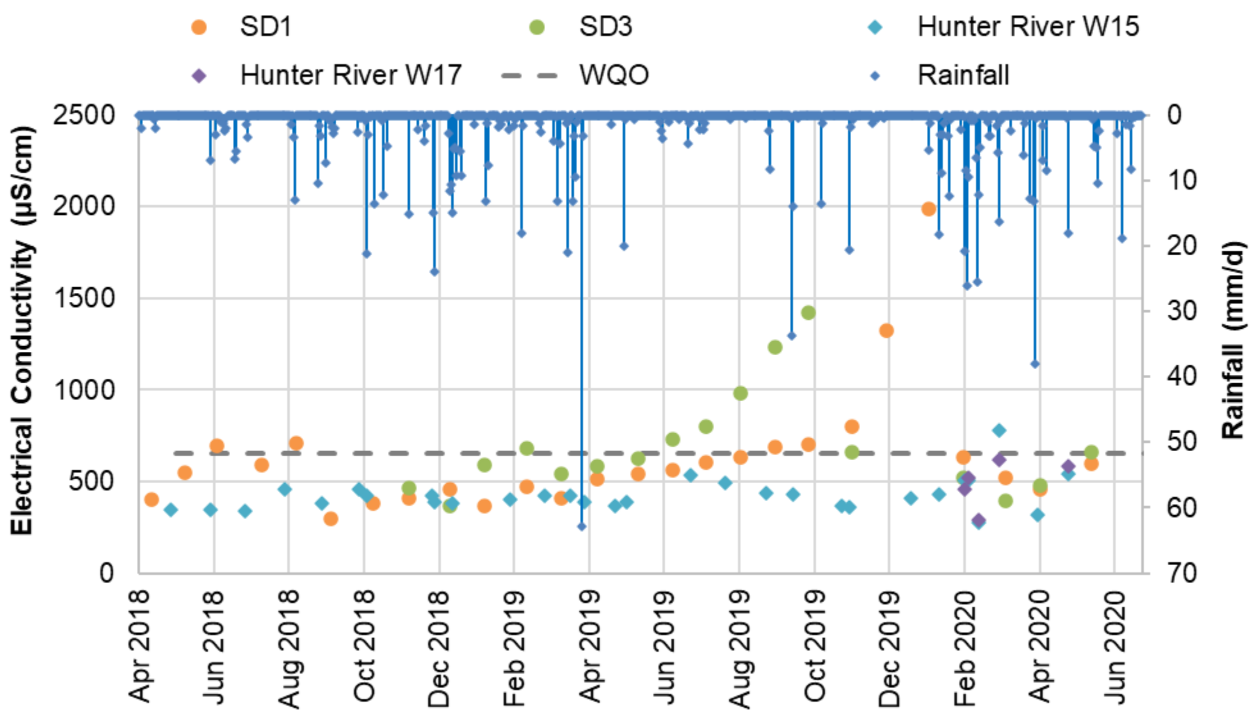

Chart 2 Electrical Conductivity Records for Sediment Dams and Hunter River

[6] SILO Point Data rainfall obtained for a point within the centre of the MPO is presented in the water quality plots. Note that records for WaterNSW Hunter River monitoring sites only extend to April 2018 and are therefore not presented.

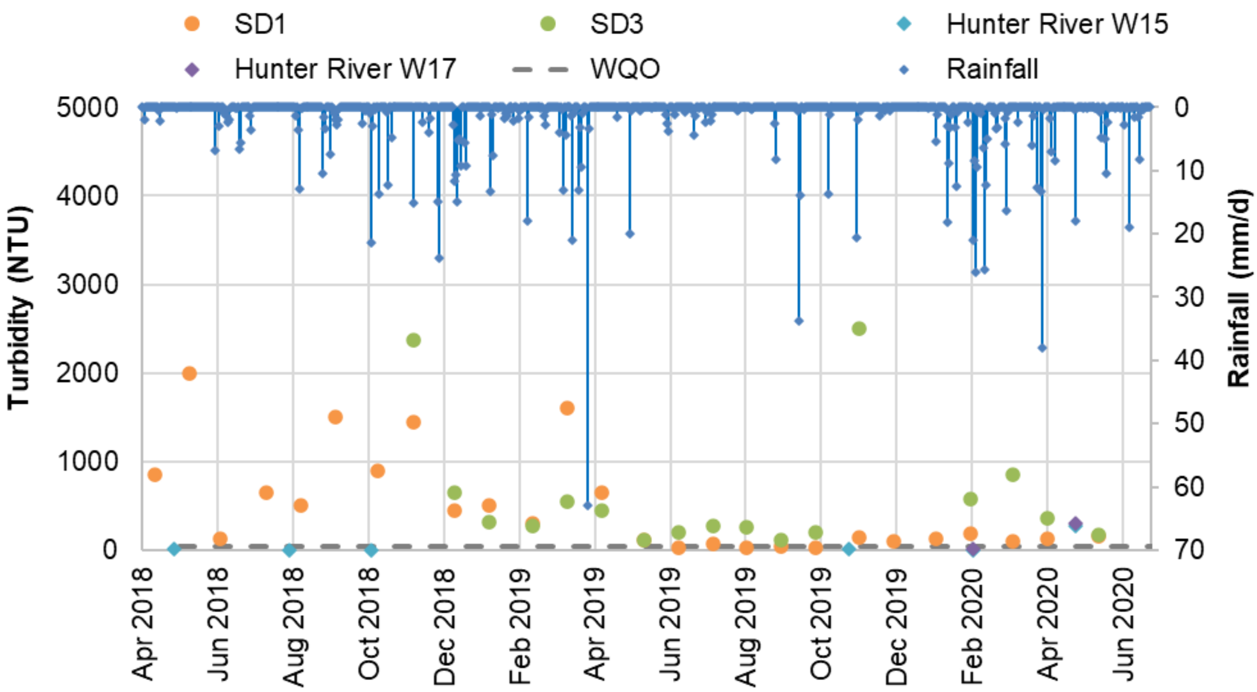

Chart 3 **Turbidity Records for Sediment Dams and Hunter River**

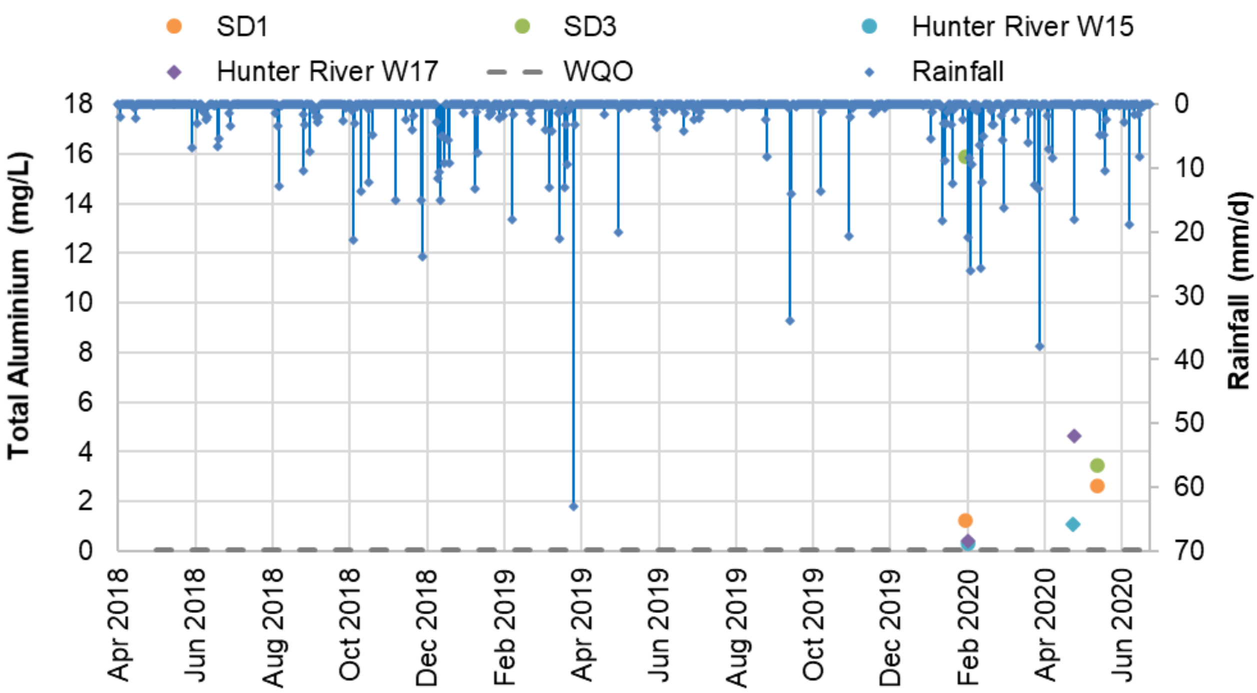

Chart 4 **Total Aluminium Records for Sediment Dams and Hunter River**

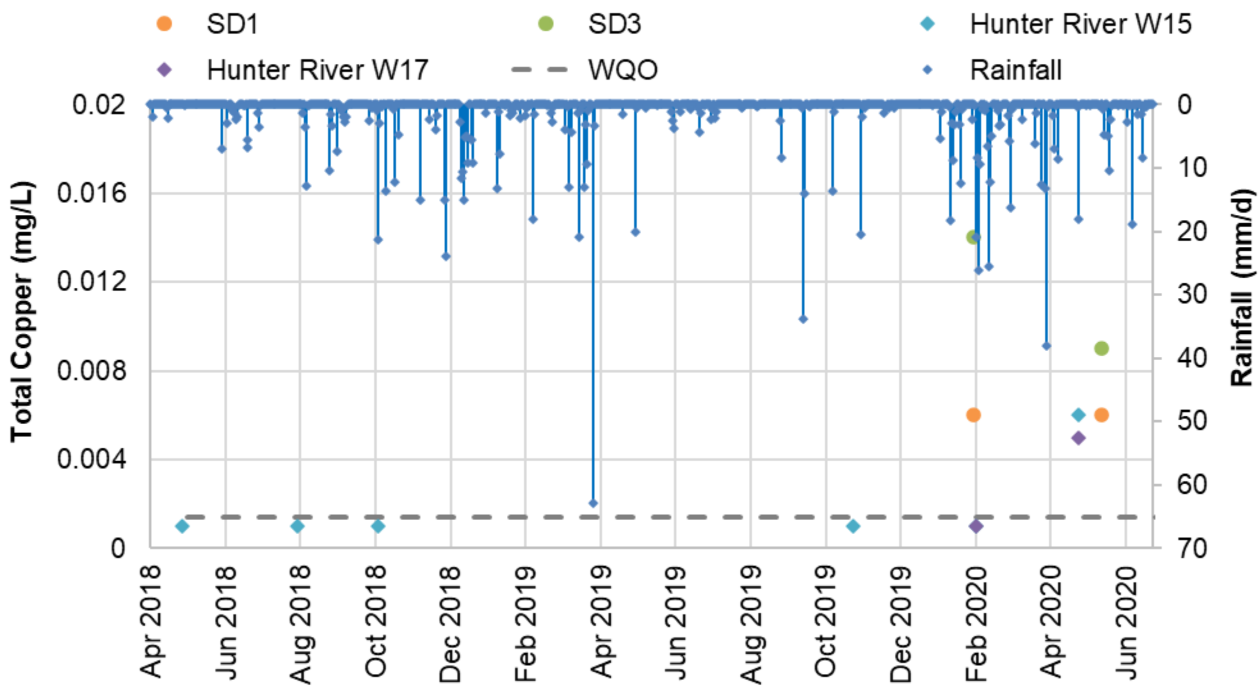

Chart 5 **Total Copper Records for Sediment Dams and Hunter River**

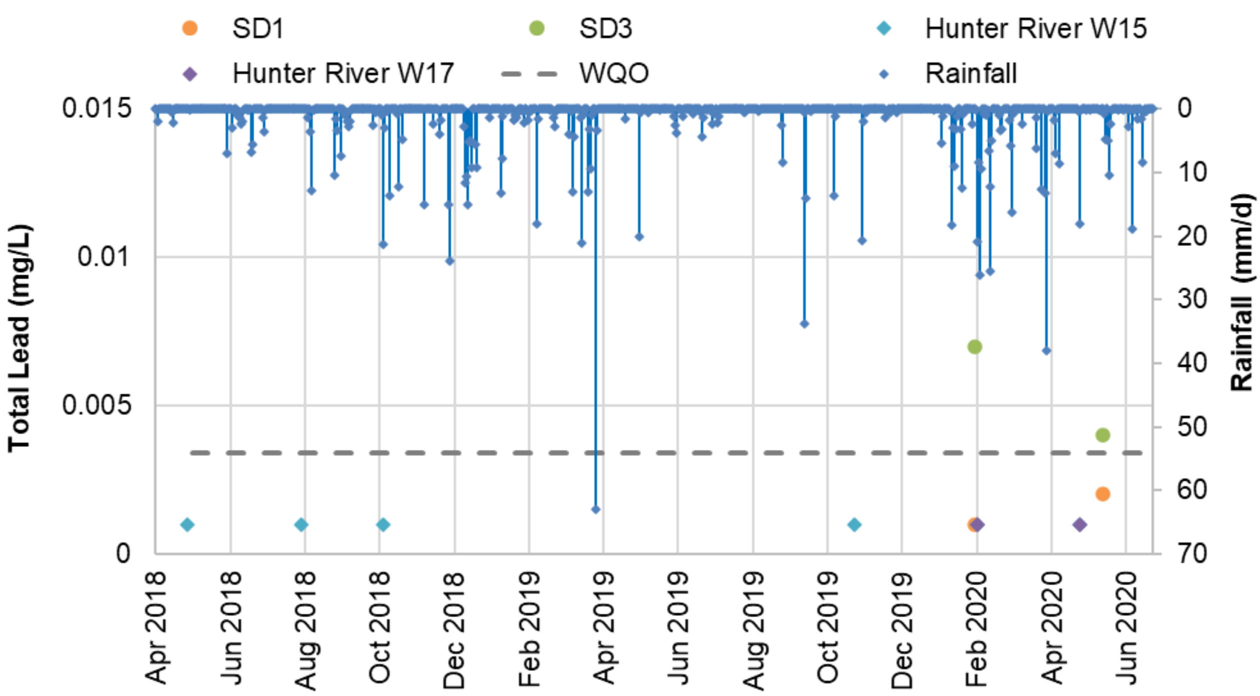

Chart 6 **Total Lead Records for Sediment Dams and Hunter River**

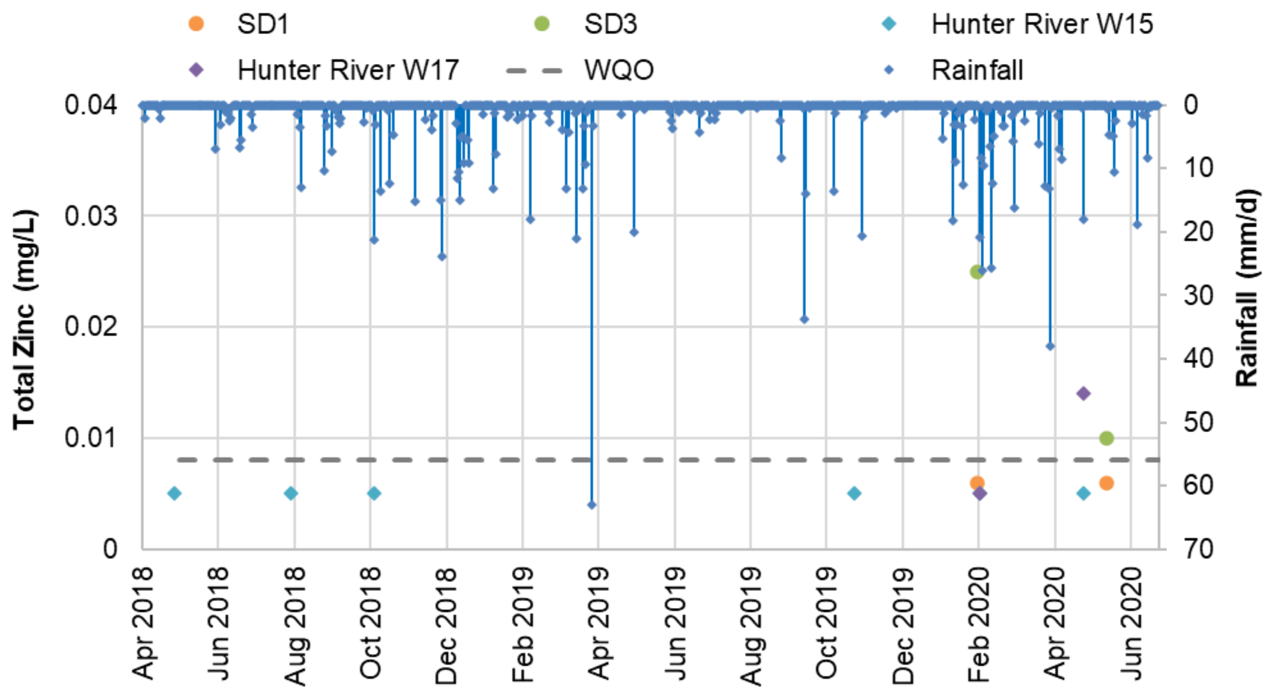

Chart 7 Total Zinc Records for Sediment Dams and Hunter River

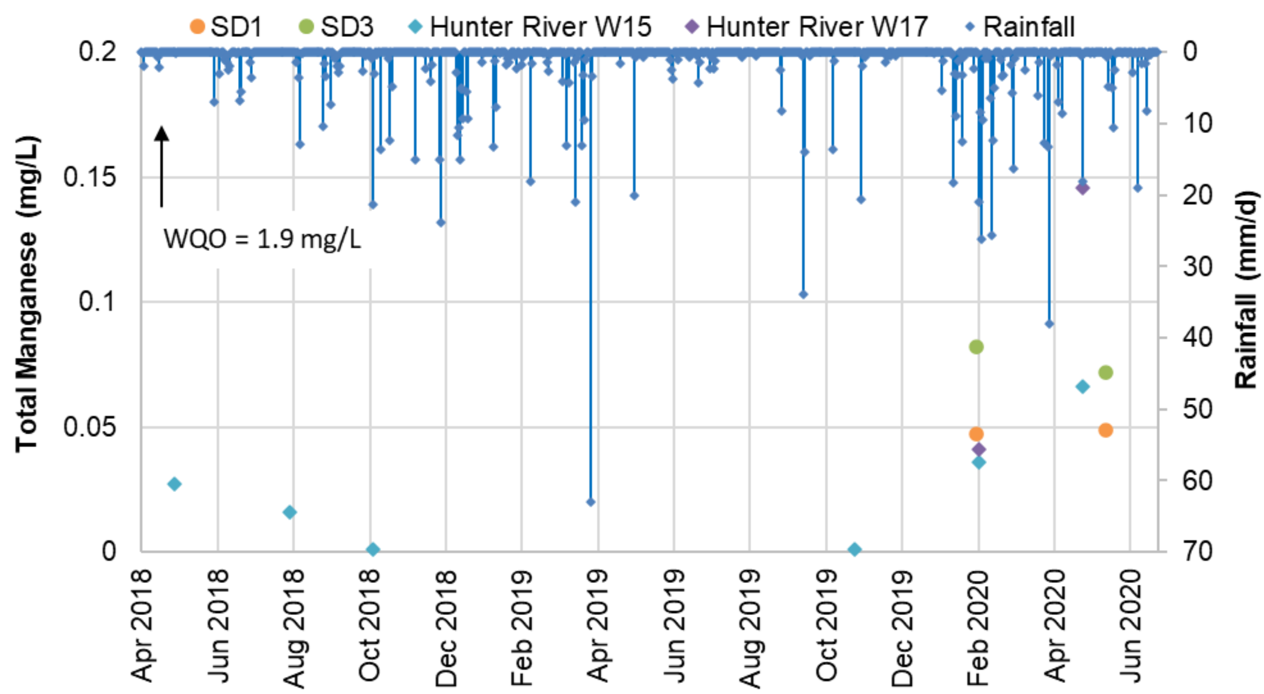

Chart 8 Total Manganese Records for Sediment Dams and Hunter River

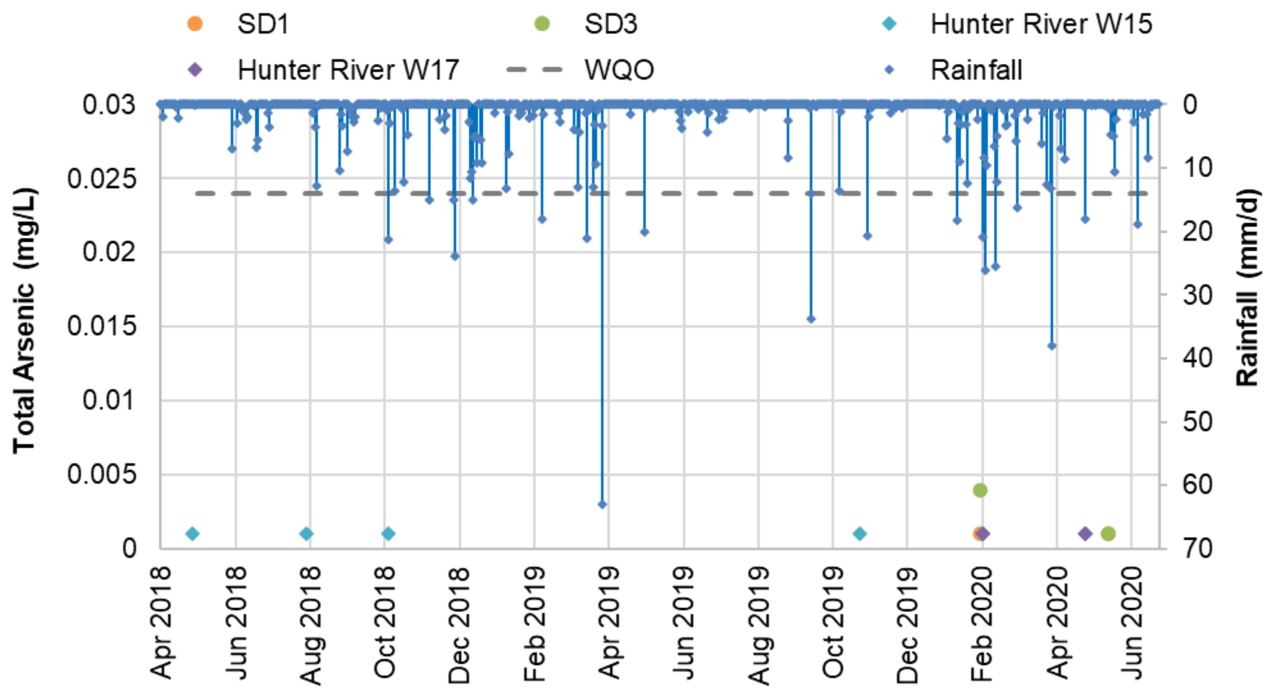

Chart 9 Total Arsenic Records for Sediment Dams and Hunter River

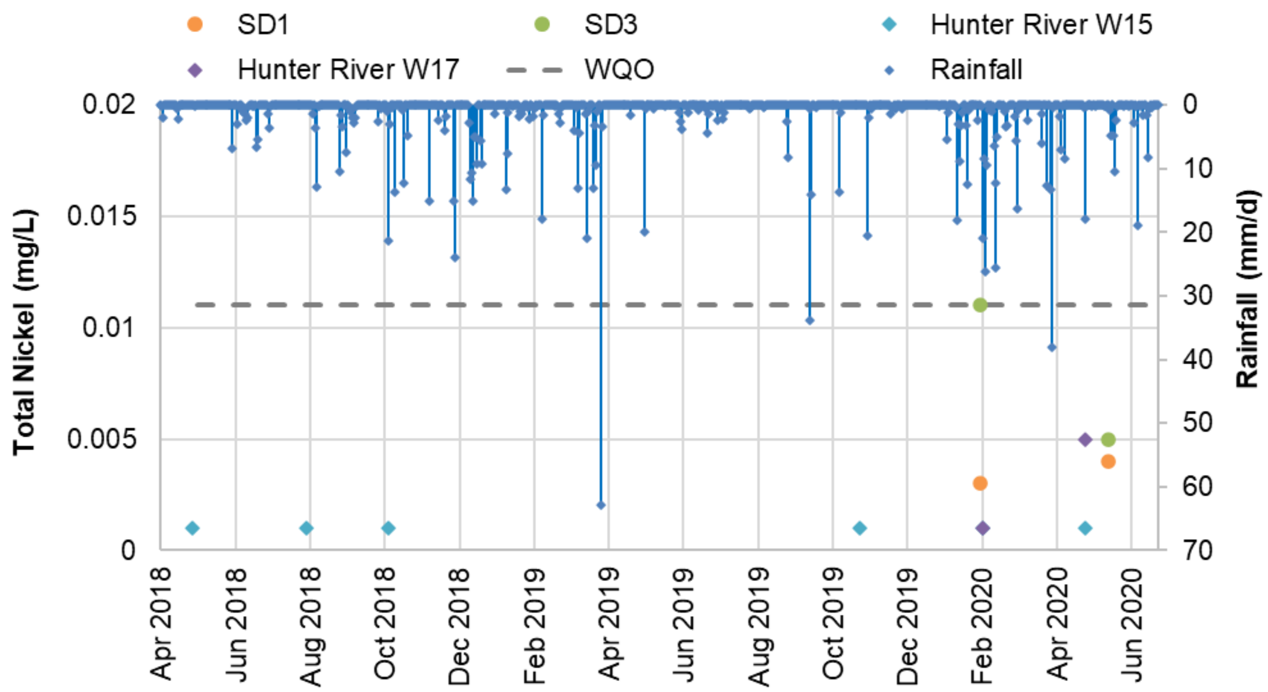

Chart 10 Total Nickel Records for Sediment Dams and Hunter River

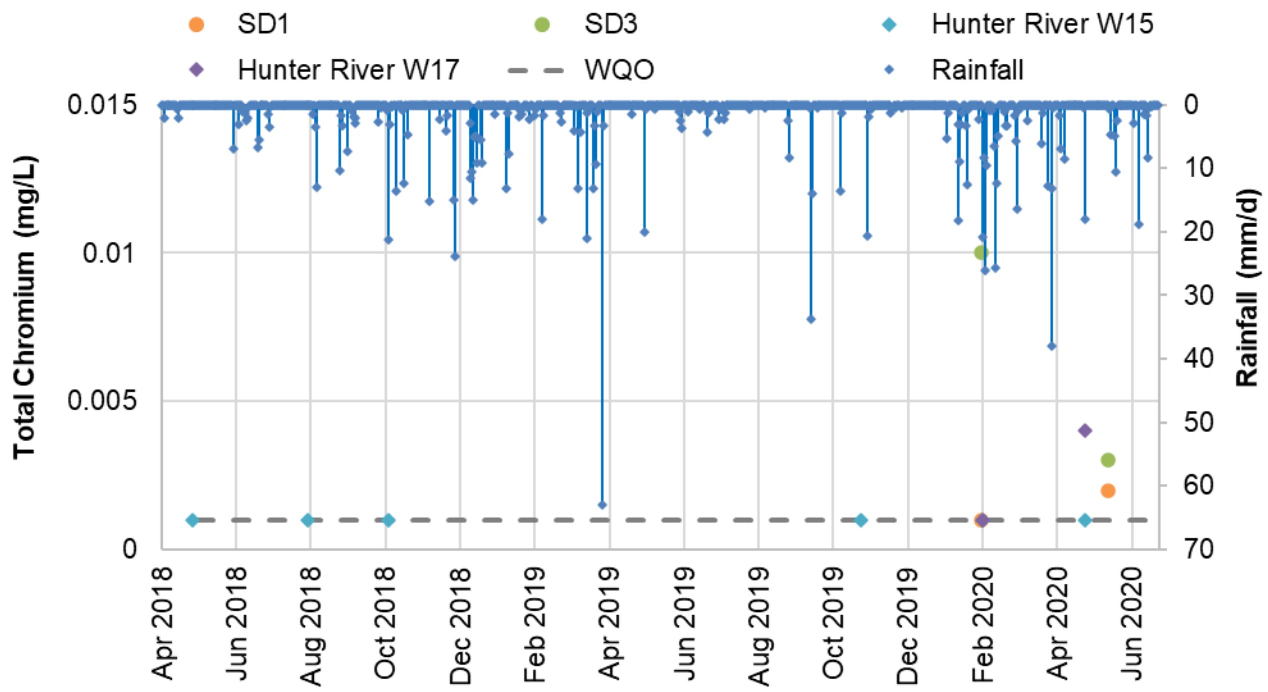

Chart 11 Total Chromium Records for Sediment Dams and Hunter River

Mine Water Dam[7]

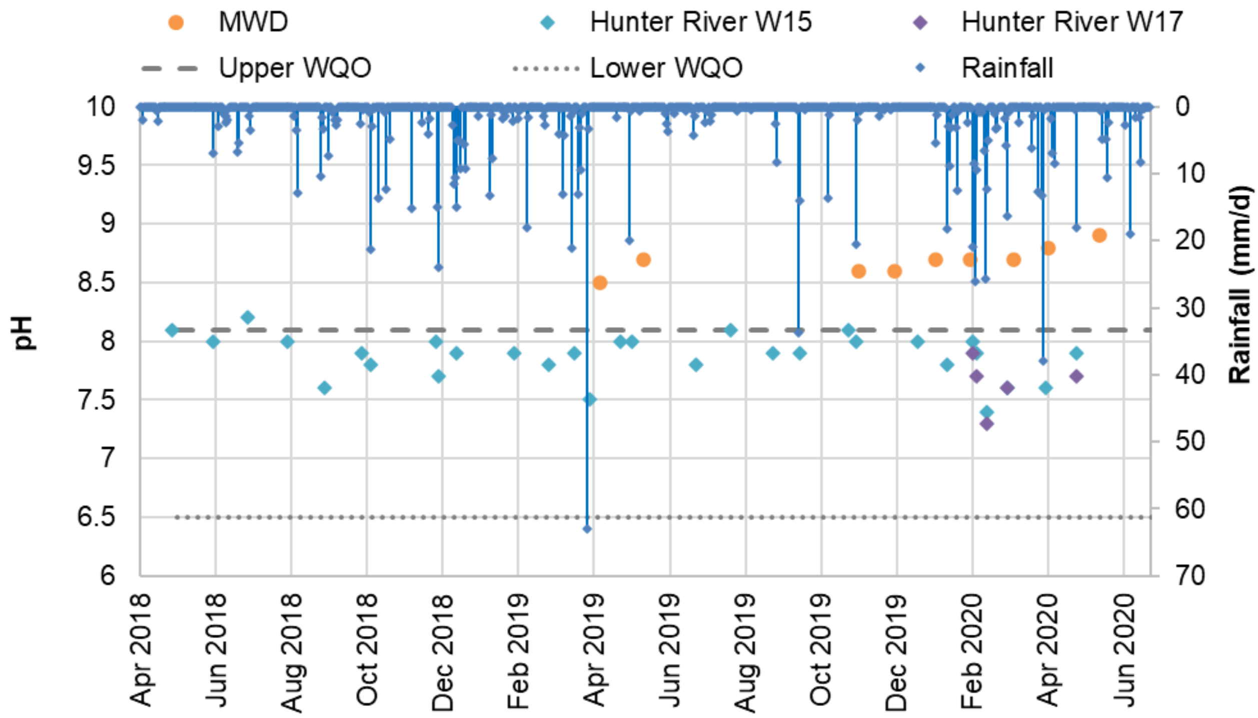

Chart 12 pH Records for MWD and Hunter River

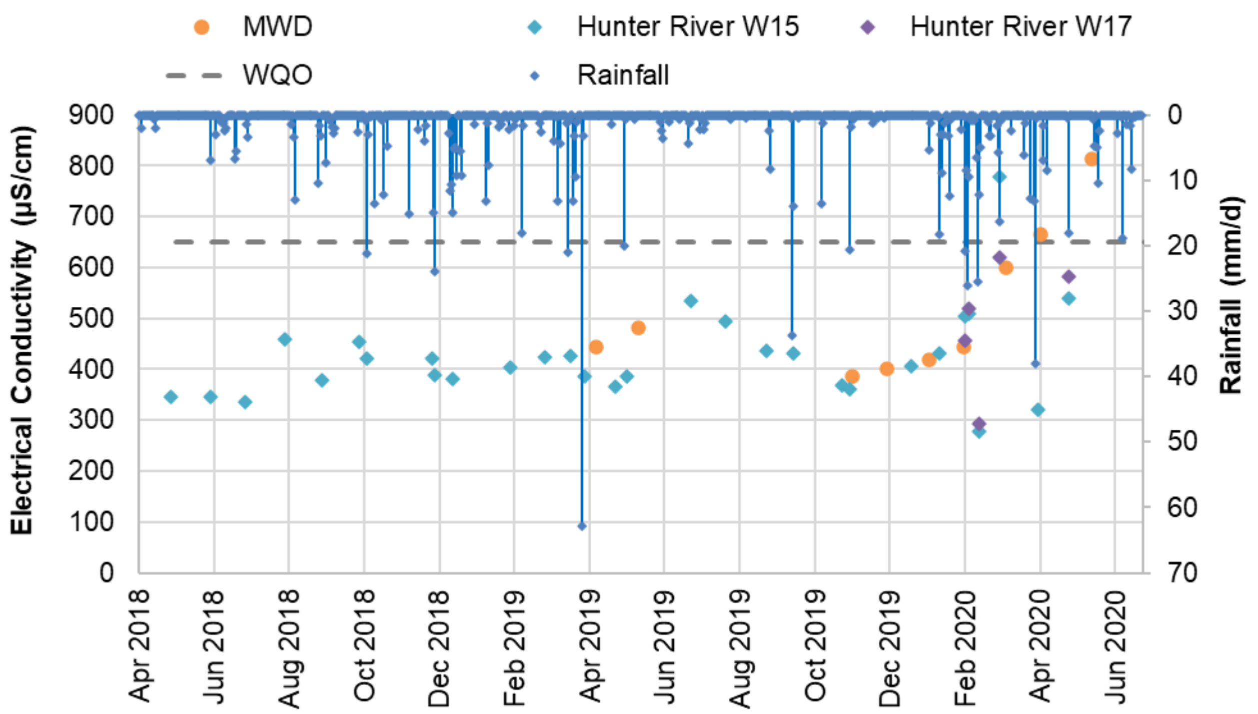

Chart 13 Electrical Conductivity Records for MWD and Hunter River

[7] SILO Point Data rainfall obtained for a point within the centre of the MPO is presented in the water quality plots. Note that records for WaterNSW Hunter River monitoring sites only extend to April 2018 and are therefore not presented.

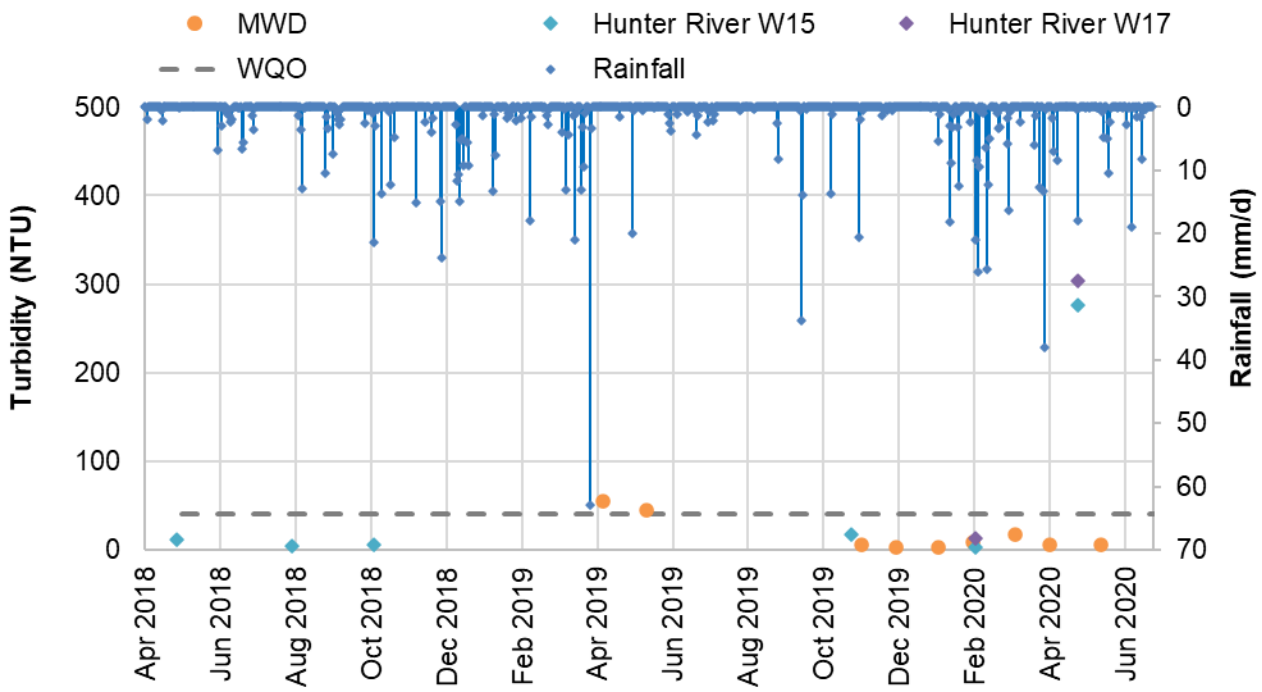

Chart 14 Turbidity Records for MWD and Hunter River

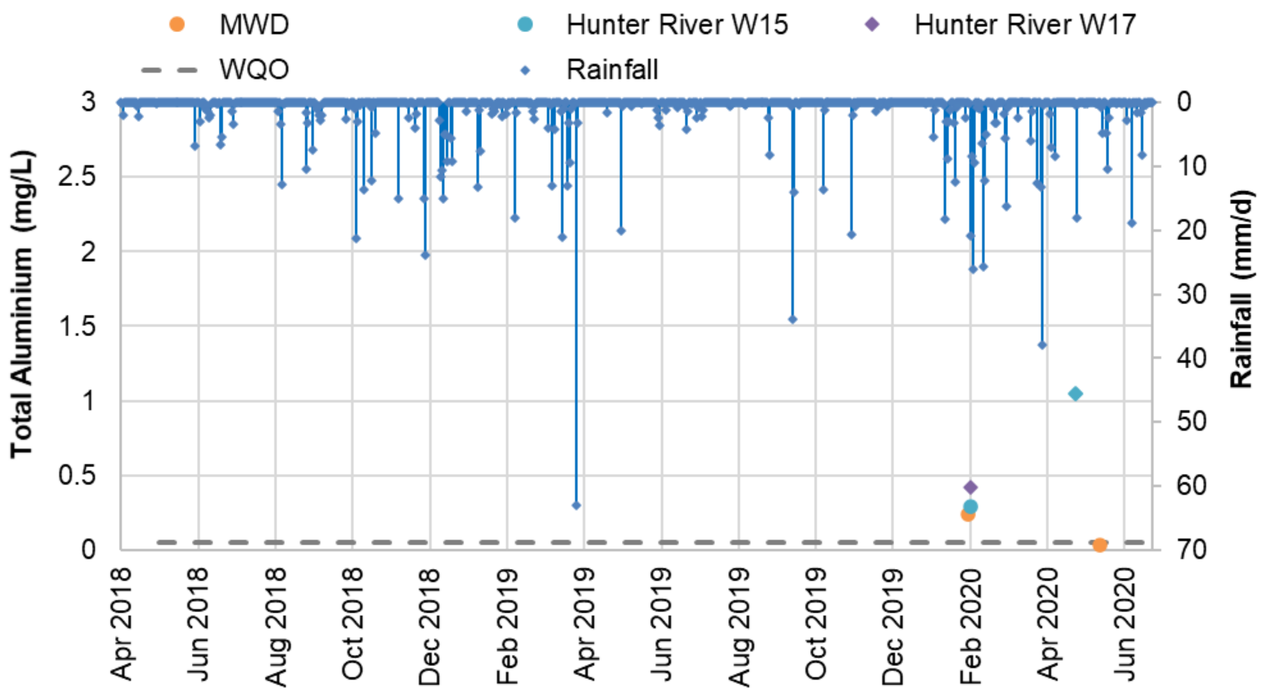

Chart 15 Total Aluminium Records for MWD and Hunter River

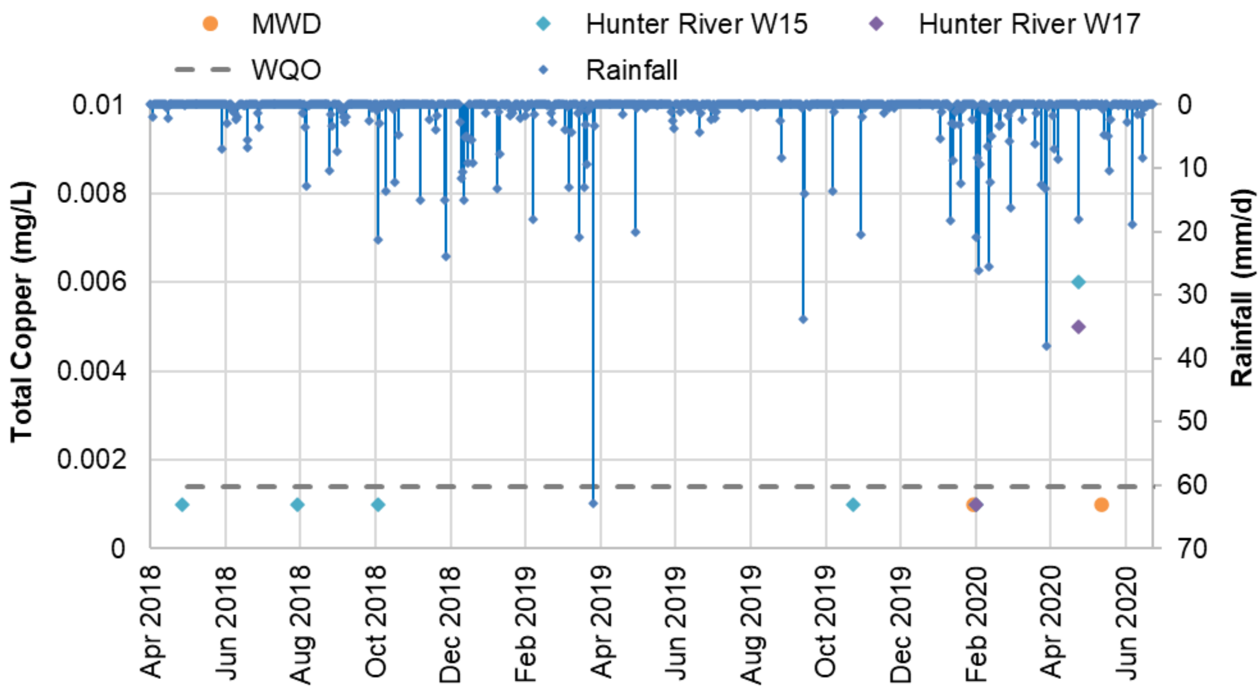

Chart 16 Total Copper Records for MWD and Hunter River

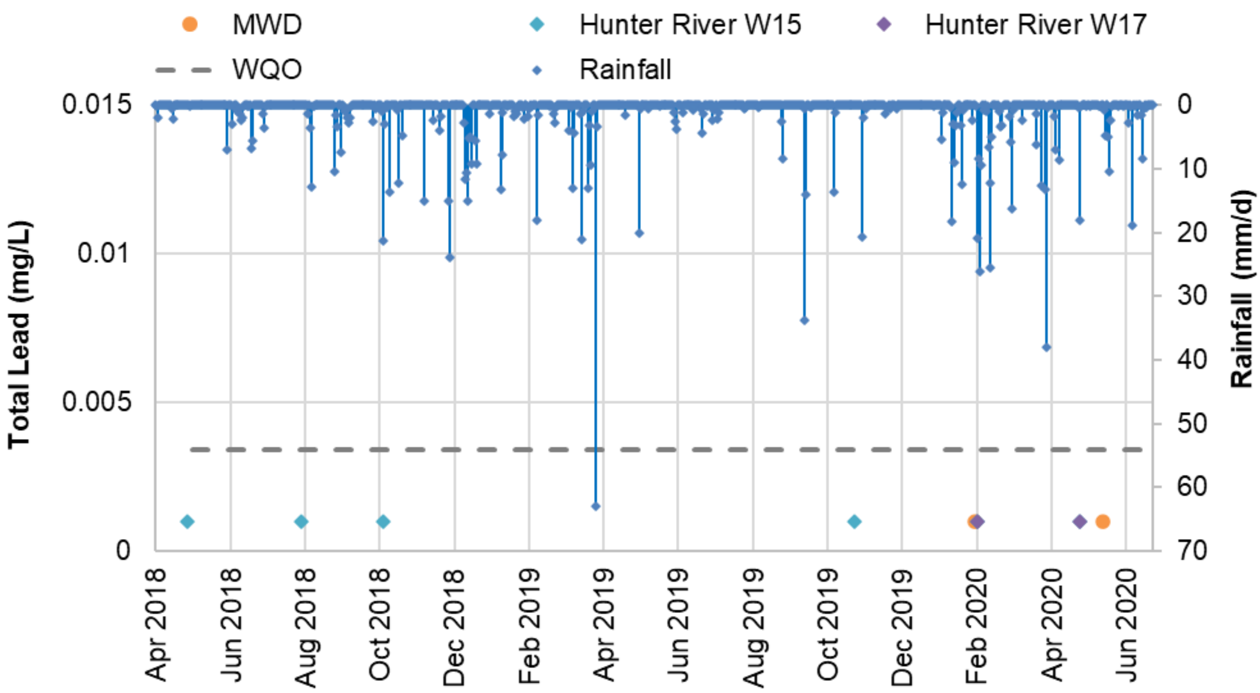

Chart 17 Total Lead Records for MWD and Hunter River

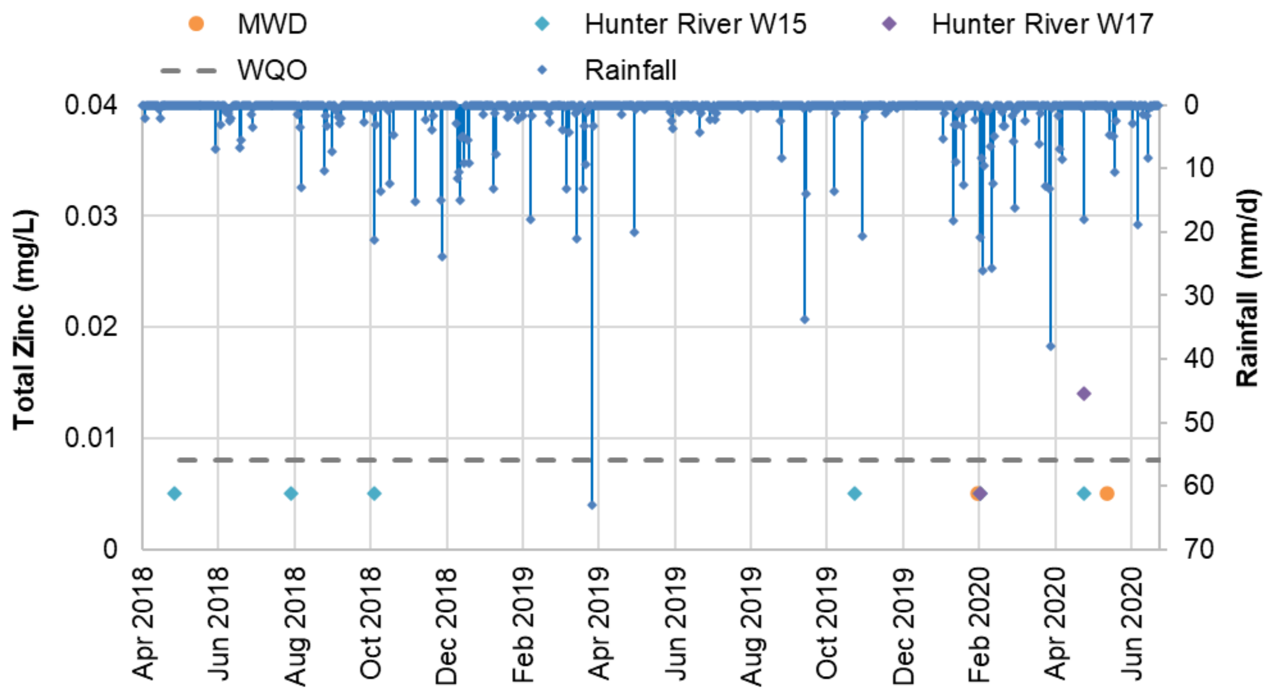

Chart 18 Total Zinc Records for MWD and Hunter River

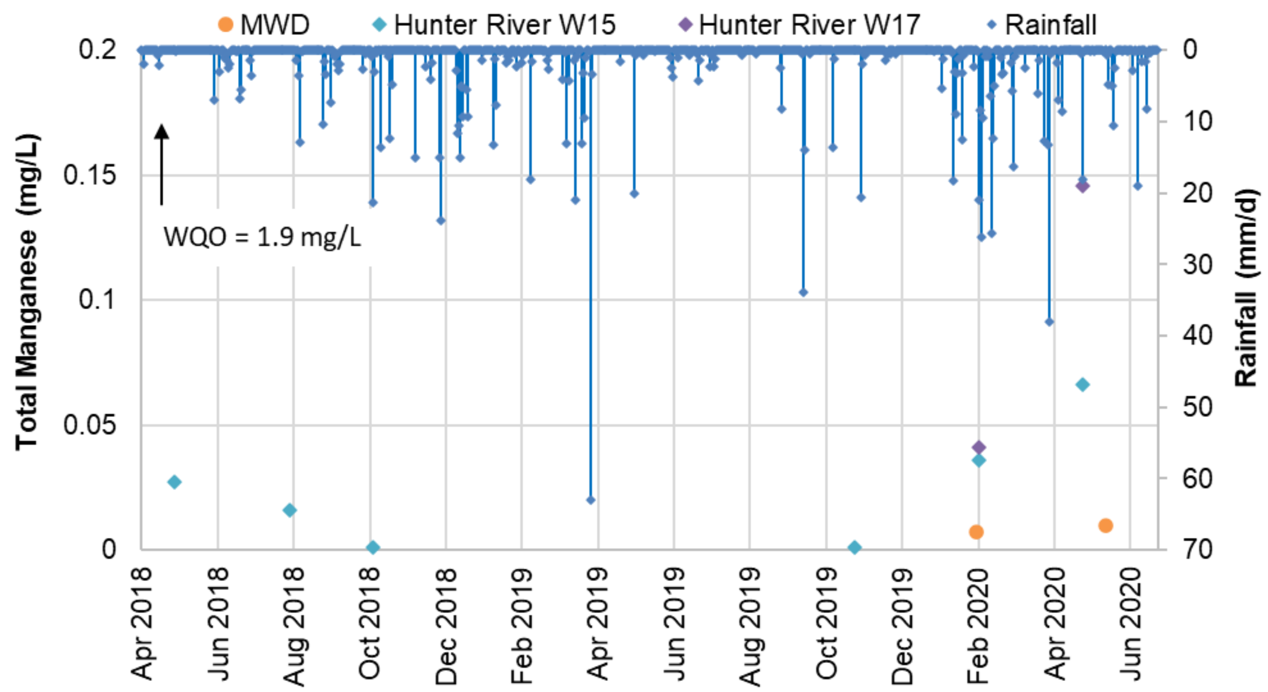

Chart 19 Total Manganese Records for MWD and Hunter River

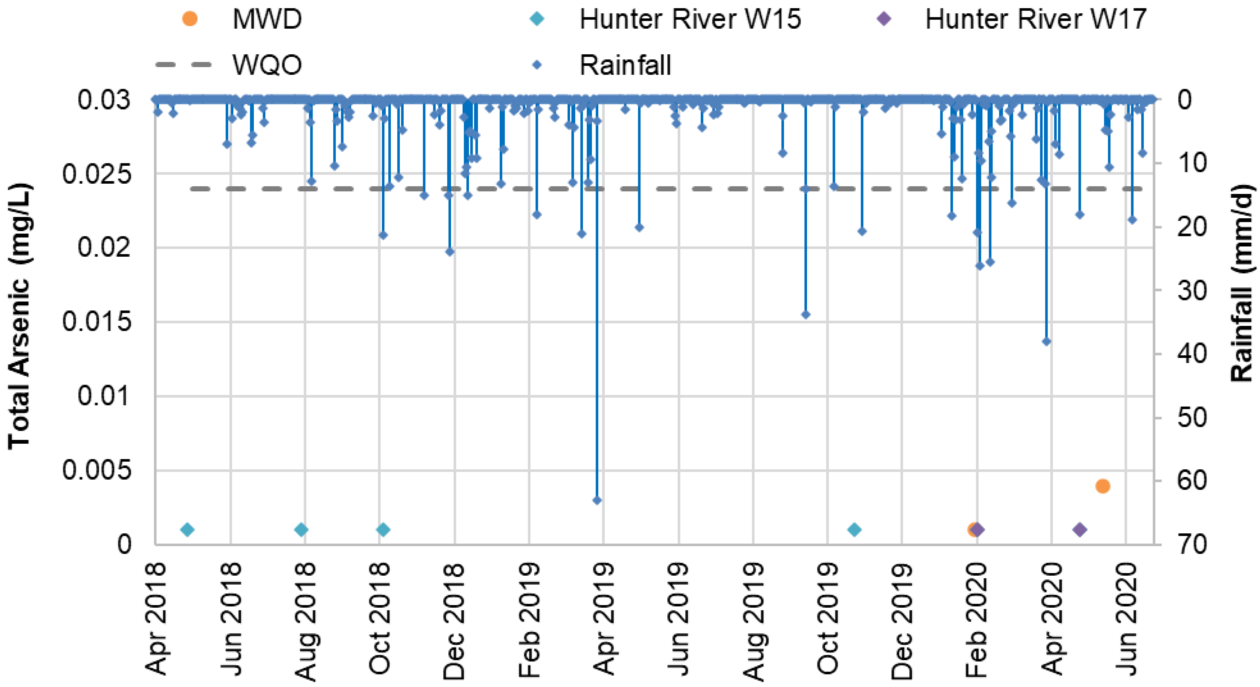

Chart 20 **Total Arsenic Records for MWD and Hunter River**

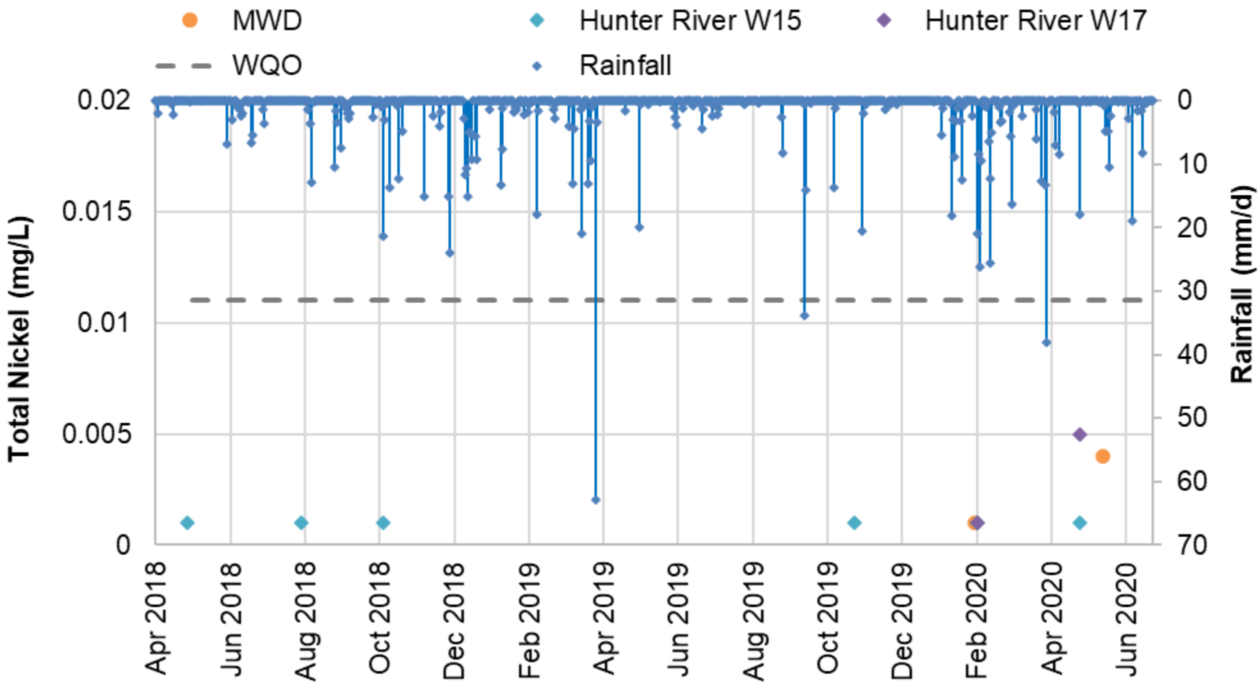

Chart 21 **Total Nickel Records for MWD and Hunter River**

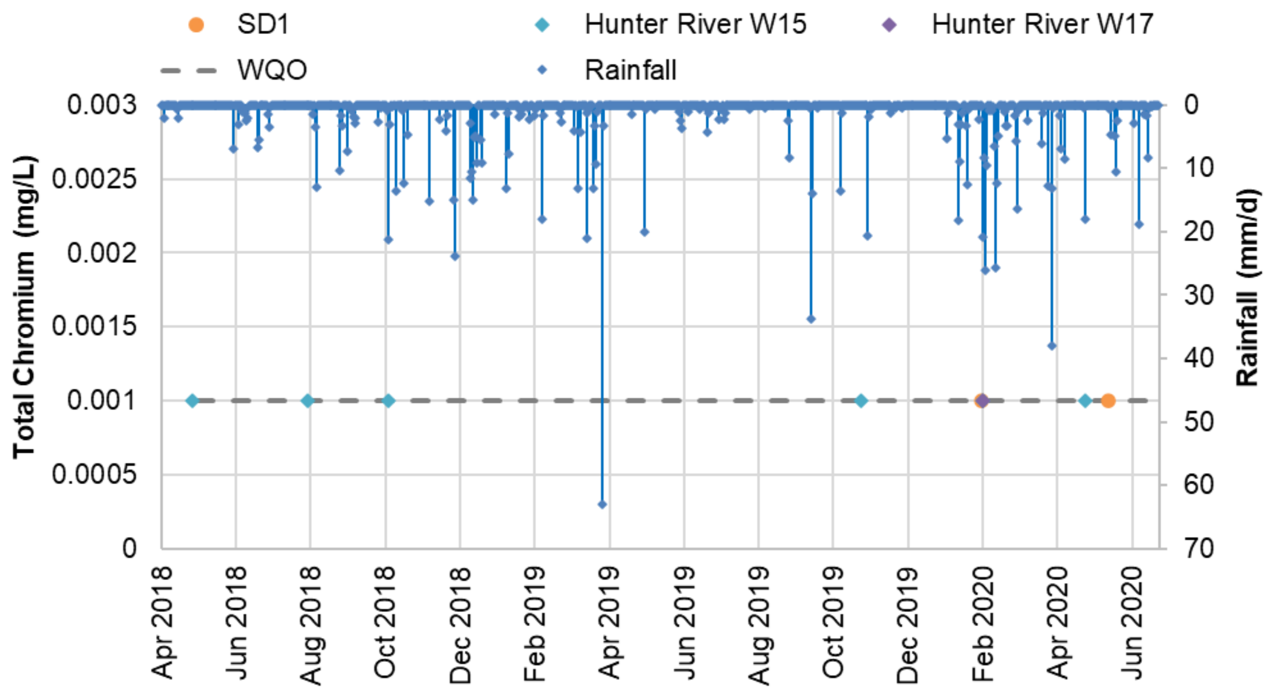

Chart 22 Total Chromium Records for MWD and Hunter River