MIDDLEMOUNT COAL MINE

WESTERN EXTENSION PROJECT (EPBC 2017/8130)

EPBC Act Preliminary Assessment Documentation

Attachment D

Surface Water Assessment

middlemount coal PTY LTD
ABN 49 122 348 412

Middlemount Coal Mine

Western Extension Project
Surface Water Impact Assessment

Middlemount Coal Pty Ltd

0469-17-E10, 3 September 2018

Report Title	Middlemount Coal Mine Western Extension Project Surface Water Impact Assessment
Client	Middlemount Coal Pty Ltd
Report Number	0469-17-E10

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1 Introduction

1.1 BACKGROUND

Middlemount Coal Pty Ltd (MCPL) owns and operates the Middlemount Coal Mine, an existing open cut coal mine, located approximately 7 kilometres (km) to the south-west of the Middlemount township within the Isaac Regional Local Government Area, Queensland. The location of the mine is shown in Figure 1.1.

The Middlemount Coal Mine Environmental Authority (EA) was amended on 29 June 2012 to approve the expansion of open cut mining operations within Mining Leases (ML) 70379 and 70417 (referred to as “Stage 2” of the Middlemount Coal Mine).

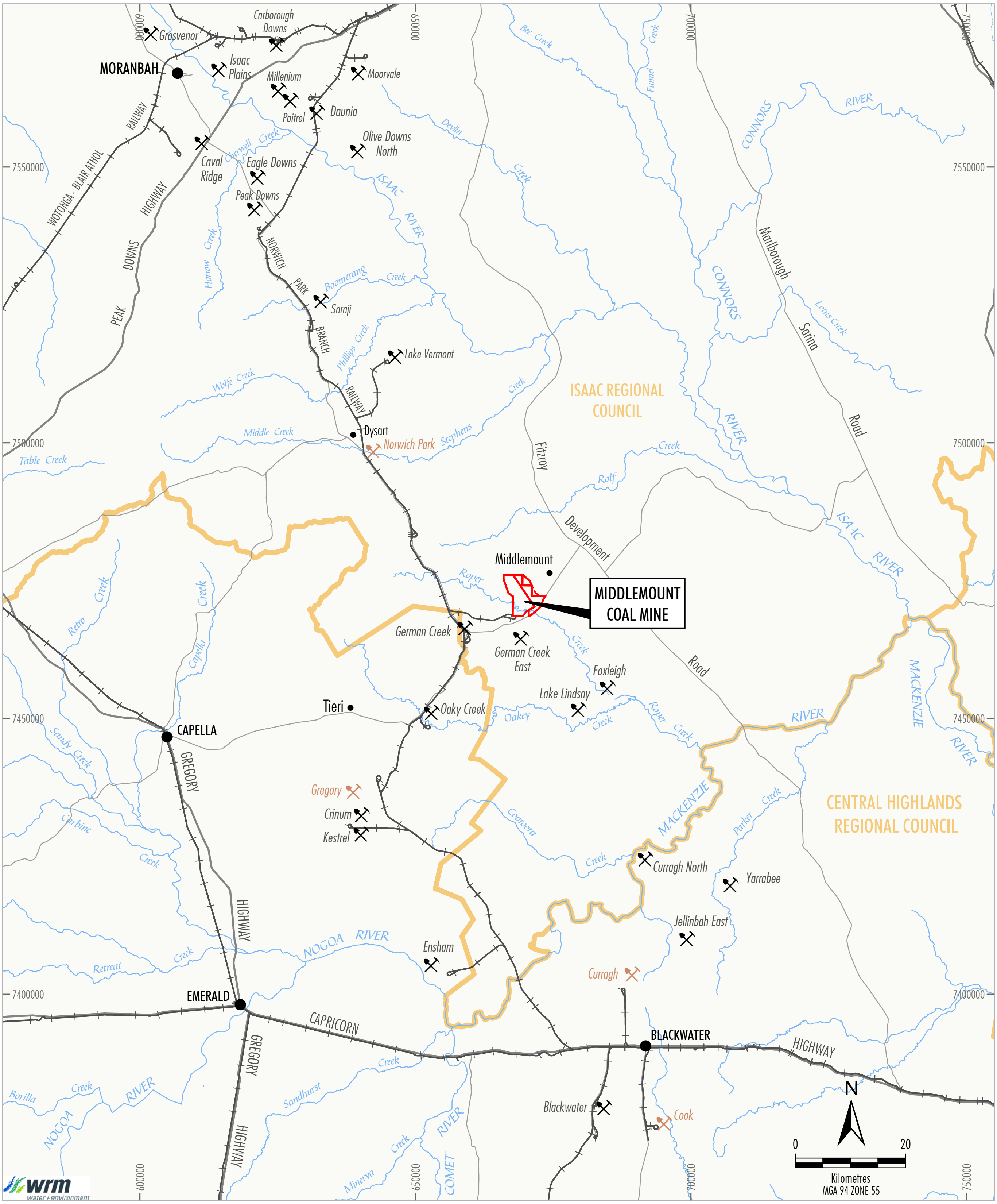
Stage 2 allows for open cut mining of run-of-mine (ROM) coal up to 24 hours per day, seven days per week, using a conventional truck and shovel fleet at a rate of up to 5.4 million tonnes per annum (Mtpa). ROM coal is mined in a general west to east direction within ML 70379, with overburden and interburden material emplaced in-pit behind the advancing open cut operations, and within the East Dump, located within ML 70417. ROM coal is processed through a coal handling and preparation plant (CHPP) to produce up to 4.1 Mtpa of Pulverised Coal Injection (PCI) and coking coal for the export market. Product coal is transported by rail to the Dalrymple Bay Coal Terminal and Abbot Point Coal Terminal.

An amendment to the Middlemount Coal Mine EA was granted on 23 September 2016 to extend the East Dump beyond part of the eastern extent of ML 70417 to alleviate the “saw tooth” layout of the currently approved dump design. This was the granting of ML700014 in February 2017. The layout of the approved final landform for Middlemount Coal Mine is shown in Figure 1.2.

1.2 PROJECT DESCRIPTION

MCPL is seeking Queensland Government and Commonwealth Government approval for changes to the approved Middlemount Coal Mine, herein referred to as the Western Extension Project (the Project). The main activities associated with the development of the Project would include:

- extension of the open cut pit within ML 70379 to the north-west;
- continued extraction of ROM coal at up to 5.7 Mtpa using conventional open cut mining equipment;
- placement of waste rock in existing emplacements, expanded emplacements (Eastern Dump) and within the mined-out void;
- continued backfilling of coarse rejects into the pit within spoil, and temporary storage of fine rejects from coal crushing and washing in existing tailings storage facility (TSF) cells for drying and reclaim for in-pit co-disposal;
- progressive development of sediment dams, pipelines and other water management equipment and structures (including levees and realignment of an existing diversion structure);
- progressive development of new haul roads and internal roads;
- continued development of soil stockpiles, laydown areas and borrow areas;
- continued use of existing and approved supporting mine infrastructure (including a CHPP and ROM and product coal stockpiles);
- continued rail transport of coal products to the Dalrymple Bay Coal Terminal, Abbott Point Coal Terminal or Wiggins Island Coal Export Terminal for export;



LEGEND
- Mining Lease Boundary
- Mining Lease Application Boundary
- Local Government Area Boundary
- Approved/Operating Coal Mine
- Under Care and Maintenance

Source: Department of Natural Resource and Mines (2017); Geoscience (2011)

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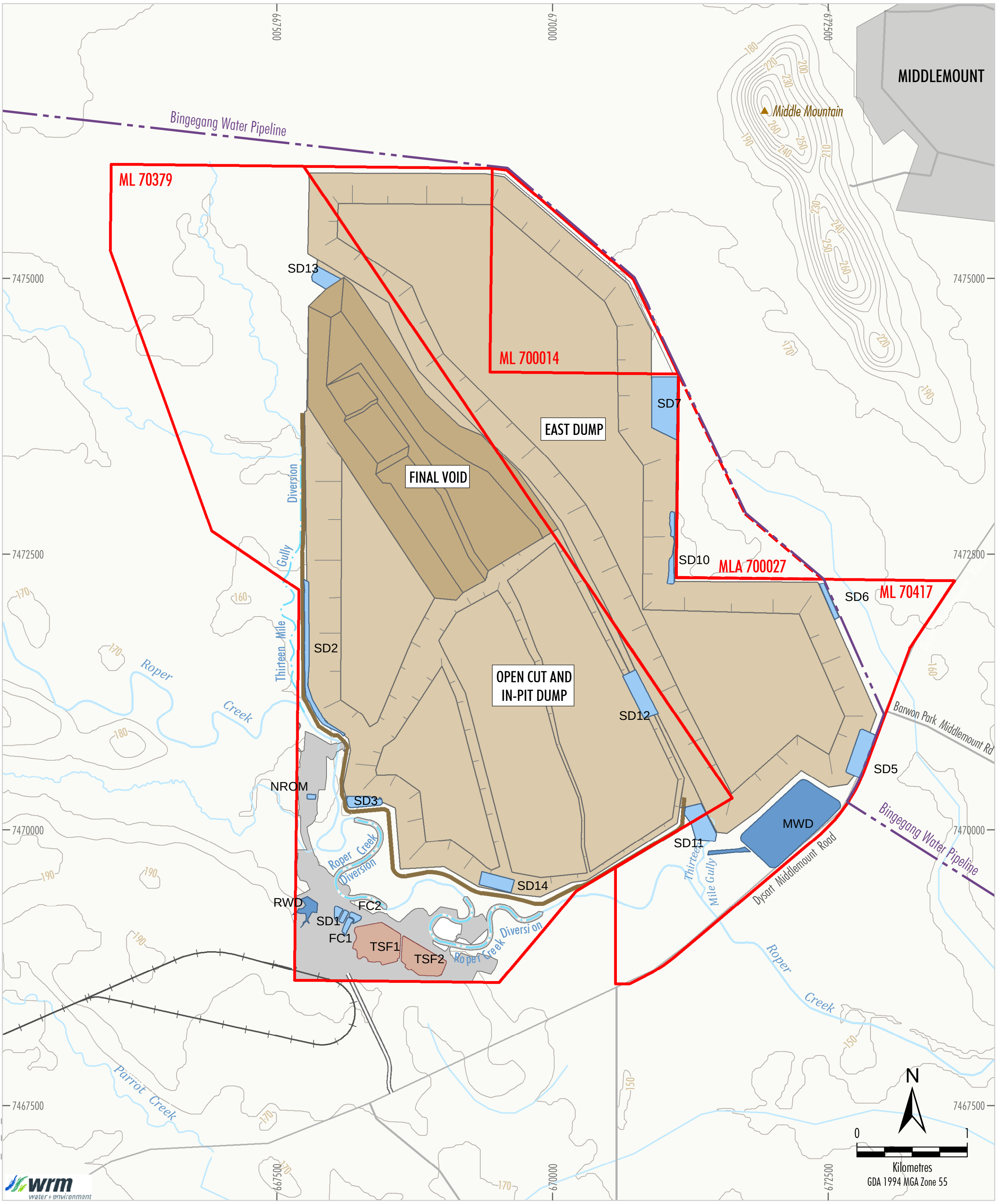
WESTERN EXTENSION PROJECT

Regional Location

Figure 1.1



LEGEND

- Mining Lease Boundary (ML)
- Mining Lease Application Boundary (MLA)

Currently Approved General Arrangement

- Mine Infrastructure Area
- Mining Pit and Spoil
- Final Void
- Tailings Storage Facility
- Sediment Dam
- Water Storage
- Diversion Structure
- Levee
- Mine Access Road
- Middlemount Rail Spur and Loop

Source: MCPL (2018); Department of Natural Resources and Mines (2017); Environmental Authority (EPML00716913) MCPL

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WESTERN EXTENSION PROJECT

Existing/Approved Middlemount Coal Mine General Arrangement

Figure 1.2

- extension of the approved mine life by approximately six years (to 2037); and
- a change to the final landform at the Middlemount Coal Mine for the end of the mine life to include two final voids.

The proposed general layout of Middlemount Coal Mine in 2023, 2028, 2033 and for the final landform are shown in Figures 1.3 to 1.6.

1.3 INDEPENDENT EXPERT SCIENTIFIC COMMITTEE GUIDELINES

The Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development gas information guidelines (IESC, 2018) for advice on coal seam gas and large coal mining development proposals. The report sections where the IESC information requirements for individual proposals have been addressed are outlined in Table 1.1

Table 1.1- IESC information requirements

Project information	Report section
Description of the proposal	
Provide a regional overview of the proposed project area including a description of the geological basin; coal resource; surface water catchments; groundwater systems; water-dependent assets; and past, current and reasonably foreseeable coal mining and CSG developments.	Sections 1, 2, 3 & 4
Describe the proposal's location, purpose, scale, duration, disturbance area, and the means by which it is likely to have a significant impact on water resources and water-dependent assets.	Sections 1, 4 & 5
Describe the statutory context, including information on the proposal's status within the regulatory assessment process and any applicable water management policies.	Refer to Main Report
Describe how impacted water resources are currently being regulated under state or Commonwealth law, including whether there are any applicable standard conditions.	Section 2.7 & 2.8
Surface water - context and conceptualisation	
Describe the hydrological regime of all watercourses, standing waters and springs across the site including:	
• geomorphology, including drainage patterns, sediment regime, and floodplain features;	Section 2.2
• spatial, temporal and seasonal trends in streamflow and/or standing water levels;	Section 2.3
• spatial, temporal and seasonal trends in water quality data (such as turbidity, acidity, salinity, relevant organic chemicals, metals, metalloids and radionuclides); and	Section 2.6
• current stressors on watercourses, including impacts from any currently approved projects.	Section 2.7
Describe the existing flood regime, including flood volume, depth, duration, extent and velocity for a range of annual exceedance probabilities. Provide flood hydrographs and maps identifying peak flood extent, depth and velocity. This assessment should be informed by topographic data that has been acquired using lidar or other reliable survey methods with accuracy stated.	Appendix B Section 7

Provide an assessment of the frequency, volume, seasonal variability and direction of interactions between water resources, including surface water/groundwater connectivity and connectivity with sea water.	Refer to Groundwater Report
Surface water – analytical and numerical modelling	
Provide conceptual models at an appropriate scale, including water quality, stores, flows and use of water by ecosystems.	Appendix A, Appendix B, Sections 5 & 7
Use methods in accordance with the most recent publication of *Australian Rainfall and Runoff* (Ball et al. 2016).	Appendix B
Develop and describe a program for review and update of the models as more data and information becomes available.	Appendix A1
Describe and justify model assumptions and limitations, and calibrate with appropriate surface water monitoring data.	Appendix A8 & Appendix B2.3
Provide an assessment of the risks and uncertainty inherent in the data used in the modelling, particularly with respect to predicted scenarios.	Section 5.5
Provide a detailed description of any methods and evidence (e.g. expert opinion, analogue sites) employed in addition to modelling.	Models verified against historical data Appendix A8
Surface water – impacts to water resources and water-dependent assets	
Describe all potential impacts of the proposed project on surface waters. Include a clear description of the impact to the resource, the resultant impact to any assets dependent on the resource (including water-dependent ecosystems such as riparian zones and floodplains), and the consequence or significance of the impact. Consider:	
• impacts on streamflow under the full range of flow conditions.	Section 7
• impacts associated with surface water diversions.	Section 6
• impacts to water quality, including consideration of mixing zones.	Section 8
• the quality, quantity and ecotoxicological effects of operational discharges of water (including saline water), including potential emergency discharges, and the likely impacts on water resources and water-dependent assets.	Section 5.3 & 8
• landscape modifications such as subsidence, voids, post rehabilitation landform collapses, onsite earthworks (including disturbance of acid-forming or sodic soils, roadway and pipeline networks) and how these could affect surface water flow, surface water quality, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	Section 5.4 & 7.5
Discuss existing water quality guidelines, environmental flow objectives and requirements for the surface water catchment(s) within which the development proposal is based.	Section 2.8
Identify processes to determine surface water guidelines and quantity thresholds which incorporate seasonal variation but provide early indication of potential impacts to assets.	Section 4.2 & 4.3
Propose mitigation actions for each identified significant impact.	Section 4
Describe the adequacy of proposed measures to prevent or minimise impacts on water resources and water-dependent assets.	Section 5

Describe the cumulative impact of the proposal on surface water resources and water-dependent assets when all developments (past, present and/or reasonably foreseeable) are considered in combination.	Section 9
Provide an assessment of the risks of flooding (including channel form and stability, water level, depth, extent, velocity, shear stress and stream power), and impacts to ecosystems, project infrastructure and the final project landform.	Section 7
Surface water – data and monitoring	
Identify monitoring sites representative of the diversity of potentially affected water-dependent assets and the nature and scale of potential impacts, and match with suitable replicated control and reference sites (BACI design) to enable detection and monitoring of potential impacts.	Section 3.4
Ensure water quality monitoring complies with relevant National Water Quality Management Strategy (NWQMS) guidelines (ANZECC/ARMCANZ 2000) and relevant legislated state protocols (e.g. QLD Government 2013).	Section 3.4
Identify data sources, including streamflow data, proximity to rainfall stations, data record duration and a describe of data methods, including whether missing data has been patched.	Section 2.3
Develop and describe a surface water monitoring programme that will collect sufficient data to detect and identify the cause of any changes from established baseline conditions, and assess the effectiveness of mitigation and management measures. The program will: • include baseline monitoring data for physico-chemical parameters, as well as contaminants (e.g. metals); • comparison of physico-chemical data to national/regional guidelines or to site-specific guidelines derived from reference condition monitoring if available; and, • identify baseline contaminant concentrations and compare these to national guidelines, allowing for local background correction if required.	Section 3.4
Describe the rationale for selected monitoring parameters, duration, frequency and methods, including the use of satellite or aerial imagery to identify and monitor large-scale impacts.	Section 3.4
Develop and describe a plan for ongoing ecotoxicological monitoring, including direct toxicity assessment of discharges to surface waters where appropriate.	Not required
Identify dedicated sites to monitor hydrology, water quality, and channel and floodplain geomorphology throughout the life of the proposed project and beyond.	Section 3.4
Water-dependent assets – context and conceptualisation	
Identify water-dependent assets, including: • water-dependent fauna and flora and provide surveys of habitat, flora and fauna (including stygofauna) (see Doody et al. [in press]). • public health, recreation, amenity, Indigenous, tourism or agricultural values for each water resource.	Section 2.8 Refer to Ecology report
Identify GDEs in accordance with the method outlined by Eamus et al. (2006). Information from the GDE Toolbox15 (Richardson et al. 2011) and GDE Atlas (CoA 2017a) may assist in identification of GDEs (see Doody et al. [in press]).	Refer to Groundwater Report
Describe the conceptualisation and rationale for likely water-dependence, impact pathways, tolerance and resilience of water-dependent assets. Examples of ecological conceptual models can be found in Commonwealth of Australia (2015).	Refer to Groundwater Report

Estimate the ecological water requirements of identified GDEs and other water-dependent assets (see Doody et al. [in press]).	Refer to Groundwater Report
Identify the hydrogeological units on which any identified GDEs are dependent (see Doody et al. [in press]).	Refer to Groundwater Report
Provide an outline of the water-dependent assets and associated environmental objectives and the modelling approach to assess impacts to the assets.	Section 2.8
Describe the process employed to determine water quality and quantity triggers and impact thresholds for water-dependent assets (e.g. threshold at which a significant impact on an asset may occur).	Section 4.5.2
Water-dependent assets – impacts, risk assessment and management of risks	
Provide an assessment of direct and indirect impacts on water-dependent assets, including ecological assets such as flora and fauna dependent on surface water and groundwater, springs and other GDEs (see Doody et al. [in press]).	Refer to Groundwater Report
Describe the potential range of drawdown at each affected bore, and clearly articulate the scale of impacts to other water users.	Refer to Groundwater Report
Indicate the vulnerability to contamination (e.g. from salt production and salinity) and the likely impacts of contamination on the identified water-dependent assets and ecological processes.	Section 2 & 3
Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion and habitat fragmentation of water-dependent species and communities.	Section 5.4
Provide estimates of the volume, beneficial uses and impact of operational discharges of water (particularly saline water), including potential emergency discharges due to unusual events, on water-dependent assets and ecological processes.	Section 8.3
Assess the overall level of risk to water-dependent assets through combining probability of occurrence with severity of impact.	Section 8
Identify the proposed acceptable level of impact for each water-dependent asset based on leading-practice science and site-specific data, and ideally developed in conjunction with stakeholders.	Section 4.5.2
Propose mitigation actions for each identified impact, including a description of the adequacy of the proposed measures and how these will be assessed.	Section 8
Water-dependent assets – data and monitoring	
Identify an appropriate sampling frequency and spatial coverage of monitoring sites to establish pre-development (baseline) conditions, and test potential responses to impacts of the proposal (see Doody et al. [in press]).	Section 4.5.2 and Section 10
Consider concurrent baseline monitoring from unimpacted control and reference sites to distinguish impacts from background variation in the region (e.g. BACI design, see Doody et al. [in press]).	
Develop and describe a monitoring program that identifies impacts, evaluates the effectiveness of impact prevention or mitigation strategies, measures trends in ecological responses and detects whether ecological responses are within identified thresholds of acceptable change (see Doody et al. [in press]).	
Describe the process for regular reporting, review and revisions to the monitoring program.	

Ensure ecological monitoring complies with relevant state or national monitoring guidelines (e.g. the DSITI guideline for sampling stygofauna (QLD Government 2015)).	
Water and salt balance, and water management quality	
Provide a quantitative site water balance model describing the total water supply and demand under a range of rainfall conditions and allocation of water for mining activities (e.g. dust suppression, coal washing etc.), including all sources and uses.	Section 7 & Appendix A
Describe the water requirements and on-site water management infrastructure, including modelling to demonstrate adequacy under a range of potential climatic conditions.	Section 7 & Appendix A
Provide estimates of the quality and quantity of operational discharges under dry, median and wet conditions, potential emergency discharges due to unusual events and the likely impacts on water-dependent assets.	Section 7 & Appendix A
Provide salt balance modelling that includes stores and the movement of salt between stores, and takes into account seasonal and long-term variation.	Section 7 & Appendix A
Cumulative impacts – context and conceptualisation	
Provide cumulative impact analysis with sufficient geographic and temporal boundaries to include all potentially significant water-related impacts.	Section 9
Consider all past, present, and reasonably foreseeable actions, including development proposals, programs and policies that are likely to impact on the water resources of concern in the cumulative impact analysis. Where a proposed project is located within the area of a bioregional assessment consider the results of the bioregional assessment.	Section 9
Cumulative impacts – impacts	
Provide an assessment of the condition of affected water resources which includes: • identification of all water resources likely to be cumulatively impacted by the proposed development; • a description of the current condition and quality of water resources and information on condition trends; • identification of ecological characteristics, processes, conditions, trends and values of water resources; • adequate water and salt balances; and • identification of potential thresholds for each water resource and its likely response to change and capacity to withstand adverse impacts (e.g. altered water quality, drawdown).	Section 9
Assess the cumulative impacts to water resources considering: • the full extent of potential impacts from the proposed project, (including whether there are alternative options for infrastructure and mine configurations which could reduce impacts), and encompassing all linkages, including both direct and indirect links, operating upstream, downstream, vertically and laterally; • all stages of the development, including exploration, operations and post closure/decommissioning; • appropriately robust, repeatable and transparent methods; • the likely spatial magnitude and timeframe over which impacts will occur, and significance of cumulative impacts; and	Section 9

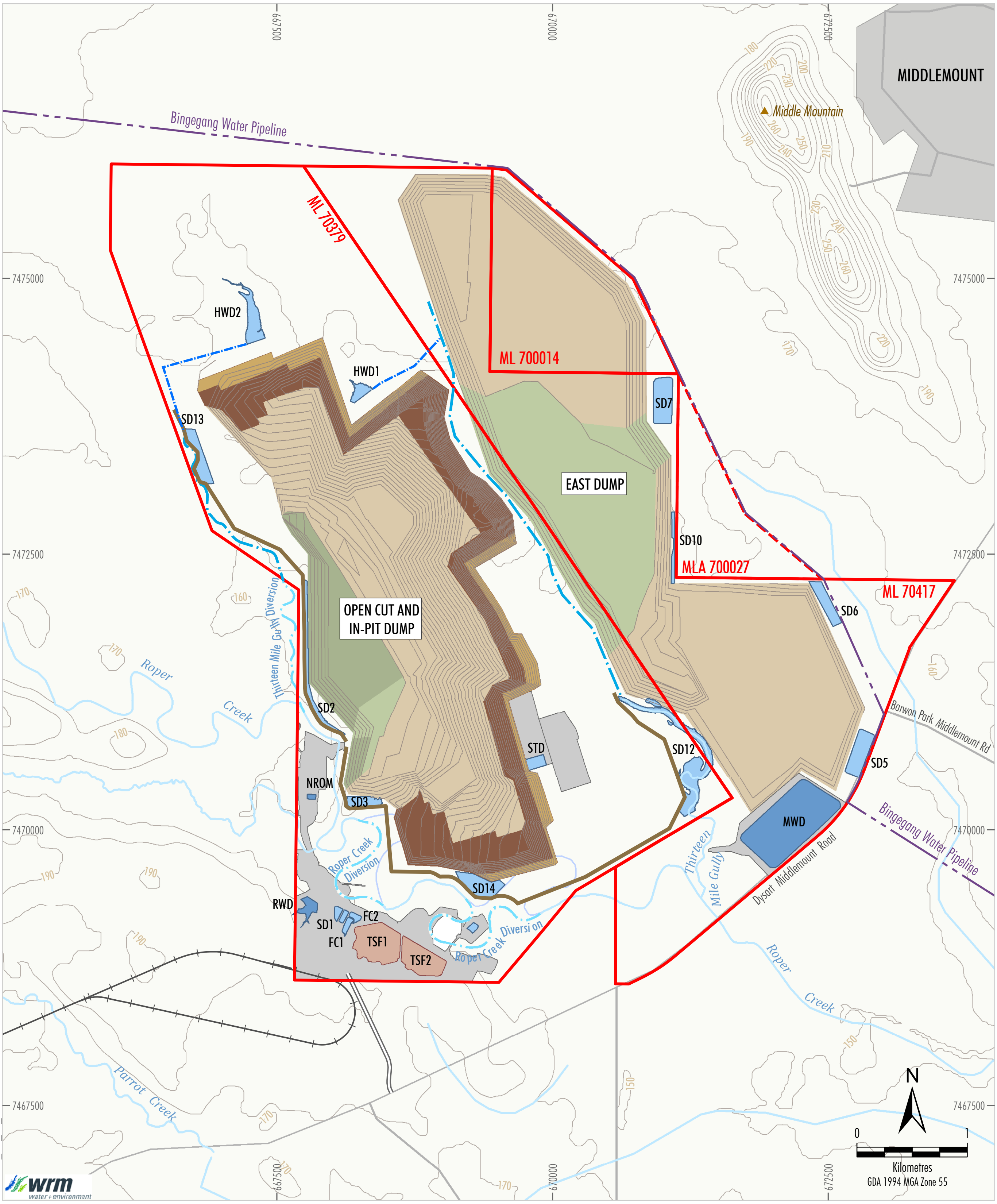
• opportunities to work with other water users to avoid, minimise or mitigate potential cumulative impacts.	
Cumulative Impacts – Mitigation, monitoring and management	
Identify modifications or alternatives to avoid, minimise or mitigate potential cumulative impacts. Evidence of the likely success of these measures (e.g. case studies) should be provided.	
Identify measures to detect and monitor cumulative impacts, pre and post development, and assess the success of mitigation strategies.	Section 9
Identify cumulative impact environmental objectives.	
Describe appropriate reporting mechanisms.	
Propose adaptive management measures and management responses.	
Final landform and voids – coal mines	
Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	
Assess the adequacy of modelling, including surface water and groundwater quantity and quality, lake behaviour, timeframes and calibration.	
Provide an assessment of the long-term impacts to water resources and water-dependent assets posed by various options for the final landform design, including complete or partial backfilling of mining voids. Assessment of the final landform for which approval is being sought should considers: • groundwater behaviour – sink or lateral flow from void. • water level recovery – rate, depth, and stabilisation point (e.g. timeframe and level in relation to existing groundwater level, surface elevation). • seepage – geochemistry and potential impacts. • long-term water quality, including salinity, pH, metals and toxicity. • measures to prevent migration of void water off-site. For other final landform options considered sufficient detail of potential impacts should be provided to clearly justify the proposed option.	Section 5.4
Assess the probability of overtopping of final voids with variable climate extremes, and management mitigations.	
Acid-forming materials and other contaminants of concern	
Identify the presence and potential exposure of acid-sulphate soils (including oxidation from groundwater drawdown).	
Identify the presence and volume of potentially acid-forming waste rock, fine-grained amorphous sulphide minerals and coal reject/tailings material and exposure pathways.	
Identify other sources of contaminants, such as high metal concentrations in groundwater, leachate generation potential and seepage paths.	Refer to Groundwater Report
Describe handling and storage plans for acid-forming material (co-disposal, tailings dam, encapsulation).	
Assess the potential impact to water-dependent assets, taking into account dilution factors, and including solute transport modelling where relevant, representative and statistically valid sampling, and appropriate analytical techniques.	

Describe proposed measures to prevent/minimise impacts on water resources, water users and water-dependent ecosystems and species.

1.4 REPORT STRUCTURE

This report is structured as follows:

- Section 2 describes the Environmental Values of the regional and local drainage receiving waters;
- Section 3 presents the surface water characteristics of the mine site;
- Section 4 describes the surface water management system including the management objectives and principles;
- Section 5 provides a summary of the water balance model results for the mine water management system;
- Section 6 provides details of the proposed Thirteen Mile Gully realignment;
- Section 7 describes the outcomes from the flood modelling assessment;
- Section 8 describes the outcomes from the impact assessment for surface water;
- Section 8.6 describes the outcomes from the cumulative impact assessment for surface water;
- Section 9 gives a list of references;
- Appendix A summarises the recent water quality monitoring data as time-series graphs;
- Appendix B describes the mine water balance model configuration; and
- Appendix C describes the existing conditions flood modelling.



LEGEND

- Mining Lease Boundary (ML)
- Mining Lease Application Boundary (MLA)
- Topsoil Stripped
- Active Open Cut Mining Area
- Active Waste Rock Emplacement
- Initial Rehabilitation
- Established Rehabilitation
- Mine Infrastructure Area
- Tailings Storage Facility
- Sediment Dam
- Water Storage
- Water Transfer Pipeline
- Diversion Structure
- Levee
- Mine Access Road
- Middlemount Rail Spur and Loop

Source: MCPL (2018); Department of Natural Resources and Mines (2017)

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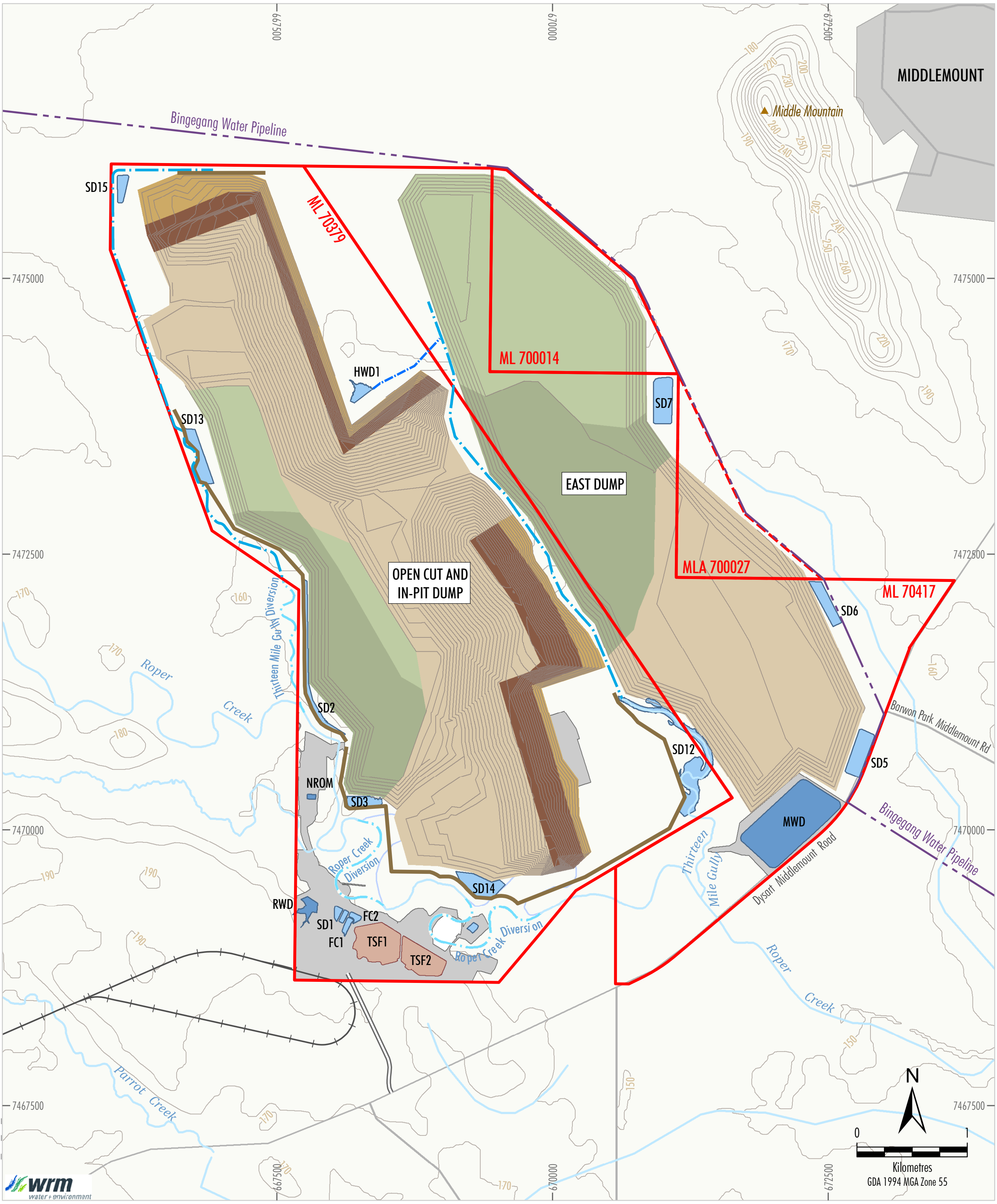
WESTERN EXTENSION PROJECT

Conceptual General Arrangement
Year 6 (2023)

Figure 1.3



LEGEND

- Mining Lease Boundary (ML)
- Mining Lease Application Boundary (MLA)
- Topsoil Stripped
- Active Open Cut Mining Area
- Active Waste Rock Emplacement
- Initial Rehabilitation
- Established Rehabilitation
- Mine Infrastructure Area
- Tailings Storage Facility
- Sediment Dam
- Water Storage
- Water Transfer Pipeline
- Diversion Structure
- Levee
- Mine Access Road
- Middlemount Rail Spur and Loop

Source: MCPL (2018); Department of Natural Resources and Mines (2017)

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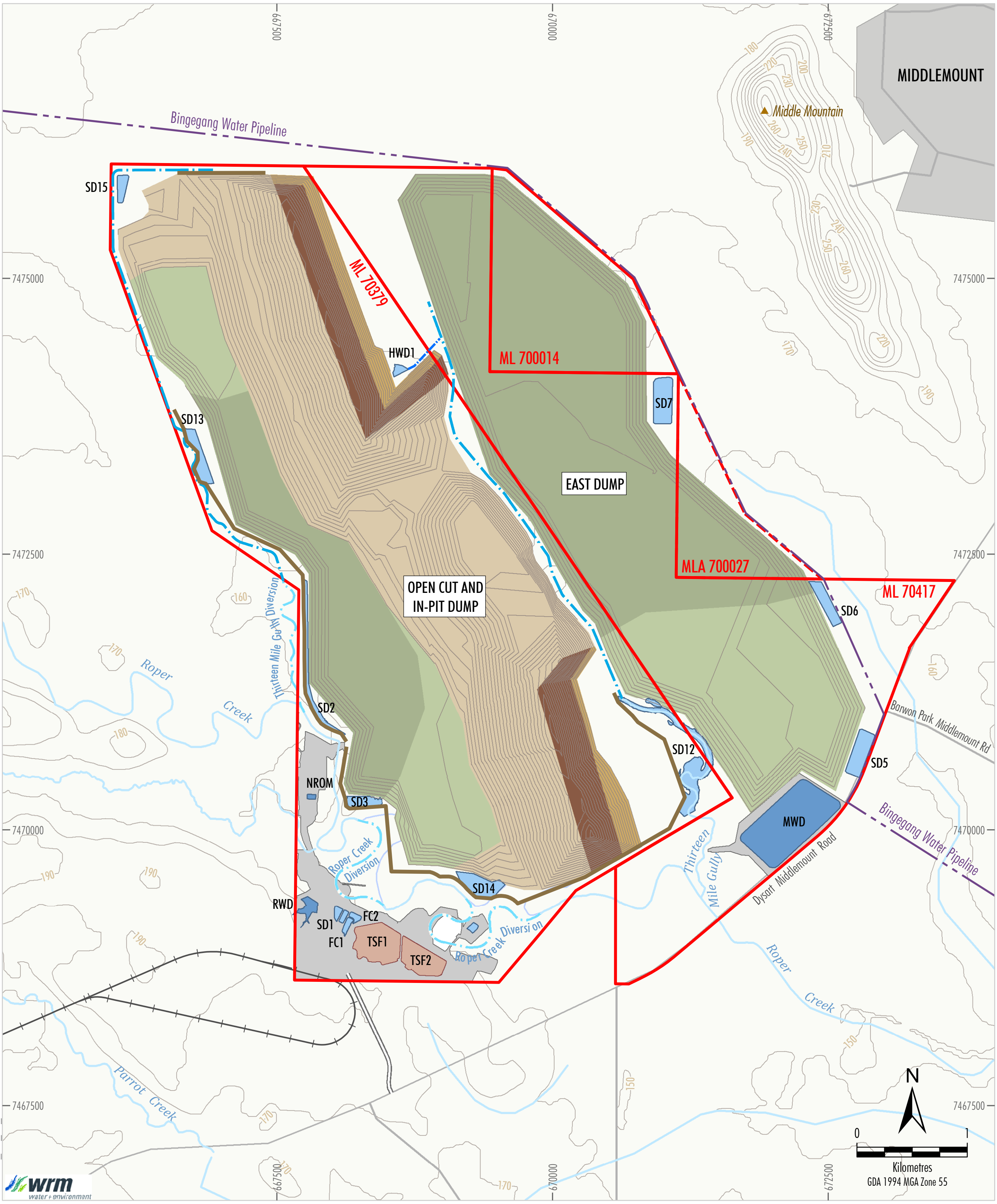
WESTERN EXTENSION PROJECT

Conceptual General Arrangement
Year 11 (2028)

Figure 1.4



LEGEND

- Mining Lease Boundary (ML)
- Mining Lease Application Boundary (MLA)
- Topsoil Stripped
- Active Open Cut Mining Area
- Active Waste Rock Emplacement
- Initial Rehabilitation
- Established Rehabilitation
- Mine Infrastructure Area
- Tailings Storage Facility
- Sediment Dam
- Water Storage
- Water Transfer Pipeline
- Diversion Structure
- Levee
- Mine Access Road
- Middlemount Rail Spur and Loop

Source: MCPL (2018); Department of Natural Resources and Mines (2017)

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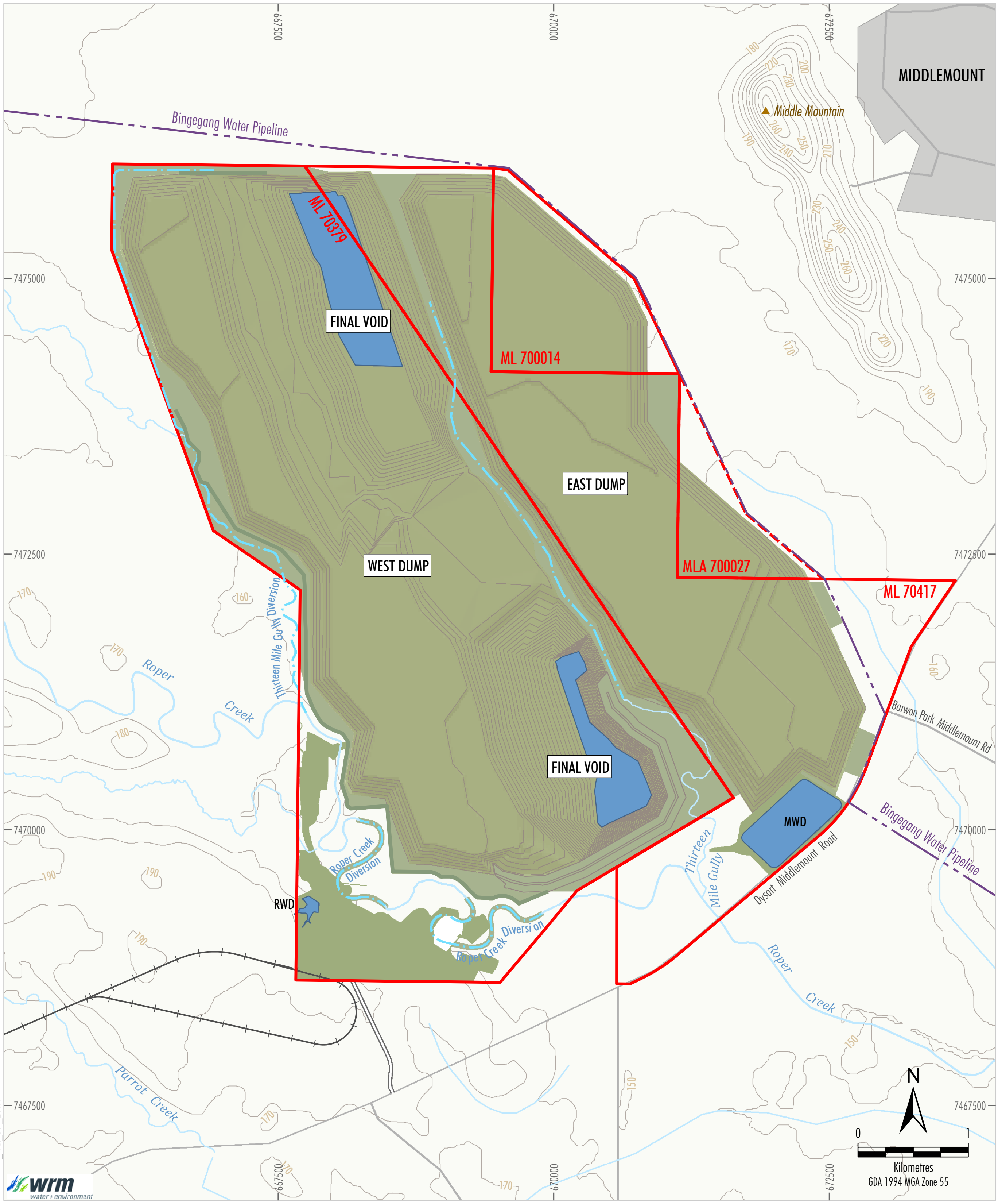
WESTERN EXTENSION PROJECT

Conceptual General Arrangement
Year 15 (2032)

Figure 1.5



LEGEND

- Mining Lease Boundary (ML)
- Mining Lease Application Boundary (MLA)
- Established Rehabilitation
- Water Storage
- Diversion Structure
- Removed Levee (Rehabilitated)
- Mine Access Road (Retained or Rehabilitated)
- Middlemount Rail Spur and Loop (Retained or Rehabilitated)

Source: MCPL (2018); AGE (2018); Department of Natural Resources and Mines (2017)

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WESTERN EXTENSION PROJECT

Conceptual General Arrangement Post-mining

Figure 1.6

2 Catchment hydrology and environmental values

2.1 GENERAL

This section describes the regional drainage characteristics in the vicinity of the Middlemount Coal Mine. The environmental values as defined by the Queensland *Environmental Protection Act 1994* (EP Act), Environmental Protection Policies (EPPs), Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (Australian and New Zealand Environment and Conservation Council [ANZECC] & Agriculture and Resource Management Council of Australia and New Zealand [ARMCANZ], 2000) (ANZECC 2000 Guidelines) and regulations of these waterways are also described.

2.2 CATCHMENT HYDROLOGY

Middlemount Coal Mine tenement areas are drained by:

- Roper Creek;
- Thirteen Mile Gully Diversion which diverts the upstream sub-catchments of Thirteen Mile Gully (north and west of the ML 70379 boundary) to Roper Creek; and
- an unnamed tributary of Roper Creek which intersects the eastern extent of ML 70417, beyond the extent of the East Dump and joins Roper Creek about 4.2 km downstream of Dysart Middlemount Road.

Figure 1.1 shows the wider locality of the Roper Creek catchment and Figure 2.1 shows the drainage characteristics in the vicinity of the Project. Roper Creek is an ephemeral watercourse flowing for short periods following rainfall. The catchment commences about 35 km to the west of the Project area. The creek traverses in an easterly direction across ML 70379 and ML 70417 before turning south-east to cross Dysart-Middlemount Road, and eventually into the Mackenzie River some 40 km to the south-east of the Project. The Mackenzie River is a major tributary of the Fitzroy River.

The total catchment area of Roper Creek to the downstream boundary of the Middlemount Coal Mine tenements, including the Thirteen Mile Gully catchment, is approximately 389 square kilometres (km^2). The catchment area of Thirteen Mile Gully to its confluence with Roper Creek is approximately 55 km^2. ML 70379, ML 70417 and ML700014 cover an area of approximately 33.8 km^2, or 9% of the Roper Creek catchment to the downstream boundary of ML 70417 and 1.3% of the Roper Creek catchment to its confluence with the Mackenzie River. No water resource development, such as dams or major irrigation infrastructure, is located within the Roper Creek catchment.

The Roper Creek catchment upstream of Dysart-Middlemount Road to the west of ML 70379 generally consists of moderately disturbed native forests with some cleared grazing land along the waterway corridor. The catchment downstream of Dysart Middlemount Road has been mostly cleared for grazing. Several operating coal mines also exist in the catchment as shown on Figure 1.1.

Figure 2.1 shows the drainage characteristics of Thirteen Mile Gully in the vicinity of the Project. In its natural state, Thirteen Mile Gully drained the runoff from upstream sub-catchments in a south-easterly direction across ML 70379 and ML 70417 and discharged into Roper Creek within ML 70417 about 350 metres (m) upstream of Dysart Middlemount Road. The upstream sub-catchments of Thirteen Mile Gully were diverted along the western boundary of ML 70379 in late 2014. A licence to divert the flow of water of Thirteen Mile Gully was issued under the Queensland *Water Act 2000* in May 2013.

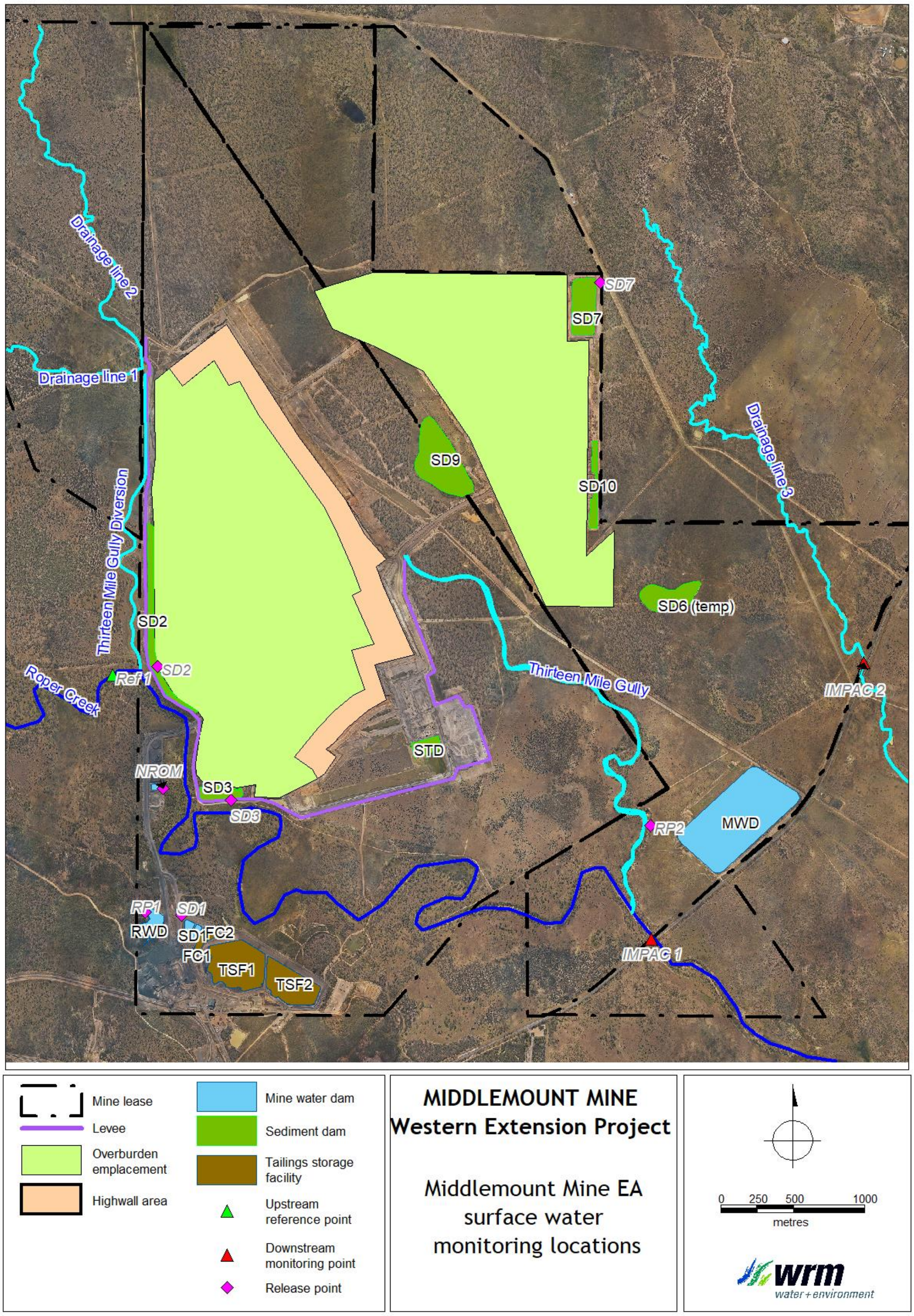


Figure 2.1 – Middlemount Coal Mine existing site characteristics and surface water monitoring locations

Upstream of the diversion, the sub-catchments of Thirteen Mile Gully drain via two drainage features; Drainage Line 1 (to the west) and Drainage Line 2 (to the north).

The Department of Natural Resources and Mines (DNRM) confirmed that these drainage lines are not watercourses, rather they are drainage features defined under the *Water Act 2000* that facilitates overland flow (DNRM, 2017).

2.3 STREAMFLOW

From 1971 to 1988, the Queensland Government operated a streamflow gauge on Roper Creek at Barwon Park (Station No. 130107A), located approximately 28 km downstream of the Project. The total catchment area draining to the Barwon Park streamflow gauge is 2,126 km^2. The maximum recorded flow rate at this station was 922 m^3/s in December 1973.

Table 2.1 shows the annual recorded runoff volume at the Barwon Park streamflow gauge for the period of record, as well as total annual rainfall taken from the SILO rainfall data. The annual volumetric runoff coefficient is low, ranging from 0.3% to 14.6% with an average of 3.7%.

Table 2.1 – Annual rainfall and runoff volumes for Roper Creek at Barwon Park gauging station

Year commencing	Annual rainfall[a] (mm)	Annual runoff volume at Barwon Park gauging station		Volumetric runoff coefficient
		(ML)	(mm)	
Oct 1971	553	12,513	5.9	0.011
Oct 1972	628	3399	1.6	0.003
Oct 1973	976	202,462	95.2	0.098
Oct 1974	840	58,052	27.3	0.033
Oct 1975	989	248,180	116.7	0.118
Oct 1976	584	18,313	8.6	0.015
Oct 1977	834	157,530	74.1	0.089
Oct 1978	584	17,894	8.4	0.014
Oct 1979	524	10,520	4.9	0.009
Oct 1980	641	34,080	16.0	0.025
Oct 1981	567	22,229	10.5	0.018
Oct 1982	805	249,154	117.2	0.146
Oct 1983	527	20,029	9.4	0.018
Oct 1984	510	3,833	1.8	0.004
Oct 1985	697	15,766	7.4	0.011
Oct 1986	519	11,152	5.2	0.010
Oct 1987	683	11,942	5.6	0.008
Mean	**674**	**64,532**	**30.4**	**0.037**

a/ Based on SILO rainfall at Middlemount Coal Mine
mm = millimetres

Figure 2.2 shows a plot of monthly runoff versus rainfall for Roper Creek at the Barwon Park stream gauge. Very little runoff is generated by the catchment for monthly rainfall below about 100 mm. Once monthly rainfall exceeds about 200 mm, the volume of surface runoff increases substantially.

Figure 2.3 shows a ranked plot of daily flows at the Barwon Park gauging station over the period of record and with all zero flows omitted. Stream flows are ephemeral with flows recorded on approximately 34% of all days. Of the days when flows were recorded, the median flow is 10 ML/day and the 20th percentile flow is 200 ML/day.

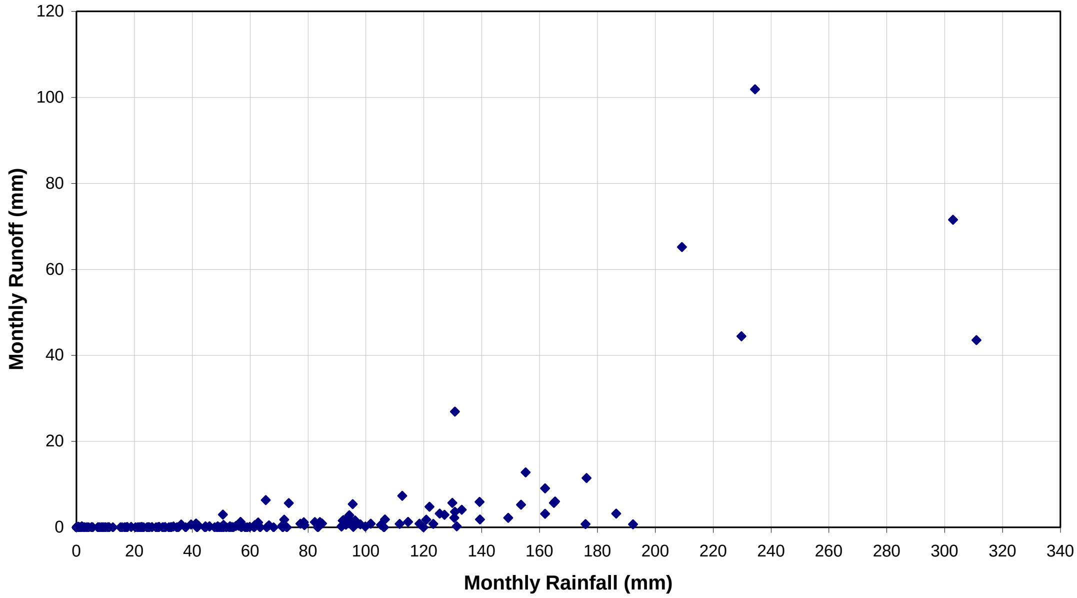


Figure 2.2 – Monthly runoff versus rainfall for Roper Creek at Barwon Park gauging station

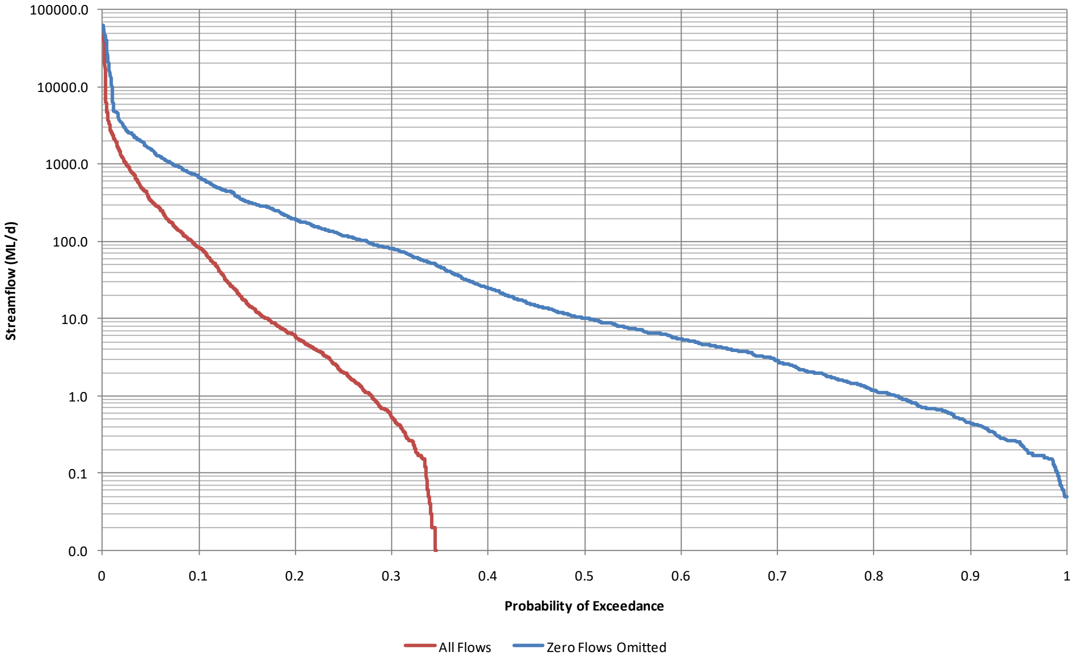


Figure 2.3 – Roper Creek at Barwon Park flow frequency curve, all flows and zero flows omitted

The magnitude of stream flows along Roper Creek near the Project would be much less than that recorded at Barwon Park as the catchment area draining to the Barwon Park streamflow gauge downstream is more than 50% larger. However, the stream flows recorded at Barwon Park provide a good indication of the behaviour of streamflow in Roper Creek following rainfall events.

2.4 GEOLOGY AND GEOCHEMISTRY

Middlemount Coal Mine is located on the northern extension of the Rangal Coal Measures on the western flank of the Bowen Basin, which is a sedimentary basin comprising Triassic and Permian aged geology. Regionally, a veneer of more recent Tertiary geology and Quaternary geology typically overlies the Bowen Basin strata.

The target coal seams at the Middlemount Coal Mine are the Middlemount, Tralee, and Pisces coal seams of the Rangal Coal Measures, a faulted and folded Permian sequence of calcareous sandstone, shale, mudstone, and coal. The main target seams are the Pisces Seam and the overlying Middlemount Seam. The depth of cover for the Pisces Seam ranges from about 30 m near the limit of oxidation (lox) line to 200 m at the eastern boundary of ML 70379. Geochemical assessment (RGS, 2013) of overburden material identified that the majority of coal and mining waste rock materials are classified as Non-Acid Forming, have excess acid buffering capacity, and a high factor of safety with respect to potential for acid generation. A recent study (RGS, 2016) did however conclude that based on the results of a number of the coal reject samples, there is some risk of acid generation over time, if left unmanaged. MCPL currently implements the management practices outlined in the *Mine By-Products Management Plan* and *Mining By-Product In-Pit Disposal Site Practice* for the Middlemount Coal Mine. Therefore, it is expected that the current management measures for coal rejects materials are sufficiently robust to avoid significant potential impacts to surface water and groundwater resources at site.

Water quality monitoring in mine affected water storages shows that runoff and seepage from the coal stockpiles, mining pits and TSF is brackish with moderate sulphate concentrations and pH levels have historically fluctuated from acidic to alkaline. However, all recent samples taken since late 2012 have been generally neutral to moderately alkaline, and not shown any evidence of acid generation.

Surface water runoff from overburden dumps is fresh to brackish with lower sulphate levels than those recorded in mine affected water dams and pH levels are moderately alkaline. Again, there has not been any evidence of acid generation, which supports the above geochemical assessment conclusions.

Salinity levels in the mine water management system may increase over time due to evapo-concentration (e.g. due to the large evaporative surface of the MWD) of on-going salt loads from coal and mining waste rock materials.

2.5 GROUNDWATER

Three hydro-stratigraphic units have been identified by AGE (2018) based on their hydraulic properties and lithology at the Middlemount Coal Mine and surrounds. From youngest to oldest, these units are:

- Quaternary aged units:
    - Alluvial aquifer – consists of localised stream channel deposits and associated flood plain deposits. These units comprise a temporary (rainfall dependent) aquifer that is limited to the immediate vicinity of Roper Creek, Thirteen Mile Gully and drainage lines within the mining leases. Neither Roper Creek or Thirteen Mile Gully are targeted for water supply within the near vicinity of the Middlemount Coal Mine. Two other creeks containing alluvial deposits also occur further afield, Rolf Creek to the north and Oaky Creek to the far south of Middlemount Coal Mine.

- Tertiary aged units:
    - Duaringa Formation – consists of thick clay-rich laterite which is sourced from highly weathered Permian sandstones and siltstones, and occasional basalt. The Duaringa Formation is not typically targeted for agricultural water supply and is (at best) a low yielding aquifer that would more commonly be regarded as an aquitard.
- Permian aged units:
    - Interburden / overburden – the bulk of the Permian coal measure strata is sandstone, siltstone, and mudstone that typically have low permeability and generally form aquitards.
    - Coal seams (principally the Middlemount and Pisces Seams) – form low to moderate yielding aquifers confined by interburden / overburden units.

Quaternary Alluvium

The Quaternary alluvium is not targeted by landholders as a groundwater supply within the study area. This outcome supports the general understanding that the Quaternary alluvium is not a productive aquifer within the study area.

Similarly, no monitoring bores have been installed within the Quaternary alluvium.

Tertiary Aquifers

MCPL has implemented an extensive groundwater monitoring bore network, located both within and outside of the Middlemount Coal Mine tenements. A number of groundwater monitoring bores focus on the Tertiary aquifers (MW2, MW3, MW6, MW9A, MW10A, MW11A, MW12A, MW13A, MW14A and MW15A). Depth to water in the monitoring bores ranges from 7.7 metres below ground level (mbgl) (MW15A) to 25.3 mbgl (MW9A), with an average depth of 17.5 mbgl.

Groundwater quality in the Tertiary aquifers is generally poor and either unsuitable or marginal for beneficial uses. This is supported by no records (within approximately 10 km of the Middlemount Coal Mine) in the DNRM registered bore database of any bores screened within the Tertiary aquifer. The average EC is greater than 20,000 microSiemens per centimetre (µS/cm) and contains elevated chloride, sodium and total dissolved solids (TDS).

Permian Aquifers

The groundwater monitoring bore network also includes monitoring of the Permian aquifers (MW1P[1], MW4, MW5, MW5M/P, MW7M/P, MW8FR and MW9M/P).

The average depth to groundwater in the Permian aquifer is greater than 30 mbgl.

Similar to the tertiary aquifers, groundwater quality is generally poor and either unsuitable or marginal for beneficial uses. The average EC is greater than 20,000 µS/cm and contains elevated chloride, sodium and TDS.

2.6 WATER QUALITY

The background water and sediment quality data for Roper Creek and the downstream catchment is described in the *Middlemount Coal Mine Receiving Environment Monitoring Plan* (REMP) (GHD, 2016). Water quality in Roper Creek is characterised by high and variable turbidity, moderate and variable EC and low dissolved oxygen concentrations at times. Nutrient levels are generally low with the exception of total nitrogen which exceeded the trigger value at most sites.

[1] Excavated within the advancing open cut.

The concentrations of most metals were very low within Roper Creek and did not exceed the EA trigger values, with the exception of aluminium. The results however demonstrated the natural variability in metals and nutrients in Roper Creek.

GHD (2016) found that the macroinvertebrate community of Roper Creek exhibited signs of stress. Given the ephemeral nature of waterways in central Queensland and the low rainfall in the region in the preceding years (i.e. 2014-15), this was to be expected. Given the lack of discharges from the Middlemount Coal Mine, there had been no indication of impacts from Middlemount Coal Mine operations on the macroinvertebrate community of Roper Creek.

Given the ephemeral nature of the upstream sub-catchments of Thirteen Mile Gully, no water quality data is available for Drainage Line 1 and Drainage Line 2.

Time series graphs of the historical water quality sampling data at the upstream and downstream surface water monitoring sites are provided in Appendix A.

2.7 EXISTING WATER USE ENTITLEMENTS

Advice from the Queensland Government indicates that there are no licensed surface water users along Roper Creek. That is, there are no users with an extraction volume issued under the provisions of the *Water Act 2000*.

There are two registered Self-Assessed Riparian Access Works located on Roper Creek which authorise stock and domestic supplies only. Section 20 of the *Water Act 2000* provides that an owner of land adjoining a watercourse may take water for domestic and stock purposes without the need for a permit or licence.

A permit to take water from Roper Creek, Connors River, Murray Creek, Lotus Creek, Clive Creek and an unnamed tributary of Isaac River (Eungy Waterhole) has been issued under the provisions of the *Water Act 2000*. Such permits are typically granted to a corporate entity, such as local government, for temporary supply of water to construction or similar projects. A total entitlement of 8.5 ML per water year is attached to this permit. The above information indicates that there is currently minimal use of surface water from Roper Creek.

2.8 ENVIRONMENTAL VALUES

The *Environmental Protection (Water) Policy 2009* (EPP (Water)), which is subordinate legislation to the EP Act, provides a framework for identifying environmental values for a waterway and determine WQOs to protect or enhance those. Environmental values (EVs) for water are the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses. These environmental values are to be protected from the effects of habitat alteration, waste releases, contaminated runoff and changed flow to ensure healthy aquatic ecosystems and waterways that are safe for community use.

Roper Creek is located within the Mackenzie River north-western tributaries region and is classified as a 'fresh' water source (Department of Environment and Heritage Protection [DEHP], 2011). The environmental values selected for protection include: aquatic ecosystem protection (Level 2 – disturbed ecosystems, Queensland Water Quality Guidelines (DEHP, 2009));

- stock watering;
- human consumption;
- primary, secondary and visual recreation;
- drinking water;
- industrial use; and
- cultural and spiritual values.

In summary, the key environmental values for water that are to be protected are:

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

3 Site characteristics

3.1 OVERVIEW

This section describes the activities at the existing and proposed Middlemount Coal Mine that could potentially generate contaminants that may impact on the environmental values of the receiving waters, if not managed. The source of the contaminants has been identified and evaluated based on water quality data that has been collected on site since 2010. The proposed changes to the water management system due to the Project are also provided.

3.2 EXISTING SITE OPERATING ACTIVITIES

The major components of the existing Middlemount Coal Mine are shown in Figure 2.1 and include:

- an open cut mining pit;
- out-of-pit spoil dumps (south, north and east);
- access and haul roads;
- mine infrastructure areas including:
  - office buildings and workshops;
  - ROM coal stockpiles; and
  - a CHPP including crushing facility, a product coal stockpile pad, a rail loop and rail loading facilities;
- TSF and In-line Flocculation Cells;
- sewerage treatment;
- flood protection levees;
- stream diversion; and
- mine water management structures.

3.3 SURFACE WATER TYPES

The surface water generated on the mine site has been categorised into types, based on water quality:

- 'Tailings return water' – water that has been used to wash coal in the CHPP. Tailings water potentially has a lower pH and higher concentrations of TDS and metals than 'Mine affected' water.
- 'Mine affected water' – surface water that has generally come in contact with coal such as in the pit, or from the ROM coal stockpile. This water may contain high TDS and metals above relevant guideline trigger values defined by ANZECC & ARMCANZ (2000).
- 'On-site stormwater' – surface runoff water from areas that are disturbed by mining operations (including out-of-pit overburden dumps and haul roads). This runoff may contain high sediment loads but is generally of neutral pH and does not contain high salt concentrations or metals.
- 'Catchment runoff water' – surface runoff from catchment areas where water quality is unaffected by mining operations. Catchment runoff water includes runoff from undisturbed areas and any fully rehabilitated areas.

- 'Contaminated water' – surface water from areas potentially containing chemicals of various types used in the mining operations (e.g. hydrocarbons). Contaminated water areas include sumps, service bays and fuel storage areas. Rainfall and resulting runoff from these areas is also potentially contaminated.
- 'External water' – External water is water sourced external to the mining operation.

3.4 SITE WATER QUALITY

Water quality data has been collected from the on-site water storages since May 2010. The parameters tested have been defined by the Queensland Government to cover the range of constituents that could impact on the environmental values of the receiving waters.

Table 3.1 shows the time periods that water quality samples have been collected in each of the water storages at Middlemount Coal Mine. The locations of the dams are shown in Figure 2.1. Table 3.2 and Table 3.3 shows the water quality of the tailings and mine affected dams.

Table 3.4 shows the water quality of sediment dams that have historically been mine water affected as they have been used for the transfer and storage of mine water.

Table 3.5 shows the water quality in the sediment dams that have not been affected by mine water. Sediment dams that are not mine affected collect runoff from the East Dump, as well as SD2. A description of the water quality draining the various areas on the mine site is given in the following section.

According to Table C3 of the Middlemount Coal Mine EA, trigger values for metals and metalloids only apply when the dissolved concentrations exceed the trigger values. The majority of the water quality sampling for metals has been reported as total concentrations, and regular reporting of dissolved concentrations has only occurred since 2015.

Time series graphs of the historical water quality sampling data is provided in Appendix A.

Table 3.1 – Water quality sampling periods

Water storage	ID	Start date	End date (latest sample)
Raw Water Dam	RWD	May 2010	October 2016
Tailings Storage Facility 1	TSF1	October 2010	October 2016
Tailings Storage Facility 2	TSF2	January 2011	January 2016
Mine Water Dam	MWD	January 2015	October 2016
North ROM Dam	NROM	January 2015	October 2016
Mining Pit		July 2015	April 2016*1
Sediment Dam 1	SD1	October 2010	October 2016
Sediment Dam 2	SD2	November 2010	October 2016
Sediment Dam 3	SD3	May 2010	October 2016
Sediment Dam 7	SD7	April 2015	April 2016
Sediment Dam 9	SD9	April 2013	January 2015
Sediment Dam 10	SD10	January 2014	October 2016

*1 Water quality from South Transfer Dam (STD) is assumed to represent mining pit water quality

Table 3.2 – Water quality summary, mine affected water dams (1 of 2)

Parameter	Units	Middlemount EA conditions		RWD				TSF 1				TSF 2			
		End of pipe limit/release contaminant trigger level	Receiving water trigger	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile
pH	-	6.5 - 9.0	6.5 - 8.5	36	6.4	8.3	8.8	28	3.8	7.9	8.9	24	7.6	7.9	8.6
EC	µs/cm	700 - 6,000	700	36	1,595	4,305	9,610	28	1,045	5,160	10,860	24	1,669	3,725	7,769
Suspended solids	mg/L	562 - 1,062	562 - 1,062	11	5	6	12	8	6	11	39	7	7	14	440
Sulphate ($SO4^{2-}$) (dissolved)	mg/L	250 - 500	250	16	254	288	379	15	203	538	822	11	235	287	457
Fluoride	mg/L	2	-	29	0.4	0.8	1.0	24	0.3	0.8	1.2	20	0.6	0.8	1.0
Aluminium (dissolved)	mg/L	0.055	-	5	0.010	0.010	0.010	4	0.010	0.015	0.034	4	0.010	0.010	0.010
Arsenic (dissolved)	mg/L	0.013	-	5	0.001	0.001	0.002	4	0.001	0.002	0.003	4	0.001	0.001	0.001
Cadmium (dissolved)	mg/L	0.0002	-	4	0.0001	0.0001	0.0001	3	0.0001	0.0001	0.0001	3	0.0001	0.0001	0.0001
Cobalt (dissolved)	mg/L	0.090	-	4	0.001	0.001	0.001	3	0.002	0.002	0.036	3	0.001	0.001	0.003
Copper (dissolved)	mg/L	0.002	-	4	0.001	0.002	0.003	3	0.001	0.002	0.003	3	0.001	0.001	0.001
Lead (dissolved)	mg/L	0.004	-	4	0.001	0.001	0.001	3	0.001	0.001	0.001	3	0.001	0.001	0.001
Nickel (dissolved)	mg/L	0.011	-	4	0.008	0.012	0.018	3	0.012	0.013	0.051	3	0.004	0.007	0.014
Zinc (dissolved)	mg/L	0.008	-	4	0.005	0.016	0.029	3	0.005	0.005	0.011	3	0.005	0.005	0.005

Table 3.3 – Water quality summary, mine affected water dams (2 of 2)

Parameter	Units	Middlemount EA conditions		MWD				NROM				Mining Pit			
		End of pipe limit/release contaminant trigger level	Receiving water trigger	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile
pH	-	6.5 - 9.0	6.5 - 8.5	8	8.4	9.1	9.7	6	7.6	9.0	9.4	2	8.7	9.0	9.3
EC	µs/cm	700 - 6,000	700	6	5,755	8,575	10,150	6	837	1,376	2,144	2	7,087	8,955	10,823
Suspended solids	mg/L	562 - 1,062	562 - 1,062	6	7	11	60	4	11	28	30	-	-	-	-
Sulphate ($SO4^{2-}$) (dissolved)	mg/L	250 - 500	250	-	-	-	-	-	-	-	-	1	1240	1240	1240
Fluoride	mg/L	2	-	6	0.9	1.05	1.2	1	1.8	2.3	3.0	-	-	-	-
Aluminium (dissolved)	mg/L	0.055	-	2	0.010	0.010	0.010	1	-	0.020	-	1	-	0.010	-
Arsenic (dissolved)	mg/L	0.013	-	2	0.002	0.002	0.002	1	-	0.001	-	1	-	0.001	-
Cadmium (dissolved)	mg/L	0.0002	-	2	0.0001	0.0001	0.0001	1	-	0.0001	-	-	-	-	-
Cobalt (dissolved)	mg/L	0.090	-	2	0.001	0.001	0.001	1	-	0.001	-	-	-	-	-
Copper (dissolved)	mg/L	0.002	-	2	0.001	0.002	0.002	1	-	0.001	-	-	-	-	-
Lead (dissolved)	mg/L	0.004	-	2	0.001	0.001	0.001	1	-	0.001	-	-	-	-	-
Nickel (dissolved)	mg/L	0.011	-	2	0.008	0.010	0.011	1	-	0.001	-	-	-	-	-
Zinc (dissolved)	mg/L	0.008	-	2	0.005	0.005	0.005	1	-	0.009	-	-	-	-	-

Table 3.4 – Water quality summary, mine affected sediment dams

Parameter	Units	Middlemount EA conditions		SD1				SD3			
		End of pipe limit/release contaminant trigger level	Receiving water trigger	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile
pH	-	6.5 - 9.0	6.5 - 8.5	32	4.8	8.3	9.1	31	8.0	8.7	9.7
Electrical conductivity	µs/cm	700 - 6,000	700	32	418	2,815	10,756	30	692	4,680	7,646
Suspended solids	mg/L	562 - 1,062	562 - 1,062	10	7	19	66	9	10	28	144
Sulphate (SO4^{2-}) (dissolved)	mg/L	250 - 500	250	14	120	302	471	11	26	250	643
Fluoride	mg/L	2	-	25	0.3	0.6	1.2	22	0.7	0.9	1.4
Aluminium (dissolved)	mg/L	0.055	-	4	0.010	0.010	0.010	4	0.016	0.040	0.274
Arsenic (dissolved)	mg/L	0.013	-	4	0.001	0.001	0.0017	4	0.001	0.002	0.003
Cadmium (dissolved)	mg/L	0.0002	-	3	0.0001	0.0001	0.0001	3	0.0001	0.0001	0.0001
Cobalt (dissolved)	mg/L	0.090	-	3	0.001	0.001	0.001	3	0.001	0.001	0.001
Copper (dissolved)	mg/L	0.002	-	3	0.001	0.001	0.002	3	0.001	0.002	0.002
Lead (dissolved)	mg/L	0.004	-	3	0.001	0.001	0.001	3	0.001	0.001	0.001
Nickel (dissolved)	mg/L	0.011	-	3	0.004	0.006	0.006	3	0.001	0.001	0.001
Zinc (dissolved)	mg/L	0.008	-	3	0.005	0.005	0.006	3	0.005	0.005	0.006

Table 3.5 – Water quality summary, on-site stormwater sediment dams

Parameter	Units	Middlemount EA conditions		SD2				SD7				SD9				SD10			
		End of pipe limit/release contaminant trigger level	Receiving water trigger	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile	No. of samples	10th %ile	Median	90th %ile
pH	-	6.5 - 9.0	6.5 - 8.5	38	3.8	8.1	9.4	6	9.1	9.7	9.9	8	8.1	8.4	9.1	9	8.4	9.0	10.0
Electrical conductivity	µs/cm	700 - 6,000	700	24	708.9	1,335	2,156	6	583	986	4,865	4	228	325	451	10	365	537	1,648
Suspended solids	mg/L	562 - 1,062	562 - 1,062	9	7	21	41	5	15	19	56	1	-	44	-	3	42	62	90
Sulphate (SO4^{2-}) (dissolved)	mg/L	250 - 500	250	13	100	158	320	-	-	-	-	-	-	-	-	-	-	-	-
Fluoride	mg/L	2	-	23	0.2	0.8	1.6	5	1.0	1.5	2.8	3	0.2	0.3	0.4	4	0.7	1.1	1.8
Aluminium (dissolved)	mg/L	0.055	-	4	0.010	0.010	0.010	2	0.012	0.020	0.028	2	1.56	3.08	4.60	-	-	-	-
Arsenic (dissolved)	mg/L	0.013	-	4	0.001	0.001	0.002	2	0.001	0.002	0.003	2	0.001	0.001	0.001	-	-	-	-
Cadmium (dissolved)	mg/L	0.0002	-	3	0.0001	0.0001	0.0001	2	0.0001	0.0001	0.0001	1	-	0.0001	-	-	-	-	-
Cobalt (dissolved)	mg/L	0.090	-	3	0.001	0.001	0.001	2	0.001	0.001	0.001	1	-	0.005	-	-	-	-	-
Copper (dissolved)	mg/L	0.002	-	3	0.001	0.001	0.002	2	0.001	0.002	0.003	1	-	0.005	-	-	-	-	-
Lead (dissolved)	mg/L	0.004	-	3	0.001	0.001	0.001	2	0.001	0.001	0.001	1	-	0.005	-	-	-	-	-
Nickel (dissolved)	mg/L	0.011	-	3	0.001	0.001	0.001	2	0.001	0.001	0.001	1	-	0.004	-	-	-	-	-
Zinc (dissolved)	mg/L	0.008	-	3	0.005	0.005	0.006	2	0.005	0.006	0.007	1	-	0.013	-	-	-	-	-

3.4.1 Tailings return water

Tailings (i.e. fine rejects) from the CHPP comprise mostly of fine silt, clay, water and coal material. Water quality monitoring of the TSF cells (TSF1 and TSF2) since October 2010 (see Table 3.2) indicates that the stored water exceeds the EPP Water WQOs and has the following characteristics:

- Brackish with a median EC of 4,145 µS/cm and 10% exceeding 10,510 µS/cm;
- Moderate sulphate with a median of 400 mg/l and 10% exceeding 790 mg/l;
- Generally slightly alkaline, with a median pH of 7.9, 10% exceeding 8.8 and 10% less than 5.2; and
- Metals (dissolved) less than the default trigger values with the exception of copper, nickel and zinc.

The tailings return water management system will remain unchanged for the Project.

3.4.2 Mine affected water

Mine affected water includes runoff collected within the open cut pit (includes groundwater), which is pumped to the MWD and runoff from the ROM and product coal stockpiles, which drains to SD1, NROM and the RWD. It also includes external water pumped in from German Creek Mine. Water quality monitoring of all mine affected water storages exceeds the EPP Water WQOs for pH, salinity, sulphate, aluminium and zinc.

For surface runoff draining coal stockpile areas only including SD1 and the NROM, the data in Table 3.2 and Table 3.3 indicates that the stored water has the following characteristics:

- Brackish with a median EC of 1,995 µS/cm and 10% exceeding 9,725 µS/cm;
- Moderate sulphate with a median of 300 mg/l and 10% exceeding 470 mg/l;
- Generally slightly alkaline, with a median of 8.3, 10% exceeding 9.2 and 10% less than 5.1; and
- Metals (total) generally below the default trigger values with the exception of zinc.

Mine affected water has historically been pumped to SD3. SD3 also temporarily received desludged pit material after the January 2013 storm event. It is no longer used for mine affected water and the recent water quality samples indicate that the residual salts and contaminants are largely removed.

The mine affected water management system will remain generally unchanged (i.e. continued collection of water, including groundwater, in the open cut pit as it advances) for the Project with augmentations as necessary. Further details are provided in Section 4.

3.4.3 On-site stormwater

On-site stormwater includes runoff from the overburden dumps and haul roads. On-site stormwater is managed under the site's Erosion and Sediment Control Plan (ESCP) (WRM, 2016a). Water quality monitoring of sediment dams (that have not been historically affected by mine water (SD2, SD7, SD9 and SD10)) since April 2013 indicates that the collected runoff has the following characteristics:

- Fresh to brackish with a median EC of 855 µS/cm and 10% exceeding 2,455 µS/cm;
- Moderate sulphate with a median of 158 mg/l and 10% exceeding 320 mg/l;
- Moderate suspended solids with a median of 32 mg/l and 10% exceeding 76 mg/l; and
- Moderately alkaline, with a median pH of 8.9, 10% exceeding 9.8 and 10% less than 7.9.

Review of Table 3.4 shows that the metals (dissolved) are generally below the release contaminant trigger levels, with the exception of:

- One copper reading in SD7; and
- Arsenic, copper, lead and zinc readings in SD9.

A further review of the sediment dam data showed that salinity values vary between seasons with elevated levels recorded during the dry season when dam levels are low and evapo-concentration has occurred. Salinity concentrations are generally lower during the wet season when surface runoff is highest.

The recorded total suspended solids concentrations are also lower than what would be otherwise expected for surface runoff from overburden waste rock material. Almost all suspended solid concentration readings were taken during the dry season, which suggest that the total suspended solids data represents water quality after long periods of settlement. It is therefore possible that the suspended solids concentrations of surface runoff to the sediment basins could be greater than recorded values to date.

Water quality monitoring of three release events from sediment dams has occurred in the months:

- January 2013 – SD1;
- January 2013 – SD3; and
- February 2014 – SD2.

Investigations into all three release events were completed to ensure compliance with the EA conditions. The release events complied with the EA conditions with the exception of the February 2014 release from SD2 which showed elevated zinc and copper concentrations. The investigation found that copper and zinc concentrations were also elevated at the upstream reference site and could be attributed to naturally higher background levels from the upstream catchment area of Roper Creek (MCPL, 2013b).

The monitoring results show that although total aluminium exceeded the trigger value in all three release events, the dissolved aluminium concentration was significantly lower than both the trigger value and the reference sites in Roper Creek. The highest dissolved aluminium concentration recorded in the three events was 0.02 mg/L.

Suspended solids concentrations were also low across all three release events with the highest concentration of 23 mg/L recorded at SD3 during the January 2013 event.

The additional disturbance footprint associated with the Project (575 hectares [ha]) will increase the volume of stormwater requiring to be contained and managed on the mine site. Notwithstanding the on-site stormwater management system will remain generally unchanged (i.e. continued collection of runoff from the overburden dumps) for the Project with augmentations as necessary. Further details, including additional sediment dams, are provided in Section 4.7.2.

3.4.4 External water

MCPL have an arrangement with Anglo American plc to supply water from the German Creek Mine for use on the mine site. Water is pumped from German Creek Mine on an 'as needed' basis and placed in the RWD, Southern Transfer Dam and MWD, up to a limit of 250 ML per month and 1,800 ML per year. Water is supplied in accordance with the Water Supply Agreement between MCPL and Anglo Coal (Capcoal Management) Pty Ltd dated 22nd December 2010.

Water captured on-site is however used in preference to the German Creek Mine water supply.

Water quality monitoring of the external water supply from German Creek Mine indicates that the water exceeds the EPP Water WQOs and has the following characteristics:

- Brackish with a median EC of 5,770 µS/cm and 10% exceeding 6,990 µS/cm;
- Moderate to high sulphate with a median of 735 mg/l and 10% exceeding 1,217 mg/l;
- Moderately alkaline with pH ranging from 8.3 to 8.8; and
- Metals (total) generally below the default trigger values with the exception of nickel and zinc.

Potable water is currently supplied via truck from Middlemount to the Middlemount Coal Mine.

External water will continue to be pumped to site on an 'as needed' basis for the Project.

4 Existing surface water management system

4.1 OVERVIEW

Middlemount Coal Mine is operated under the MCPL Environmental Management System. The documents related to the mine water management system include:

- Middlemount Coal Mine Environmental Management Plan (MCPL, 2017);
- Water Management Plan (WRM, 2016b);
- Water Management Site Practice (MCPL, 2014a);
- Site Water Balance (WRM, 2014);
- Regulated Structures Operational Management Plan (MCPL, 2014b);
- Receiving Environment Monitoring Design Plan (GHD, 2016);
- Erosion and Sediment Control Plan (WRM, 2016a); and
- Severe Weather Site Practice (MCPL, 2013a).

The location of the existing mine water management infrastructure is shown Figure 2.1, and is shown schematically in Figure 4.1. Descriptions of the tailings return water management system, mine affected water, on-site stormwater, contaminated and catchment runoff water management systems for the Project are provided below. The mine water management system framework will generally not change as a result of the Project. However, a number of additional sediment dams are proposed as part of the Project.

4.2 SURFACE WATER MANAGEMENT OBJECTIVES

The objective of the mine water management system is to manage all types of water on site to meet operational, social and environmental objectives encapsulated by the sites EA (EPML00716913).

There are two key water management system objectives:

- have a strategy that ensures Middlemount Coal Mine minimises mine affected water spills and has sufficient water available for operation in dry times; and
- to be a good custodian of society's water resources.

Specific objectives for each water type are as follows:

- External water: Ensure that external water allocation and associated infrastructure is sufficient to meet site demands under low rainfall conditions.
- Mine affected water: Minimise uncontrolled discharges in wet periods and to ensure adequate water supplies are maintained for site demand during dry periods.
- Groundwater: Understand, manage and minimise the potential impact of the water management system on the regional groundwater system.
- On-site stormwater: Maintain water quality leaving the Erosion and Sediment Control (ESC) structures to a quality as close to background levels as reasonably possible.
- Catchment runoff water: Ensure that it is separated from the mine affected and on-site stormwater systems and allowed to pass uninterrupted down the catchment.

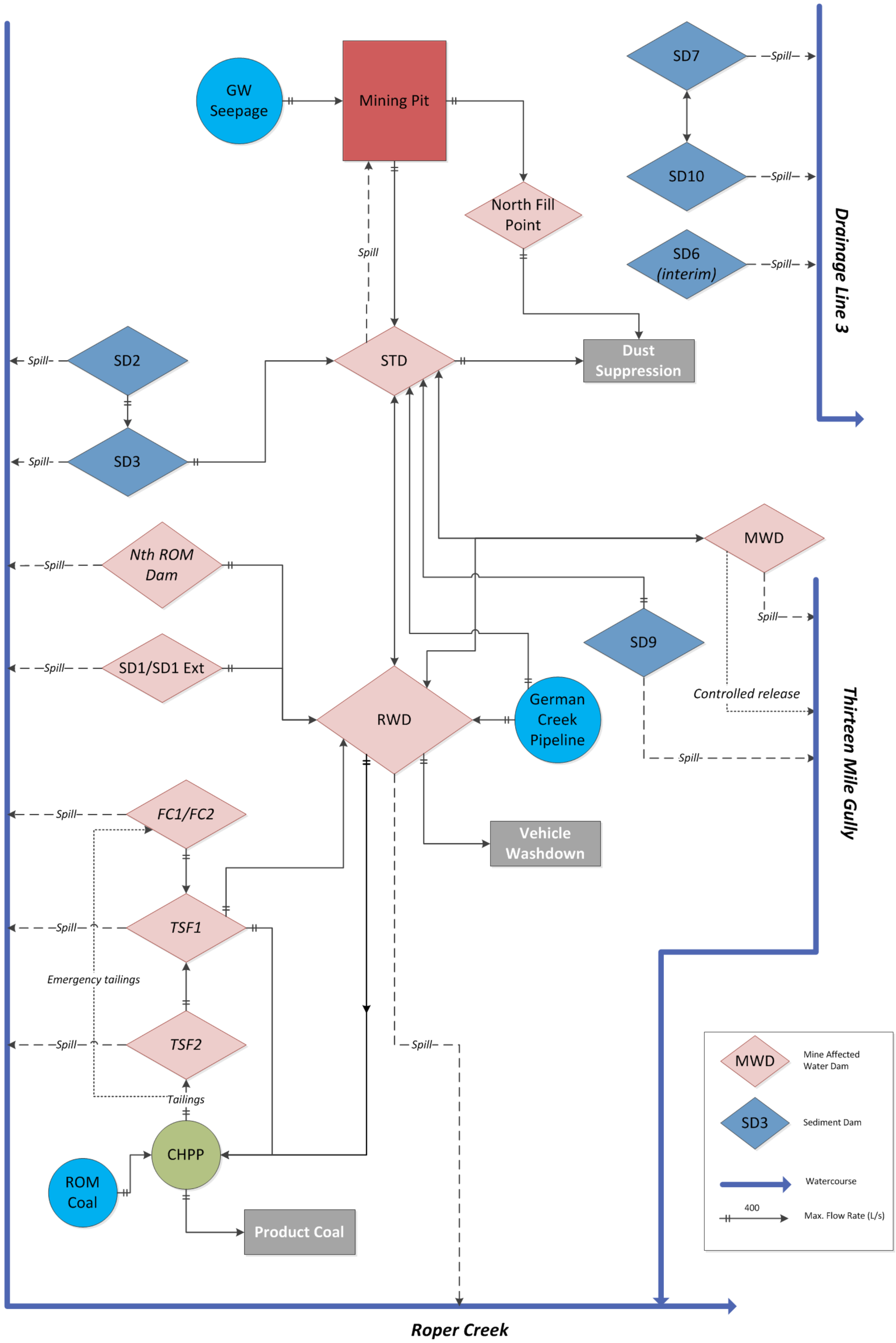


Figure 4.1 – Existing water management system schematic

4.3 SURFACE WATER MANAGEMENT PRINCIPLES

The general principles to manage surface water for the site are as follows:

- The separation of catchment runoff, on-site stormwater, mine affected water, tailings return water and contaminated water.
- Minimise the area of surface disturbance, thus minimising the volume of on-site stormwater capture or contaminated water runoff.
- Collect and contain on site all potential mine affected water pumped from the open cut pits in dedicated mine water storages. The mine water storages will be used as the primary water source for the CHPP and for dust suppression.
- Retain and reuse on site any on-site stormwater runoff that has high sediment concentrations whenever possible. If not, release it in a controlled manner (i.e. following settlement) in compliance with the ESCP.
- Minimise the potential for generation of contaminated water by installing a roof over the bunded areas. Where this is not possible, use oil and water separators or collect and contain the potentially contaminated water within the bunds and pump it to the mine affected water storages.
- Maximise the use of on-site water and thus minimise the need for importing external water.
- Prioritise the use of poorer quality water over better quality water.
- Complete flood mitigation works to provide a minimum of 0.1% AEP immunity from Thirteen Mile Gully and Roper Creek floods.

4.4 TAILINGS AND REJECTS CIRCUIT

The TSFs at the Middlemount Coal Mine comprise a series of 4 in-line flocculation cells (ILF cells) (within TSF2), emergency ILF cells (at FC1/FC2) and the inactive TSF (TSF1). All tailings facilities are constructed with earth embankments on all sides and do not receive runoff from external catchments. The tailings circuit is managed as follows:

- Fine rejects are pumped to the ILF cells at TSF2 (or emergency cells FC1/FC2).
- Flocculant is added prior to removal of water from the TSFs.
- Decant water is pumped to TSF1 then returned to the CHPP and RWD for reuse.
- Fine tailings are dried and reclaimed for in-pit disposal.

The inactive TSF (TSF1) is only used for the temporary storage of decant water. FC1 and FC2 have not been utilised for tailings since the construction of the ILF cells within TSF2.

Coarse rejects are managed separately to the fine rejects and disposed of within overburden emplacements.

Refer to Figure 2.1 and Figure 4.1 for the locality and configuration of the tailings circuit.

4.5 MINE AFFECTED WATER MANAGEMENT

Mine affected water is managed as follows:

- There are two main mine water management dams: RWD; and MWD. Mine water in excess of the Raw Water Dam capacity is stored in the MWD.
- Transfer dams located in the vicinity of the mining pit are used as staging dams to transfer mine water to the RWD or MWD and as a source of water for dust suppression. The transfer dams are of turkey’s nest or sump type construction with no external catchment area.

- Water captured in the mining pit may also be pumped directly to the RWD or the MWD (via the transfer dams).
- Runoff from a section of the haul road immediately north of the CHPP and portions of the ROM and coal stockpile area drains to SD1. SD1 is dewatered to the RWD for reuse in the CHPP. Any overflow from SD1 drains to the SD1 extension dam.
- A dedicated pump is permanently situated at SD1 to minimise the chance of uncontrolled releases during rain events.
- Runoff from the northern ROM and hardstand area is captured in the NROM and transferred to the RWD for reuse in the CHPP.
- Controlled releases can be made from the MWD, Sediment Dams 1, 2, 3, 7, the RWD, and the NROM.

4.5.1 Mine affected water management storages

Figure 2.1 shows the location of the mine water management storages. A summary of the mine affected water storages, their capacities and surface areas are provided in Table 4.1.

Table 4.1 – Existing mine affected water management storages

Dam Name	Storage volume at FSL (ML)	Surface area at FSL (ha)	Maximum water depth (m)	Catchment area (ha)	Releases to
RWD	191	2.7	13.0	25.5	Roper Creek
MWD	1,928	28.6	8.1	30.0	Thirteen Mile Gully
SD1	46	0.7	2.9	16.2	Roper Creek
STD	26	2.0	3.0	36.1	Mining Pit
NROM	4	0.2	3.0	5.5	Roper Creek
Mining Pit	24,500	104.5	68.0	463.5	-
TSF 1	187^	14.3	12.8	15.5	Roper Creek*
TSF 2 (4 ILF cells)	535^	9.1	8.9	9.7	Roper Creek*
FC1/FC2	52	1.4	7.1	3.1	Roper Creek*

^Excludes volume of tailings placed within storage.
* No releases are expected to occur from either of the TSFs or FC1/FC2.

4.5.2 Environmental Authority (EA) – release conditions

The current MCM EA (EPML00716913) took effect on 21 May 2018. The EA conditions require that mine affected water may only be released from designated release points when water quality is within defined end-of-pipe limits. A description of these compliance conditions is given below.

Table 4.2 lists all the mine affected water release points and associated receiving water for the current water management system (Table C1 in the MCM EA). The locations of the release points are shown in Figure 2.1.

Table 4.3 shows the mine affected water release limits given in the MCM EA. Condition C4 requires that water is only released when the water quality is within these limits.

Condition C9 of the EA requires that the release of mine affected waters must only take place during periods of natural flow at a flow gauging station at Ref 1 as specified in Table 4.4. Further, Condition C10 requires that the release of mine affected water must not exceed the EC and sulphate release limits specified in Table 4.4.

Table 4.2 - Mine affected water release points (EA Table C1)

Release point	Easting	Northing	Mine affected water source and location	Monitoring point	Receiving waters
RP 1	667,725	7,469,370	RWD	Spillway/pipe	Roper Creek
RP 2	671,743	7,469,842	MWD	Spillway/pipe	Roper Creek
SD 1	668,008	7,469,218	SD1	Spillway/pipe	Roper Creek
SD 2	668,093	7,470,858	SD2	Spillway/pipe	Roper Creek
SD 3	668,457	7,470,213	SD3	Spillway/pipe	Roper Creek
SD 7	671,125	7,474,067	SD7	Spillway/pipe	Roper Creek
NROM	667,858	7,470,294	NROM	Spillway/pipe	Roper Creek

Table 4.3 - Mine affected water release limits (EA Table C2)

Quality characteristic	Units	Minimum	Maximum
EC	µs/cm	See Table 4.4	
pH	pH units	6.5	9.0
Turbidity	NTU	N/A	No limit
Suspended solids	mg/L	N/A	Flow < $2m^3/s$ - 562 mg/L Flow > $2m^3/s$ - 1,062 mg/L
Sulphate	mg/L	See Table 4.4	

Table 4.4 - Mine affected water release during flow events (EA Table C4)

Gauging station	Recording frequency	Flow criteria for release	Maximum release rate (for all combined RP flows)	Release limit	
				EC (µs/cm)	Sulphate (mg/L)
Ref 1	Continuous (minimum daily)	<u>Low flow</u> For a period of 28 days following natural flow events that exceed 2 m^3/s	0.4 m^3/s	700	250
		<u>Medium flow</u> >2 m^3/s	1.12 m^3/s	1,500	250
		<u>High flow</u> >10 m^3/s	5.6 m^3/s	1,500	250
		<u>High flow</u> >10 m^3/s	1.6 m^3/s	3,500	300
		<u>Very high flow</u> >25 m^3/s	2.1 m^3/s	6,000	500

4.6 CONTAMINATED WATER MANAGEMENT SYSTEM

4.6.1 Chemical storage

Primary chemical storage areas at Middlemount Coal Mine are located on the mine infrastructure area at the workshop and the CHPP workshop area. These storage facilities have been constructed and bunded generally in accordance with the relevant specifications of *AS1940 – Storage and Handling of Flammable and Combustible Liquids* (AS1940). Hazardous substances operating procedures are in place at these operations. A register is also maintained on site for all chemicals. Where appropriate, safety data sheets will be kept in storage areas or accessed online, as required.

4.6.2 Fuel storage

Fuel storage areas are a potential source of hydrocarbons. Primary fuel storage areas at the mine infrastructure area have been constructed and bunded in accordance with the relevant specifications of *AS1940 – Storage and Handling of Flammable and Combustible Liquids* (AS1940). Fuel storage areas have also been constructed at service and operational points across the mining lease.

Fuel storage areas associated with Middlemount Coal Mine operations are inspected regularly, with repair and maintenance work completed on an as-needs basis. Bunds filled with stormwater are drained (i.e. diesel/oil storage bunding at warehouse drains to oil sump and onto oil separator system) or pumped out by a licensed contractor as soon as practicable to maintain the bund volume.

4.6.3 Sewage

Middlemount Coal Mine has installed a sewerage treatment plant that collects effluent from the main administration building, workshop, project offices and CHPP. Treated effluent from the sewage treatment plant is discharged to TSF1 for re-use in the CHPP. All other sewerage generated on site is trucked off site by registered waste transport contractors.

4.7 ON-SITE STORMWATER MANAGEMENT SYSTEM

4.7.1 Overview

On-site stormwater runoff from the overburden dumps is managed in accordance with the ESCP. The ESCP adopts the three cornerstones of erosion and sediment control:

- Drainage control – prevention or reduction of soil erosion caused by concentrated flows and appropriate management and separation of the movement of diverted and surface water through the area of concern.
- Erosion control – prevention or minimisation of soil erosion (from dispersive, non-dispersive or competent material) caused by rain drop impact and exacerbated overland flow on disturbed surfaces.
- Sediment control – trapping or retention of sediment either moving along the land surface, contained within runoff (i.e. from up-slope erosion) or from windborne particles.

The Project will require a combination of the three control measures to effectively manage sediment and erosion at the site.

4.7.2 Sediment dam sizing

Sediment dams capture runoff from overburden dumps in accordance with the ESCP (WRM, 2016a). The proposed sediment dams have been sized in accordance with the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008). Runoff collected in the dams will be released to the downstream environment in accordance with the Middlemount Coal Mine EA conditions or pumped back into the mine water system to maintain capacity.

The proposed sediment dams have been based on the following design standards and methodology:

- "Type D/F" sediment basins;
- total sediment basin volume = settling zone + sediment storage volume. The sediment storage volume is the portion of the basin storage volume that progressively fills with sediment until the basin is de-silted. The settling zone is the minimum required free storage capacity that must be restored within 5 days after a runoff event;
- sediment basin settling volume based on 85th percentile 5-day duration rainfall of 33.6 mm) with an adopted volumetric event runoff coefficient for disturbed catchments of 0.59 (Group D soils – clay); and
- solids storage volume = 50% of settling zone volume.

Table 4.5 shows the maximum contributing catchment areas and design volumes for each of the proposed sediment dams. The locations of the proposed sediment dams are shown in Figure 1.3 to Figure 1.5.

Five new sediment dams (SD5, SD6, SD12, SD13 and SD14) would be constructed by 2023 to capture runoff from the expanding overburden dump. By 2023, the temporary existing sediment dam SD6 would be removed and replaced with a permanent dam. By 2028, the existing sediment dam SD10 would be removed due to the expanding open cut and waste dump footprints. A new dam SD15 would also be required by 2028.

Table 4.5 – Proposed sediment dam sizes

Sediment Dam	Maximum catchment area (ha)	Sediment Basin Requirements			Overflows to
		Settling Volume (ML)	Sediment Storage Volume (ML)	Total Volume (ML)	
SD5	225.3	44.3	22.1	66.4	Drainage Line 3
SD6	216.5	42.6	21.3	63.8	Drainage Line 3
SD12	501.3	98.6	49.3	147.8	Thirteen Mile Gully
SD13	142.2	28.0	14.0	41.9	Thirteen Mile Gully Diversion
SD14	58.5	11.5	5.7	17.2	Roper Creek
SD15	28.4	5.6	2.8	8.4	Drainage Line 2

4.8 CATCHMENT RUNOFF WATER MANAGEMENT SYSTEM

4.8.1 Flood protection levees

Flood levees are used across the Middlemount Coal Mine to prevent up-catchment floodwater from Roper Creek and Thirteen Mile Gully from entering the mine water management system. The location of the existing levee is shown in Figure 4.2. This levee has been progressively constructed since 2008 and is a regulated structure under the EP Act.

Further modification of this levee was proposed and assessed as part of the Stage 2 Project as mining progresses in a southerly and easterly direction. Diversions of Roper Creek are proposed as part of the construction of these levees. The location of the approved Stage 2 levee (and Roper Creek diversions) is shown in Figure 1.2.

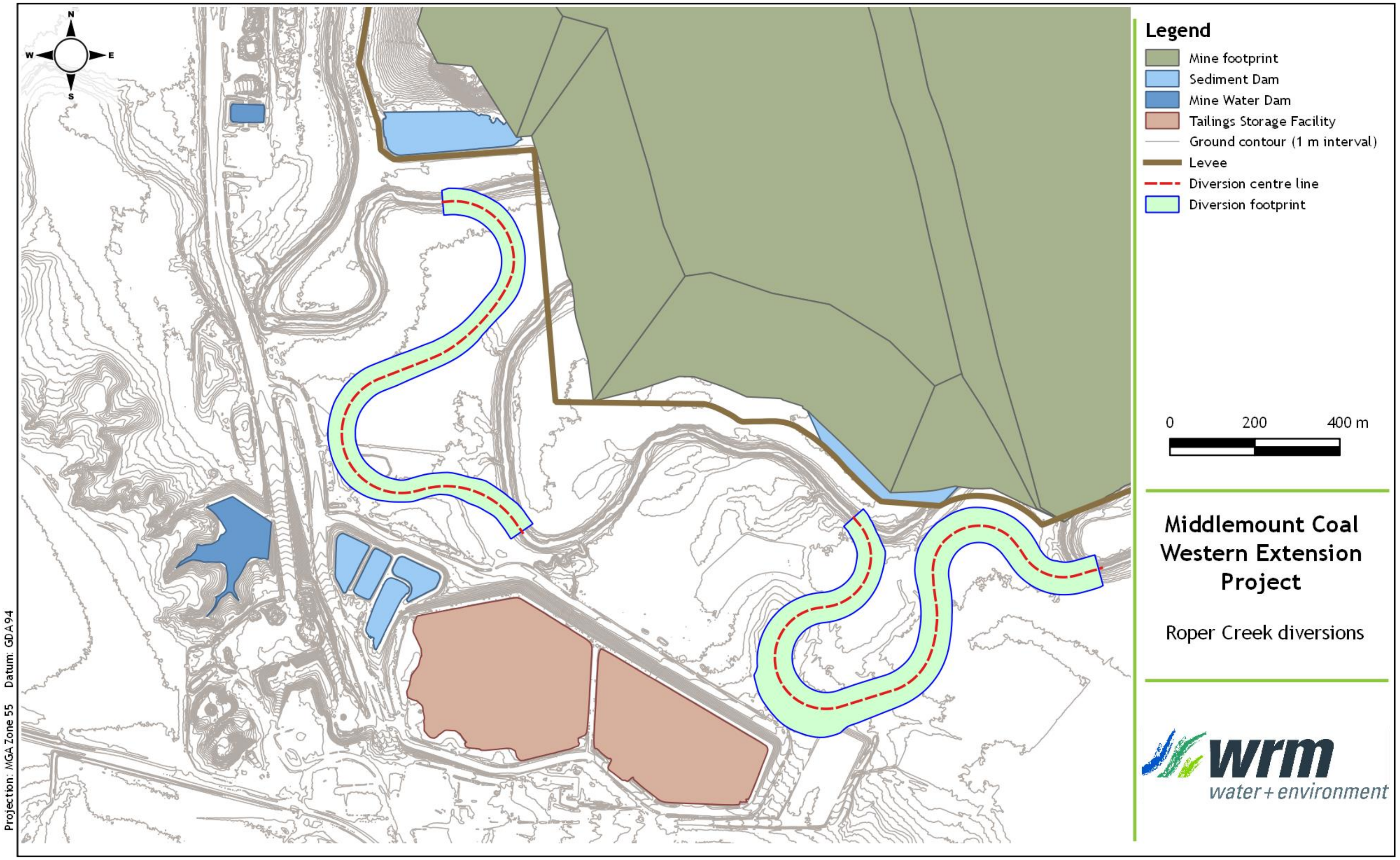


Figure 4.2 – Roper Creek diversions

The Project proposes to change the approved Stage 2 levee to allow mining of the western extension area. The alignment of the unconstructed sections around the southern end of the mining area (and the Roper Creek diversions) remain unchanged from that approved as part of Stage 2. The location of the proposed levee change is shown in Figure 1.3.

The modified levee will be a regulated structure under the EP Act and will therefore be required to have a crest above the 0.1% AEP event. An assessment of the levee against the requirements of the EP Act is given in Section 7.4.

4.8.2 Waterway diversions

Three waterway diversions were proposed as part of the Stage 2 Project; two diversions of Roper Creek and a diversion of Thirteen Mile Gully into Roper Creek along the eastern boundary of the mine.

MCPL holds approvals under the *Sustainable Planning Act 2009* (SPA) and licences under the *Water Act 2000* to divert the flow of water of Thirteen Mile Gully and Roper Creek. The Thirteen Mile Gully diversion has been constructed and its location is shown in Figure 1.2. The approved configurations of the proposed Roper Creek diversions are shown in Figure 4.2. The diversions are proposed to be constructed prior to 2023.

It is proposed to extend and realign the Thirteen Mile Gully diversion as part of the Project (see Figure 1.3). The diversion would commence about 1 km upstream of the commencement of the existing levee along Drainage Line 1 and drain into the existing diversion about 1 km downstream of the commencement of the existing diversion. A concept design and an assessment of the diversion realignment is given in Section 6.

4.8.3 Up-catchment runoff water diversions

A series of up-catchment water drains and temporary dams are proposed to capture and divert catchment runoff water around the mining areas. The indicative locations of the proposed drain and dams for the various mine Phases are shown in Figure 1.3 to Figure 1.5. Descriptions of the drains are as follows:

- By 2023, two dams (HWD1 and HWD2) will be constructed to the north of the mining areas to capture overland flows. The captured overland flows will either be pumped around the mining areas or a temporary drain constructed to free drain the captured flows.
- By 2028, the HWD 2 will be mined through and a new permanent up-catchment water drain constructed to divert the catchment to the north of mining area back to Drainage Line 1. This up-catchment water drain will remain a feature at the end of mining.

4.9 EXTERNAL WATER SUPPLY

MCPL have an arrangement with Anglo American to supply water from the German Creek Mine. Water is pumped from German Creek on an ‘as needed’ basis and placed in the RWD up to a limit of 250 ML per month and 1,800 ML per year.

Water is supplied in accordance with the Water Supply Contract between MCPL and Anglo Coal (Capcoal Management) Pty Ltd dated 22 December 2010.

External water will continue to be pumped to site on an ‘as needed’ basis for the Project. The modelling results presented in Section 5.3 0 show that the current agreement with Anglo American is more than sufficient to meet the mines external water supply requirements.

Water captured on-site will however continue to be used in preference to the German Creek Mine water supply.

5 Water management system assessment

5.1 OVERVIEW

The performance of the mine affected water management system was assessed using the OPSIM water balance model. OPSIM is a computer-based operational simulation model that has been developed to assess the dynamics of the water balance under varying rainfall and catchment conditions throughout the development of the Project. The model has been in operation since the conception of the mine and has been continually updated as data becomes available or mining operations have changed. The model will be continually updated throughout the life of the Project.

The OPSIM model dynamically simulates the operation of the water management system and keeps complete account of all site water volumes and representative water quality on a daily time step. Full details of the configuration and calibration of the Middlemount Coal Mine OPSIM model, including input assumptions, are provided in Appendix B.

The Middlemount Coal Mine OPSIM model was used to predict the performance of the following:

- overall water balance – the average inflows and outflows of the water management system for a number of representative realisations (Section 5.3.1);
- mine water inventory and salinity – the risk of accumulation (or reduction) of the overall mine water inventory and associated water quality (Section 5.3.2);
- in-pit storage – the risk of accumulation of water in the mining pit, and the associated water volumes (Section 5.3.3);
- external water demand – the risk and associated volumes of requiring imported external water (via the Anglo pipeline) to supplement site mine water supplies (Section 4.9);
- uncontrolled spillway discharges – the risk of uncontrolled discharge from the mine affected water storages to the receiving environment (Section 5.3.5); and
- controlled releases – the risk and associated volumes of controlled release of mine affected water to the receiving environment (Section 5.3.5).

5.2 INTERPRETATION OF RESULTS

In interpreting the results of the water balance assessment, it should be noted that the results provide a statistical analysis of the water management system's performance over the 20 years of mine life, based on 109 realisations with different climatic sequences.

The model results are presented as a probability of exceedance. For example, the 10th percentile represents 10% probability of exceedance and the 90th percentile results represent 90% probability of exceedance. There is an 80% chance that the result will lie between the 10th and 90th percentile traces.

Whether a percentile trace corresponds to wet or dry conditions depends upon the parameter being considered. For site water storage, where the risk is that available storage capacity will be exceeded, the lower percentiles correspond to wet conditions. For example, there is only a small chance that the 1 percentile storage volume will be exceeded, which would generally correspond to wet conditions.

For external site water supply volumes (for example), where the risk is that insufficient water will be available, there is only a small chance that more than the 1 percentile water supply volume would be required. This would generally correspond to dry climatic conditions.

It is important to note that a percentile trace shows the likelihood of a particular value on each day and does not represent continuous results from a single model realisation. For example, the 50th percentile trace does not represent the model time series for median climatic conditions.

5.3 WATER BALANCE MODEL RESULTS

5.3.1 Overall water balance

Water balance results for all of the 109 modelled realisations are presented in Table 5.1, averaged over each model phase. The results presented in Table 5.1 are the average of all realisations and will include wet and dry periods distributed throughout the mine life. Rainfall yield for each Phase is affected by the variation in climatic conditions within the adopted climate sequence.

Table 5.1 - Annual water balance - all realisations

Component	Process	Average annual volume (ML/year) per model Phase				
		Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Inflows	Catchment runoff & direct rainfall	1,510	2,112	2,140	2,311	3,042
	Groundwater inflows	716	851	724	905	455
	External supply	745	574	703	571	514
	Total inflows	**2,972**	**3,537**	**3,568**	**3,787**	**4,010**
Outflows	Evaporation	916	963	956	965	1,005
	Dust suppression	1,143	1,143	1,143	1,143	1,143
	Net CHPP demand	604	608	610	577	424
	Controlled releases	204	296	263	310	388
	Spillway overflows - mine water dams	0	0	0	0	0
	Spillway overflows - sediment dams	147	457	585	776	805
	Total outflows	**3,013**	**3,467**	**3,557**	**3,772**	**3,766**
	Change in volume	**-41**	**70**	**11**	**15**	**244**

Table 5.2 presents representative long-term mine site water balance results based on simulation results for the wet (10th percentile), median (50th percentile) and dry (90th percentile) 20-year rainfall sequences.

Table 5.1 and Table 5.2 provide an indication of the long-term average annual inflows and outflows. Key outcomes from the overall water balance are as follows:

- With the exception of Phase 1, minor on-site water accumulation is predicted across the Phases, increasing towards the end of the Project (Phase 5) as the total mine catchment increases and dust suppression demands reduce;
- The groundwater inflows (which are based on the calibrated model predictions by AGE (2018)) are generally consistent between Phase 1 and Phase 4, with a reduction towards the end of the Project in Phase 5;
- Average annual external water supply requirements vary between 510 to 750 ML/year over the life of the Project.
- There were no modelled spillway overflows from the mine affected water dams over the life of the Project.
- The Project has minimal impact on the overall water balance for the mine. The key change is an increase in overall catchment runoff volumes associated with the additional catchment area captured within the mine water management system.

Table 5.2 - Average annual water balance - wet (10th percentile), median (50th percentile and dry (90th percentile) rainfall sequences

Component	Process	Representative 20-year climatic sequence		
		Wet (10th %ile)	Median (50th %ile)	Dry (90th %ile)
Inflows	Catchment runoff & direct rainfall	2,526	2,062	1,629
	Groundwater inflows	730	730	730
	External supply	587	596	704
	Total inflows	**3,843**	**3,388**	**3,063**
Outflows	Evaporation	919	944	886
	Dust suppression	1,089	1,089	1,089
	Net CHPP demand	554	554	554
	Controlled releases	364	290	186
	Spillway overflows - mine affected water dams	0	0	0
	Spillway overflows - sediment dams	800	515	312
	Total outflows	**3,726**	**3,392**	**3,027**
	Change in volume	**117**	**-4**	**36**

5.3.2 Mine site storage inventory and salinity

Figure 5.1 shows the modelled behaviour of the MWD over the 20-year simulation period. The MWD is the primary mine affected water storage on the site and is therefore indicative of the overall mine water storage behaviour. Although the capacity of the MWD is 1,928 ML, the maximum operating storage level of the MWD is set at 1,815 ML to prevent uncontrolled spills.

If the MWD is anticipated to exceed 1,815 ML, water will be managed within the individual dams rather than pumped to the MWD. Releases from the MWD are restricted when the stored volumes fall below 500 ML to maintain water for mine site use. The following is of note:

- The MWD does not empty over the simulation period due to the supply of water via the Anglo pipeline from German Creek Mine; and
- The maximum volume in the MWD stays within 20 ML of the maximum operating volume (1,815 ML).

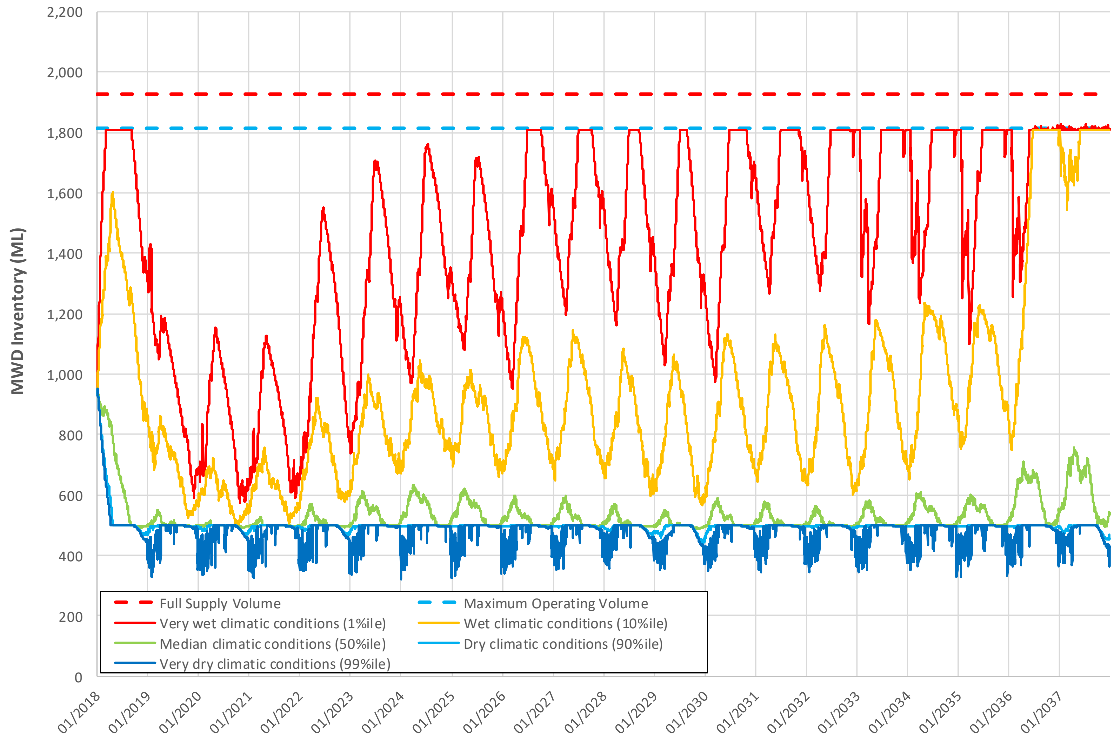


Figure 5.1 – Forecast MWD inventory

Figure 5.1 shows the modelled salinity of the MWD over the 20-year simulation period. The following is of note:

- The initial modelled salinity of 5,750 µs/cm reduces rapidly over the first two years of the simulation.
- During dryer climatic conditions, the salinity of MWD is expected to be around 2,500 to 4,500 µs/cm. This is due to the greater reliance on the water supply from the Anglo pipeline, which has a modelled salinity of 4,200 µs/cm.
- During median climatic conditions, the salinity of MWD is expected to be around 1,500 to 3,000 µs/cm.
- During wetter climatic sequences, the salinity of MWD is expected to reduce to around 1,000 to 2,500 µs/cm. This is due to the reduced reliance on the water supply from the Anglo pipeline.

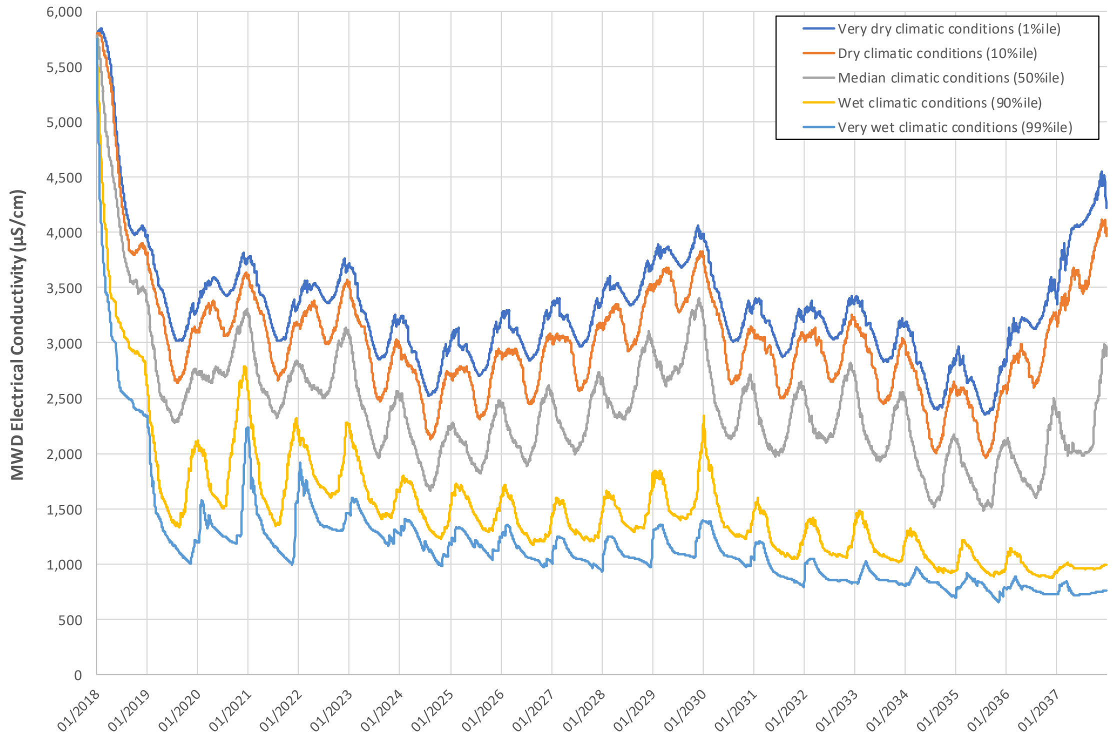


Figure 5.2 – Forecast MWD salinity

5.3.3 Pit inundation characteristics

Figure 5.3 shows the modelled behaviour of the mining pit over the 20-year simulation period.

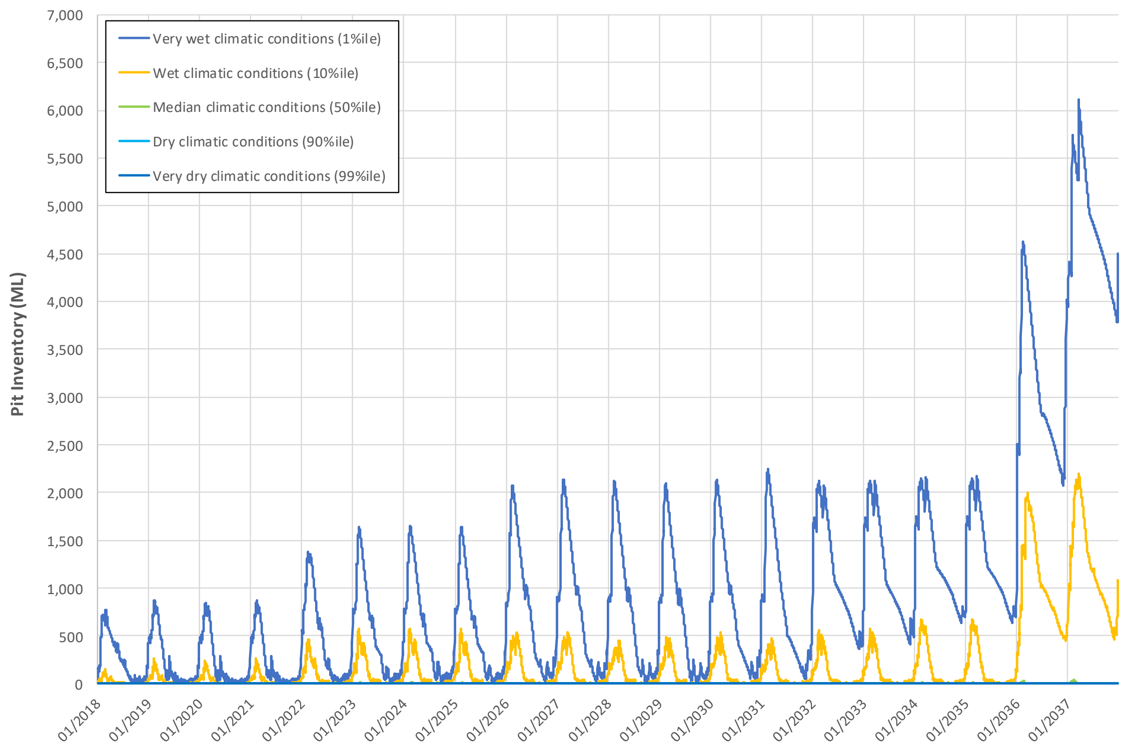


Figure 5.3 – Forecast mining pit inventory

The pit inundation characteristics provides an indication as to whether there is sufficient in-pit pumping infrastructure and out-of-pit storage volume to prevent operational problems. The following is of note:

- There is a relatively low risk of accumulating significant volumes of water in the pit up until Year 2036. After this time, the estimated volumes increase significantly due to the reduction in overall site demands as well as the increase in site catchments during the last few years of the Project (Phase 5).
- There is a 1% chance that the pit volume will not exceed 2,240 ML up until Year 2036 (Phases 1 to 4). This increases to 6,120 ML between Year 2036 and 2037 (Phase 5).
- There is a 10% chance that the pit volume will not exceed 680 ML up until Year 2036 (Phases 1 to 4). This increases to 2,200 ML between Year 2036 and 2037 (Phase 5).

These modelling results indicate that the risk of excessive pit inundation is relatively low up until Year 2036 (Phases 1 to 4) due to the storage capacity available in the MWD and the existing pit pump capacity. Between Year 2036 and 2037 (Phase 5) the risk of inundation is similar; however, the potential volume of inundation increases due to the reduction in site water demands and increased catchments captured within the mine water management system. However, the risk at this time is still relatively low with a 50% chance of having no pit inundation.

5.3.4 Water supply reliability

The model results show that the mine water management system including the external water supply via the Anglo pipeline from German Creek Mine can meet all mine site demands over the 20-year Project life. Further to this, the modelling indicates that:

- an external water supply source is required in almost all years to satisfy demand;
- there is a 50% chance that between 420 ML/year and 990 ML/year water will be required from an external water source over the Project life; and
- the maximum annual demand for external water was modelled at 1,530 ML/year. This remains within the current 1,800 ML/year (250 ML/month) cap of the external Water Supply Contract with Anglo.

That is, the existing external water supply arrangements with Anglo (via the pipeline from German Creek Mine) will remain unchanged for the Project.

5.3.5 Uncontrolled discharges

The water balance model shows that there are no modelled uncontrolled discharges from the mine affected water dams over the simulation period. Therefore, the operational procedures given in the Regulated Dams Operational Management Plan (MP214-001) achieve the assessment criteria objective of a less than 10% chance of uncontrolled discharges from the mine affected water dams.

That is, the Project will continue to achieve the assessment criteria objective of a less than 10% chance of uncontrolled discharges from the mine affected water dams.

5.3.6 Controlled releases

The water balance model simulates controlled releases from the MWD to Roper Creek based on the conditions of the EA. Although controlled releases can be made from other storages, it is only made from the MWD under the current mine affected water management system. The predicted annual controlled release volumes are provided in Table 5.3.

Table 5.3 – Summary of simulated controlled releases – annual volume

Year	Annual controlled releases (ML/year)				
	1%ile	10%ile	50%ile	90%ile	99%ile
2018	363	181	0	0	0
2019	1,183	907	181	0	0
2020	1,002	726	181	0	0
2021	1,045	726	181	0	0
2022	1,088	907	181	0	0
2023	1,270	907	181	0	0
2024	1,227	959	181	0	0
2025	1,270	959	181	0	0
2026	1,097	916	181	0	0
2027	1,183	959	181	0	0
2028	1,140	864	181	0	0
2029	1,097	864	181	0	0
2030	1,088	864	181	0	0
2031	1,183	959	181	0	0
2032	1,097	959	181	0	0
2033	1,194	959	181	0	0
2034	1,457	1,002	181	0	0
2035	1,539	1,054	181	0	0
2036	1,636	1,057	181	0	0
2037	2,093	1,192	181	0	0

The following of note:

- There are opportunities to release water from the MWD to Roper Creek around 50% of the time, in any year during the Project. These opportunities are based on the flow in Roper Creek, the modelled salinity in the MWD and the inventory in the MWD being above 500 ML.
- For very wet climatic conditions (1%ile), the model simulated between 363 ML and 2,093 ML of releases from the MWD each year.
- For wet climatic conditions (10%ile), the model simulated between 181 ML and 1,192 ML of releases from the MWD each year.
- For median climatic conditions (50%ile), the model simulated between 0 ML and 181 ML of releases from the MWD each year.
- For the dry (90%ile) and very dry (99%ile) climatic conditions, there were no modelled releases from the MWD.

The above results show that the existing mine affected water infrastructure at the Middlemount Coal Mine and the existing approved EA conditions are sufficient for the Western Extension Project without change.

5.3.6.1 Release scenarios

The water balance model results were analysed in further detail to assess the modelled controlled releases from the mine affected water management system. The release scenarios were investigated to include:

- Scenario 1 – The highest flow rate released from the site.
- Scenario 2 – The highest concentration of EC released from the site; and

The release events were compared to the approved flow criteria detailed in Table 4.4. The release scenarios were assessed against the following three conditions:

- Flow criteria – The flow criteria is based on the flow rate within the receiving waters. The flow criteria specify the maximum release rate and EC release limit for all release points;
- Maximum release rate – The maximum combined release rate from all release points for a given flow criteria; and
- EC release limit – The maximum EC for releases from mine water dams for a given flow criteria.

For a release scenario to comply with the release rules, the maximum release rate and EC release limit must be below the specified corresponding flow criteria in Table 4.4.

Scenario 1 – Highest release flow rate

The highest modelled release rate for the Project is 2.1 m^3/s, which is the maximum allowable discharge rate under the approved release strategy. Figure 5.4 and Figure 5.5 show the release rate and EC from the site compared to the flow rate in Roper Creek. The approved receiving water flow criteria and release conditions listed in Table 4.4 are also shown.

There is only one flow criteria and corresponding maximum release rate during this release:

- The Very High flow criteria of greater than 25 m^3/s at the start of the release. This flow criteria allows a maximum release rate of 2.1 m^3/s with a maximum EC of 6,000 µS/cm.
- When the receiving waters flow rates declines to zero, the modelled release from site ceases.

The OPSIM model predicts that during this Scenario 1 release, the controlled release from the site would be compliant in terms of release rates and EC using the proposed flow criteria in the receiving waters (Table 4.4).

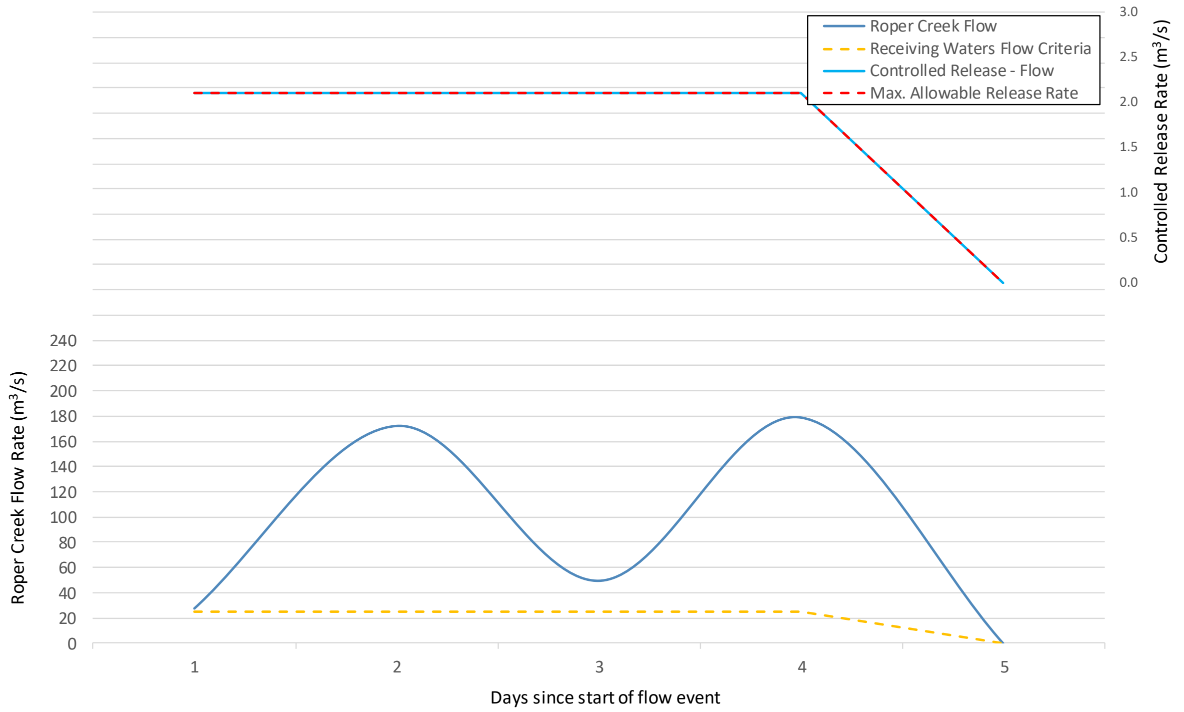


Figure 5.4 - Release rate compared to flow rate in Roper Creek and corresponding flow criteria and maximum release rate - Scenario 1

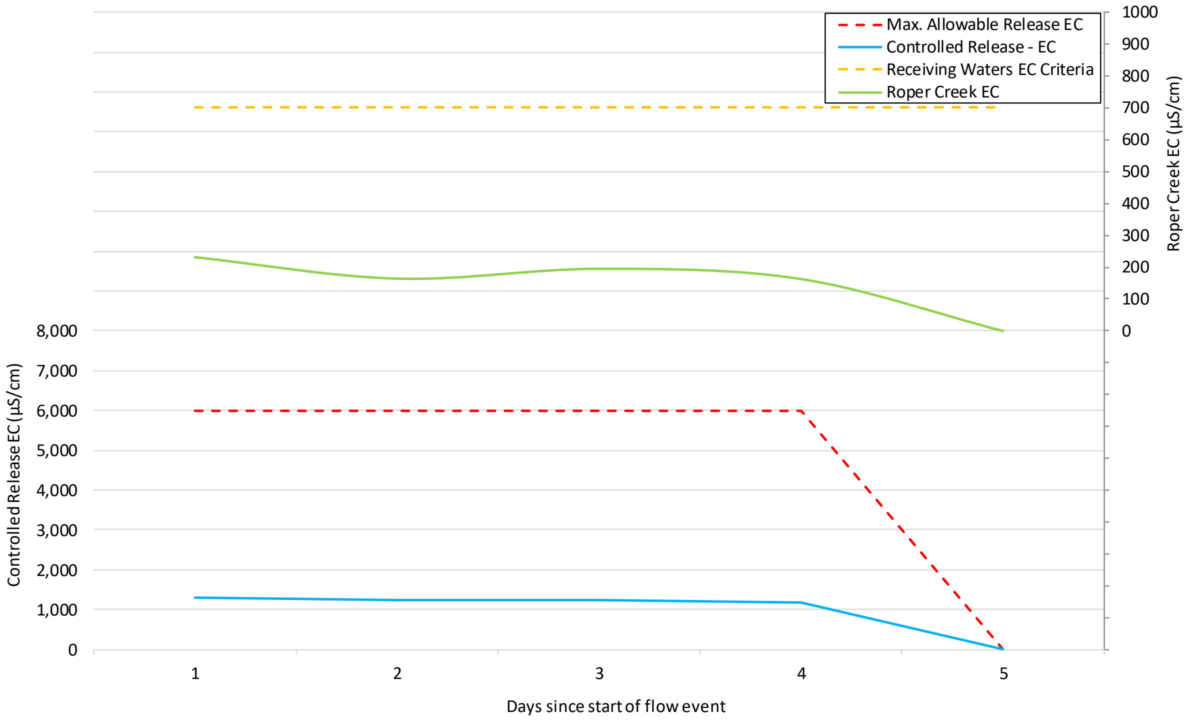


Figure 5.5 - Release water EC compared to EC in Roper Creek and corresponding EC criteria and maximum allowable release EC - Scenario 1

Scenario 2 – Highest concentration of EC released

The highest modelled release EC for the Project is around 3,500 µs/cm. Figure 5.6 and Figure 5.7 show the release rate and EC from the Project compared to the flow rate in Roper Creek. The proposed receiving water flow criteria and release conditions listed in Table 4.4 are also shown.

There are is only one flow criteria and corresponding maximum release rate during this release:

- The Very High flow criteria of greater than 25 m^3/s at the start of the release. This flow criteria allows a maximum release rate of 2.1 m^3/s with a maximum EC of 6,000 µS/cm;
- When the receiving waters flow rates declines to zero, the modelled release from site ceases.

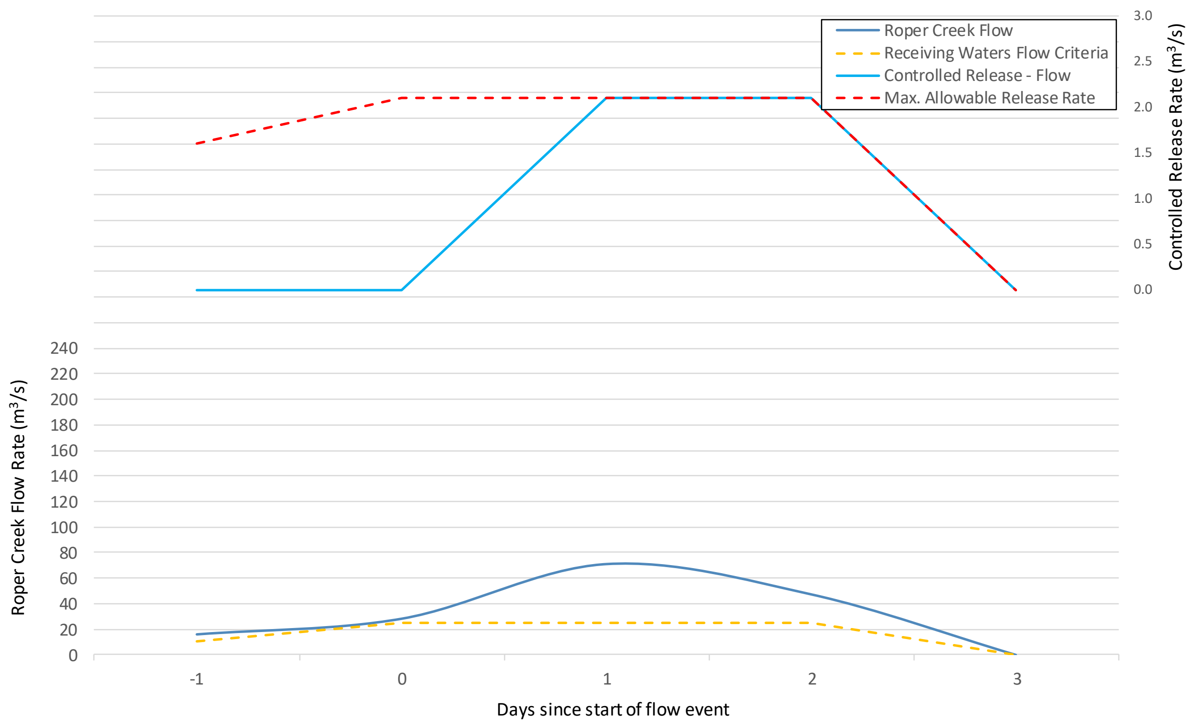


Figure 5.6 - Release rate compared to flow rate in Roper Creek and corresponding flow criteria and maximum release rate - Scenario 2

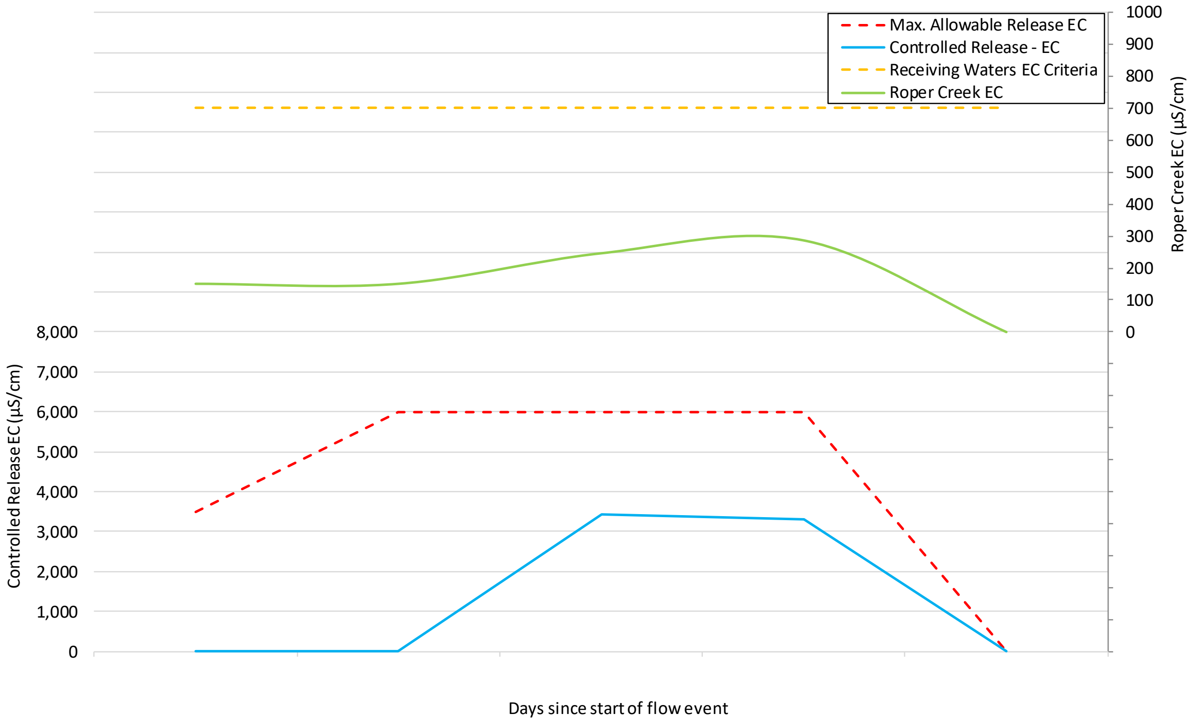


Figure 5.7 - Release water EC compared to EC in Roper Creek and corresponding EC criteria and maximum allowable release EC - Scenario 2

5.4 FINAL VOID BEHAVIOUR

5.4.1 Overview

Water levels in the final voids will vary over time, depending on the prevailing climatic conditions, and the balance between evaporation losses and inflows from rainfall, surface runoff, and groundwater. A GOLDSIM model (separate to the OPSIM model used for the operational modelling) was used to assess the likely long-term water level behaviour of the final voids. The historical rainfall and evaporation sequences (128 years) were repeated 5 times to create an indicative long-term climate record.

The volume of water in the voids is calculated at each time step as the sum of direct rainfall to the water surface, catchment runoff and groundwater inflows, less evaporation losses.

5.4.2 Final void configuration

The final void configuration and contributing catchment areas are shown in Figure 5.8 and Table 5.4. The final catchment draining to the voids will be minimised using upslope diversion drains, as shown in Figure 5.8. A depth varying storage evaporation factor has been applied to each void to simulate the change in evaporation as void water levels increase. The storage evaporation factors are as follows:

- Bottom of void - 0.5
- 10 m from top of void - 0.95
- Top of void - 1.0

Table 5.4 - Contributing catchment to final void

Final void	Contributing catchment (ha)
North Void	390.5
South Void	345.4

5.4.3 Stage-storage characteristics

The stage-storage curve for North Void and South Void have been estimated from the final landform terrain model provided by MCPL. The geometries of the final voids are summarised in Table 5.5.

The depths of each void at the end of mining vary from north to south across both mine pits, with the pit floor elevation extending to the base of the coal seams mined within each void. The two voids are separated by spoil backfill that rises up to 180 mAHD.

Table 5.5 - Modelled final void geometry

Final void	Depth (m)	Top surface area (ha)	Full supply volume (ML)
North Void	120	302	15,770
South Void	240	272	12,100

5.4.4 Groundwater inflows

Groundwater inflows to the north and south void were provided by AGE (2018). These inflow rates take into account the movement of water between the North Void and South Void through the in-pit spoil which separates the voids. Groundwater inflows at water levels above the provided inflow curves have been assumed to be zero. This assumption is not expected to have a significant impact to the final void water level behaviour given that the predicted groundwater inflows to the final void are relatively small.

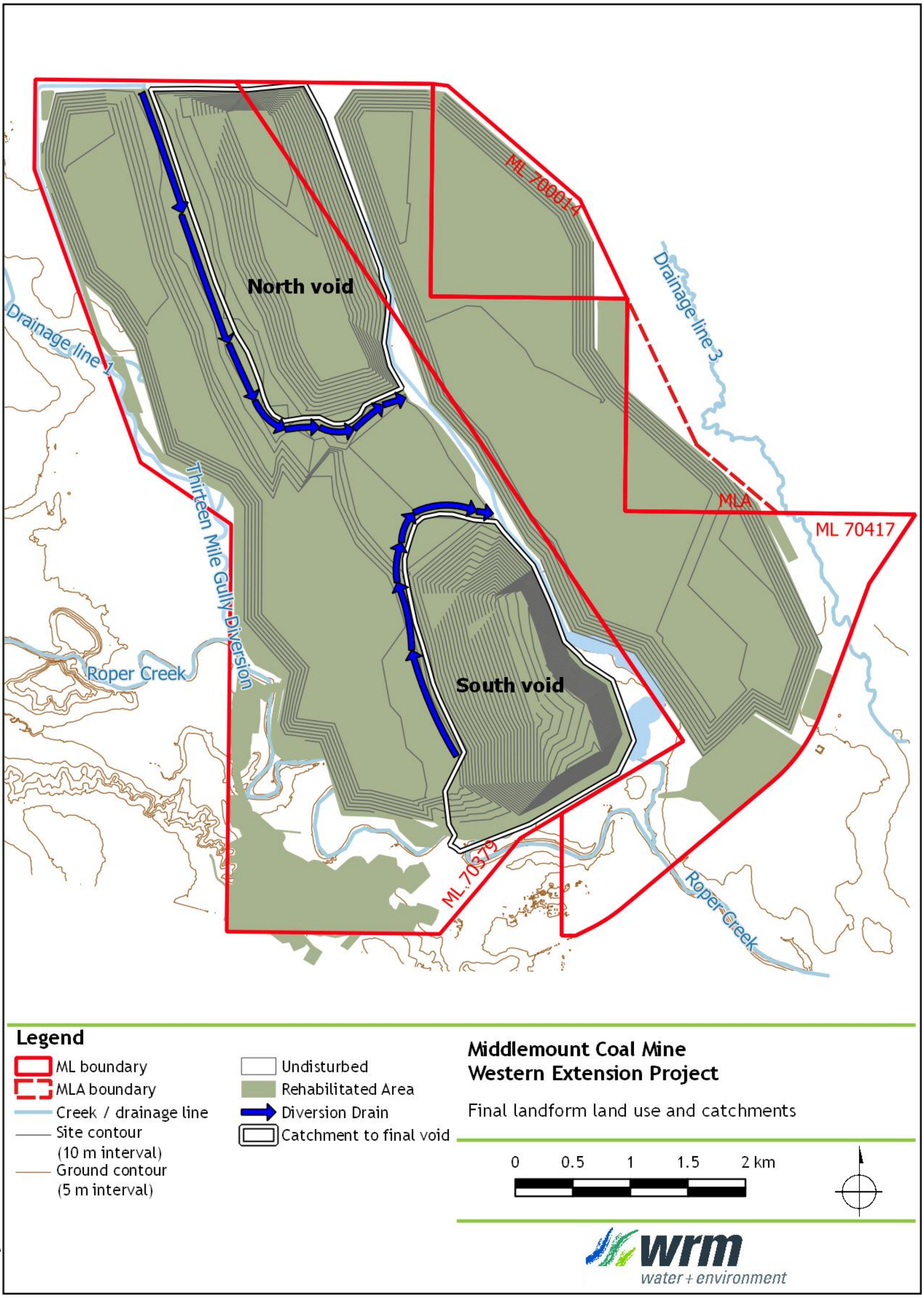


Figure 5.8 – Final void catchment plan

5.4.5 Model results

Figure 5.9 and Figure 5.10 show the simulated long-term water levels in the final voids. The model results show the following:

- North Void
  - The water level reaches a level between 60 mAHD and 65 mAHD relatively quickly and varies between these levels and empty throughout the simulation.
  - The average stored volume is predicted to be 460 ML.
  - The maximum modelled water level is around 95 m below the North Void full supply level.
  - Salt accumulates within the North Void at an average rate of around 63 tonnes per year. The void becomes hyper-saline within the first 100 years of the simulation.
- South Void
  - The water level reaches equilibrium between -70 mAHD and -30 mAHD relatively quickly and generally varies between these levels throughout the simulation.
  - The average stored volume is predicted to be 1,500 ML.
  - The maximum modelled water level is around 175 m below the South Void full supply level.
  - Salt accumulates within the South void at an average rate of around 155 tonnes per year. The void becomes hyper-saline within the first 100 years of the simulation.

The final void modelling indicates that the expected water levels are well below the full supply levels for each void, and the voids will remain as long-term groundwater sinks in perpetuity with no escape of contained water into the Rangal Coal Measures or Fort Cooper Coal Measures (AGE, 2018). As there is no mechanism to lose salt within the closed void system, the voids continually accumulate salt over time and become hypersaline within the first 100 years of the simulation.

The modelling also indicates that there would be no interaction between the long-term water levels within North Void and South Void. This is expected given the large difference in pit floor levels, as well as the small groundwater inflows. The water level response in each void is primarily driven by climatic conditions (rainfall runoff and evaporation) rather than interaction with the groundwater system. Further commentary on the interaction (or lack of) between the final voids is provided in the AGE groundwater assessment (AGE, 2018).

5.5 LIMITATIONS OF THE WATER BALANCE MODEL

The water balance model developed for the Project is based on the best information currently available and is expected to provide a reasonable representation of the performance of the mine water management system. The model will be updated and validated in the future when more suitable site-specific data becomes available. The performance of the actual system may differ from the model predictions for a variety of reasons, including different climatic sequences and hydrologic behaviour of catchments, as well as variations in operating procedures due to potential equipment failure or operation system error.

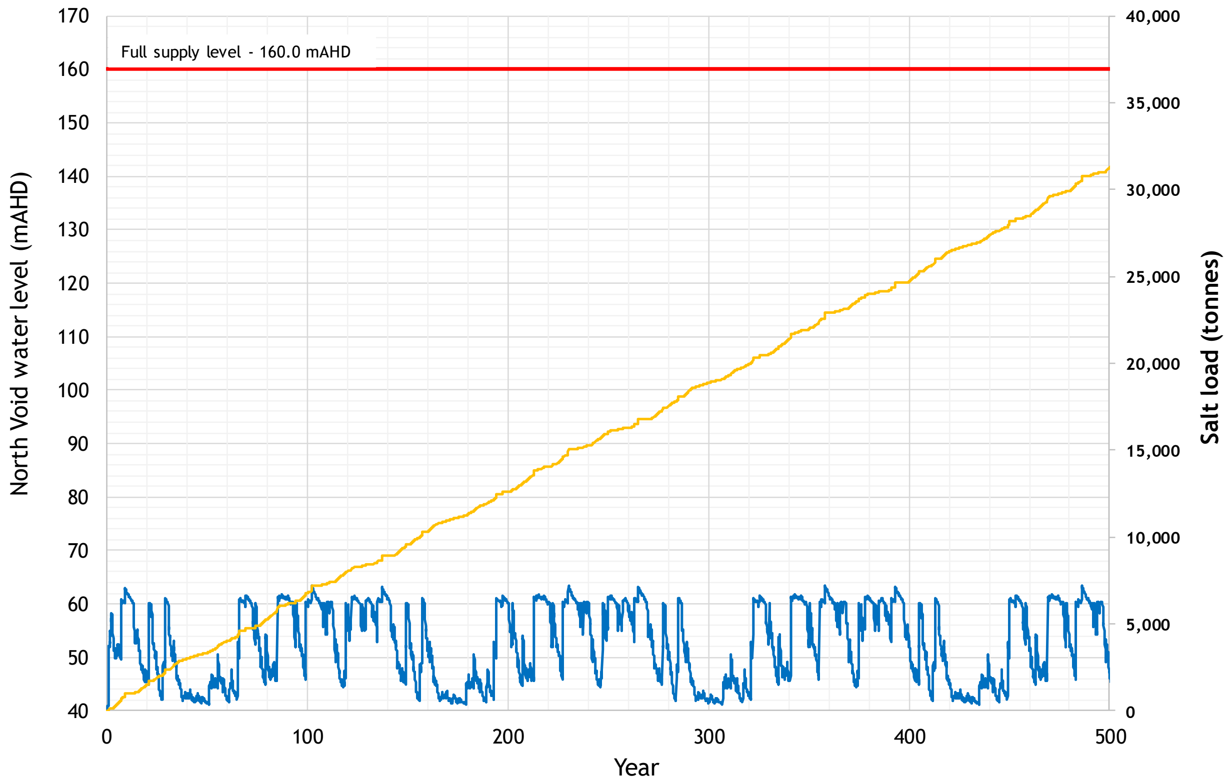


Figure 5.9 - Final void water levels and salt load- North Void

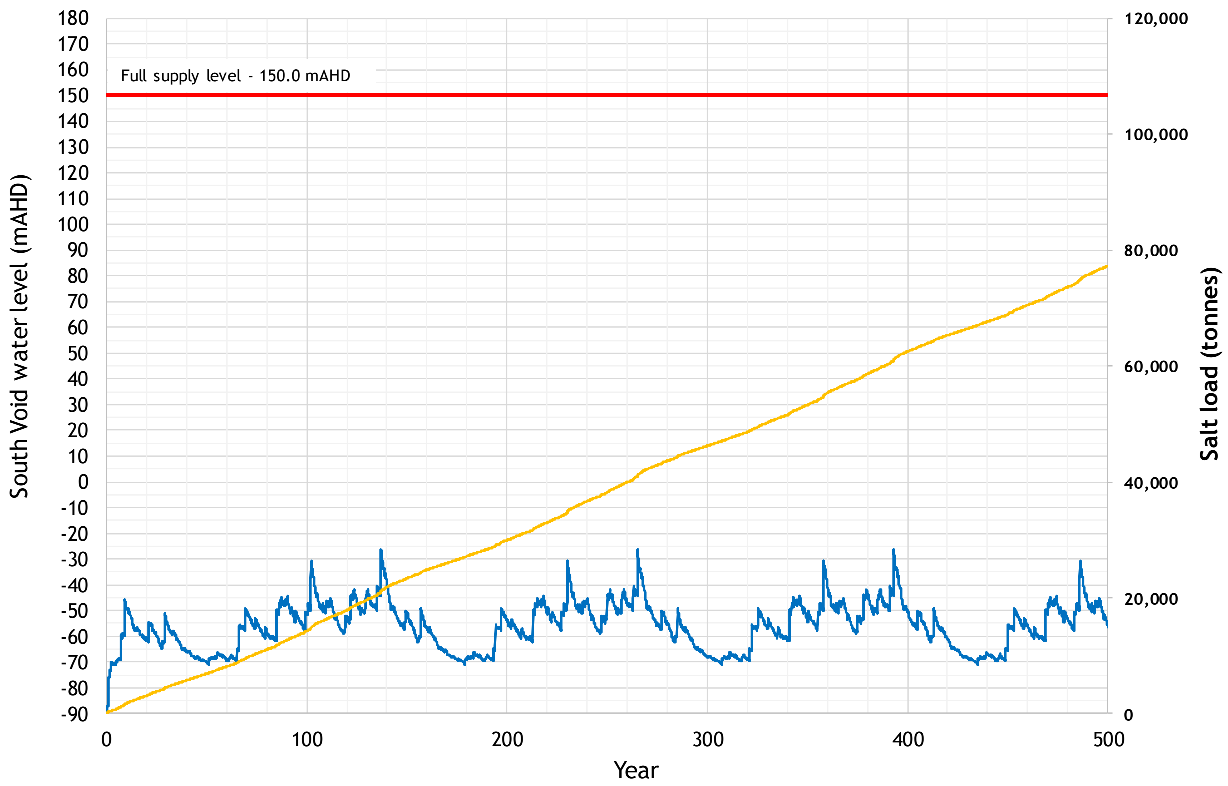


Figure 5.10 - Final void water level and salt load - South Void

6 Proposed Thirteen Mile Gully Diversion realignment

6.1 OVERVIEW

The upstream sub-catchments of Thirteen Mile Gully were diverted along the eastern boundary of ML 70379 in late 2014. A licence to divert the flow of water of Thirteen Mile Gully was issued under the *Water Act 2000* in May 2013 and a SPA approval was granted in July 2013. Upstream of the diversion, the sub-catchments of Thirteen Mile Gully drain via two drainage features; Drainage Line 1 (to the west) and Drainage Line 2 (to the north). The DNRM confirmed that these drainage lines are not watercourses, rather they are 'drainage features', as defined under the Water Act 2000 that facilitates overland flow (DNRM, 2017).

It is proposed to realign Drainage Line 1 and the upper reach of the Thirteen Mile Gully diversion as part of the Project. The new alignment is shown in Figure 6.1 and will be constructed prior to 2028.

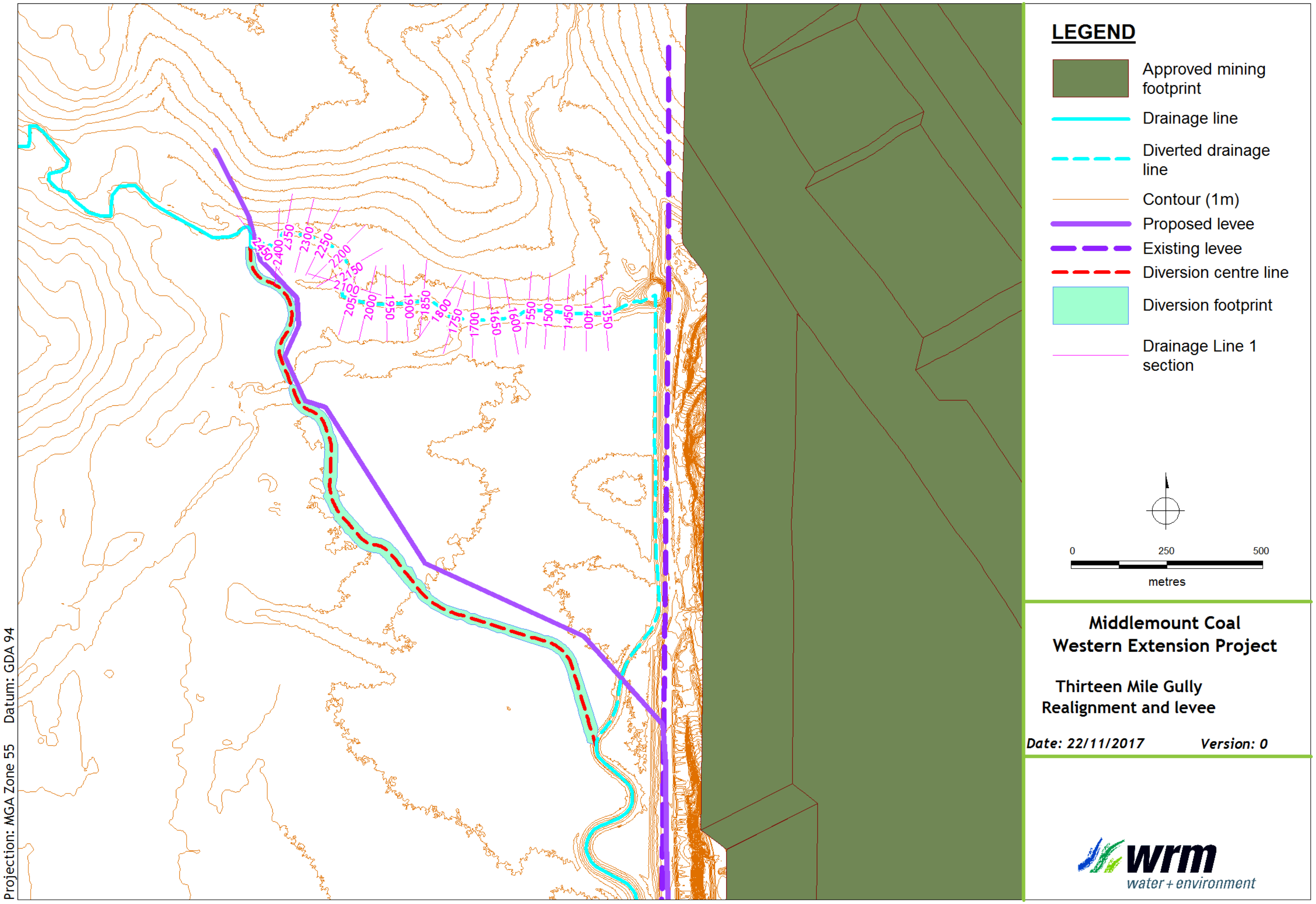
6.2 ADOPTED DESIGN APPROACH

Although Drainage Line 1 is not a watercourse, the proposed diversion realignment has been designed in accordance with the key principals and outcomes outlined in the Queensland watercourse diversion guidelines (DNRM, 2014). These outcomes are as follows:

> **Outcome 1:** The permanent watercourse diversion incorporates natural features (including geomorphic and vegetation) present in the landscape and in local watercourses.
>
> **Outcome 2:** The permanent watercourse diversion maintains the existing hydrologic characteristics of surface water and groundwater systems.
>
> **Outcome 3:** The hydraulic characteristics of the permanent watercourse diversion are comparable with other local watercourses and are suitable for the region in which the watercourse diversion is located.
>
> **Outcome 4:** The permanent watercourse diversion maintains sediment transport and water quality regimes that allow the watercourse diversion to be self-sustaining, while minimising any impacts to upstream and downstream reaches.
>
> **Outcome 5:** The permanent watercourse diversion and associated structures maintain equilibrium and functionality and are appropriate for all substrate conditions they encounter.

To achieve these outcomes, the hydraulic and geomorphic characteristics of the stream to be diverted, or an adjacent stream, have been used as a 'template' to assist with the design of the proposed diversion realignment. The proposed diversion is expected to perform in a similar manner during runoff events to the existing channel and be stable in the long term if it has similar hydraulic and geomorphic characteristics.

The existing hydraulic and geomorphic characteristics of Drainage Line 1 downstream of the diversion has been used as the 'template' for the design.



Projection: MGA Zone 55 Datum: GDA 94

Figure 6.1 - Thirteen Mile Gully diversion realignment

6.3 DRAINAGE LINE 1 CHARACTERISTICS

6.3.1 Channel characteristics

Figure 6.2 shows typical cross sections of Drainage Line 1 from the commencement of the proposed realignment to the commencement of the existing diversion. The locations of the sections are shown in Figure 6.1. The elevations of the cross sections upstream of Section 1750 m have been adjusted to be approximately at the same elevation. Similarly, the cross sections downstream of Section 1750 m have been adjusted but at a level 3 m lower.

The results show that Drainage Line 1 is distinctly different upstream and downstream of Section 1750. At this section, the broader Roper Creek floodplain drains into Drainage line 1 increasing the catchment area by up to 50%. The initial overflows from Roper Creek also drain into Drainage Line 1 at this location. Although the channel depths are similar, the channel is more confined upstream of this location with typical bank slopes of 1V:4H. the downstream bank slopes are generally about 1V:10H and the bed is slightly wider.

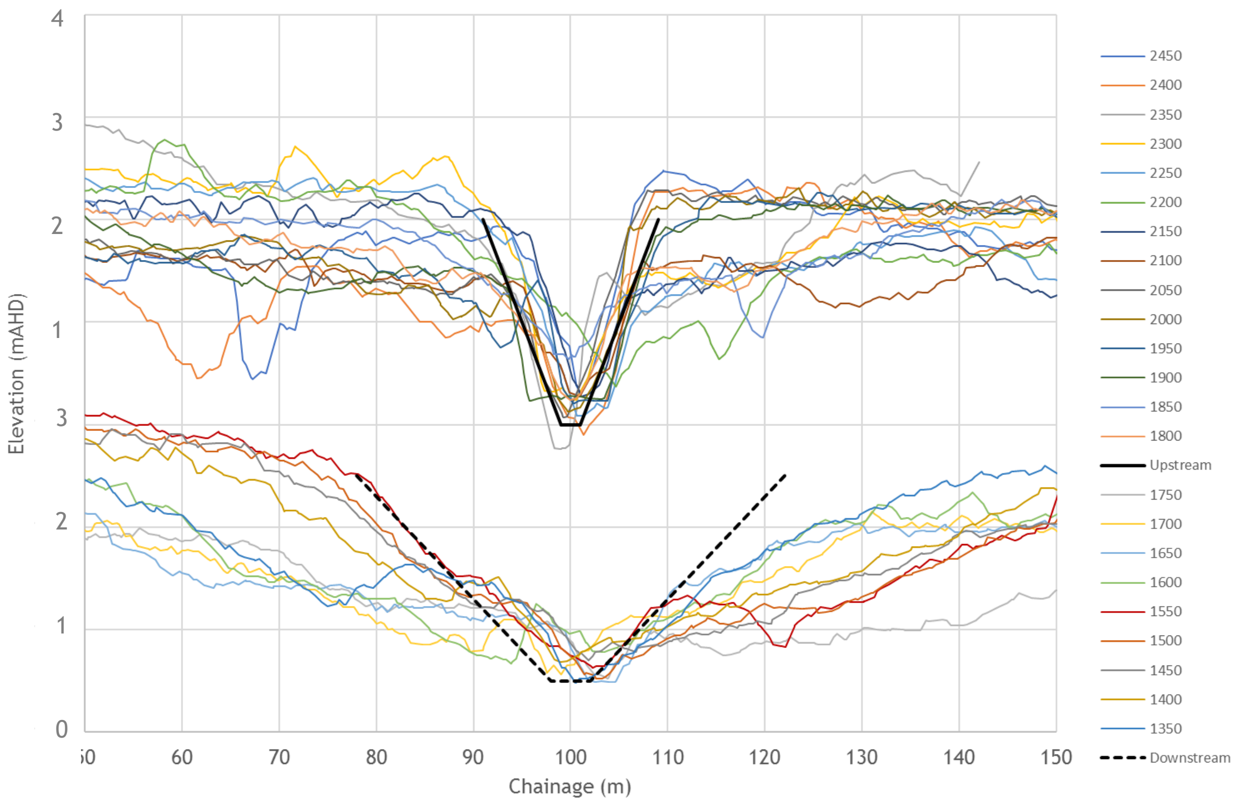


Figure 6.2 – Drainage Line 1 channel cross sections

6.3.2 Hydraulic and geomorphic characteristics

Table 6.1 shows the hydraulic and geomorphic characteristics of Drainage Line 1 from the commencement of the proposed realignment to the commencement of the existing diversion.

Table 6.1 – Drainage Line 1 hydraulic and geomorphic characteristics

Parameter		Drainage Line 1 characteristic	
		Upstream	Downstream
Grade (%)		0.18	0.18
Bed Width (m)		1 to 2	2 to 5
Mean Top Width (m)		28	50
Depth to Floodplain (m)		1.5 to 2.5	0.5 to 1.5
Meander Radius (m)		40 to 85	>500
Meander Sinuosity Index		1.24	1.02
Meander Wavelength (m)		100 to 300	300
Meander Amplitude (m)		40 to 100	4
2 Year ARI	Mean Velocity (m/s)	0.8	0.5
	Mean Bed Shear Stress (N/m^2)	12.6	5.9
	Mean Stream Power (N/m s)	9.9	3.0

The hydraulic characteristics were determined by developing a HEC-RAS one dimensional hydraulic model (USACE, 2016) of the channel. The HECRAS model was used to determine the bed shear stress (BSS), stream power and velocity of the existing Thirteen Mile Gully channel for a typical bank full flow event. The bank full flow is the maximum flow that the channel can carry before it overflows onto the adjacent floodplain. In geomorphologic studies, the bank full flow is often considered to be the stream forming flow because it often exerts the greatest influence on channel geometry. The channel shape, peak flood velocities, shear stresses and stream power for this event were used to define the characteristics of the diversion.

In this situation, it was not possible to accurately model a larger event because Drainage Line 1 floodwater overflows and drains along separate flow paths to the channel. Roper Creek floodwater also drains into the channel during large events. An assessment of the performance of the channel during overflow events including Roper Creek overflow events is given in Section 7.

6.4 PROPOSED REALIGNMENT CHARACTERISTICS

Figure 6.1 shows the configuration of the Thirteen Mile Gully diversion realignment. The proposed concept design will replicate the hydraulic and geomorphic characteristics of Drainage Line 1 channel as much as possible. Given that additional catchment from Drainage Line 2 will enter the diversion at this location, the downstream characteristics of Drainage Line 1 have been adopted for the entire length of the realignment with the exception of a steeper bank slope of 1V:6H. The following is of note with respect to the proposed realignment:

- the channel depth will vary from 0.5 m to 3 m deep (see Figure 6.3);
- the bed slope is 0.18% (see Figure 6.3); and
- the meander geometry will replicate the downstream drainage line 1 characteristics (see Table 6.1)

These parameters are similar to the existing characteristics of Drainage Line 1 and will therefore have similar hydraulic characteristics up to the bank full flow.

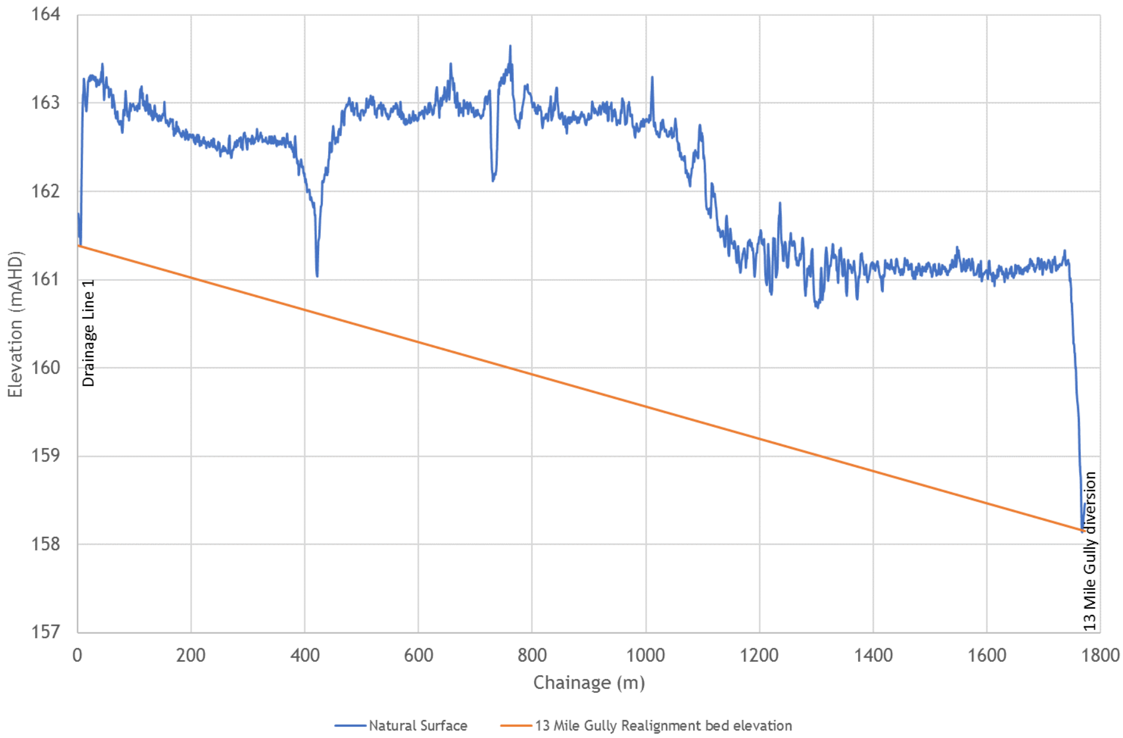


Figure 6.3 – Thirteen Mile Gully realignment longitudinal section

6.5 OUTCOME ASSESSMENT

An assessment of the proposed diversion against the outcomes in the Queensland watercourse diversion guidelines is as follows:

- **Outcome 1**: The proposed realignment will replicate the natural features of Drainage Line 1. A revegetation plan will be developed as part of the detailed design that will use vegetation characteristics seen in Drainage Line 1.
- **Outcome 2**: The proposed diversion realignment will receive the same catchment area as Drainage Line 1 and will therefore have the same hydrological characteristics. It also crosses the same flat floodplain topography at a shallow depth and will therefore not intersect groundwater systems.
- **Outcome 3**: The hydraulic characteristics of the diversion realignment are comparable with Drainage Line 1 as it has the same bed slope and channel characteristics. It also has an unconfined floodplain to allow for natural channel evolution processes to occur.
- **Outcome 4:** The diversion realignment will maintain sediment transport and water quality as it has the same bed slope (and therefore hydraulic gradient) and geomorphic characteristics as the existing Drainage Line 1.
- **Outcome 5:** Geotechnical and geological characteristics of the substrate material along the diversion realignment are expected to be similar to that encountered for the 13 Mile Gully Diversion as it crosses the same Roper Creek floodplain. Given this, the proposed diversion is expected to maintain equilibrium and functionality and is appropriate for the expected substrate conditions.

6.6 MONITORING

An operation and monitoring plan will be developed for the proposed diversion as part of detailed design that will be consistent with the monitoring programme developed for the existing Thirteen Mile Gully diversion. Collection of monitoring data will help identify any issues with the construction of the diversion and assist with relinquishment at mine closure. The monitoring plan will be prepared using the process documented in Queensland watercourse diversion guidelines (DNRM, 2014).

7 Flood modelling assessment

7.1 OVERVIEW

An Unified River Basin Simulator (URBS) hydrological model (Carroll, 2004) and a TUFLOW two-dimensional hydraulic model (WBM, 2017) were developed to simulate the flood behaviour of Roper Creek and Thirteen Mile Gully in the vicinity of the Project. The URBS and TUFLOW models were calibrated to recorded water levels and surveyed peak flood levels for the January 2013 ex tropical Cyclone Oswald flood event. Descriptions of the development and calibration of the models and the design discharges and flood levels under existing conditions are given in Appendix C. The calibrated existing conditions TUFLOW model was reconfigured to represent:

- approved (Stage 2) mine conditions;
- proposed mine conditions; and
- final landform conditions (post-mine).

The peak food levels, extents and depths were determined for the 5% and 1% AEP events for the approved and proposed mine conditions models. These events were used to assess the flood impacts of the Project.

The 0.1% AEP design flood was used to define the crest height of the proposed flood protection levees for the proposed mine conditions and the Probable Maximum Flood (PMF) was used to assess the immunity of the final void under the final landform conditions.

7.2 APPROVED CONDITIONS FLOODING

Figure 7.1 and Figure 7.2 show the flood levels, depths and extents across the Project area for the 5% AEP and 1% AEP events for the approved Stage 2 conditions. The following changes are proposed between the existing conditions (shown in Appendix C) and the approved Stage 2 conditions:

- Roper Creek will be diverted in two locations; and
- The flood levee will be extended around the south of the mining area.

Descriptions of the approved diversions and the levee are given in Section 4.8. The Roper Creek diversions were carved out of the two-dimensional grid and modelled as 1D sections, consistent with Roper Creek and the old sections of Roper Creek were filled in to match the surrounding ground levels. The flood levee was modelled as a high wall to ensure it provided flood immunity for all design floods.

7.3 PROPOSED CONDITIONS FLOODING AND FLOOD IMPACTS

Figure 7.3 and Figure 7.4 show the flood levels, depths and extents across the Project area for the 5% AEP and 1% AEP events for proposed conditions. The flood impacts for these events (proposed minus approved conditions) are shown in Figure 7.5 and Figure 7.6. The results show the following:

- For the 5% AEP event, peak flood levels in the Roper Creek channel increase by up to 0.1 m across the Project area but are generally unaffected further upstream of the mine. Overbank flood levels increase by up to 0.1 m along the Thirteen Mile Gully diversion with the exception of slightly higher increases along the Thirteen Mile Gully realignment. The minor increases would appear to be due to the change in flood storage and the change in location of the inflows from Drainage Line 2.

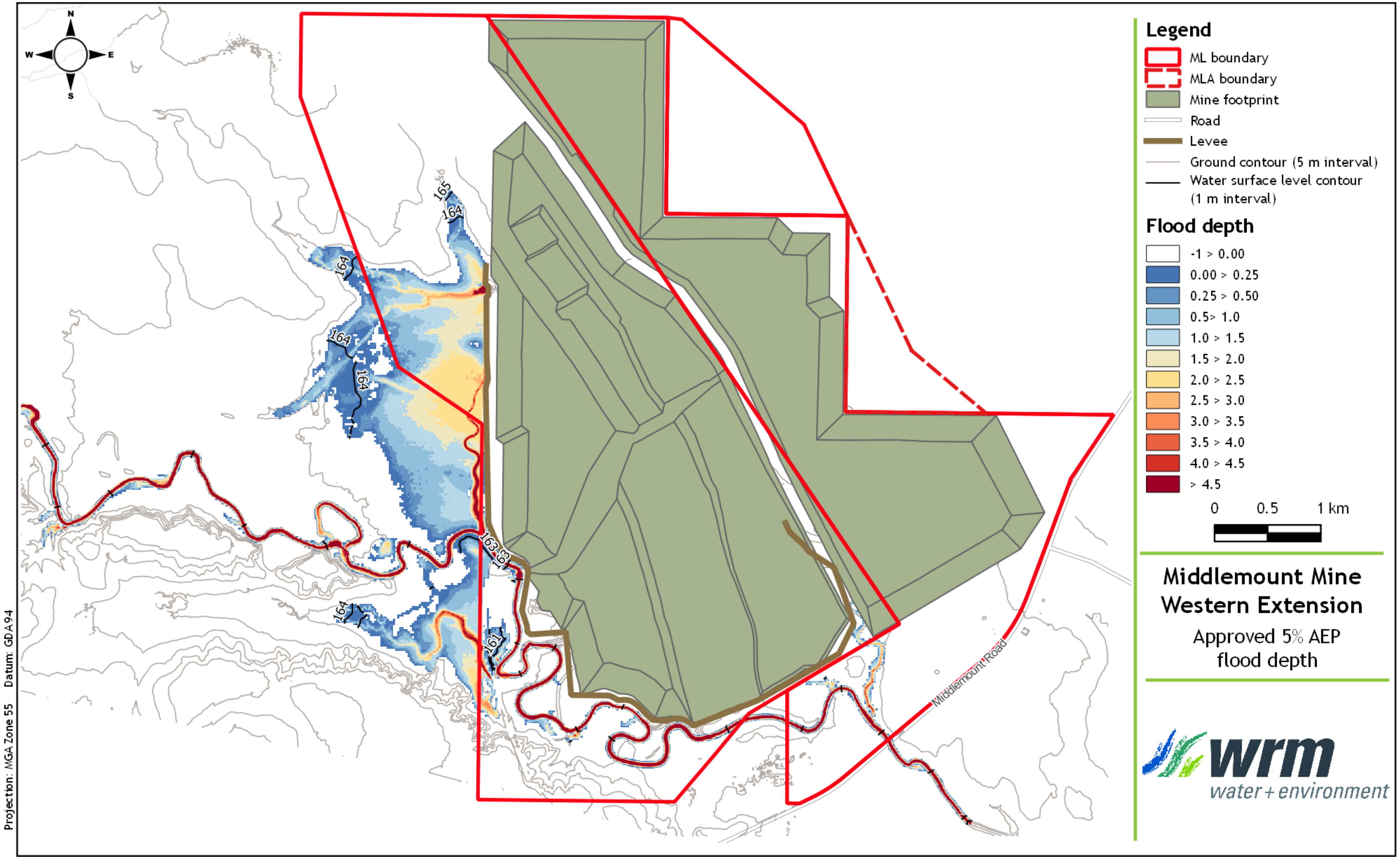


Figure 7.1 – Flood depths and extent, approved conditions, 5% AEP

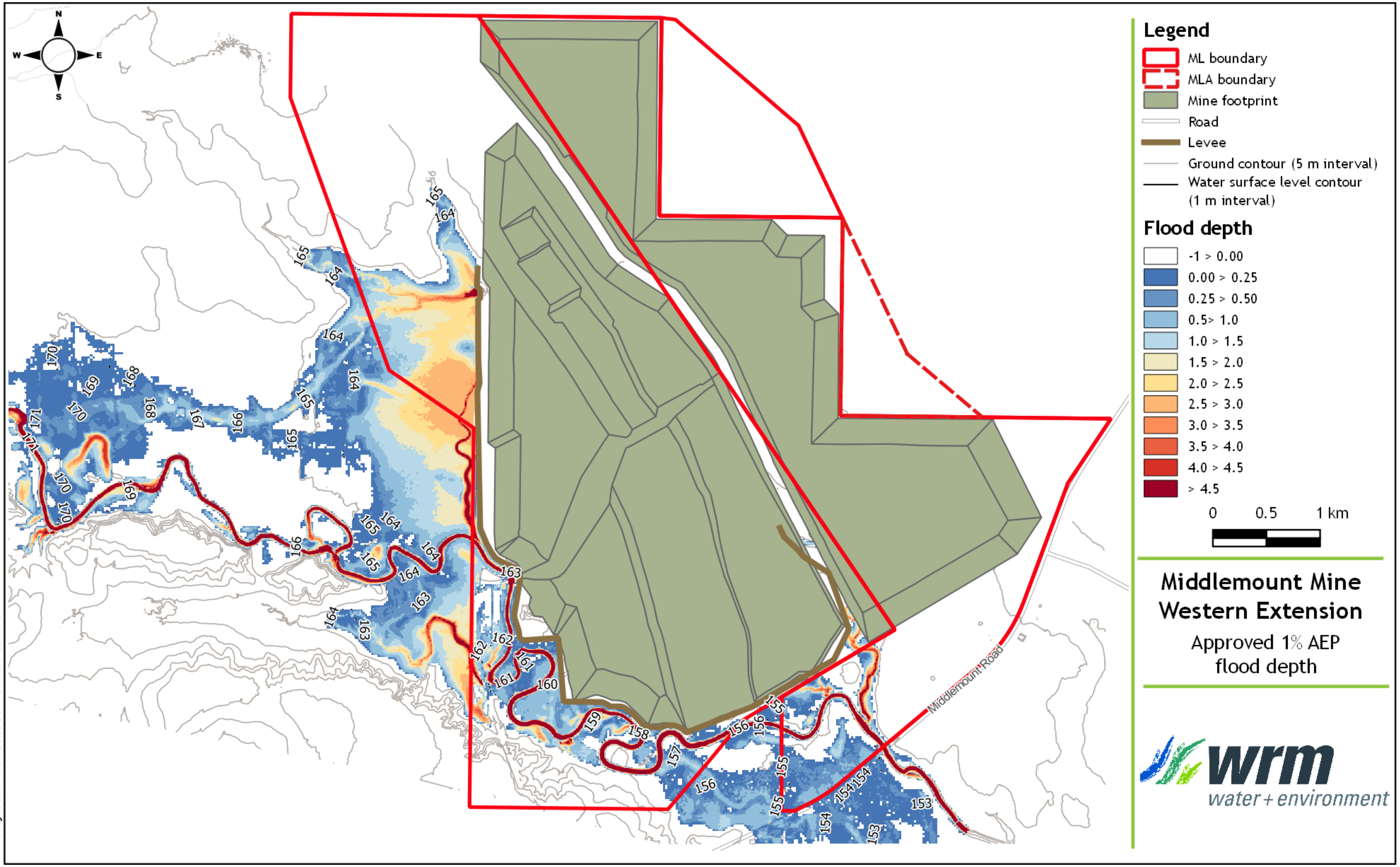


Figure 7.2 - Flood depths and extent, approved conditions, 1% AEP

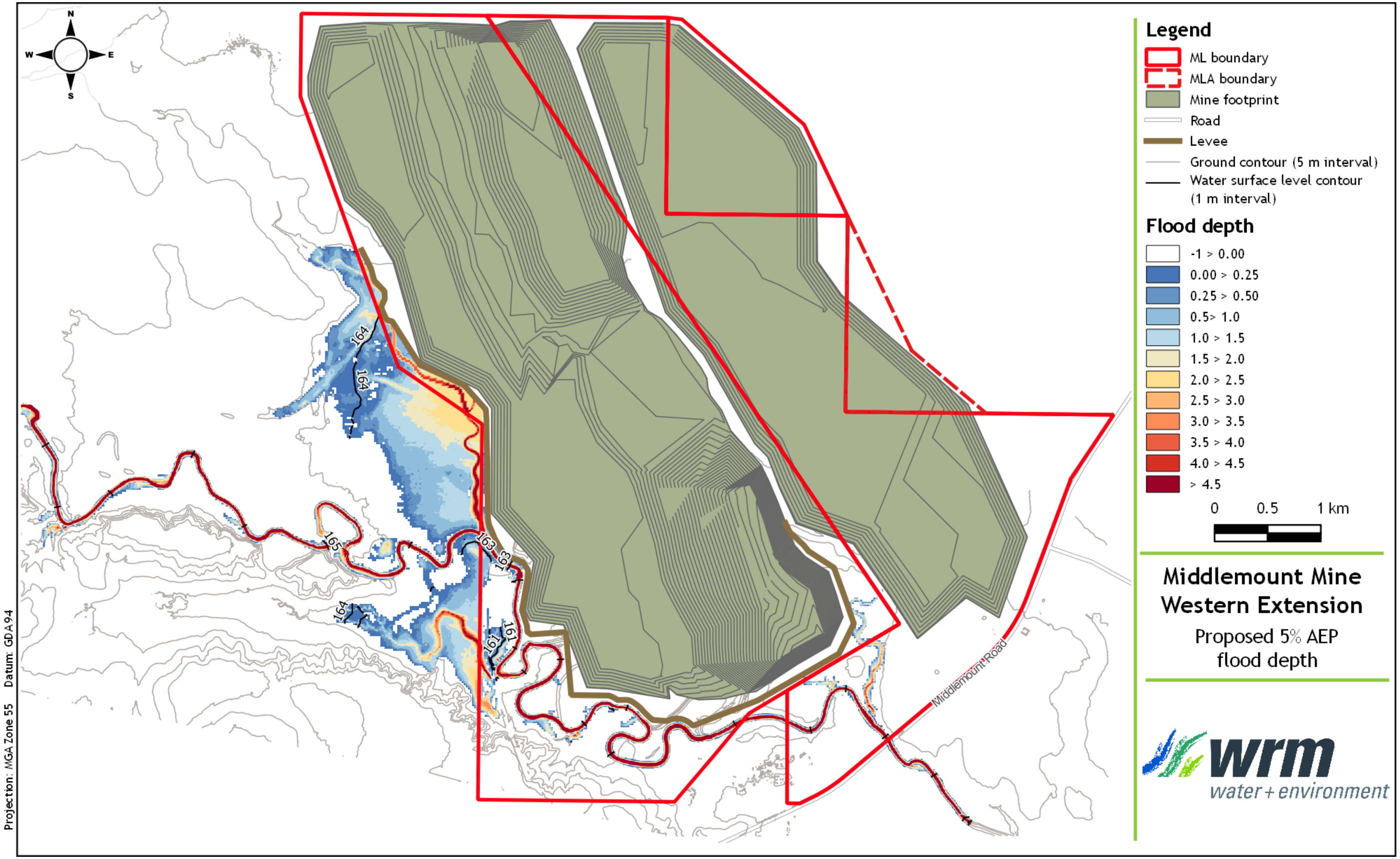


Figure 7.3 - Flood depths and extent, proposed conditions, 5% AEP

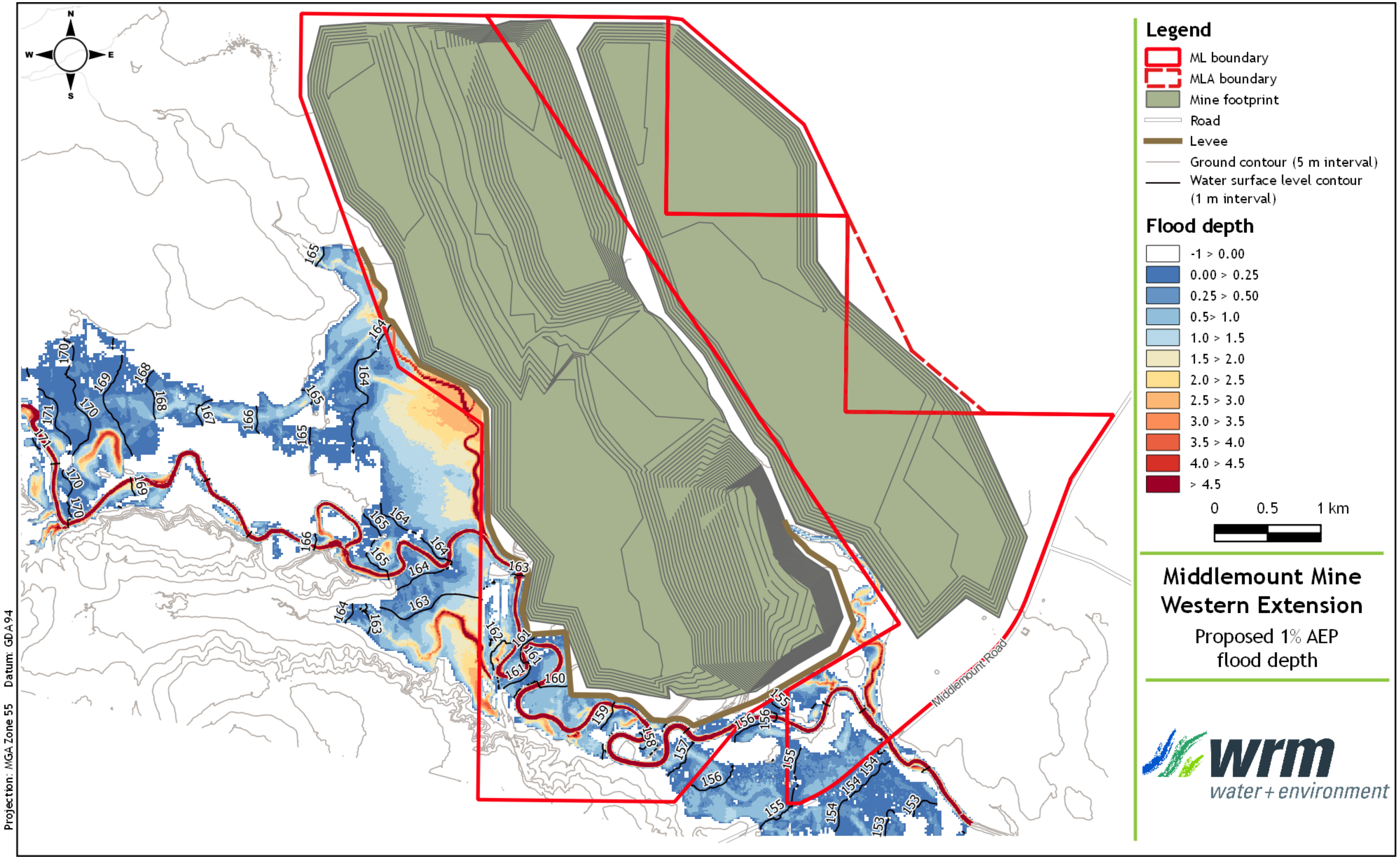


Figure 7.4 - Flood depths and extent, proposed conditions, 1% AEP

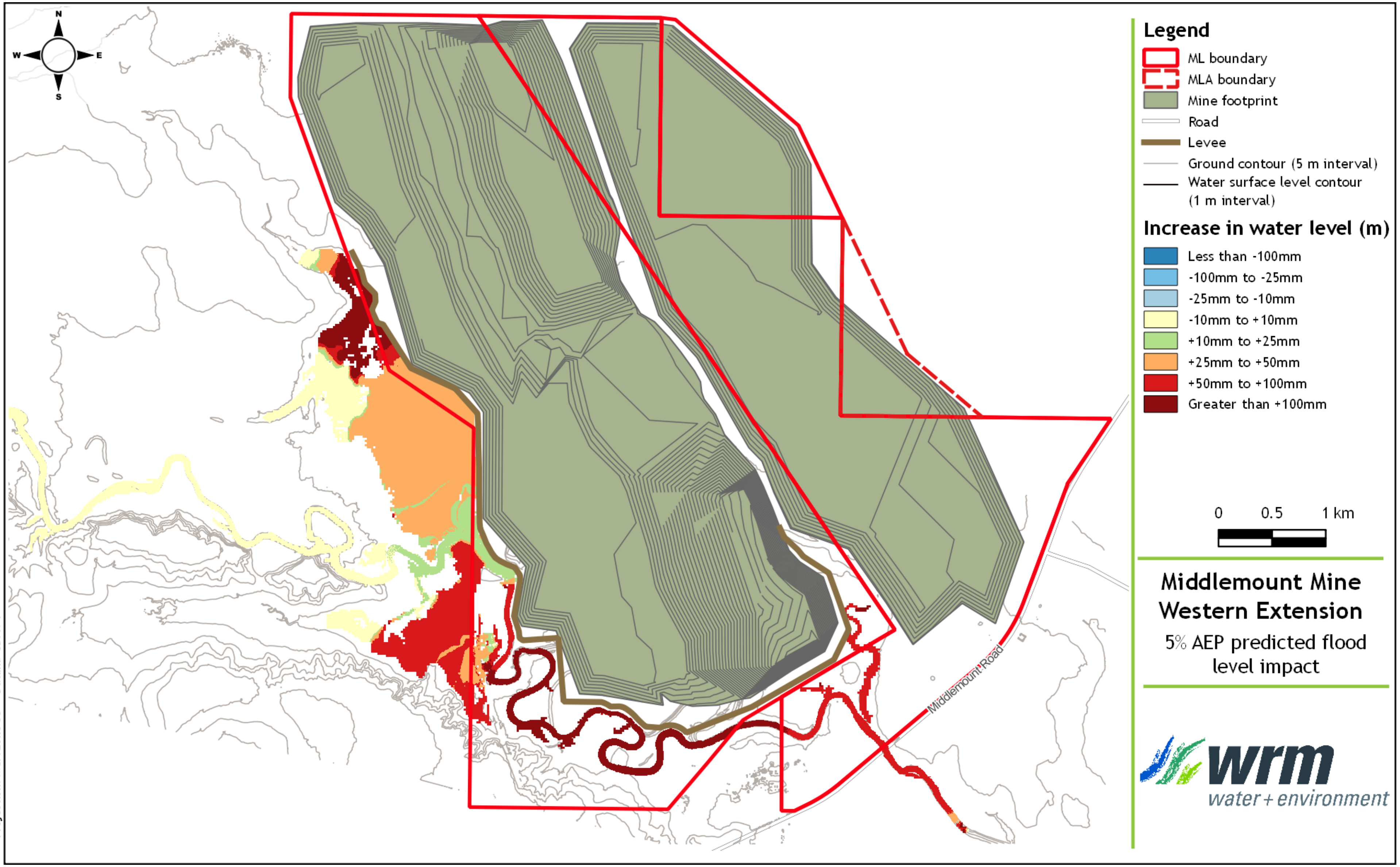


Figure 7.5 - Flood impacts, proposed minus existing conditions, 5% AEP

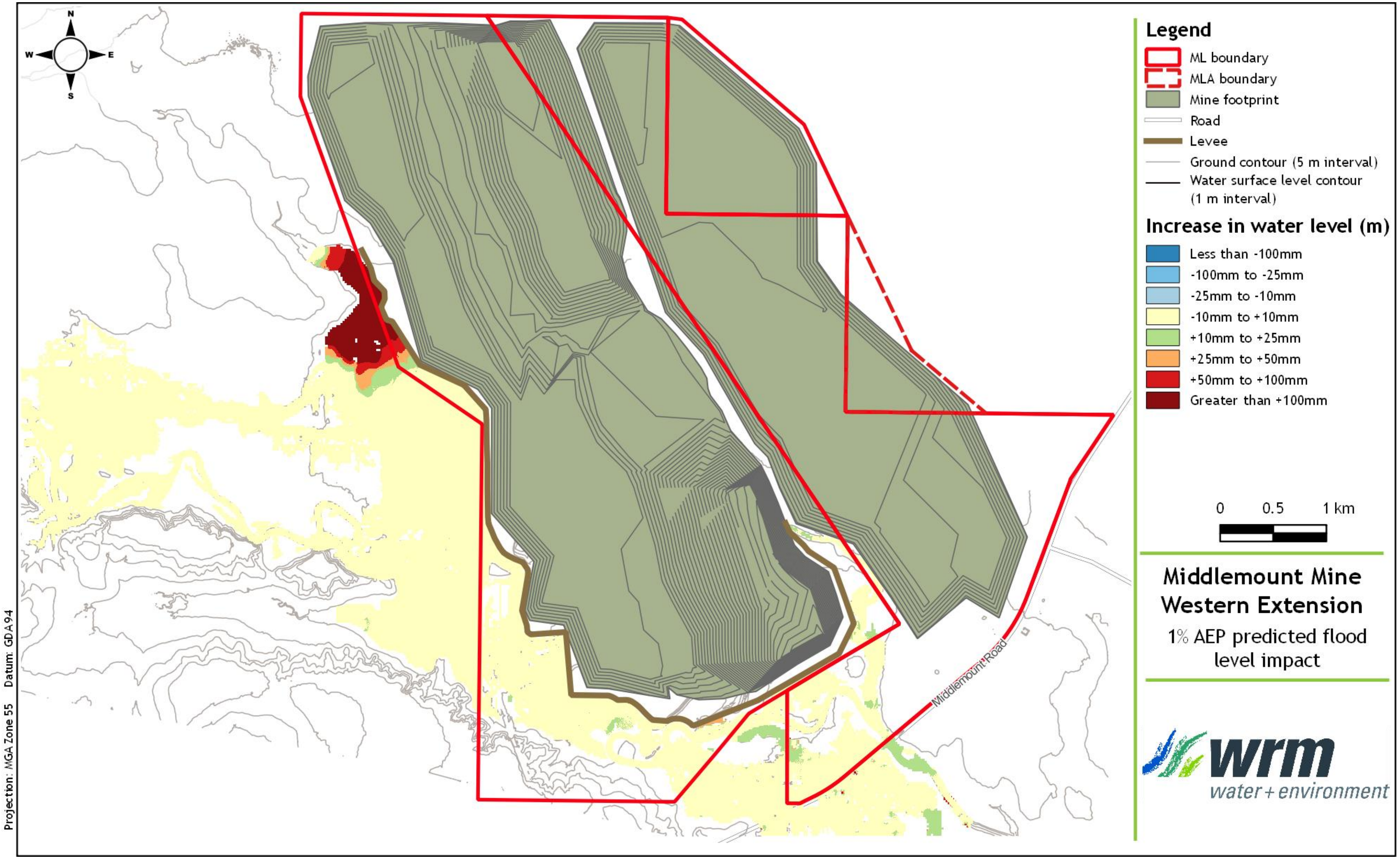


Figure 7.6 – Flood impacts, proposed minus existing conditions, 1% AEP

- For the 1% AEP event, peak flood levels are effectively unchanged from approved conditions except along the Thirteen Mile Gully realignment, which are up to 0.2 m higher and downstream of the mine with increases of up to 0.01 m due to the change in floodplain storage.

7.4 FLOOD LEVEE ASSESSMENT

The proposed realigned flood protection levee along the western extension area will be a regulated structure designed such that the crest level is above the 0.1% AEP design event. The extent and depth of inundation for the 0.1% AEP flood with the proposed levee in place is shown in Figure 7.7.

The results show that the proposed levee alignment and extent will sufficiently prevent the inundation of the open cut pit throughout the life of the Project. Detailed design plans of the proposed levee together with a consequence assessment and certification by a suitably qualified and experienced person(s) will be prepared prior to commencement of construction of the levee for assessment and approval by the administering authority.

7.5 FINAL LANDFORM ASSESSMENT

Figure 7.8 shows the final landform and the extent of the PMF from Roper Creek. The proposed final landform for the Project will include two final voids. The southern void is located on the pre-mine Roper Creek floodplain. A flood bund will be constructed around the southern void to prevent floodwater from entering. The flood bund will be up to 100 m wide at the crest and be incorporated into the rehabilitated final landform to form a self-sustaining structure that does not require long term maintenance. The bund will have a crest height above the PMF level from Roper Creek. The PMF is defined as the largest flood that could conceivably occur at a particular location and is estimated from probable maximum precipitation (PMP). Details of the methodology to define the PMF is given in Appendix C.

It is also proposed to remove the flood protection levees on the western side of the mine such that the rehabilitated out-of-pit overburden areas will prevent floodwater from entering the pit. There is at least 150 m of out-of-pit overburden area and 1 km of in-pit overburden between the floodplain and the final void, which is more than adequate to prevent floodwater from entering the final void.

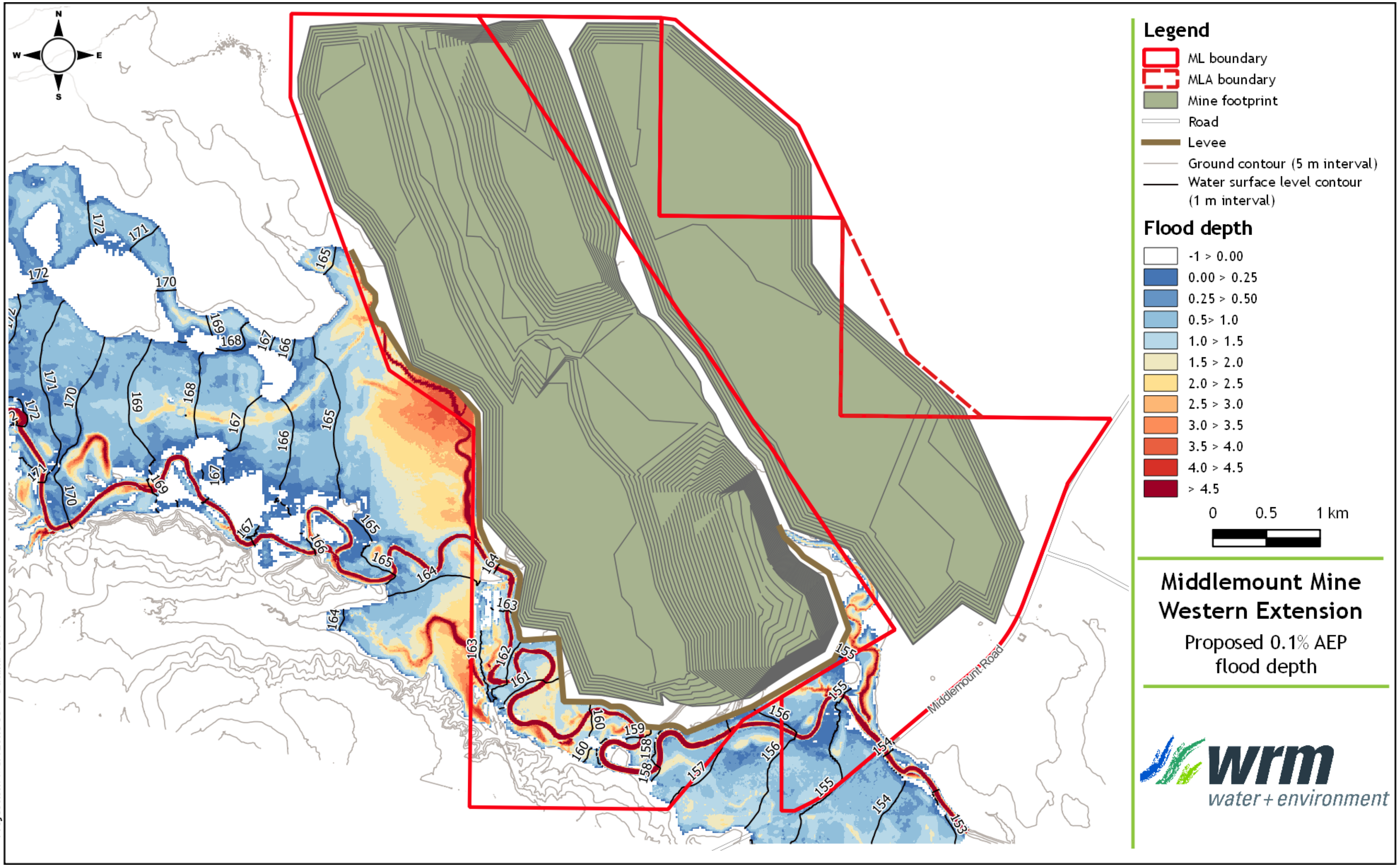


Figure 7.7 - Flood depths and extent, proposed conditions, 0.1% AEP

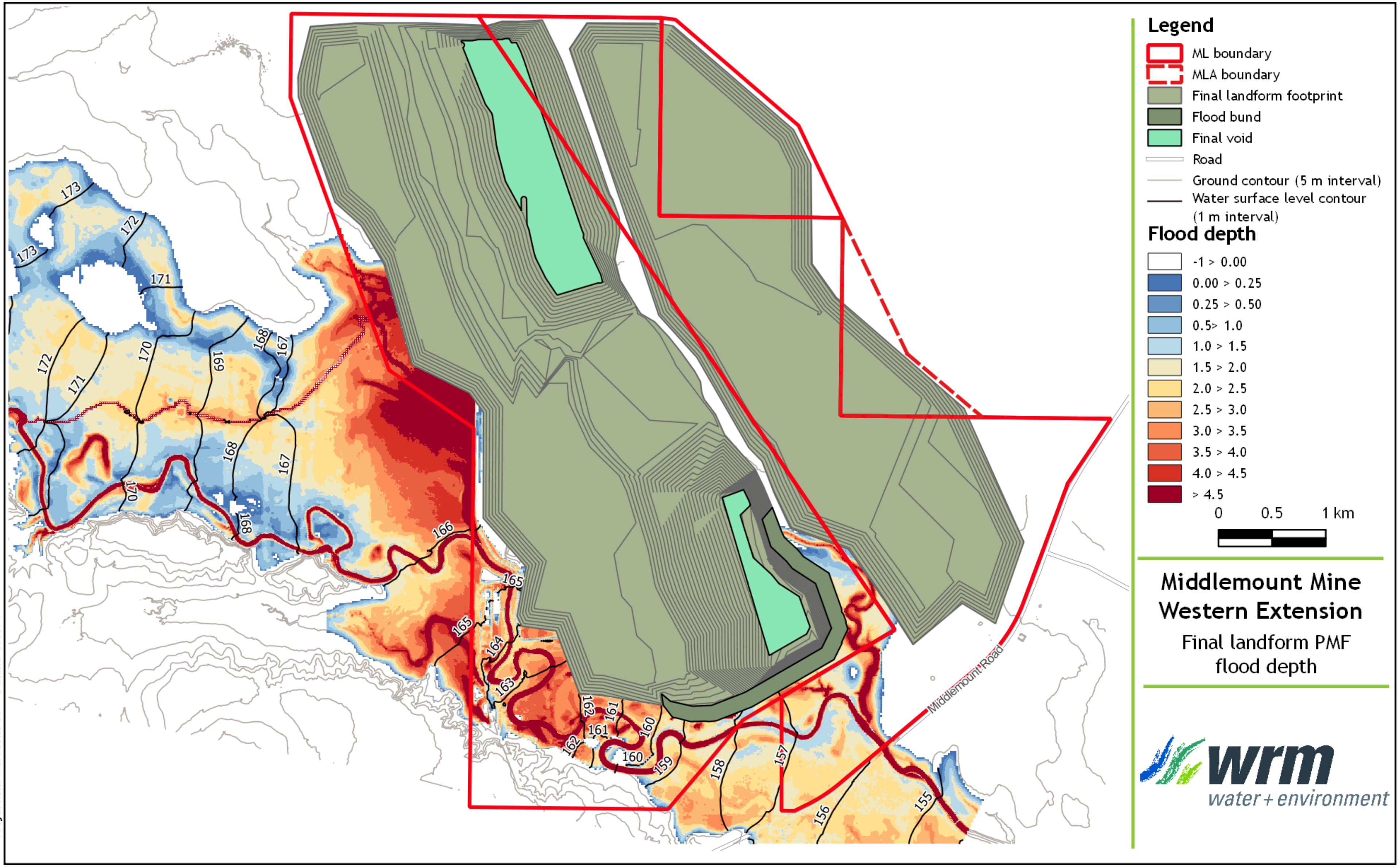


Figure 7.8 - Flood depths and extent, Final landform conditions, PMF

8 Mitigation and management measures

8.1 POTENTIAL IMPACTS

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

- impacts on flows and the flooding regime of Roper Creek;
- impacts on regional water availability due to the potential need to obtain water from external sources to meet operational water requirements of mining operations;
- impacts on stream flows due to loss of catchment area draining to local drainage paths due to capture of runoff within onsite storages and the open cut pit;
- adverse impacts on the quality of on-site stormwater runoff draining from the disturbance areas to the various receiving waters surrounding the Project, during both construction and operation of the Project;
- adverse impacts on environmental values in Roper Creek associated with controlled releases from the mine water management system; and
- cumulative impacts of all projects in the region on the environmental values of the receiving waters.

An assessment of each of these potential impacts of the Project is provided in the following sections.

The assessment of surface water impacts has been undertaken based on commonly applied methodologies for the simulation of hydrologic and hydraulic processes using currently available data. The adopted approach is considered suitable for quantifying impacts to a level of accuracy consistent with current industry practice. Certain aspects of the project, such as changes to landforms due to construction of overburden emplacements or mine subsidence, will create impacts that are irreversible, although this does not mean that any such impacts are necessarily detrimental to the environmental values of receiving waters.

8.2 FLOODING IMPACTS

Potential impacts of the Project on flood levels and flood velocities in Roper Creek are addressed in Section 7 of this report. There are no significant impacts in comparison to the approved conditions for either the operational or final landform phases of the Project.

8.3 REGIONAL WATER AVAILABILITY IMPACTS

The water balance modelling results indicates that around 700 ML/year will be required from the external supply (Anglo pipeline), under median climatic conditions. This is a reduction from previous modelling results undertaken as part of the North-eastern Extension Surface Water Assessment (WRM, 2016c), which predicted around 1,000 ML/year would be required under median climatic conditions.

This reduction is due to a combination of higher predicted groundwater inflows, the increase in overall catchment area as well as changes to the adopted CHPP and dust suppression demands.

As the external water supply is sourced from the mine affected water reserves of a neighbouring mine, the external supply requirements will have no impact on regional water availability.

8.4 STREAM FLOW IMPACTS

8.4.1 During active mining operations

8.4.1.1 Whole of mine

During active mining operations, the mine water management system will capture runoff from areas that would have previously flowed to the receiving waters of Roper Creek and Thirteen Mile Gully. The captured catchment area will change as the mine develops. A breakdown of the catchment areas reporting to the whole of mine water management system is provided in Table 8.1.

The total catchment area of Roper Creek to the downstream boundary of the Middlemount Coal Mine tenements, including the Thirteen Mile Gully catchment, is approximately 389 km^2. The maximum captured catchment areas represent:

- Between 3.2% and 7.6% of the Roper Creek catchment to the downstream boundary of the mine, depending on the Phase.
- Of the total Phase 5 captured catchment area, a maximum of 13.5 km^2 is captured in pits and mine affected dam catchments. This represents only 3.5% of the Roper Creek to the downstream boundary of the mine.
- The remaining catchment drains off site through the on-site stormwater management system.

Table 8.1 – Catchment area captured within the whole mine water management system

Catchment	Total catchment area (km^2)	Captured catchment area (km^2)				
		Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Roper Creek (to d/s of site)	389	12.8	24.4	27.4	28.5	29.4

Given that the runoff volumes from the on-site stormwater management areas will be higher than under natural conditions, the loss of stream flows will likely be less than the loss of catchment area (proportionally).

On this basis, the loss of catchment flows in Roper Creek would be indiscernible. The potential impact on water quantity in Roper Creek due to the whole of mine is considered negligible, particularly given that no water resource development, such as dams or major irrigation infrastructure is located within the Roper Creek catchment.

8.4.1.2 Project only

The Project will result in changes to flows in local creeks due to the progressive extension of open cut mining operations to the north west and associated subsequent capture and re-use of drainage from operational catchment areas.

The additional surface disturbance area associated with the Project would excise a maximum of 495.1 ha during operations from the catchment area of the former Thirteen Mile Gully and other associated drainage features, and 77.9 ha from the catchment area of an unnamed drainage line to the east of the East Dump. This represents approximately 9% of the total catchment area of the former Thirteen Mile Gully (approximately 5,600 ha) (of which the majority has already been diverted to Roper Creek by the existing/approved Thirteen Mile Gully Diversion) and approximately 4% of the total catchment area of the unnamed drainage line to the east of the Project (approximately 1,920 ha).

The maximum loss of catchment due to the Project is only 573 ha (5.7 km^2), which represents less than 1.5% of the Roper Creek catchment to the downstream boundary of the mine. The loss of catchment flows in Roper Creek would be indiscernible, and as such

the potential impact on water quantity in Roper Creek due to the Project Only is considered negligible.

8.4.2 Final landform

At the completion of mining, permanent drainage of waste rock emplacement areas will be installed to minimise capture of surface runoff into the final voids in general accordance with the configuration shown in Figure 5.8. The majority of the disturbed area at the site will be rehabilitated and allowed to drain back to Roper Creek. A residual area of approximately 7.4 km^2 will continue to drain to the final voids.

The net change in catchment area draining from the site is summarised in Table 8.2. The changed topography as a result of the final landform will have the following impacts on catchment area:

- The catchment draining to Roper Creek (to the downstream of site) will reduce by around 7.4 km^2 (compared to pre-mining conditions), a decrease of less than 2%.
- The loss of catchment flows in Roper Creek would be indiscernible, and as such the potential impact on water quantity in Roper Creek due to the final landform is considered negligible.

Table 8.2 – Final landform – captured catchment areas

Catchment	Pre-mining catchment area (km^2)	Post-mining catchment area (km^2)	Pre-mining captured catchment area (km^2)
Roper Creek (to d/s of site)	389	381.6	7.4

8.5 REGIONAL WATER QUALITY AND ENVIRONMENTAL VALUES

8.5.1 Overview

Section 4 describes the objectives and principals of the water management system, which have been developed to protect water quality and the environmental values of the waterways potentially affected by the Project. No changes are proposed to these objectives and principals as part of the project and the water management system and infrastructure remains mostly unchanged.

The general principles of the water management system, are as follows:

- A **catchment runoff water management system** that separates clean water from mine affected, on-site stormwater wherever possible. Details of the proposed waterway diversions and associated levee infrastructure are provided in Section 7.
- An **on-site stormwater management system** that contains runoff that potentially has high sediment concentrations in sediment dams. Water collected in the sediment dams will be managed in accordance with the ESCP and used for dust suppression or will overflow to receiving watercourses after a period of settling. Details of the on-site water management system are provided in Section 4.7.
- A **mine affected water management system** that contains potentially saline runoff from the pit and Mine Infrastructure Area (including ROM coal stockpile) in mine affected water dams. Mine affected water will be used as a priority in meeting makeup demand in the CHPP (after supplies are used from the tailings water management system) and for road watering. Water from the mine affected water management system may only be released to the downstream environment in compliance with the EA conditions. Details of the existing and proposed mine affected water management system and its expected performance are provided in Section 4.5 and Section 5.

- A **tailings water management system** that contains and dewaters the tailings and allows for maximum recycle of water to the CHPP. Details of the tailings and rejects circuit are provided in Section 4.4.
- A **contaminated water management system** that collects and contains all potentially contaminated water on site. This water will be recycled for use on the mine site without releasing it to the natural watercourses. Details of the existing and proposed mine affected water management system and its expected performance are provided in Section 4.5.

8.5.2 Performance of the water management system

An assessment of the water management system is given in Section 5. The results of the water balance modelling indicate that, under the current model assumptions and configuration, there are no uncontrolled spills of mine affected water from the site to the receiving environment.

Some overflow of water from sediment dams may occur during wet periods that exceed the design standard of the sediment control system (Section 4.7). As described in Section 3.4.3, water quality monitoring of three release events from sediment dams over 2013/14 indicated that the releases complied with the EA conditions with the exception of zinc and copper. However, it should be noted zinc and copper concentrations were also elevated at the upstream reference site, which indicates that the elevated levels are due to naturally higher background concentrations.

The additional disturbance footprint associated with the Project (575 ha) will increase the volume of stormwater requiring to be contained and managed on the mine site. Notwithstanding, the on-site stormwater management system will remain generally unchanged (i.e. continued collection of runoff from the overburden dumps) for the Project with augmentations as necessary.

On this basis, it is unlikely that overflows from sediment dams will have a measurable impact on receiving water quality.

8.5.3 Controlled releases

There are no proposed changes to the current release conditions as prescribed in Condition C5 of the site's EA (EPML00716913, dated 21 May 2018).

EC has been used as an indicator of water quality impacts of mine discharges. Of the water quality parameters tested in both the local waterways and at the mine, EC was found to vary the most from the WQOs with no significant differences measured in metal toxicants between mine runoff and regional water quality.

Figure 8.1 shows a ranked plot the modelled EC in Roper Creek downstream of the controlled release point on days when there is a controlled release opportunity (i.e. when the Roper Creek flow exceeds the minimum flow criteria and there is water available for release). The plot shows the modelled EC in Roper Creek both with and without controlled releases from the Project (from 109 model realisations). That is, it shows the potential impact of controlled releases on the salinity of Roper Creek immediately downstream of the mine.

The results show that:

- The minimum EC in Roper Creek on a controlled release day is around 255 µs/cm, which is around 105 µs/cm higher than the modelled background salinity;
- There is a 50% chance that the downstream Roper Creek EC will be greater than 400 µs/cm during a controlled release (250 µs/cm above modelled background salinity);
- There is a 10% chance that the downstream Roper Creek EC will be greater than 540 µs/cm during a controlled release (390 µs/cm above modelled background salinity);

- The EC in Roper Creek is below the receiving water contaminant trigger level of 700 µs/cm on all release days.

The model predicts that the EC in Roper Creek would be affected by controlled or active releases from the site on around 11% of all Roper Creek flow days.

On this basis, the modelling demonstrates that the implementation of the water management system would mitigate any impacts of the Project on downstream water quality or impact on the environmental values of the downstream waterway.

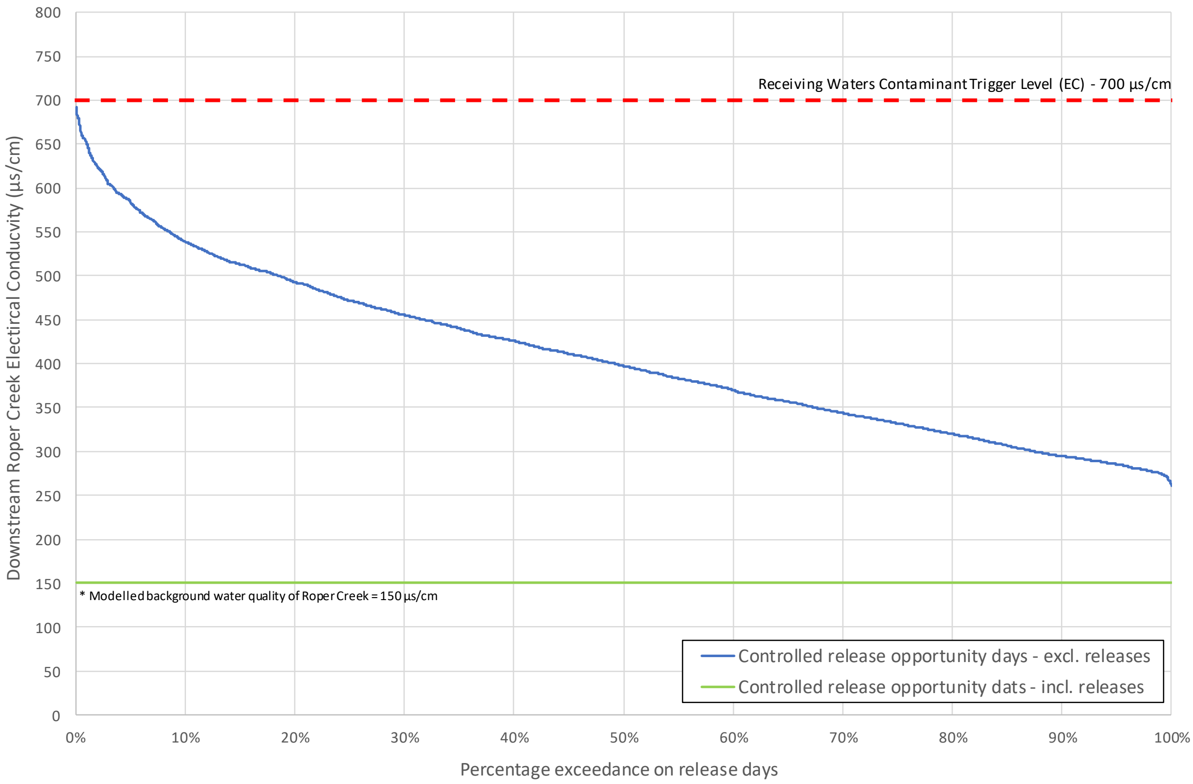


Figure 8.1 - Ranked plot of downstream receiving water quality - including and excluding modelled releases

8.5.4 Monitoring and maintenance

It will be necessary to manage each of these systems to ensure that they are operating as designed.

- Continual monitoring of water quality and storage volumes in the mine affected storages will be undertaken to ensure that uncontrolled spills do not occur and cause a downstream impact.
- The pit and MWD pumps will be inspected and operated regularly to ensure they will operate when required.
- Sediment dams will be cleaned out on a regular basis to maintain the available sediment storage volume.
- Sediment dam monitoring would be used to validate the anticipated quality of water runoff reporting to sediment dams. Initially, sediment dam monitoring would occur on a quarterly basis to demonstrate the water quality of stored waters is consistent with the relevant operating parameters to allow releases from sediment dams to occur when required. Subject to demonstrating the water quality objectives can be met, the frequency of monitoring and suite of parameters for the sediment dam

monitoring would be reviewed and updated accordingly (e.g. to be sampled only when releases occur).

- Diversion drains will be monitored regularly to ensure they are operating as designed and do not allow mixing of clean and dirty water.
- Contaminated water sumps and interceptors are to be inspected and cleaned out regularly.
- Continual monitoring of potable water quality to ensure it meets potable water standards.

8.6 CUMULATIVE IMPACTS – SURFACE WATER

8.6.1 Overview

The objective of this assessment is to identify the potential for impacts from the Project to have compounding interactions with similar impacts from other projects, including activities proposed, under development or already in operation within a suitable region of influence of the Project.

There are three levels at which cumulative impacts may be relevant:

- Localised cumulative impacts – These are the impacts that may result from multiple existing or proposed mining operations in the immediate vicinity of the Project. Localised cumulative impacts include the effect from concurrent operations that are close enough to potentially cause additive effect on the receiving environment. For the purposes of this assessment, all existing and proposed projects located within the Roper Creek catchment have been included.
- Regional cumulative impacts – These include the Project's contribution to impacts that are caused by mining operations throughout the Bowen Basin region or at a catchment level. Each coal mining operations in itself may not represent a substantial impact at a regional level; however, the cumulative effect on the receiving environment may warrant consideration.
- Global cumulative impacts – These include impacts that the Project might contribute to at a global scale. The only potential global scale impact for the Project is greenhouse gas emissions, and as such has not been addressed in this assessment.

8.6.2 Existing projects

Projects which are currently operating within the Roper Creek catchment and have been included in the cumulative impacts assessment for the Project, and are listed in Table 8.3.

Note that all of the projects listed below are located on waterways which discharge into Roper Creek downstream of the Project, as follows:

- Parrot Creek discharges into Roper Creek approximately 14 km downstream of the Project.
- Oaky Creek discharges into Roper Creek approximately 32 km downstream of the Project.

There are no active projects located within the Roper Creek catchment upstream of the Project. The southern extent of Norwich Park Mine (which is currently closed) is located on Roper Creek upstream of the Project.

Table 8.3 - Existing projects considered in the cumulative impact assessment

Project Proponent	Description	Operational status	Relationship to the Project Mining Lease: Timing	Relationship to the Project Mining Lease: Location
Capcoal Complex - Anglo Coal	Open cut and underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project	• German Creek - located 10 km southwest of the Project on Parrot Creek • German Creek East - located 6 km south of the Project on Parrot Creek • Oak Park - located 14 km south of the Project on Parrot Creek • Lake Lindsay - located 24 km southeast of the Project on Oaky Creek
Foxleigh Mine - Middlemount South	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the Project	Located 15 km southeast of the Project on Roper Creek
Oaky Creek Mine - Glencore	Underground coal mine (with inactive open cut pits)	Operating	May have overlapping operational phases with the construction and operations of the Project	Located 25 km southwest of the Project on Oaky Creek
Norwich Park Mine- BMA	Open cut coal mine	Ceased production indefinitely	Unlikely to have overlapping operational phases with the construction and operations of the Project	Located 24 km northwest of the Project on Roper Creek

8.6.3 New or developing projects

Relevant projects that have been considered include:

- Projects within the predicted sphere of influence of the Project, as listed on the Department of State Development, Infrastructure and Planning website that are undergoing assessment under the Queensland *State Development and Public Works Organisation Act 1971* for which an Initial Advice Statement (IAS) or an Environmental Impact Statement (EIS) are available; and
- Projects within the predicted sphere of influence of the project, which are listed on the website of the DEHP that are undergoing assessment under the EP Act for which an IAS or an EIS are available.

There have been no projects identified as currently undergoing assessment or having recently completed assessment under these processes.

8.6.4 Cumulative impacts – surface water quality

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

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

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

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

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

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

Mine affected water from the proposed Project will be managed through the existing Middlemount Coal Mine mining complex water management system as this allows water to be reused in coal handling and preparation. The EA EPML00716913 is in line with the model water conditions, with discharge conditions and in-stream trigger levels aligned with WQOs in the EPP (Water). Using a water balance model, an analysis has been undertaken of the

effect of water from the Project on the ability of Middlemount Coal Mine to maintain compliance with environmental authority conditions. This analysis indicates that the addition of mine affected water from the Project makes no difference to the compliance profile for Middlemount Coal Mine and is negligible in terms of salt load to the Mackenzie River.

While the EPA cumulative impact assessment of mining in the Fitzroy Basin focussed on salinity as the key water quality issue related to mining activities, surface disturbance associated with mining activities can result in erosion and increased sediment levels in surface waters. The Great Barrier Reef outlook report also identified that the Fitzroy Basin contributed one of the highest sediment loads to the reef, largely attributing sediment loads to use of land for agricultural activities (Great Barrier Reef Marine Park Authority [GBRMPA], 2009).

The Queensland Government commissioned an assessment of mine affected water releases in the Fitzroy River basin during the 2012–2013 wet season (known as the Pilot Scheme).

The report (Gilbert and Sutherland and Marsden Jacob Associates, 2013) concluded that the Fitzroy River as a whole is not currently ‘at capacity’ in terms of salt load at a catchment or sub-catchment scale (Gilbert and Sutherland and Marsden Jacob Associates, 2013).

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

The water quality assessment undertaken for the Project has identified that sediment inputs can be controlled through drainage, erosion and sediment control measures. On this basis, the proposed Project is not expected to make any significant contribution to cumulative sediment loads in the Fitzroy River Basin.

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

8.6.5 Cumulative impacts – surface water flows

In Queensland, the water resource planning process focussed on balancing water extraction and use with protection of ecosystems and takes into account cumulative impacts from major water storages and extraction. The Project does not require any additional raw water allocations and therefore does not contribute to cumulative impacts in relation to extraction of surface water resources from the catchment. The Project will locally impact flows in Roper Creek and its minor tributaries due to water being captured within the site water management system. The impacts of these changes in conjunction are outlined in Section 8.4. No other projects have been identified which would further increase these impacts.

8.7 PROPOSED EA AMENDMENTS

8.7.1 Authorised releases

There are no additional mine affected water dams proposed as part of the Project. As such, there are no new authorised release points as listed in Table C1 of the EA.

The additional sediment dams will be managed under the ESCP and therefore require no changes to the EA.

8.7.2 Mine affected water release limits and trigger levels

There are no proposed changes to the mine affected water release limits, release contaminant trigger investigations levels or mine affected water release conditions in Table C2, Table C3 and Table C4 of the Middlemount EA.

8.7.3 Mine affected water release events

There are no additional stream gauges proposed as part of the Project. The existing stream gauge is adequate to define the trigger release conditions from the existing mine water release points.

8.7.4 Receiving environment monitoring

There are no proposed changes to the receiving water monitoring locations given in Table C6 of the EA. In addition, the monitoring locations and regime given in the Middlemount REMP (GHD, 2016) does not change.

8.7.5 Location and basic specification of regulated dams

There are no new regulated dams proposed as part of the Project.

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Appendix A – Water quality sampling plots

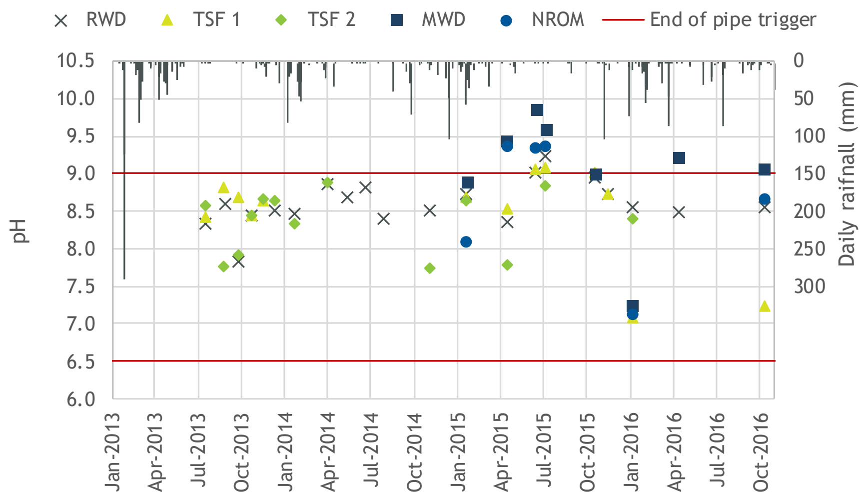


Figure A.1 - pH - Mine affected water dams

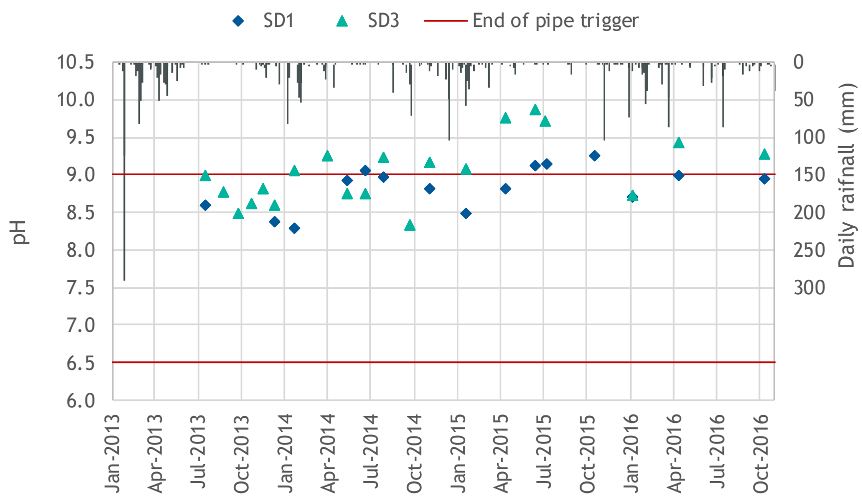


Figure A.2 - pH - Mine affected sediment dams

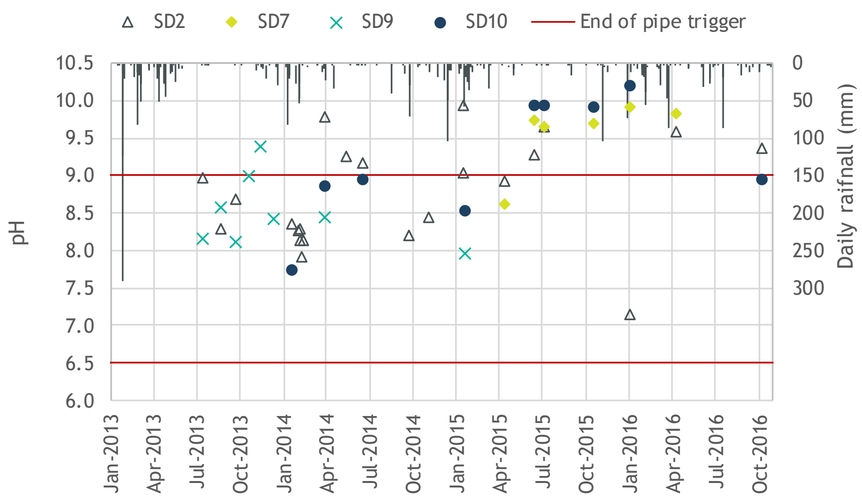
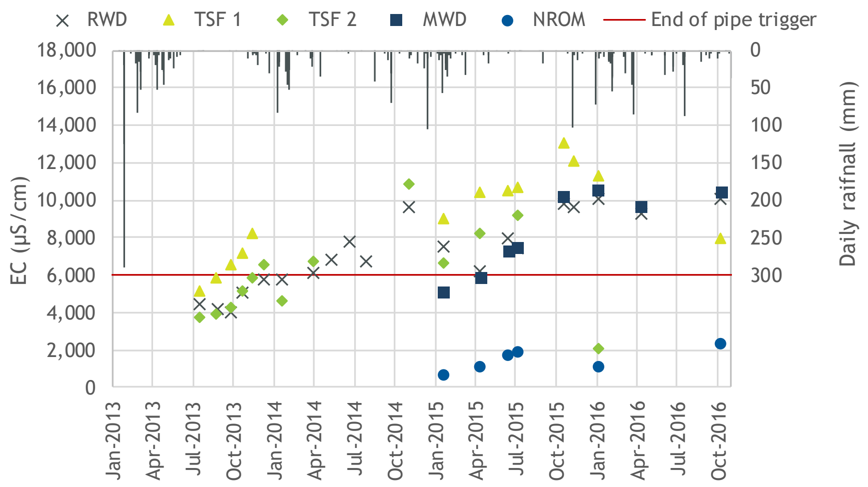
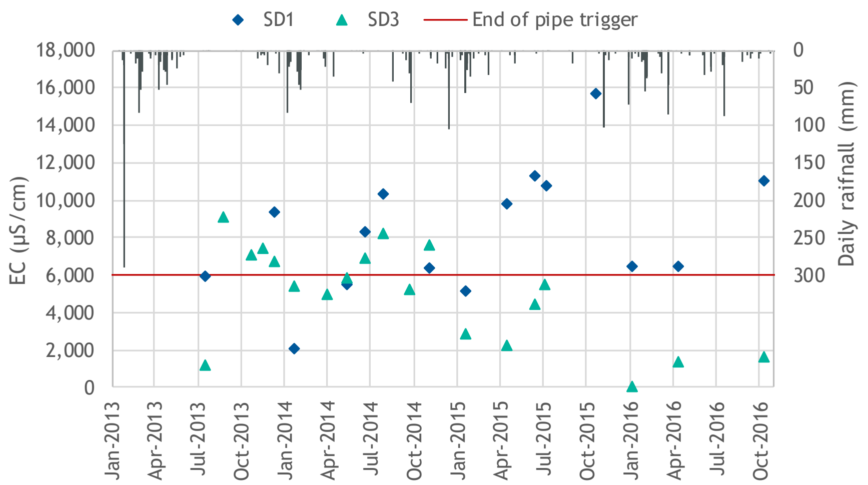


Figure A.3 - pH - On-site stormwater sediment dams



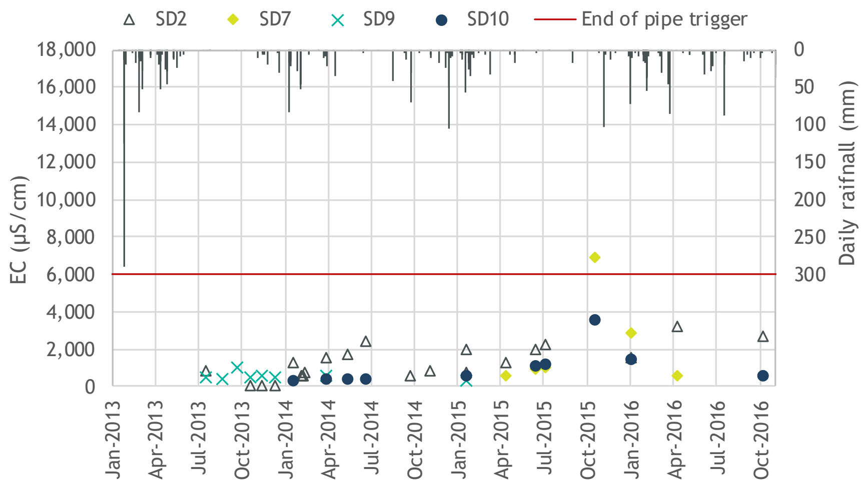
End of pipe trigger based on very high flow (see Table 4.4)

Figure A.4 - EC - Mine affected water dams



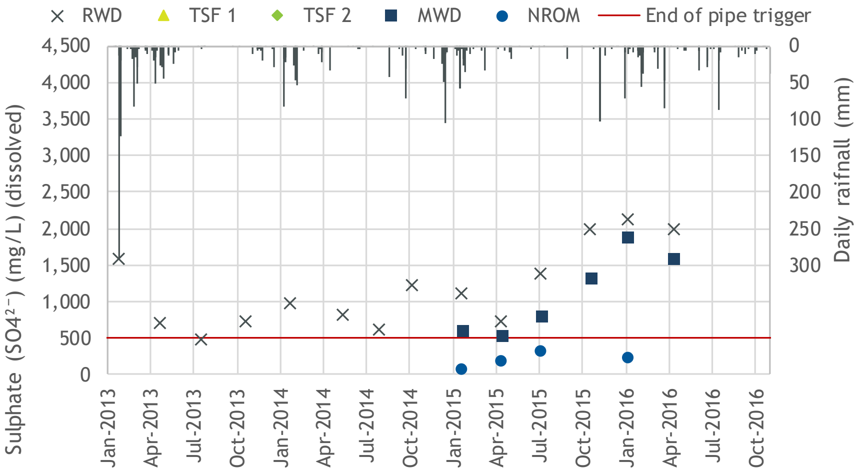
End of pipe trigger based on very high flow (see Table 4.4)

Figure A.5 - EC - Mine affected sediment dams



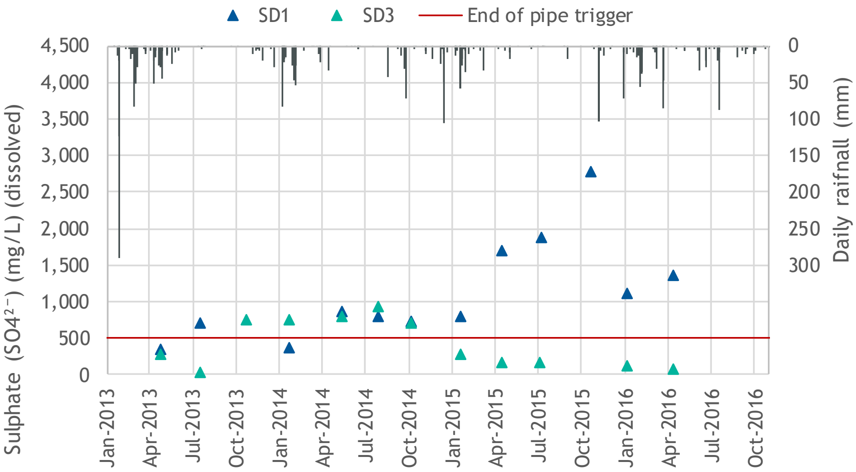
End of pipe trigger based on very high flow (see Table 4.4)

Figure A.6 - EC - On-site stormwater sediment dams



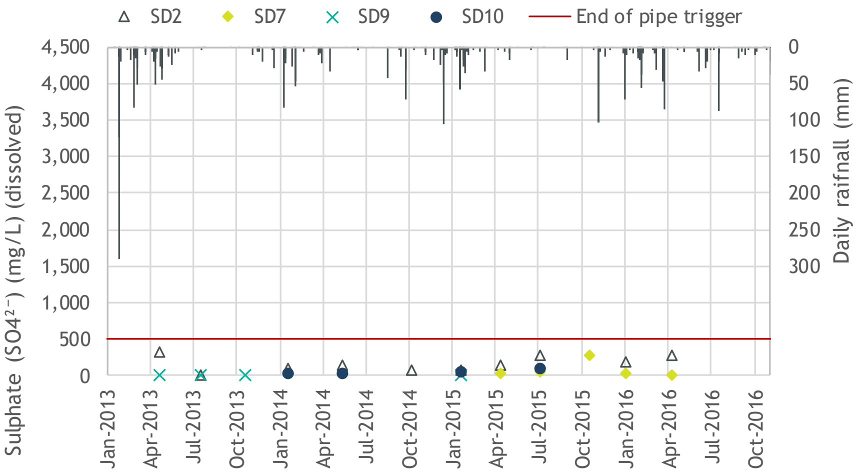
End of pipe trigger based on very high flow (see Table 4.4)

Figure A.7 - Suspended solids - Mine affected water dams



End of pipe trigger based on very high flow (see Table 4.4)

Figure A.8 - Suspended solids - Mine affected sediment dams



End of pipe trigger based on very high flow (see Table 4.4)

Figure A.9 - Suspended solids - On-site stormwater sediment dams

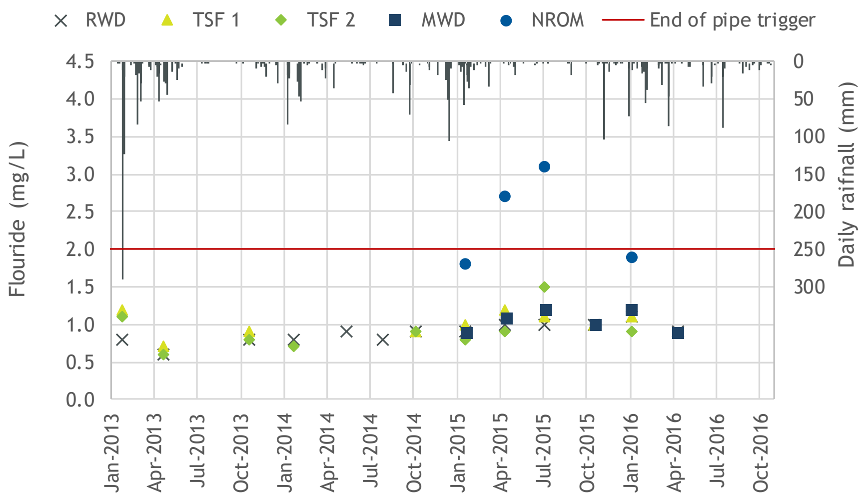


Figure A.10 - Fluoride- Mine affected water dams

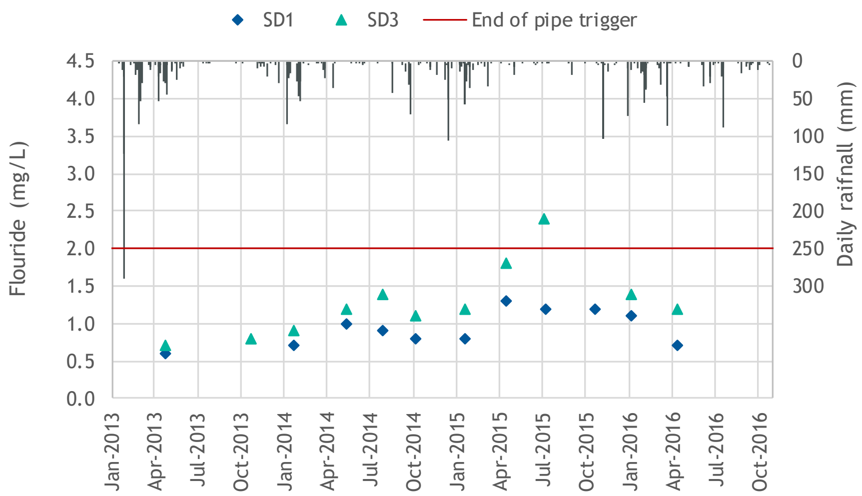


Figure A.11 - Fluoride - Mine affected sediment dams

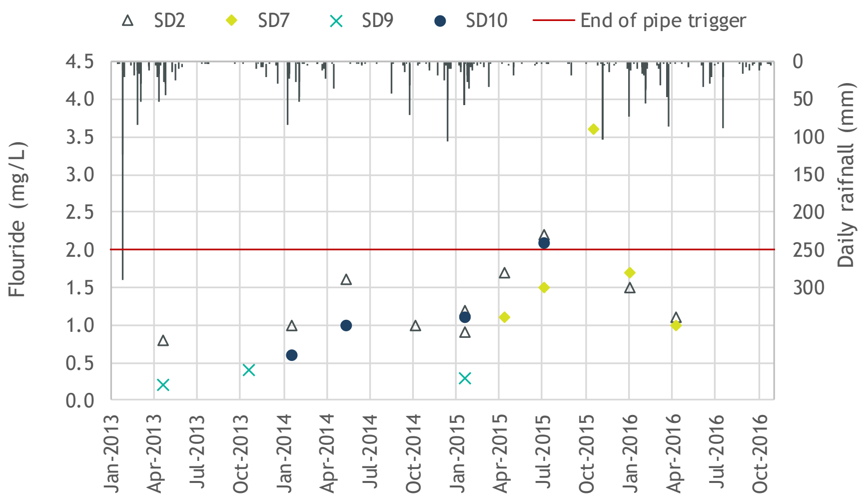


Figure A.12 - Fluoride - On-site stormwater sediment dams

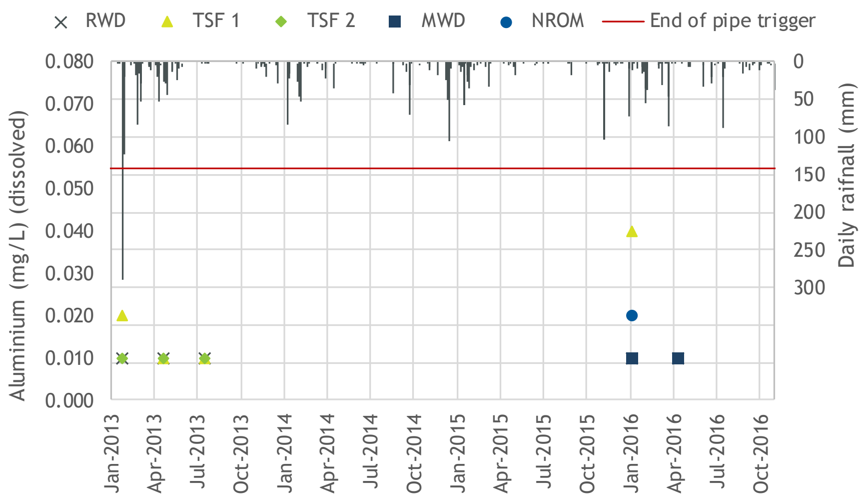


Figure A.13 - Aluminium (dissolved) - Mine affected water dams

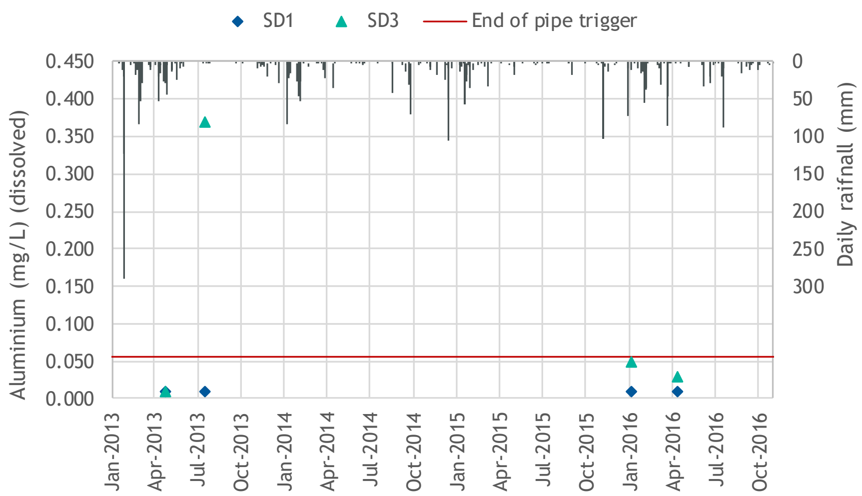


Figure A.14 - Aluminium (dissolved) - Mine affected sediment dams

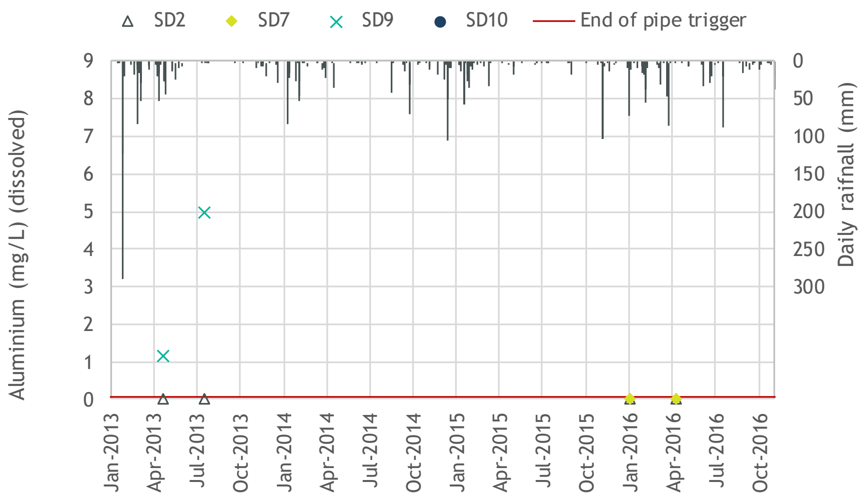


Figure A.15 - Aluminium (dissolved) - On-site stormwater sediment dams

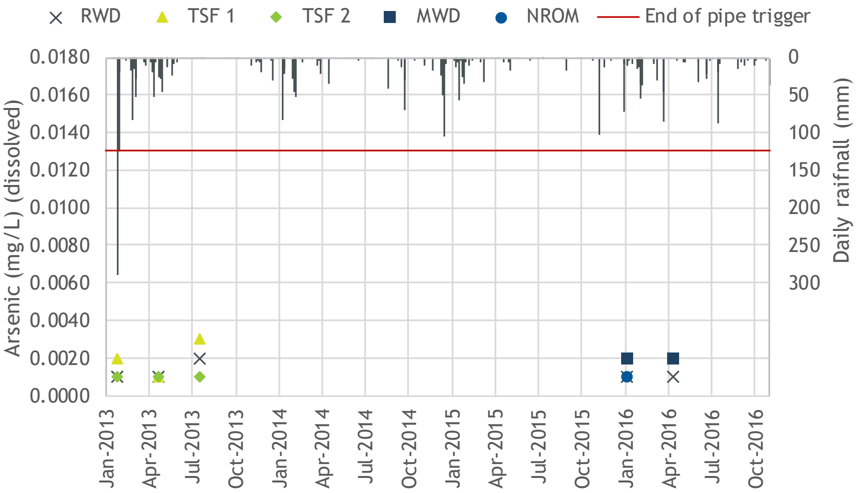


Figure A.16 - Arsenic (dissolved) - Mine affected water dams

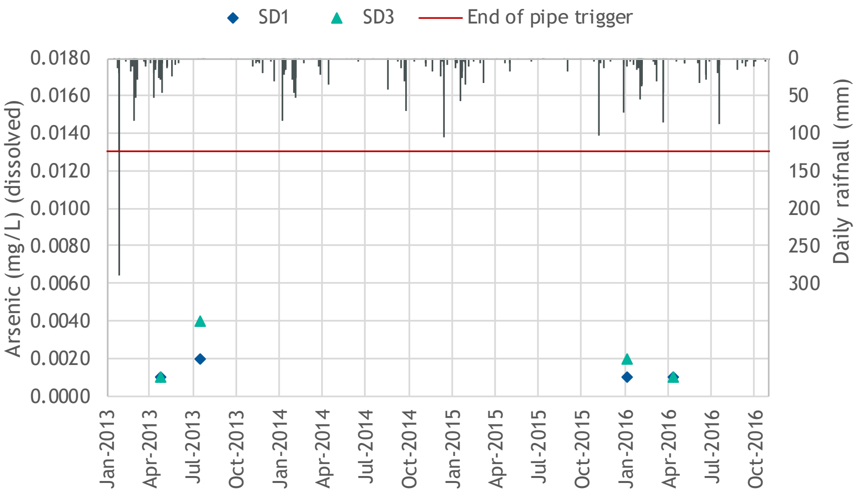


Figure A.17 - Arsenic (dissolved) - Mine affected sediment dams

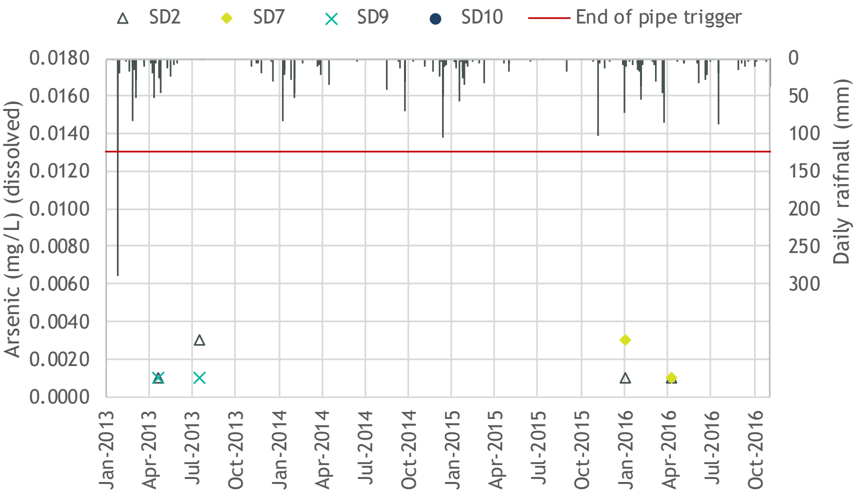


Figure A.18 - Arsenic (dissolved) - On-site stormwater sediment dams

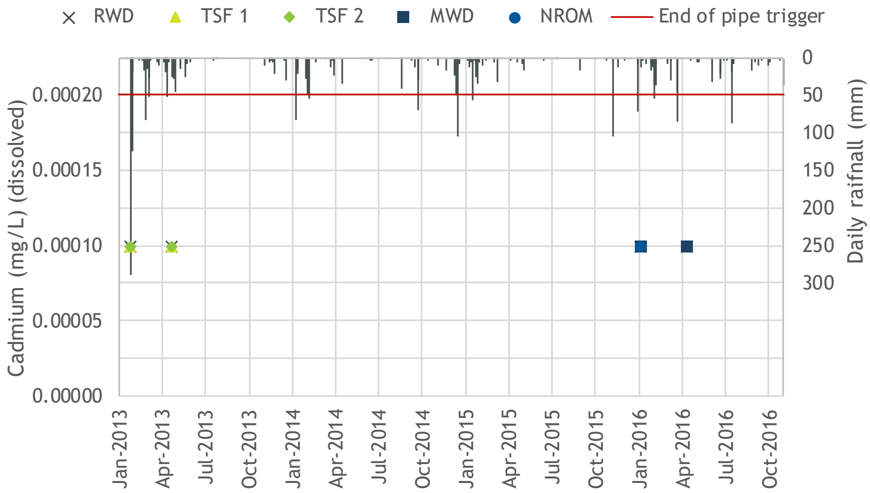


Figure A.19 - Cadmium (dissolved) - Mine affected water dams

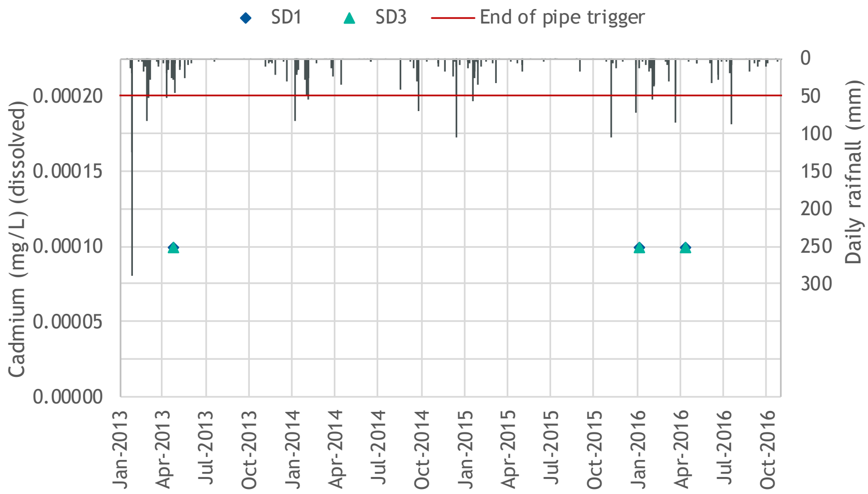


Figure A.20 - Cadmium (dissolved) - Mine affected sediment dams

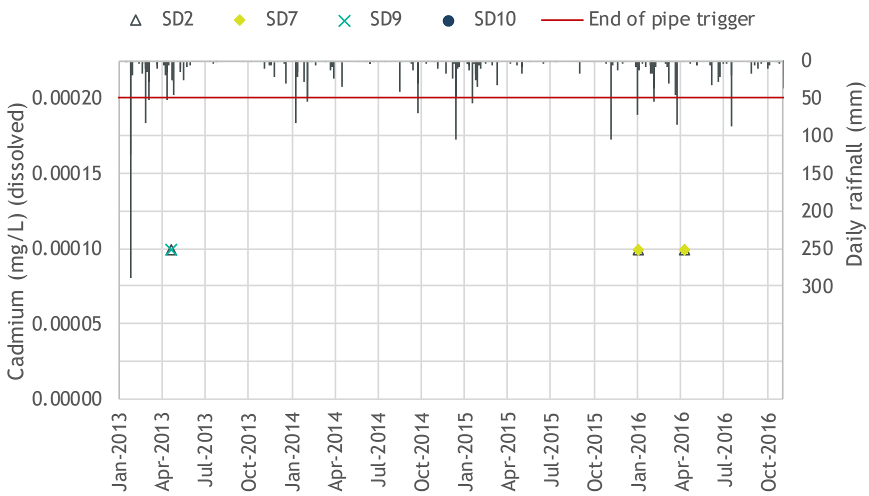


Figure A.21 - Cadmium (dissolved) - On-site stormwater sediment dams

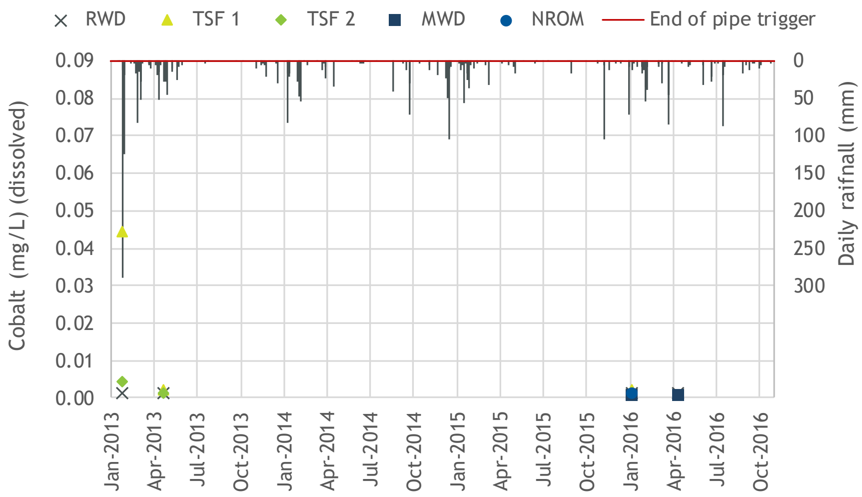


Figure A.22 - Cobalt (dissolved) - Mine affected water dams

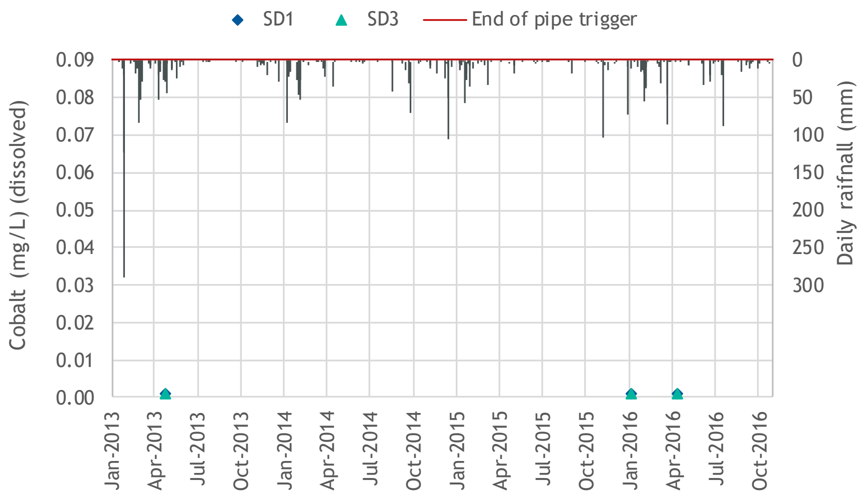


Figure A.23 - Cobalt (dissolved) - Mine affected sediment dams

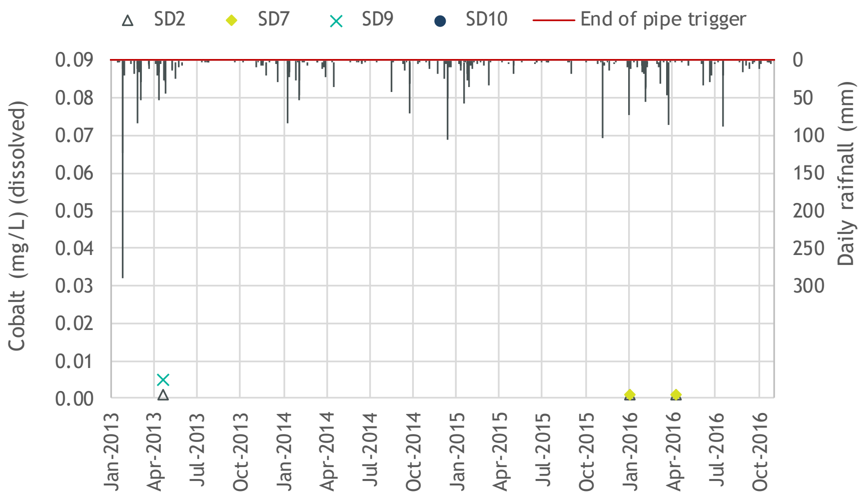


Figure A.24 - Cobalt (dissolved) - On-site stormwater sediment dams

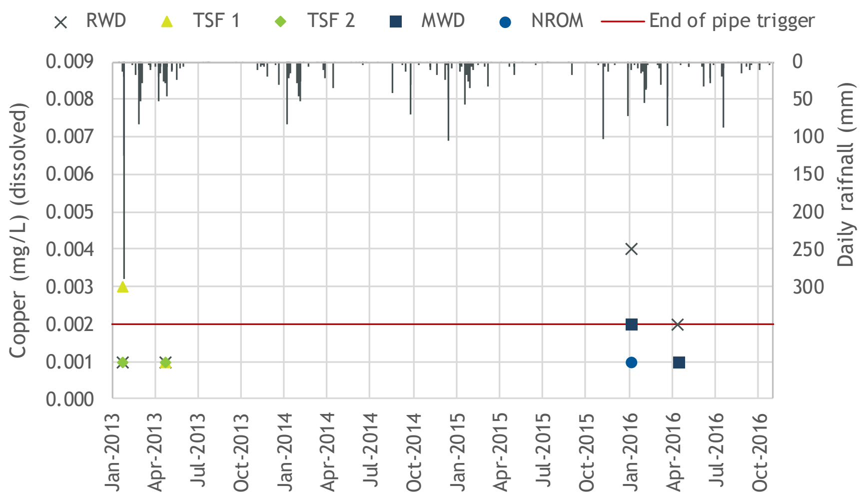


Figure A.25 - Copper (dissolved) - Mine affected water dams

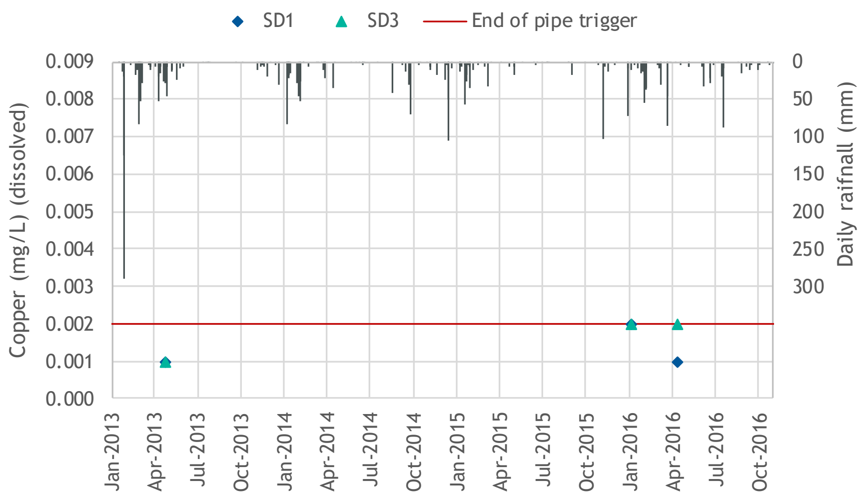


Figure A.26 - Copper (dissolved) - Mine affected sediment dams

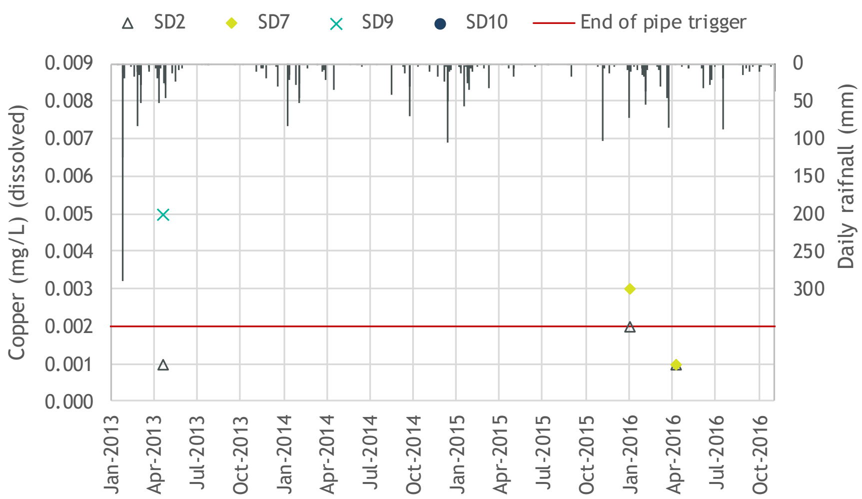


Figure A.27 - Copper (dissolved) - On-site stormwater sediment dams

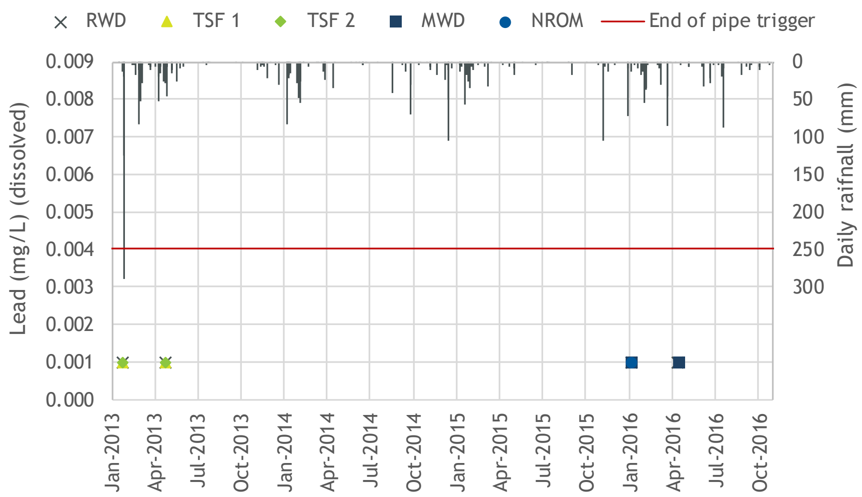


Figure A.28 - Lead (dissolved) - Mine affected water dams

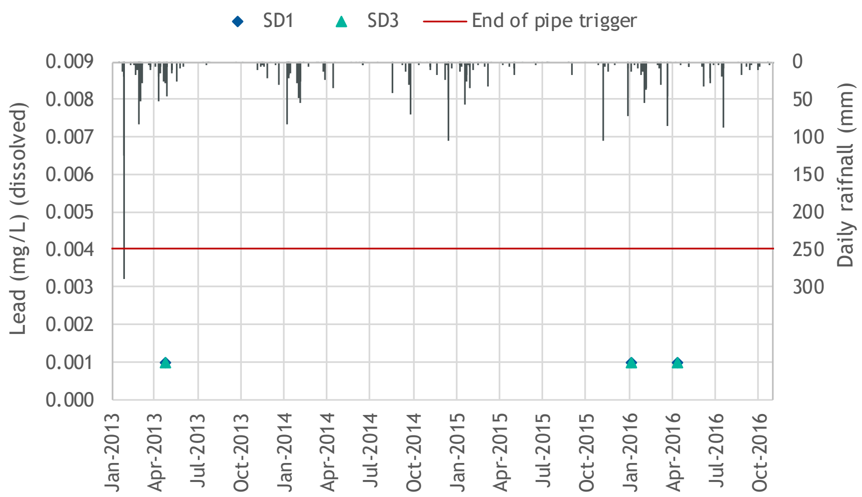


Figure A.29 - Lead (dissolved) - Mine affected sediment dams

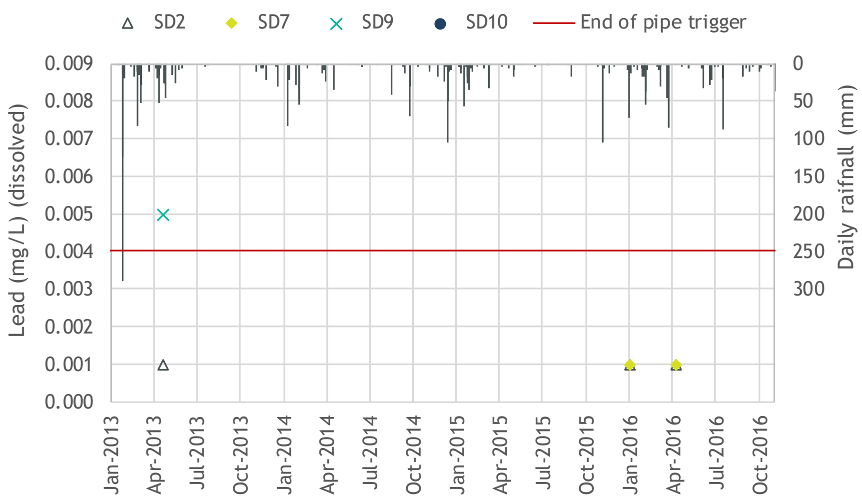


Figure A.30 - Lead (dissolved) - On-site stormwater sediment dams

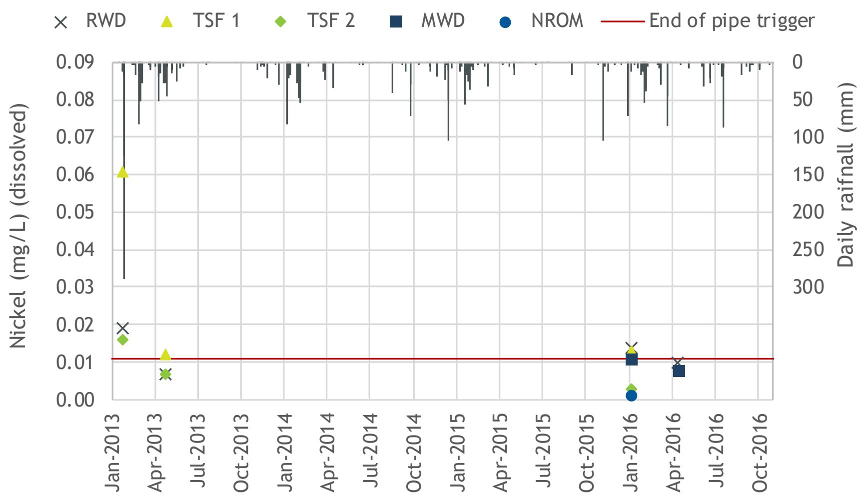


Figure A.31 - Nickel (dissolved) - Mine affected water dams

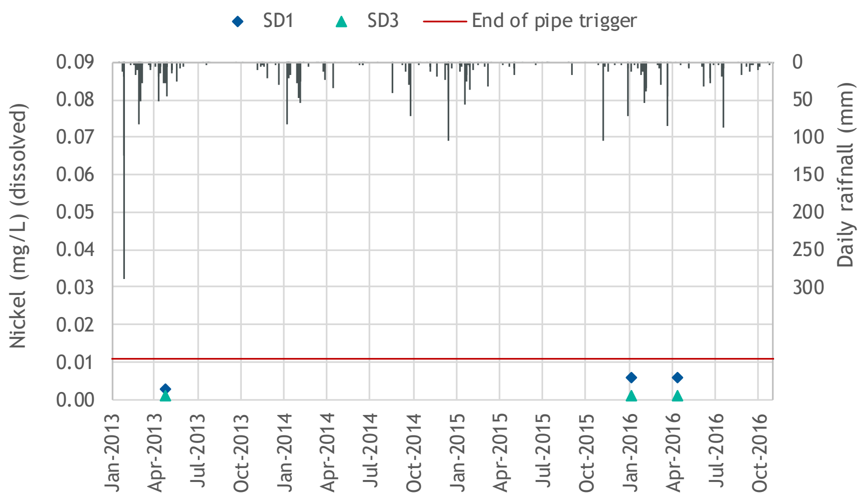


Figure A.32 - Nickel (dissolved) - Mine affected sediment dams

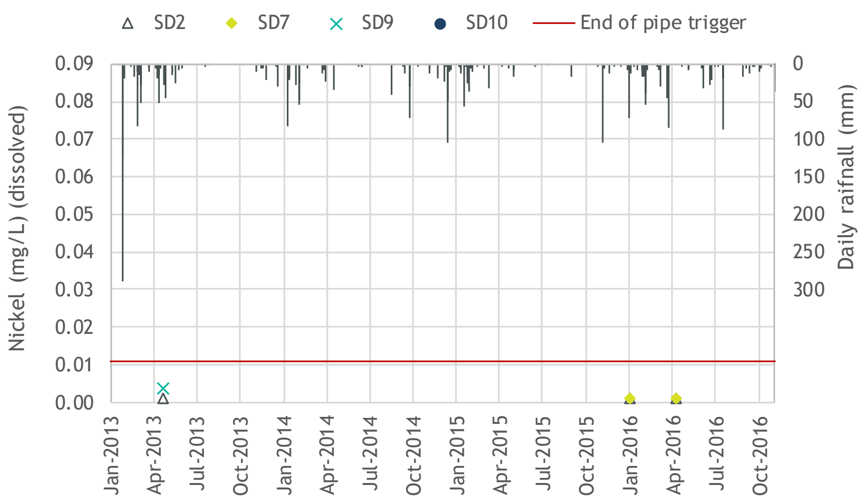


Figure A.33 - Nickel (dissolved) - On-site stormwater sediment dams

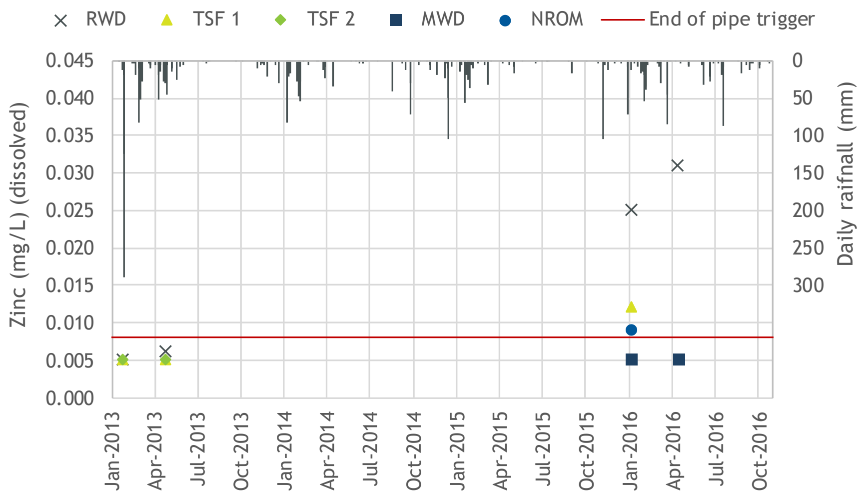


Figure A.34 - Zinc (dissolved) - Mine affected water dams

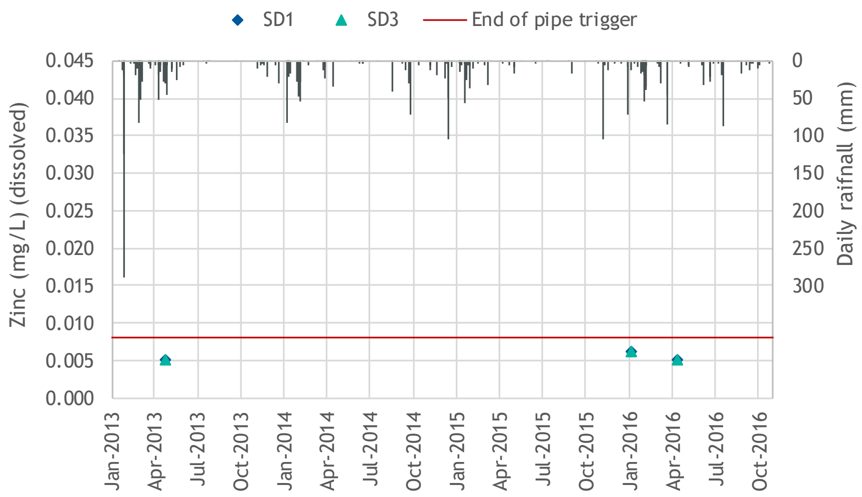


Figure A.35 - Zinc (dissolved) - Mine affected sediment dams

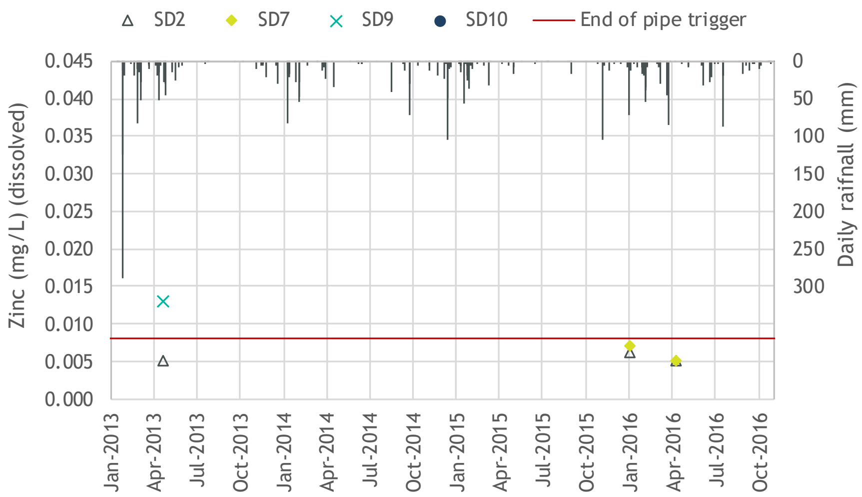


Figure A.36 - Zinc (dissolved) - On-site stormwater sediment dams

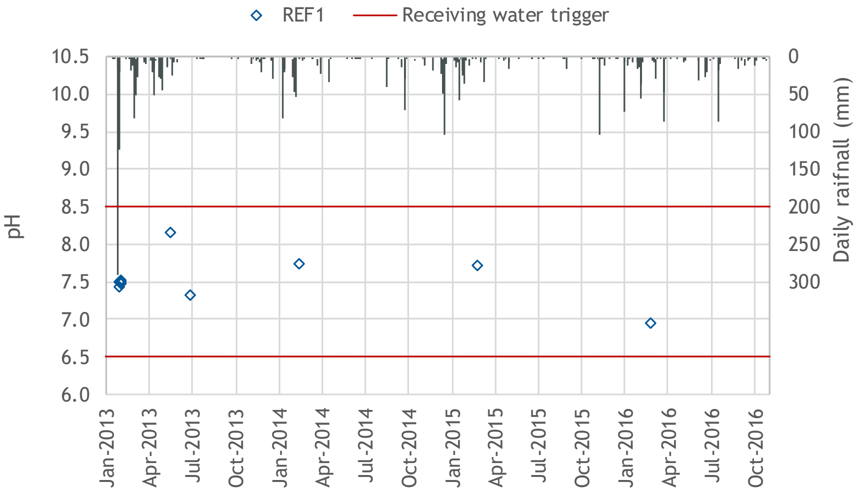


Figure A.37 - pH - Upstream surface water monitoring locations

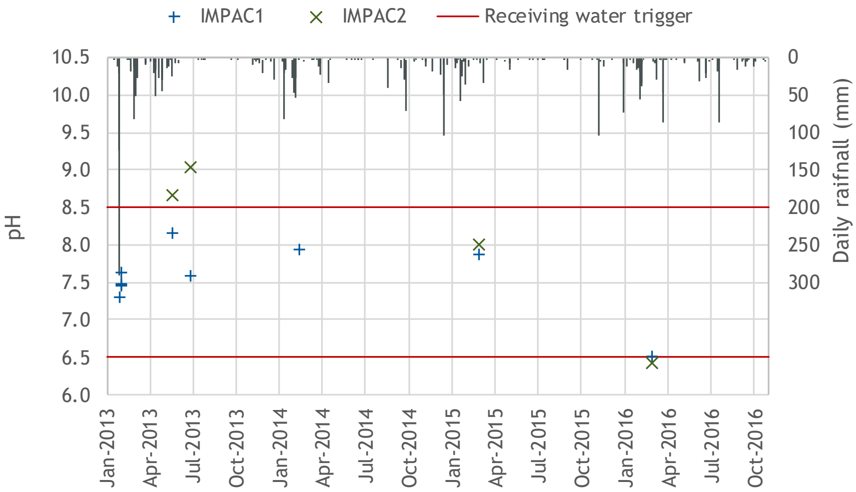
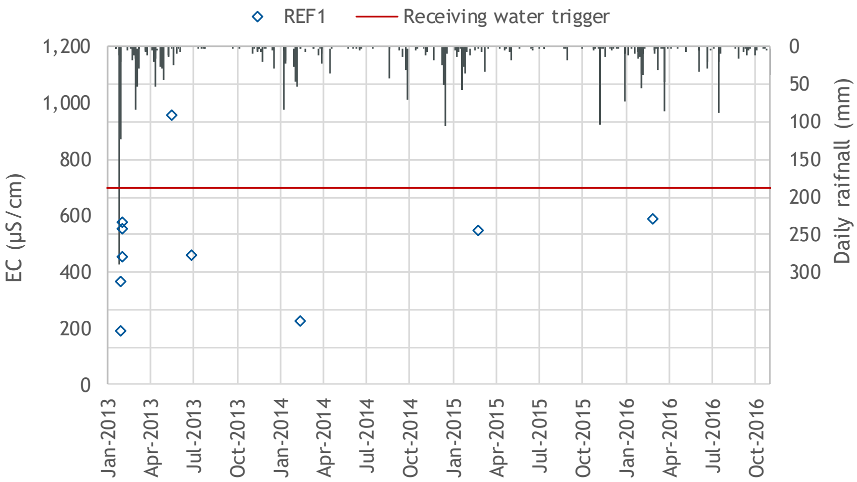
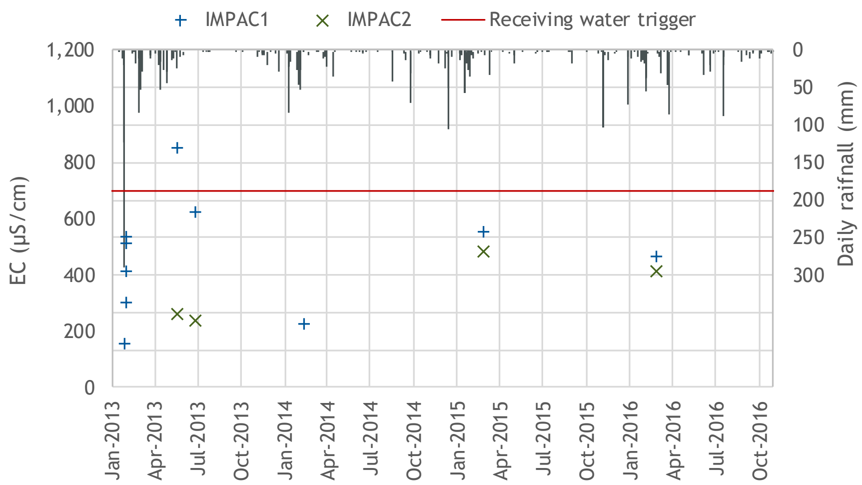


Figure A.38 - pH - Downstream surface water monitoring locations



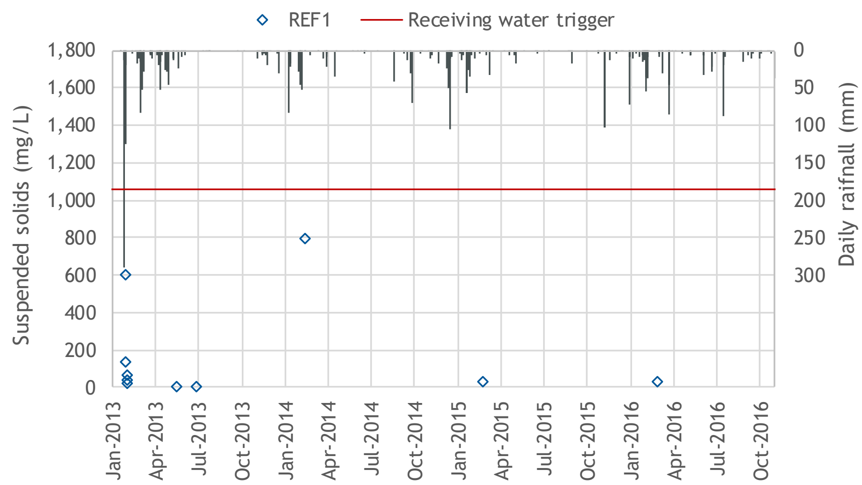
Receiving water trigger based on very high flow (see Table 4.4)

Figure A.39 - EC - Upstream surface water monitoring locations



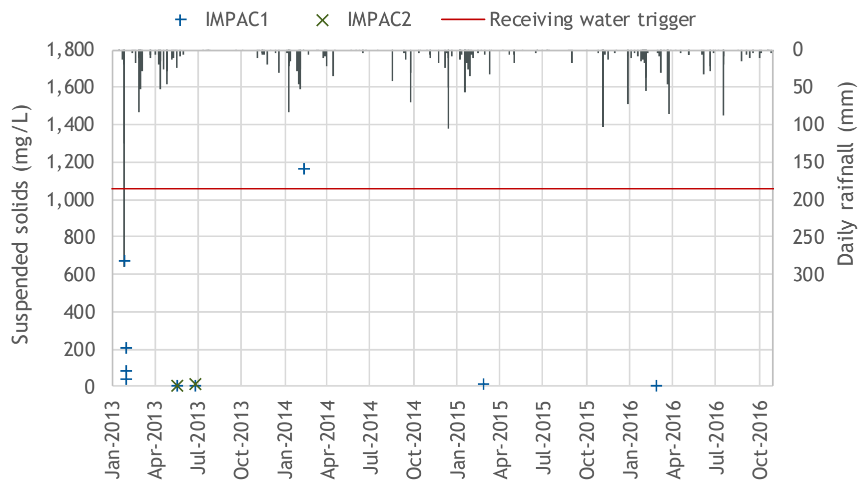
Receiving water trigger based on very high flow (see Table 4.4)

Figure A.40 - EC - Downstream surface water monitoring locations



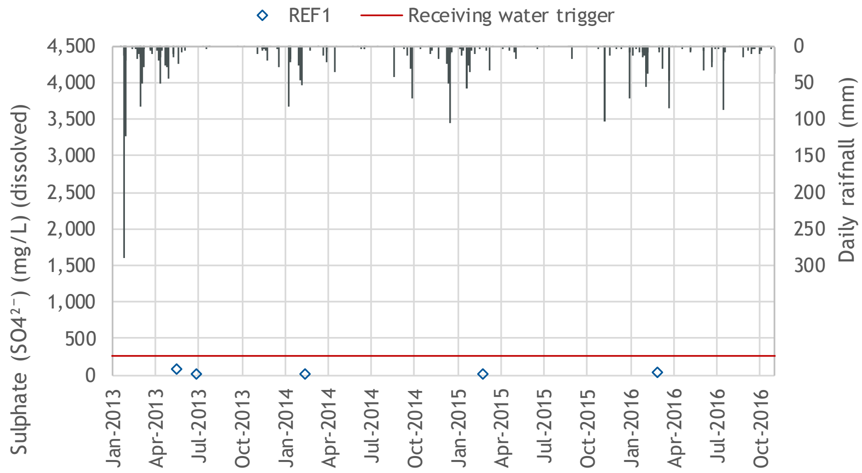
Receiving water trigger based on high flow (see Table 4.3)

Figure A.41 - Suspended solids - Upstream surface water monitoring locations



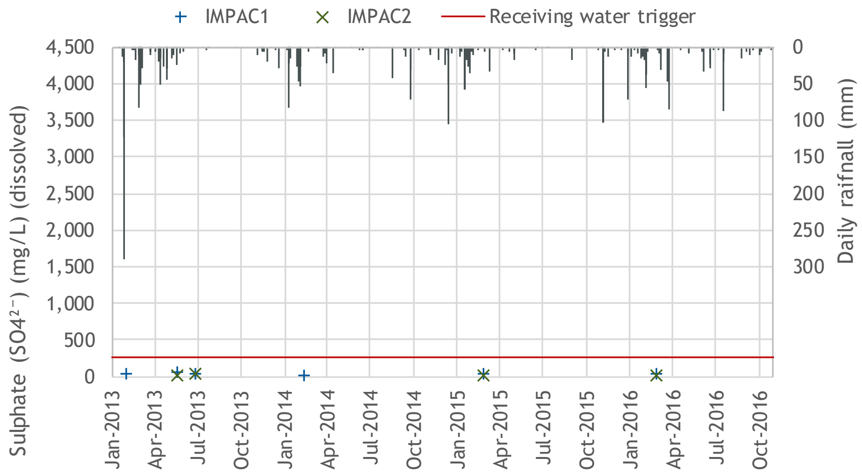
Receiving water trigger based on high flow (see Table 4.3)

Figure A.42 - Suspended solids - Downstream surface water monitoring locations



Receiving water trigger based on very high flow (see Table 4.4)

Figure A.43 - Sulphate - Upstream surface water monitoring locations



Receiving water trigger based on very high flow (see Table 4.4)

Figure A.44 - Sulphate - Downstream surface water monitoring locations

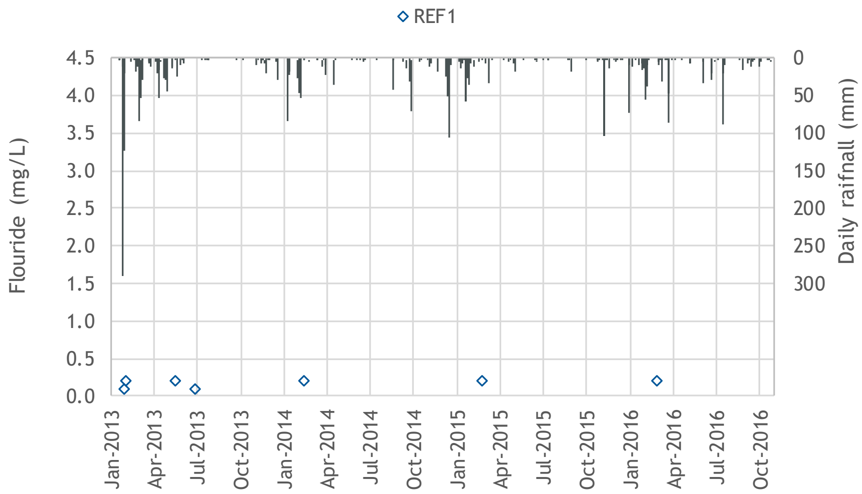


Figure A.45 - Fluoride - Upstream surface water monitoring locations

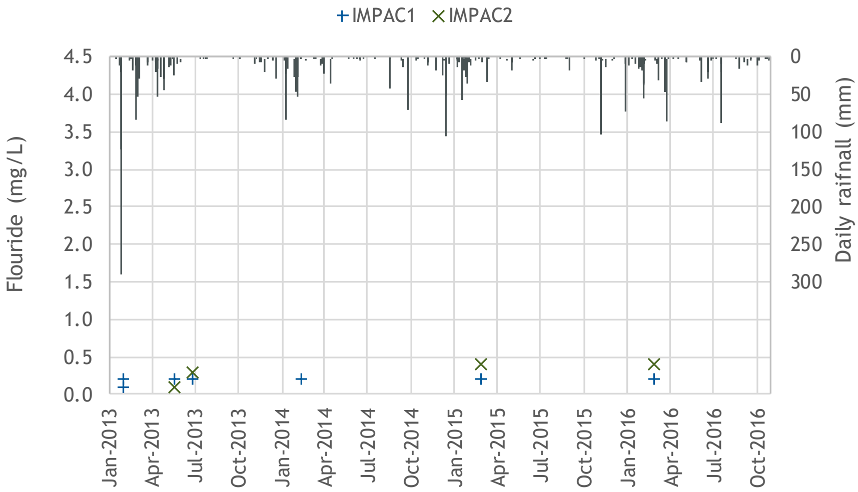


Figure A.46 - Fluoride - Downstream surface water monitoring locations

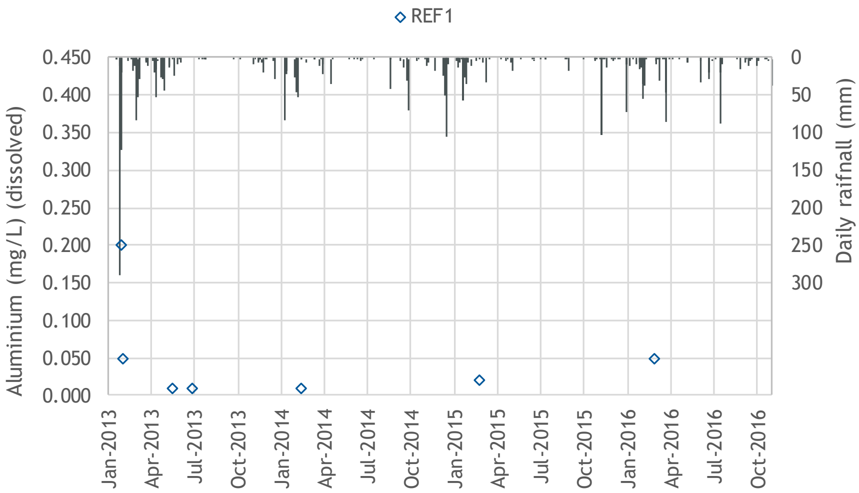


Figure A.47 - Aluminium (dissolved) - Upstream surface water monitoring locations

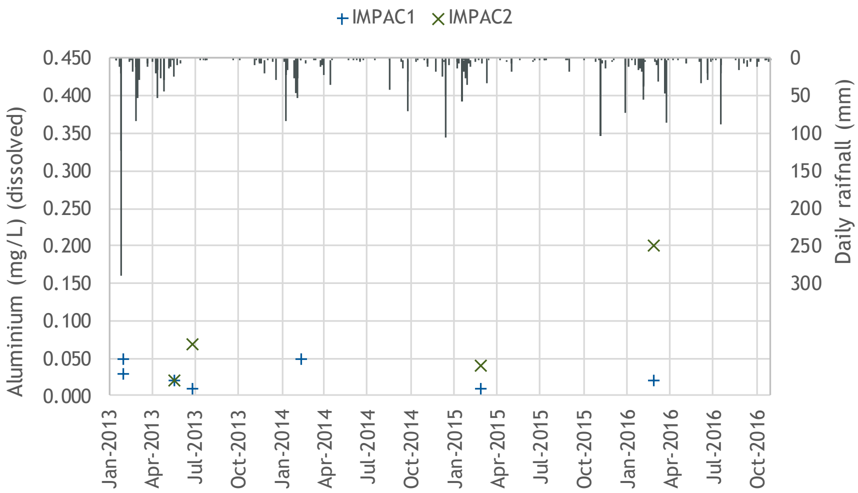


Figure A.48 - Aluminium (dissolved)- Downstream surface water monitoring locations

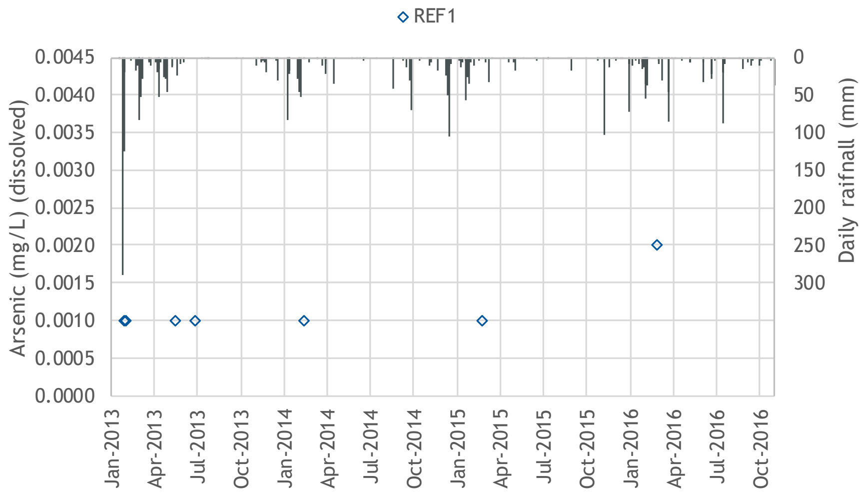


Figure A.49 - Arsenic (dissolved)- Upstream surface water monitoring locations

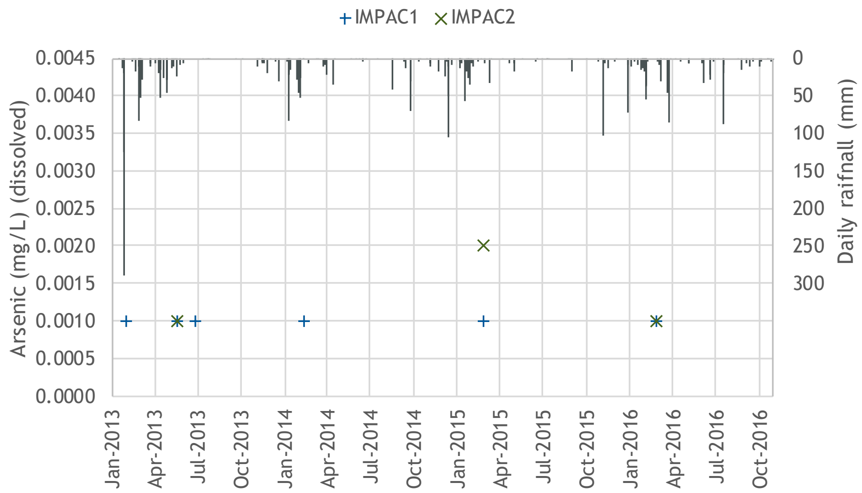


Figure A.50 - Arsenic (dissolved)- Downstream surface water monitoring locations

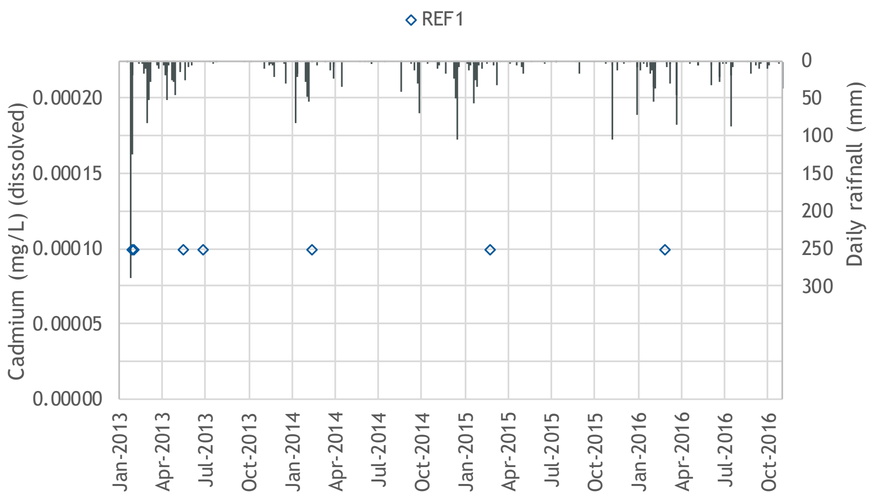


Figure A.51 - Cadmium (dissolved) - Upstream surface water monitoring locations

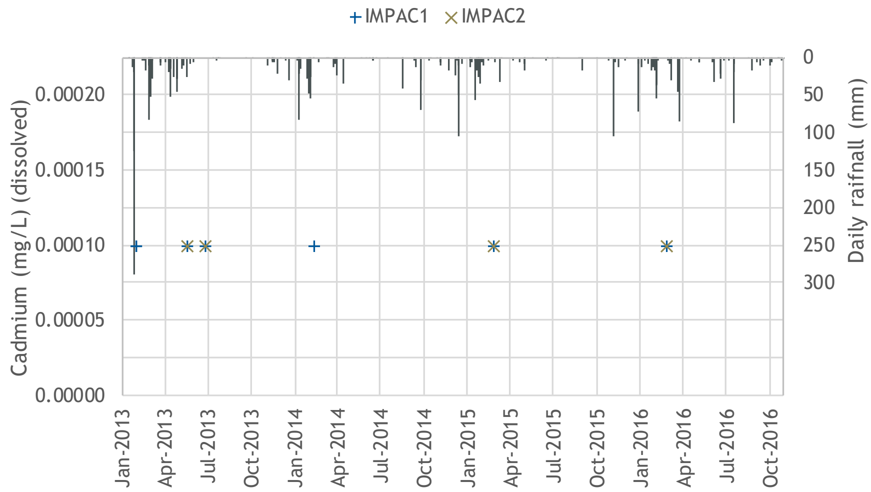


Figure A.52 - Cadmium (dissolved) - Downstream surface water monitoring locations

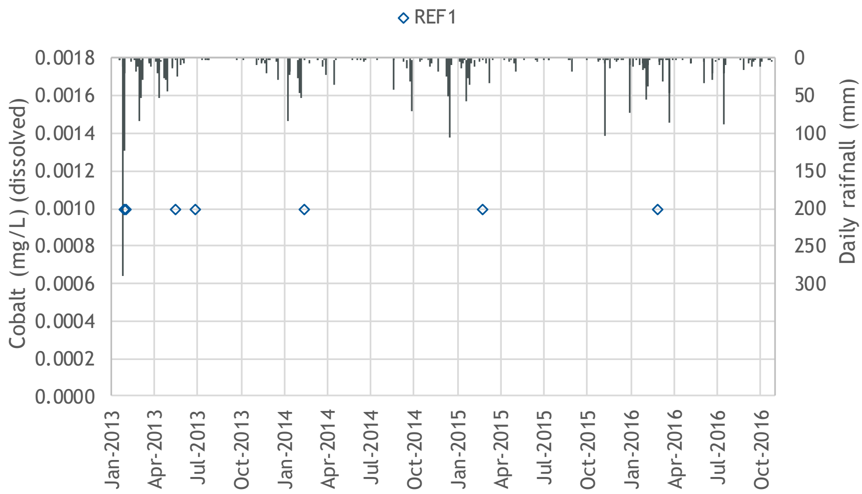


Figure A.53 - Cobalt (dissolved) - Upstream surface water monitoring locations

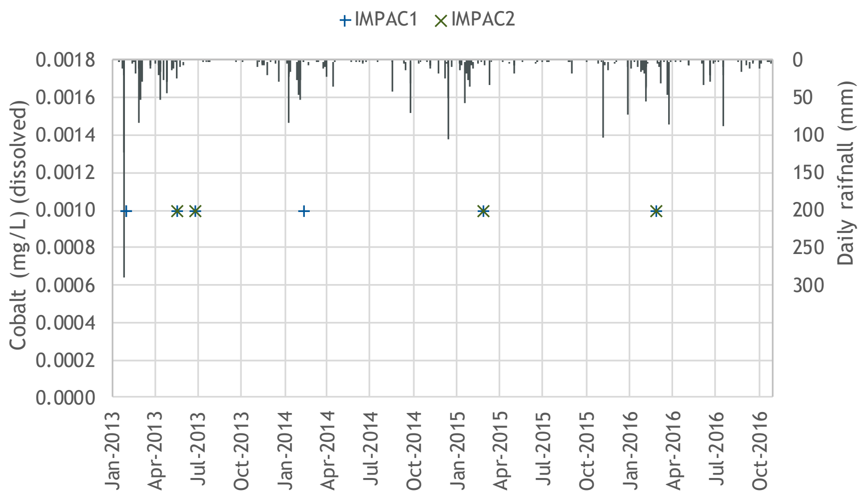


Figure A.54 - Cobalt (dissolved) - Downstream surface water monitoring locations

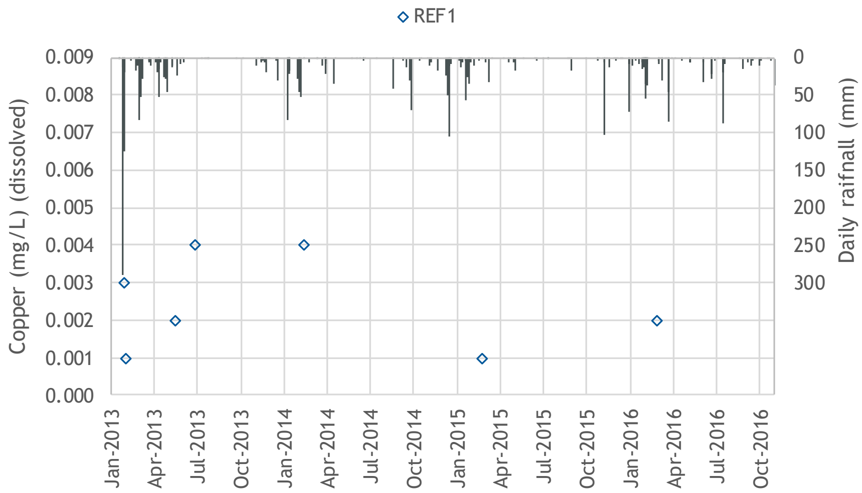


Figure A.55 - Copper (dissolved) - Upstream surface water monitoring locations

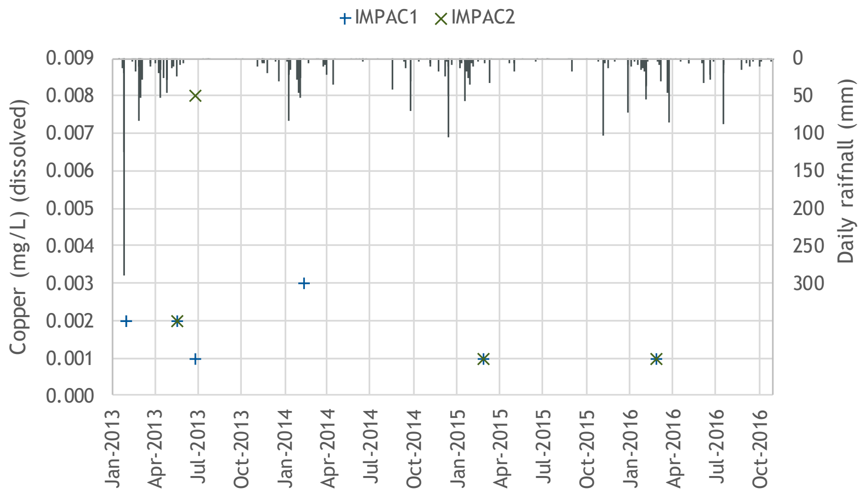


Figure A.56 - Copper (dissolved) - Downstream surface water monitoring locations

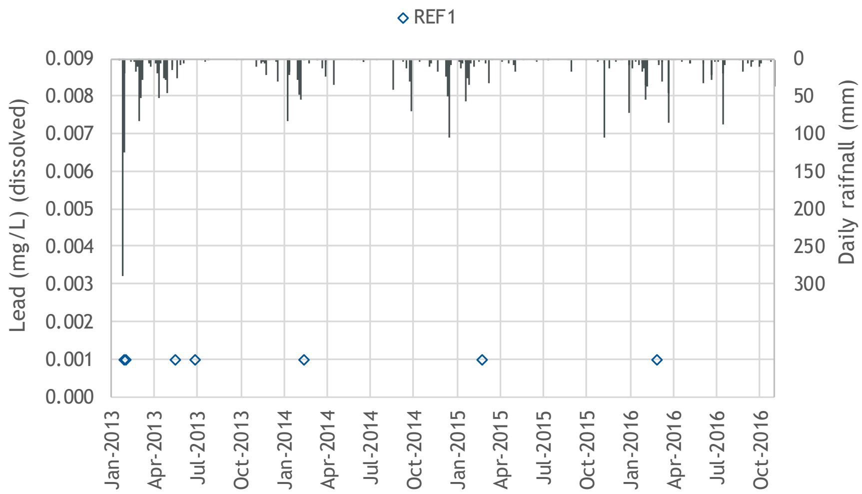


Figure A.57 - Lead (dissolved) - Upstream surface water monitoring locations

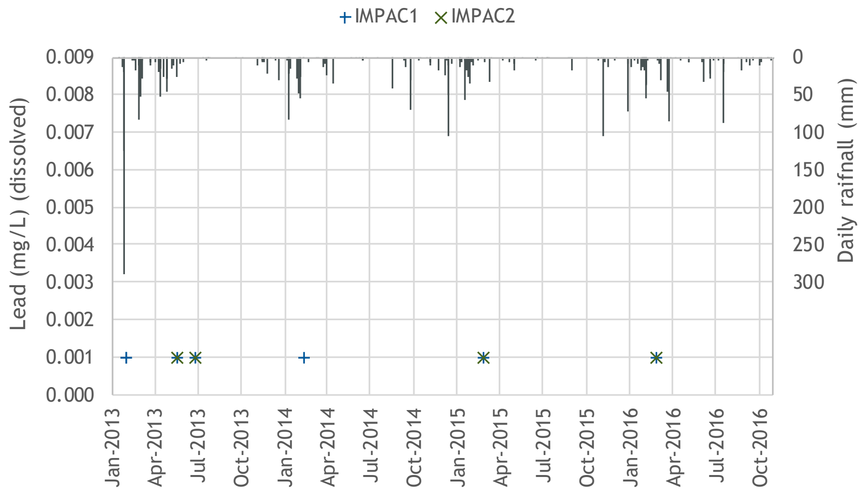


Figure A.58 - Lead (dissolved) - Downstream surface water monitoring locations

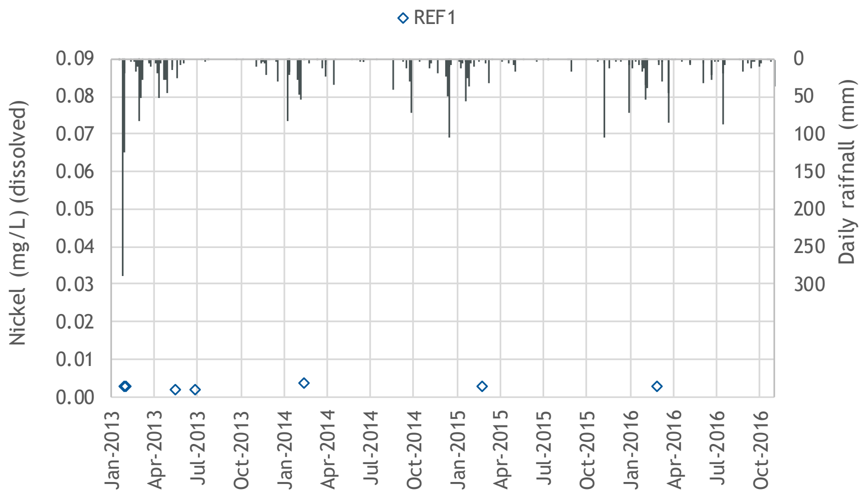


Figure A.59 - Nickel (dissolved) - Upstream surface water monitoring locations

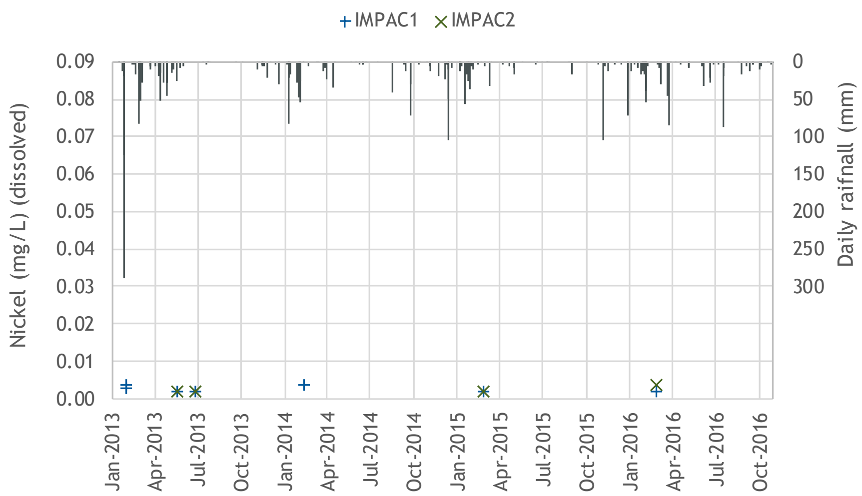


Figure A.60 - Nickel (dissolved) - Downstream surface water monitoring locations

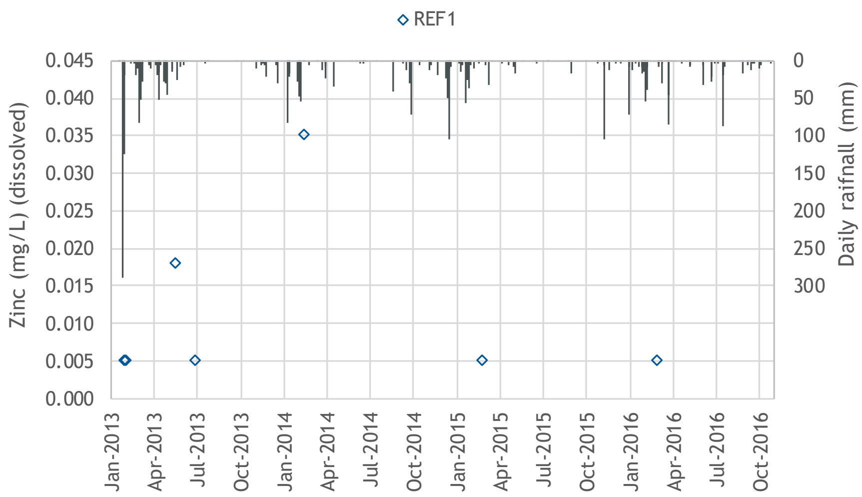


Figure A.61 - Zinc (dissolved) - Upstream surface water monitoring locations

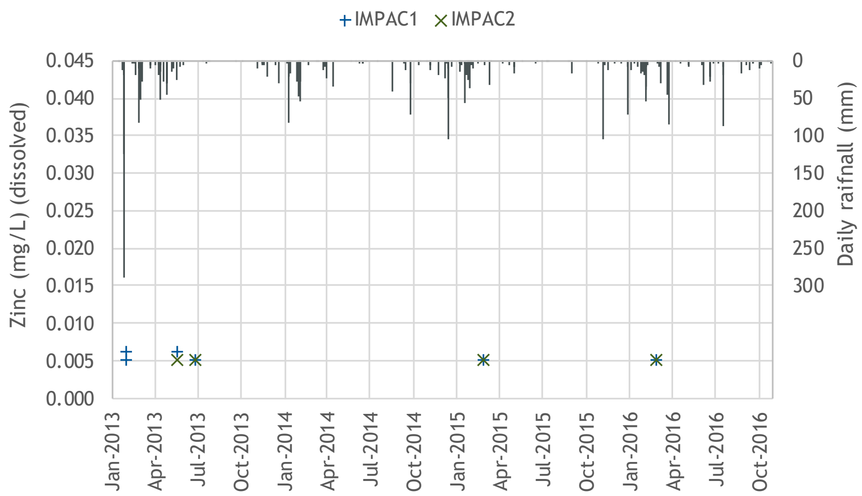


Figure A.62 - Zinc (dissolved) - Downstream surface water monitoring locations

Appendix B- Mine water balance model configuration

Contents

B1 Overview

A computer-based operational simulation model (OPSIM) was used to assess the dynamics of the water balance under varying rainfall and catchment conditions throughout the development of the Project. This model has been in operation since the conception of the mine and has been continually updated as data becomes available or mining operations have changed. The model will be continually updated throughout the life of the Project.

The OPSIM model dynamically simulates the operation of the water management system and keeps complete account of all site water volumes and representative water quality on a daily time step.

The model has been configured to simulate the operation of all major components of the water management system. The simulated inflows and outflows included in the model are given in Figure A.1.

Table B.1 - Simulated inflows and outflows to the mine affected water management system

Inflows	Outflows
Direct rainfall on water storage surfaces	Evaporation from water surface of storages
Catchment runoff	CHPP demand
Groundwater inflows	Dust suppression demand
External water supply (Anglo)	Vehicle wash down
	Offsite spills from storages
	Controlled Releases

B2 Climate data

Rainfall is recorded on a daily basis at Middlemount Coal Mine and is available from January 2008 to July 2017. This dataset is too short for water balance model forecasting and therefore regional data is required to provide a long-term rainfall dataset.

A representative long-term rainfall dataset was obtained was obtained from the Queensland Government Department of Science, Information Technology and Innovation (DSITI) Datadrill service for the period January 1889 to December 2017 (129 years)(DSITI, 2017). Morton's Lake evaporation has been used to estimate evaporation losses from storages.

Table A.2 shows the long-term monthly averages for Morton's Lake evaporation and monthly Datadrill rainfall data.

Figure A.1 shows the annual distribution of average monthly rainfall and evaporation from the Datadrill dataset. The evaporation pattern indicates higher evaporation in the warmer months and less evaporation in the colder months. The rainfall pattern shows most rainfall occurring during the summer months. Mean monthly evaporation is significantly higher than mean monthly rainfall throughout the year.

Table B.2 - Long-term average rainfall and evaporation (1889 - 2017)

Month	SILO Datadrill rainfall (mm)	Morton's Lake evaporation (mm)
January	116.6	202.1
February	97.7	170.2
March	66.6	170.2
April	32.7	133.9
May	29.9	102.2
June	31.1	81.0
July	23.9	90.9
August	19.2	118.1
September	18.5	151.0
October	35.6	188.1
November	55.6	199.8
December	97.1	211.8
TOTAL	**625**	**1,819**

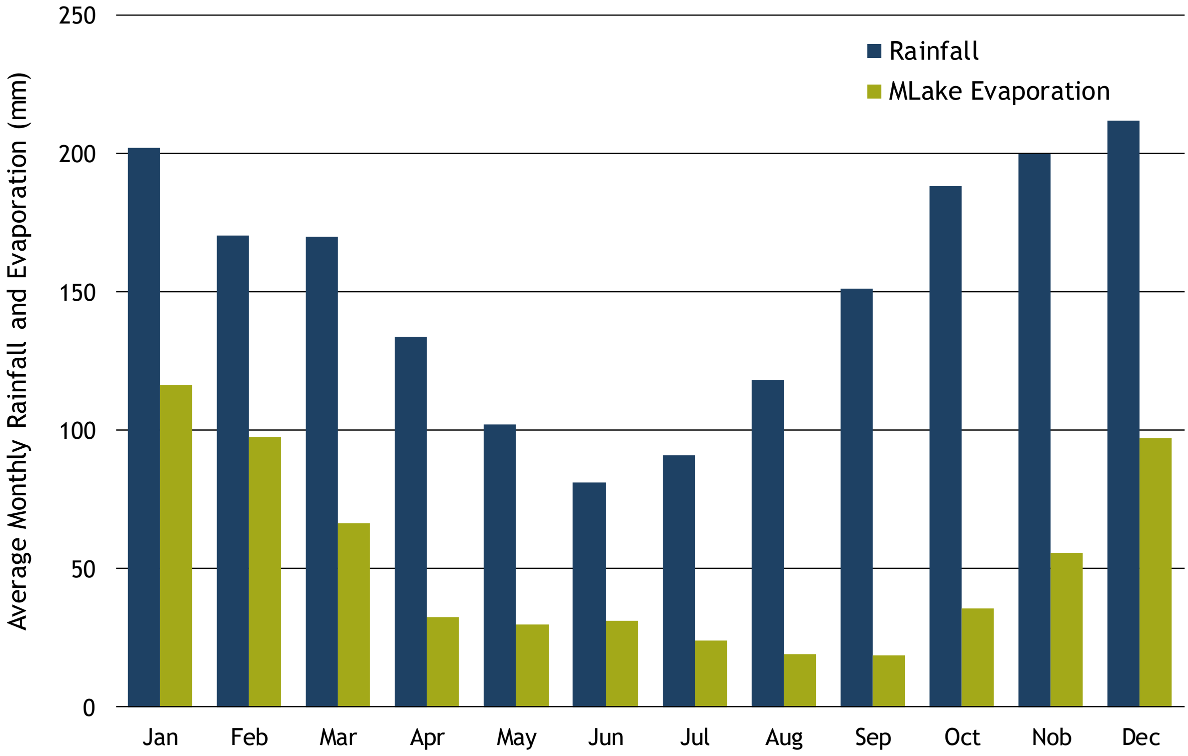


Figure B.1 - Distribution of monthly rainfall and evaporation (Data source: DSITI, 2017)

B3 Simulation methodology

The simulation used the 'forecast' simulation method in OPSIM. The model was run on a daily timestep for 20 years, to match the operational phase of the mine life, and incorporated five different representative Phases of the mine life. Although the catchment areas will continuously change as the mine progresses, the adopted approach of modelling discrete Phases will provide a reasonable representation of site conditions over the 20 year period. The adopted model Phases are summarised in Table A.3.

Table B.3 - Adopted model phases

Representative mine phase	Applied range of mine life	Phase duration
Phase 1	Year 2018 - 2021	4 years
Phase 2	Year 2022 - 2025	4 years
Phase 3	Year 2026 – 2030	5 years
Phase 4	Year 2031 – 2035	5 years
Phase 5	Year 2036 - 2037	2 years

The forecast simulation type allows the model configuration to change over the modelled 20 years by linking the representative phases, reflecting variations in the water management system over time such as catchment area, production and groundwater inflows.

The changes in the physical layout and site catchment areas are provided in Section A4. The adopted operating rules for the water balance model assessment are summarised in Table A.9.

To assess the effects of varying climatic conditions, the forecast model was run for 109 realisations (with each realisation corresponding to the 20-year mine life), using 129 years of climatic data available from January 1889 to December 2017. A different rainfall input sequence is applied to each realisation. The first realisation adopts climatic data from 1889 to 1908, the second from 1890 to 1909 and so on through the 129 years of simulated climatic data. A percentile analysis of the resultant realisations can then be undertaken at user-defined confidence intervals to assess the behaviour of the various storages over extended dry and wet periods, reflecting the full range of climatic conditions experienced in the last 129 years.

B4 Catchment area and land use classifications

To adequately simulate the site water balance, the mine site catchments were classified as either:

- Undisturbed, representing natural areas;
- Roads / hardstand, representing coal stockpile areas and mine infrastructure such as haul roads and plant area;
- Mining pit, representing the pit floor;
- Spoil dump, representing uncompacted dumped overburden material;
- Rehabilitated spoil, representing both initial and established rehabilitation areas;
- Tailings, representing the surface area of the TSF's / flocculation cells; and
- Cleared, representing pre-strip areas ahead of mining.

Catchment areas and associated land use classifications within the mine have been determined from topographic mapping (dated June 2017), aerial photography (dated June 2017) and plans of operations disturbance areas for each mine phase provided by Middlemount Coal Pty Ltd.

Figure A.2 to Figure A.6 shows the locations of catchment areas and land use classifications for the water balance model, which have been summarised in Table A.4 to Table A.8.

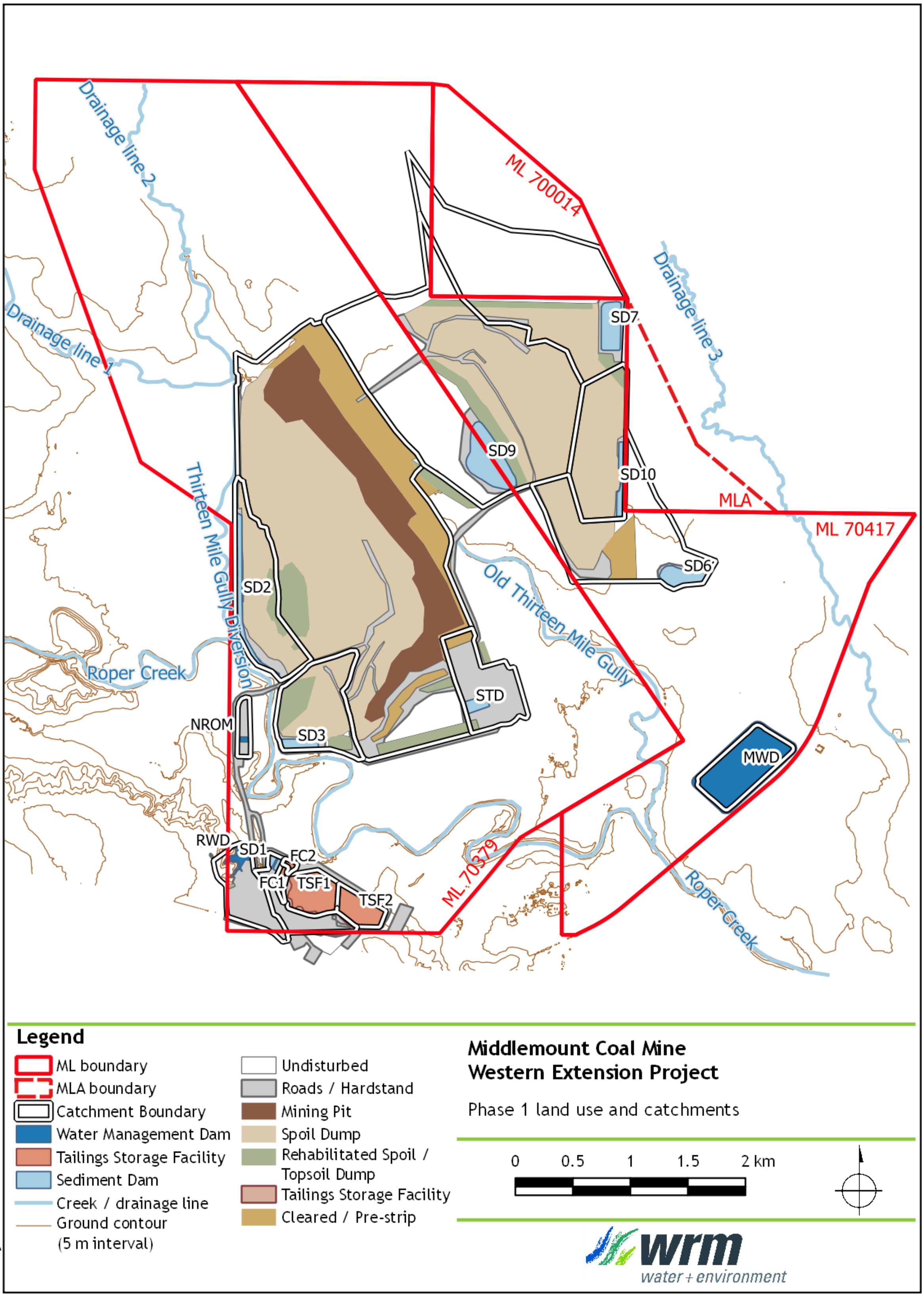


Figure B.2 – Catchment and land use breakdown – Phase 1

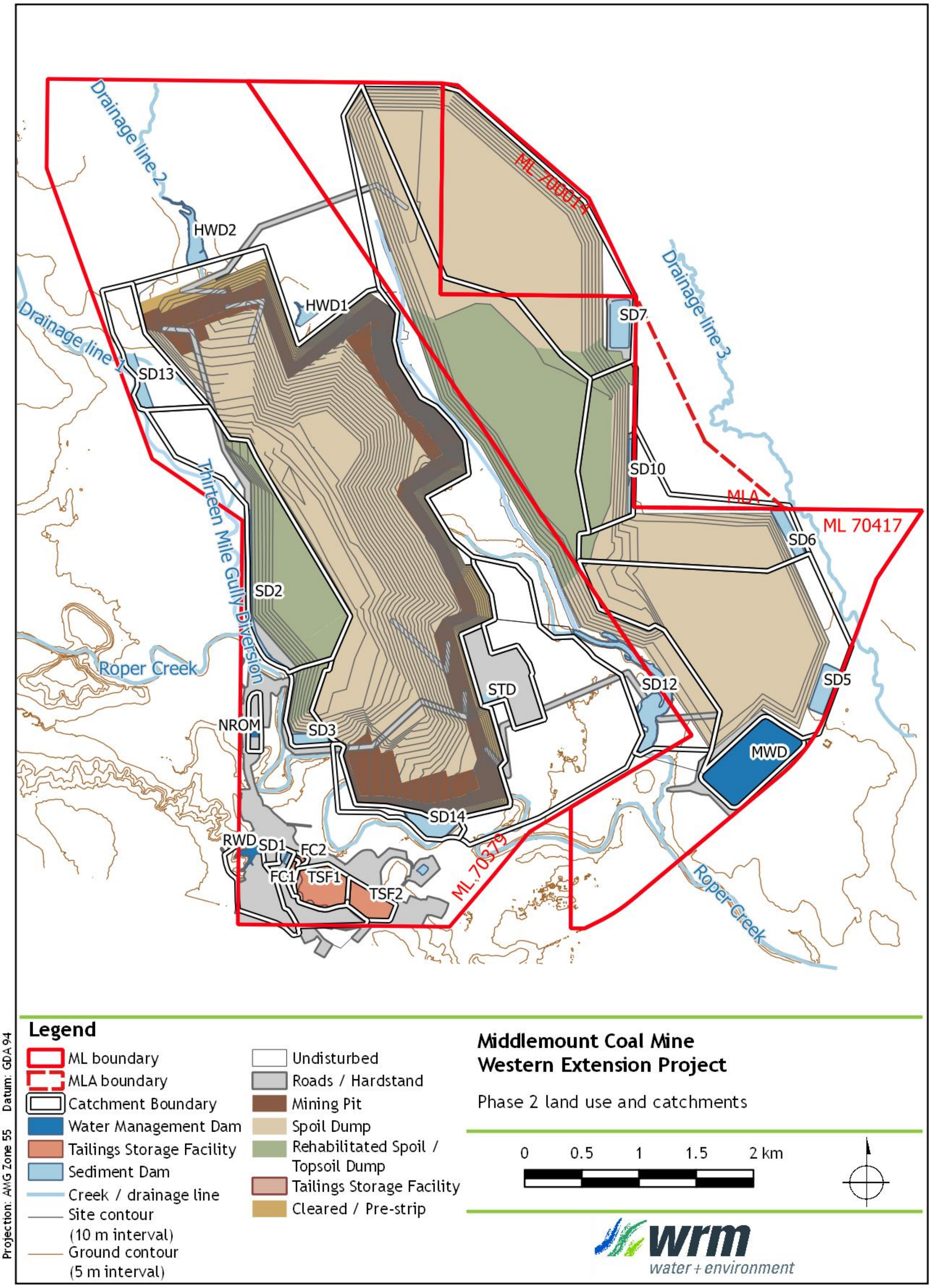


Figure B.3 – Catchment and land use breakdown – Phase 2

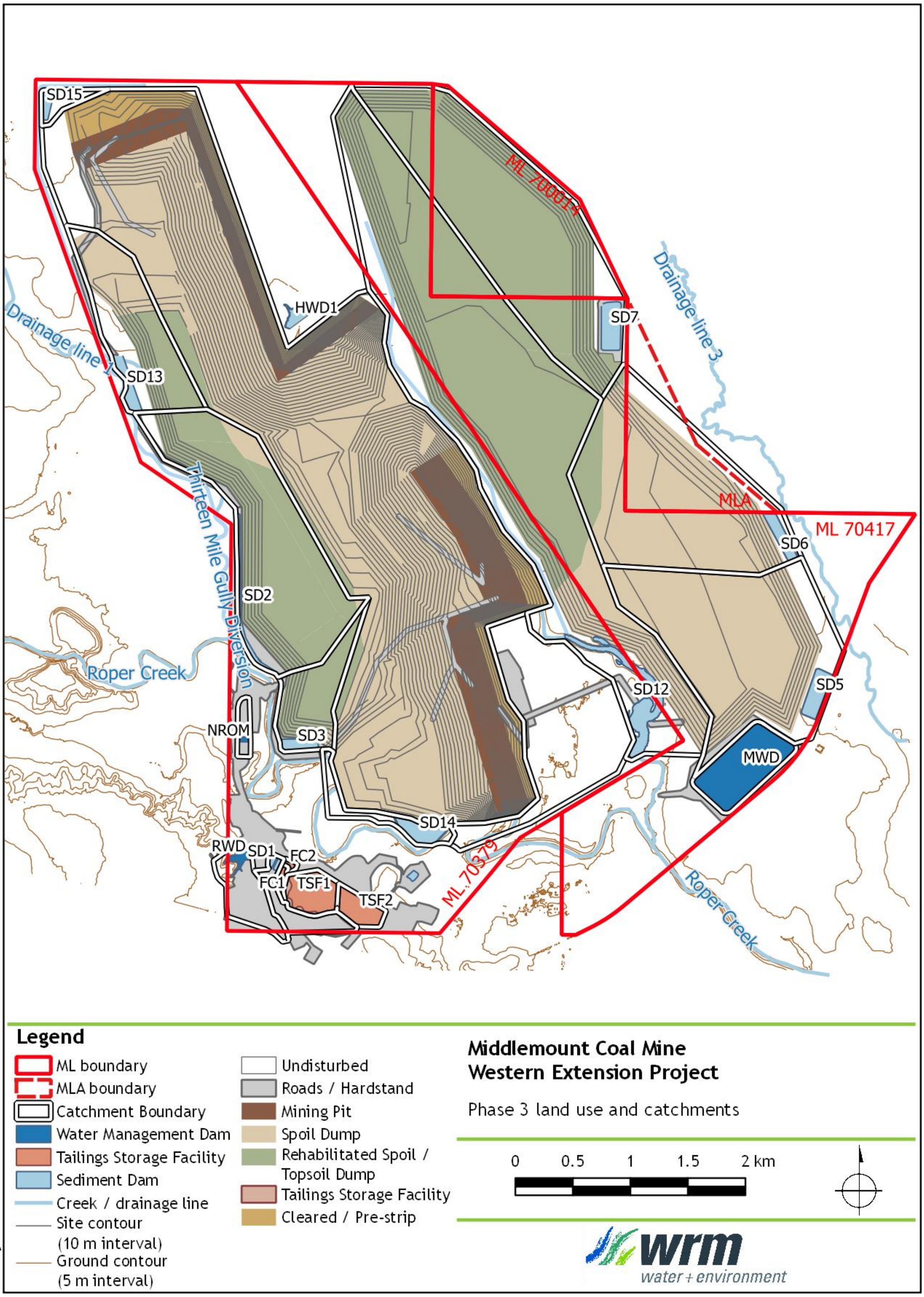


Figure B.4 – Catchment and land use breakdown – Phase 3

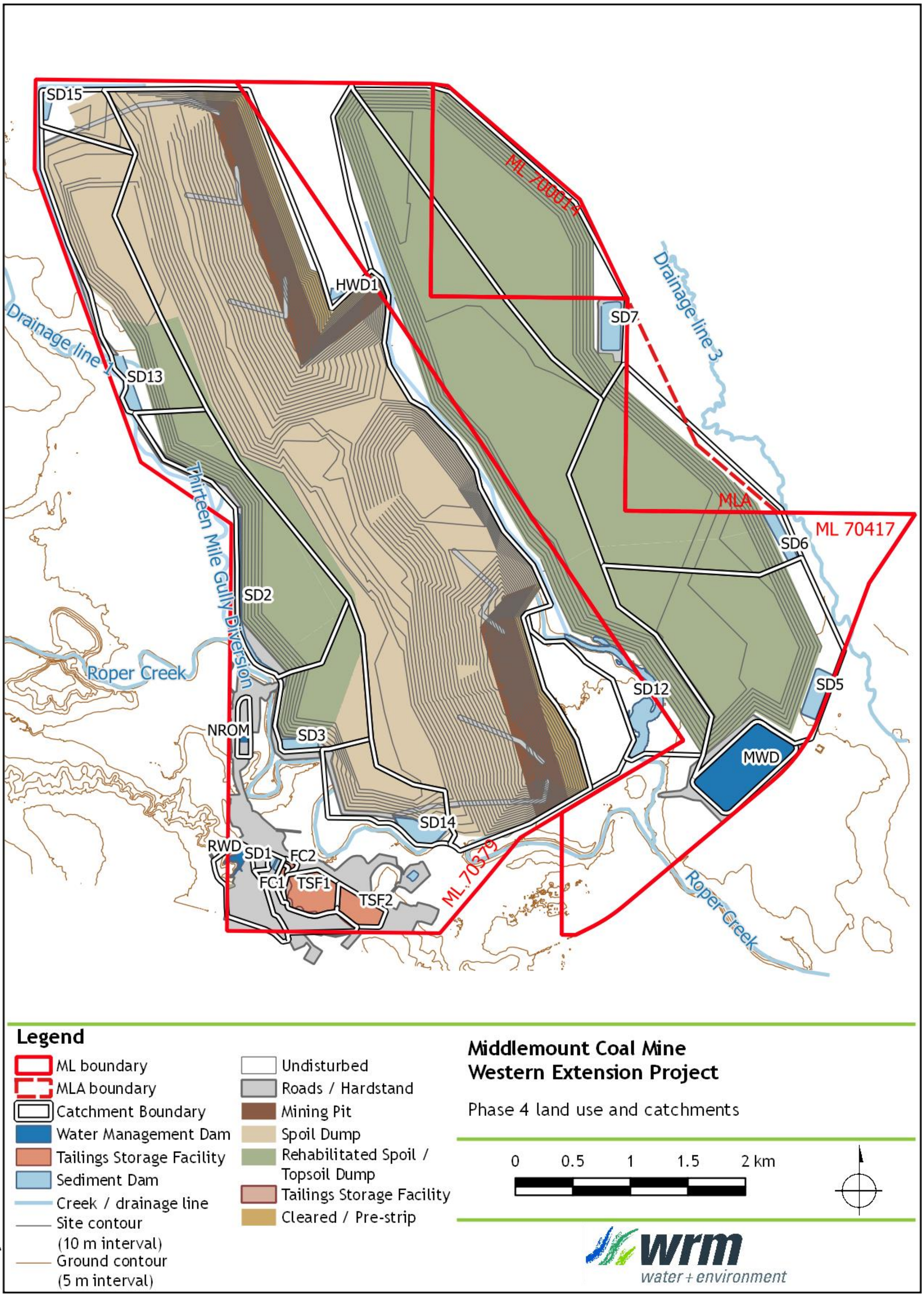


Figure B.5 – Catchment and land use breakdown – Phase 4

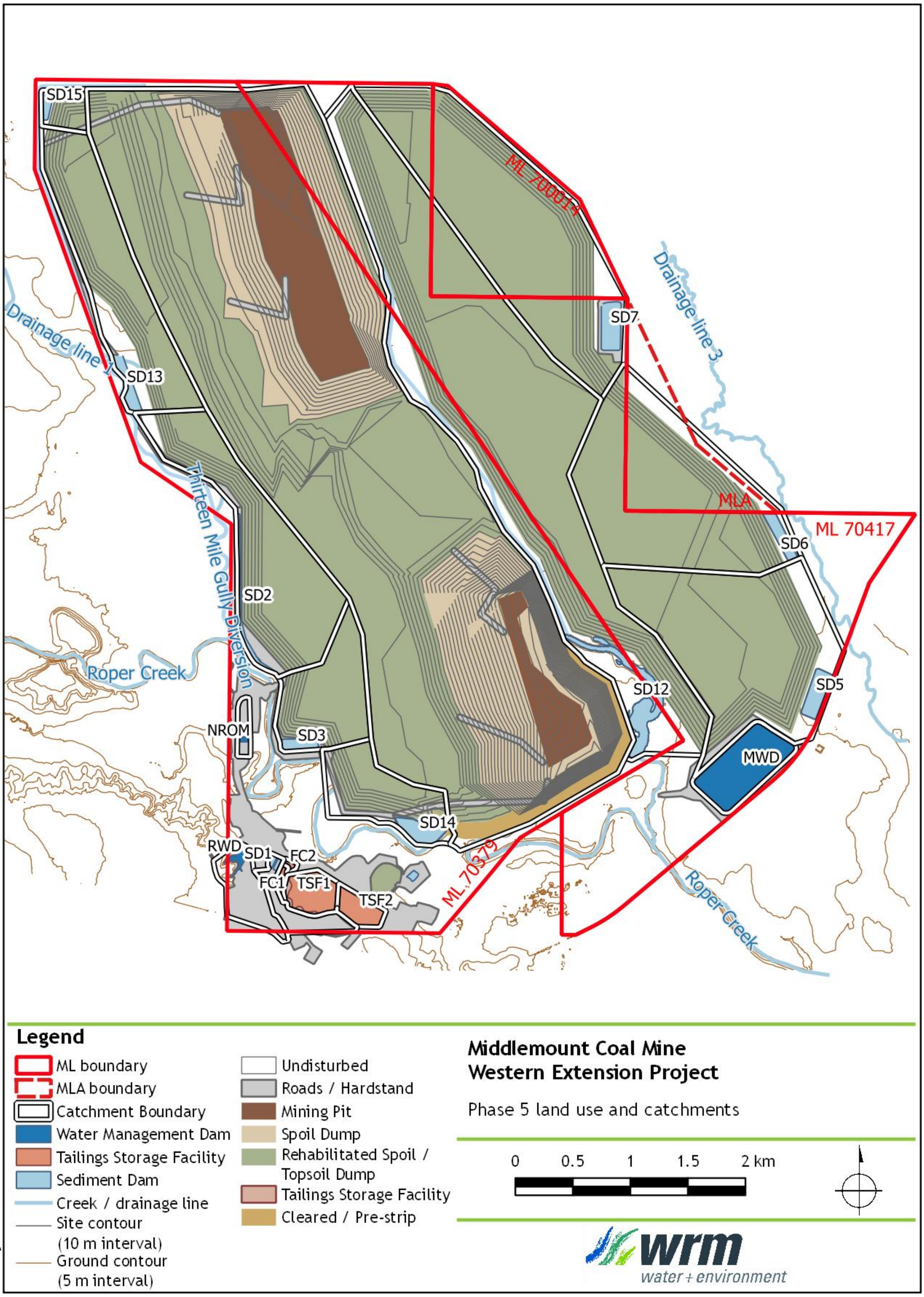


Figure B.6 – Catchment and land use breakdown – Phase 5

Table B.4 - MCM catchment area and land use breakdown - Phase 1 (existing)

Dam name	Catchment area (ha)							
	Undisturbed	Roads / Hardstand	Mining pit	Spoil Dump	Rehab	Tailings	Cleared / Pre-strip	TOTAL
Mine affected water dams								
Mining pit	24.5	30.6	99.8	212.0	24.8	0.0	71.8	463.5
STD	0.0	32.6	0.0	0.0	0.7	0.0	2.8	36.1
RWD	4.0	21.4	0.0	0.0	0.2	0.0	0.0	25.5
MWD	0.0	30.0	0.0	0.0	0.0	0.0	0.0	30.0
NROM	0.0	5.5	0.0	0.0	0.0	0.0	0.0	5.5
TSF1	0.0	0.1	0.0	0.0	0.0	15.4	0.0	15.5
TSF2	0.0	0.0	0.0	0.0	0.0	9.7	0.0	9.7
SD1	0.4	15.1	0.0	0.0	0.0	0.7	0.0	16.2
Sediment dams								
SD2	0.0	14.6	0.0	34.8	5.3	0.0	0.0	54.7
SD3	0.5	9.5	0.0	34.8	2.3	0.0	0.0	47.1
SD7	101.1	13.8	0.0	30.9	7.7	0.0	0.0	153.5
SD9	111.9	35.6	0.0	109.6	16.0	0.0	0.7	273.7
SD10	2.1	4.4	0.0	46.9	1.6	0.0	0.0	54.9
SD6 (interim)	38.1	14.7	0.0	26.0	0.0	0.0	11.2	90.0

Table B.5 - MCM catchment area and land use breakdown - Phase 2

Dam name	Catchment area (ha)							
	Undisturbed	Roads / Hardstand	Mining pit	Spoil Dump	Rehab	Tailings	Cleared / Pre-strip	TOTAL
Mine affected water dams								
Mining pit	29.0	27.4	182.6	435.4	6.0	0.0	54.6	735.1
STD	0.0	33.4	0.0	0.0	0.0	0.0	0.0	33.4
RWD	4.0	21.4	0.0	0.0	0.2	0.0	0.0	25.5
MWD	0.0	36.1	0.0	0.0	0.0	0.0	0.0	36.1
NROM	0.0	5.5	0.0	0.0	0.0	0.0	0.0	5.5
TSF1	0.0	0.1	0.0	0.0	0.0	15.4	0.0	15.5
TSF2	0.0	0.0	0.0	0.0	0.0	9.7	0.0	9.7
SD1	0.0	15.5	0.0	0.0	0.0	0.7	0.0	16.2
Sediment dams								
SD2	28.5	14.8	0.0	0.5	92.7	0.0	0.0	136.5
SD3	0.1	5.8	0.0	3.8	10.3	0.0	0.0	20.0
SD7	15.8	12.0	0.0	255.2	10.3	0.0	0.0	293.2
SD9	-	-	-	-	-	-	-	-
SD10	3.4	2.9	0.0	18.2	35.5	0.0	0.0	60.0
SD5	24.6	11.7	0.0	188.7	0.3	0.0	0.0	225.3
SD6	30.2	4.1	0.0	73.9	3.3	0.0	0.0	111.5
SD12	122.3	40.9	0.0	121.0	194.1	0.0	0.0	478.2
SD13	34.2	5.5	0.1	0.0	0.0	0.0	0.1	39.9
SD14	10.7	7.1	0.1	0.0	0.0	0.0	0.0	17.9
SD15	-	-	-	-	-	-	-	-

Table B.6 - MCM catchment area and land use breakdown - Phase 3

Dam name	Catchment area (ha)							
	Undisturbed	Roads / Hardstand	Mining pit	Spoil Dump	Rehab	Tailings	Cleared / Pre-strip	TOTAL
Mine affected water dams								
Mining pit	38.7	34.7	155.5	637.4	24.4	0.0	87.4	978.0
STD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RWD	4.0	21.4	0.0	0.0	0.2	0.0	0.0	25.5
MWD	0.0	36.1	0.0	0.0	0.0	0.0	0.0	36.1
NROM	0.0	5.5	0.0	0.0	0.0	0.0	0.0	5.5
TSF1	0.0	0.1	0.0	0.0	0.0	15.4	0.0	15.5
TSF2	0.0	0.0	0.0	0.0	0.0	9.7	0.0	9.7
SD1	0.0	15.5	0.0	0.0	0.0	0.7	0.0	16.2
Sediment dams								
SD2	3.0	15.6	0.0	8.9	151.6	0.0	0.0	179.1
SD3	0.5	5.9	0.0	1.9	35.6	0.0	0.0	43.9
SD7	15.8	12.0	0.0	0.0	225.4	0.0	0.0	253.2
SD9	-	-	-	-	-	-	-	-
SD10	-	-	-	-	-	-	-	-
SD5	24.6	11.6	0.0	174.5	0.0	0.0	0.0	210.7
SD6	25.7	4.1	0.0	165.9	20.8	0.0	0.0	216.5
SD12	69.6	37.2	0.0	61.1	333.3	0.0	0.1	501.3
SD13	15.5	7.5	0.0	29.6	34.4	0.0	0.0	87.0
SD14	11.0	6.7	0.0	0.1	0.0	0.0	0.0	17.9
SD15	4.9	2.7	0.0	0.0	0.0	0.0	0.8	8.4

Table B.7 - MCM catchment area and land use breakdown - Phase 4

Dam name	Catchment area (ha)							
	Undisturbed	Roads / Hardstand	Mining pit	Spoil Dump	Rehab	Tailings	Cleared / Pre-strip	TOTAL
Mine affected water dams								
Mining pit	23.7	27.8	121.3	795.7	34.6	0.0	55.6	1058.7
STD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RWD	4.0	21.4	0.0	0.0	0.2	0.0	0.0	25.5
MWD	0.0	36.1	0.0	0.0	0.0	0.0	0.0	36.1
NROM	0.0	5.5	0.0	0.0	0.0	0.0	0.0	5.5
TSF1	0.0	0.1	0.0	0.0	0.0	15.4	0.0	15.5
TSF2	0.0	0.0	0.0	0.0	0.0	9.7	0.0	9.7
SD1	0.0	15.5	0.0	0.0	0.0	0.7	0.0	16.2
Sediment dams								
SD2	3.0	15.3	0.0	0.0	128.5	0.0	0.0	146.9
SD3	0.5	5.4	0.0	17.6	43.6	0.0	0.0	67.1
SD7	15.8	12.0	0.0	0.0	225.4	0.0	0.0	253.2
SD9	-	-	-	-	-	-	-	-
SD10	-	-	-	-	-	-	-	-
SD5	24.6	11.6	0.0	0.0	174.5	0.0	0.0	210.7
SD6	25.7	4.1	0.0	0.0	186.7	0.0	0.0	216.5
SD12	67.0	34.0	0.0	0.0	394.6	0.0	0.0	495.6
SD13	15.7	8.1	0.0	87.3	31.1	0.0	0.0	142.2
SD14	6.6	13.2	0.0	38.6	0.0	0.0	0.0	58.5
SD15	8.4	4.6	0.0	15.3	0.0	0.0	0.0	28.4

Table B.8 - MCM catchment area and land use breakdown - Phase 5

Dam name	Catchment area (ha)							
	Undisturbed	Roads / Hardstand	Mining pit	Spoil Dump	Rehab	Tailings	Cleared / Pre-strip	TOTAL
Mine affected water dams								
Mining pit	12.6	29.1	157.2	997.3	0.0	45.4	12.6	1241.6
STD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RWD	4.0	21.4	0.0	0.2	0.0	0.0	4.0	25.5
MWD	0.0	36.1	0.0	0.0	0.0	0.0	0.0	36.1
NROM	0.0	5.5	0.0	0.0	0.0	0.0	0.0	5.5
TSF1	0.0	0.1	0.0	0.0	15.4	0.0	0.0	15.5
TSF2	0.0	0.0	0.0	0.0	9.7	0.0	0.0	9.7
SD1	0.0	15.5	0.0	0.0	0.7	0.0	0.0	16.2
Sediment dams								
SD2	3.0	15.3	0.0	128.5	0.0	0.0	3.0	146.9
SD3	0.5	5.1	0.0	61.5	0.0	0.0	0.5	67.1
SD7	15.8	12.0	0.0	225.4	0.0	0.0	15.8	253.2
SD9	-	-	-	-	-	-	-	-
SD10	-	-	-	-	-	-	-	-
SD5	24.6	11.6	0.0	174.5	0.0	0.0	24.6	210.7
SD6	25.7	4.1	0.0	186.7	0.0	0.0	25.7	216.5
SD12	58.6	34.0	0.0	394.7	0.0	0.0	58.6	487.3
SD13	14.7	7.6	0.0	110.1	0.0	0.0	14.7	132.5
SD14	7.1	13.0	0.0	36.6	0.0	1.7	7.1	58.5
SD15	1.0	3.2	0.0	9.9	0.0	0.0	1.0	14.0

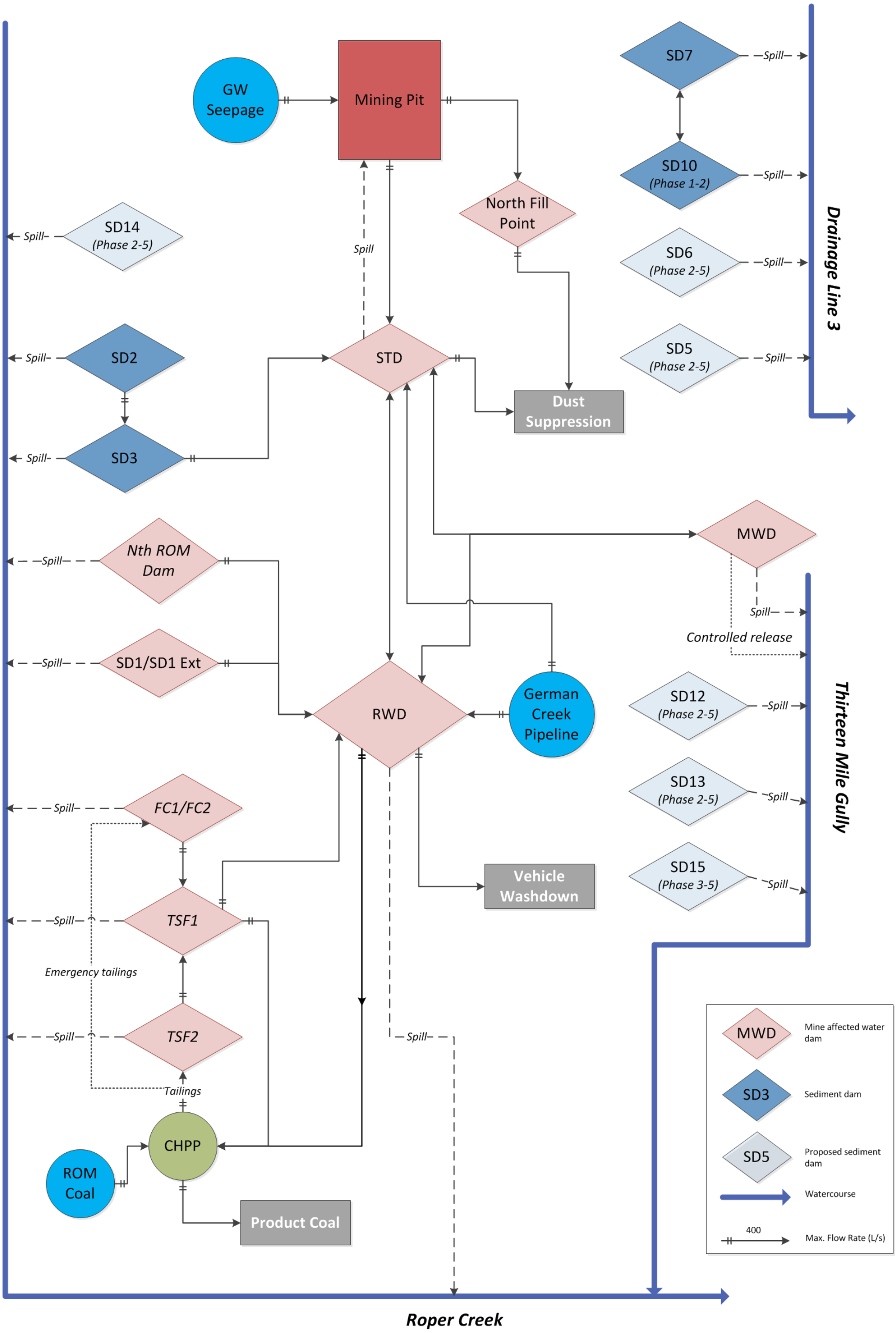


Figure B.7 – Water management system schematic – Phase 2 to Phase 5

Table B.9 – Water management system operating rules

Item	Node Name	Operating Rules
1.0	***External water supply***	
1.1	German Creek water supply	• Supplies water to RWD and STD as required, in accordance with the arrangement detailed in Section 4.10. • Water is imported if the combined inventory of RWD and MWD reduces below 500 ML.
2.0	***Water demands***	
2.1	CHPP	• Supplied from RWD and TSF1
2.2	Haul road dust suppression	• Supplied from STD and North Fill Point
2.3	Vehicle washdown	• Supplied from RWD
3.0	***Open-cut operations***	
3.1	Mining pit	• Receives groundwater inflows at the estimated rates shown in Section A7. • Continuous dewatering to STD at a maximum rate of 100 L/s, or 180 L/s if the pit water inventory exceeds 50 ML.
4.0	***Water storages***	
4.1	RWD	• Existing mine affected water dam • Receives pumped transfers from STD, TSF1, NROM, SD1 and MWD • Pumps to STD as required at a maximum rate of 100 L/s • Can receive inflows from German Creek water supply • Supplies water to the CHPP and vehicle washdown demands • Overflows to Roper Creek
4.2	MWD	• Existing mine affected water dam • Receives pumped transfers from STD • Pumps to STD as required at a maximum rate of 100 L/s • Pumps to RWD (bypassing STD) • Supplies water to dust suppression demand • Can make controlled releases to Thirteen Mile Gully • Overflows to Thirteen Mile Gully
4.3	STD	• Existing mine affected water dam - will be replaced/relocated in Phase 3 at a location to be determined at a later date • Can receive pumped inflows from the Mining pit, RWD, MWD, SD3 and SD9 • Pumps to RWD, MWD and SD3 at a maximum rate of 100 L/s as required • Supplies water to dust suppression demand • Overflows to the Mining Pit
4.4	NROM	• Existing mine affected water dam • Pumps to RWD at a maximum rate of 100 L/s • Overflows to Roper Creek
4.5	SD1/SD1 Extension	• Existing mine affected water dam • Pumps to RWD at a maximum rate of 100 L/s • Overflows to Roper Creek (via SD1 Extension)
4.6	SD2	• Existing sediment dam • Pumps to SD3 at a maximum rate of 100 L/s • Overflows to Roper Creek
4.7	SD3	• Existing sediment dam • Pumps to STD at a maximum rate of 100 L/s • Receives pumped transfers from SD2 • Overflows to Roper Creek

Item	Node Name	Operating Rules
4.8	SD7	• Existing sediment dam • Pumps to SD10 at a maximum rate of 100 L/s • Receives pumped transfers from SD10 • Overflows to Drainage Line 3
4.9	SD9	• Existing sediment dam • Active only in Phase 1 • Pumps to STD at a maximum rate of 100 L/s • Overflows to Thirteen Mile Gully
4.10	SD10	• Existing sediment dam • Active only in Phase 1 and 2 • Pumps to SD7 at a maximum rate of 100 L/s • Overflows to Drainage Line 3
4.11	SD5	• Proposed sediment dam (to be constructed by Phase 2) • Overflows to Drainage Line 3
4.12	SD6	• Proposed sediment dam (to be constructed by Phase 2) • Overflows to Drainage Line 3
4.13	SD12	• Proposed sediment dam (to be constructed by Phase 2) • Overflows to Thirteen Mile Gully
4.14	SD13	• Proposed sediment dam (to be constructed by Phase 2) • Overflows to Thirteen Mile Gully
4.15	SD14	• Proposed sediment dam (to be constructed by Phase 2) • Overflows to Roper Creek
4.16	SD15	• Proposed sediment dam (to be constructed by Phase 3) • Overflows to Thirteen Mile Gully
4.17	TSF1	• Receives decant water from TSF2 (active flocc cells) • Supplies water to Raw Water Dam and the CHPP as required • Overflows to Roper Creek
4.18	TSF2	• A series of 4 flocc cells • Receives the tailings waste stream, where flocculant is added to remove water • Decant water is pumped to TSF1 temporarily, before being pumped to RWD and the CHPP as required • Overflows to Roper Creek
4.19	FC1/FC2	• Emergency flocc cells • Pumps to TSF1 at a maximum rate of 100 L/s • Overflows to Roper Creek
5.0	***Receiving waters***	
5.1	Roper Creek	• Receives storage overflows from RWD, SD1, SD2, SD3, SD14, TSF1, TSF2 and FC1/FC2
5.2	Thirteen Mile Gully	• Receives storage overflows from MWD, SD9, SD12, SD13 and SD15
5.2	Drainage Line 3	• Receives storage overflows from SD7, SD10, SD5 and SD6
6.0	***All storages***	• All storages and pits receive local catchment runoff and lose water through evaporation

B5 Catchment yield (AWBM) parameters

The OPSIM model uses the Australian Water Balance Model (AWBM) (Boughton, 2004) to estimate daily runoff from daily rainfall. The AWBM is a saturated overland flow model which allows for variable source areas of surface runoff.

The AWBM uses a group of connected conceptual storages (three surface water storages and one ground water storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and is reduced by evapotranspiration. Simulated surface runoff occurs when the storages fill and overflow. Figure A.8 shows a conceptual configuration of the AWBM model.

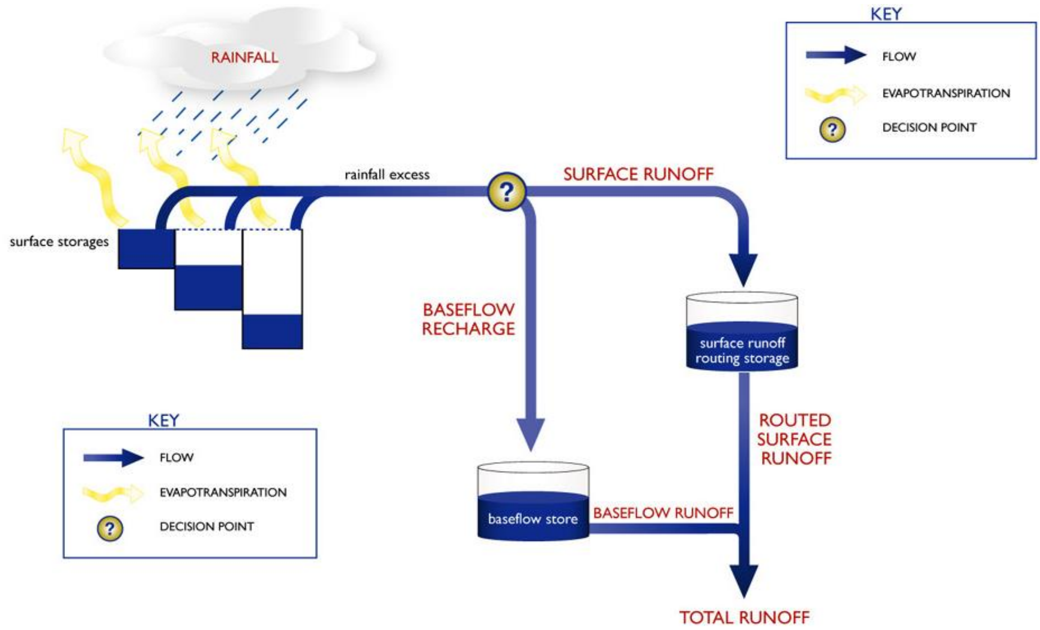


Figure B.8 – AWBM model configuration

The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a daily balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow subsurface store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying by the contributing catchment area. The model parameters define the storage depths, the proportion of the catchment draining to each of the storages, and the rate of flux between them (Boughton & Chiew, 2003).

The adopted AWBM parameters for the various catchment types (given in Table A.4) on the mine site are shown in Table A.10.

Data was not available to calibrate the model for each of the individual on-site catchment runoff types. The AWBM model parameters were initially based on the latest Middlemount Coal Mine water balance model used as part of the North-eastern Extension Project (WRM, 2016). The adopted parameters were then adjusted so that the modelled MWD and mining pit inventory matched the recorded MWD and mining pit inventory.

The AWBM model was calibrated to recorded streamflow in Roper Creek as part of the EIS studies for the Stage 1 Middlemount Coal Mine. Details of this calibration can be found in WRM (2010).

To represent undisturbed areas on the mine site, the same parameters as Roper Creek were used, with the baseflow component removed, since baseflow is related to hydrological processes at a large scale. The simulated runoff coefficient for undisturbed areas expressed as a percentage was 6.5%, which is similar to the value for the Roper Creek catchment.

Disturbed catchments, which include hardstand, mining pit and tailings areas, are characterised by hard surfaces which inhibit water infiltration, resulting in much higher rates of surface runoff. To represent disturbed catchments, the depth of the model surface stores was substantially reduced and baseflow eliminated. The simulated volumetric runoff percentage for disturbed catchments was 39.5%, about 6 times higher than undisturbed catchments. This value is similar to typical values for urban catchments, which have similar characteristics.

The adopted model parameters for spoil dump areas have been based on the calibration outcomes presented in Table A.10. The simulated volumetric runoff percentage of 4.0% is slightly lower than undisturbed catchments.

Rehabilitated catchments have been assumed to have similar rainfall runoff characteristics as undisturbed catchments. We have adopted the 'undisturbed' parameter set for rehabilitated catchments. The adopted model parameters for cleared catchments have been selected based on experience with other coal mines in the area.

Table B.10 – AWBM parameters

AWBM Model Parameter		Roper Creek	Undisturbed catchments	Disturbed catchments	Spoil Dump	Rehab	Cleared
Surface Store Depth (mm)	C1	24	24	4	40	24	20
	C2	118	118	20	200	118	100
	C3	268	268	40	400	268	200
Partial Areas	A1	0.062	0.062	0.33	0.1	0.062	0.1
	A2	0.439	0.439	0.33	0.4	0.439	0.4
Base flow index	BFI	0.936	0	0	0.9	0	0
Base flow recession constant	Kb	0.53	0	0	0.8	0	0
Surface flow recession constant	Ks	0.73	0	0	0	0	0
Long-term runoff coefficient (%)	C_v	6.5%	6.5%	39.5%	4.0%	6.5%	9.5%

B6 Water demands

B6.1 COAL HANDLING AND PREPARATION PLANT (CHPP)

The projected annual coal production schedule at Middlemount Coal Mine over the Project life is summarised in Table A.11.

MCPL records CHPP water use as well as the volumes of water decant from the tailings disposal system and returned to the CHPP. The makeup water, supplied from the RWD, is the difference between the CHPP water use and the volume of water returned to the CHPP from TSF1. The tailings disposal system has been treated as a closed loop water circuit with the reuse of decant water taken into account with the provided CHPP water use data.

The adopted CHPP demand has been based on a net consumption rate of 113 L/ROM tonne (including return water from the TSF1), which is based on the historical net CHPP usage over 2016 and 2017. The forecast net CHPP consumption over the Project life is provided in Table A.11.

Table B.11 - Forecast annual production data and water usage

Phase	Year	CHPP production and water usage		
		Feed tonnage (Mt)	Net CHPP Usage (ML)	Net CHPP Usage (ML/day)
1	2018	5.46	617.7	1.69
	2019	5.39	610.0	1.67
	2020	5.09	575.6	1.58
	2021	5.38	609.4	1.67
2	2022	5.40	611.1	1.67
	2023	5.40	611.1	1.67
	2024	5.41	612.8	1.68
	2025	5.40	611.1	1.67
3	2026	5.40	611.1	1.67
	2027	5.40	611.1	1.67
	2028	5.41	612.8	1.68
	2029	5.40	611.1	1.67
	2030	5.40	611.1	1.67
4	2031	5.40	611.1	1.67
	2032	5.41	612.8	1.68
	2033	4.91	555.7	1.52
	2034	5.05	571.4	1.57
	2035	4.99	564.8	1.55
5	2036	4.75	537.5	1.47
	2037	2.82	318.9	0.87

B6.2 HAUL ROAD DUST SUPPRESSION

Mine site haul road dust suppression water is currently sourced from water cart fill points located at the MWD and STD. After the STD is mined through by Phase 3, dust suppression demand will be sourced from MWD or the STD replacement dam, at a location still to be determined. Dust suppression water is preferentially sourced from the lowest quality water that is available on site. This is controlled on a daily basis by site personnel. This has been represented in the water balance model by preferentially pumping water from the mining pit and MWD to the STD before pumping water from the sediment dams.

MCPL has supplied historical monthly dust suppression demand volumes based on truck fill counts and truck capacity over the period January 2016 to July 2017. MCPL also advised that there is also an approximate 25 ML/month of unmetered usage. The estimated average daily dust suppression demand over the period January 2016 to July 2017 was 3.05 ML/day, however the seasonal distribution of this demand varies.

Based on this information, the adopted average daily dust suppression water demand for each month is shown in Figure A.9.

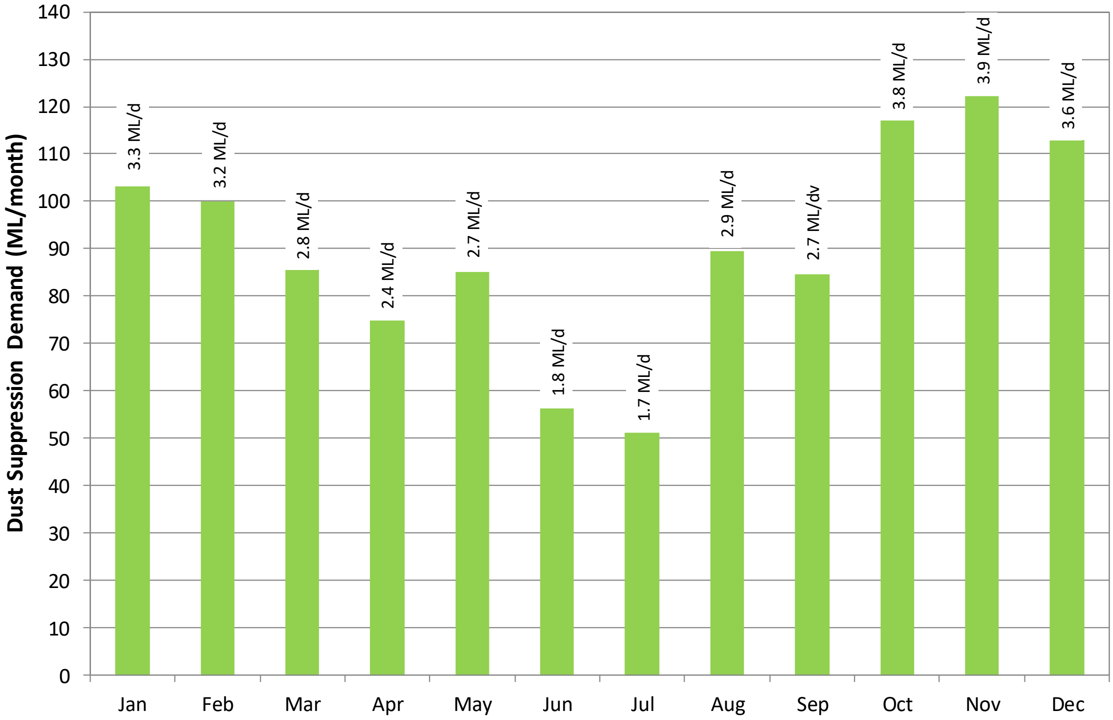


Figure B.9 - Adopted average monthly dust suppression demands

B7 Groundwater inflows

The adopted groundwater inflows to the open cut and underground mining areas are based on estimates provided by AGE (2018) and are summarised in Table A.12. No allowance has been made for residual groundwater losses associated with evaporation along the open cut face.

Table B.12 – Forecast groundwater inflows

Phase	Year	Total groundwater inflows	
		ML/year	ML/day
1	2018	605	1.66
	2019	837	2.29
	2020	605	1.66
	2021	819	2.24
2	2022	635	1.74
	2023	879	2.41
	2024	995	2.72
	2025	895	2.45
3	2026	845	2.31
	2027	799	2.19
	2028	642	1.76
	2029	510	1.40
	2030	828	2.27
4	2031	846	2.31
	2032	775	2.12
	2033	855	2.34
	2034	1,030	2.82
	2035	1,022	2.80
5	2036	640	1.75
	2037	266	0.73

B8 Model calibration

B8.1 MODEL OVERVIEW

Calibration of the Middlemount Coal Mine water balance model has been undertaken against recorded site data (including water storage volumes) over the period from January 2016 to August 2017. The model was configured to reflect the site operations during this period, with appropriate transfer rates, system configuration and water inflows and outflows. Site rainfall data was used for the calibration.

Calibration of the water balance model was undertaken against the recorded combined inventory for the MWD and the mining pit. To achieve a satisfactory calibration outcome, changes to a number of the previously adopted AWBM rainfall runoff parameters were required.

B8.2 CALIBRATION RESULTS

The initial model run using the previously adopted AWBM parameters resulted in a significant difference between modelled and observed inventory. The model substantially overestimated the inventory, particularly during periods of high rainfall. This suggests that the AWBM parameters required adjustment to better match the observed inventory.

The following changes were made to the AWBM parameters:

- Increase in the soil moisture capacity for the disturbed land use;
- Increase in the soil moisture capacity for the pit land use; and
- Increase in the soil moisture capacity for spoil dump land use.

The observed and modelled inventory for the combined MWD and mining pit inventory is presented in Figure A.10, along with the site rainfall for the calibration period.

Review of Figure A.10 indicates the following:

- The simulated combined inventory generally reproduces the observed inventory fluctuations over the calibration period between January 2016 and March 2017.
- The modelled increase in inventory at the end of March 2017 (due to Cyclone Debbie) of around 350 ML is not as evident in the recorded inventories. During this period, only 50 ML of pit water was recorded.
- Given the magnitude of the rainfall at this time (around 165 mm over two days), the volume of water collected in-pit would likely have been significantly higher. It is possible that water was stored in-pit but was not recorded. This would potentially account for the differences in modelled and observed inventory.
- The calibration results are considered to be within reasonable bounds given the potential variability in mine affected water movements about the site and water losses, and the constraints imposed on the water balance model by the operational guidelines.

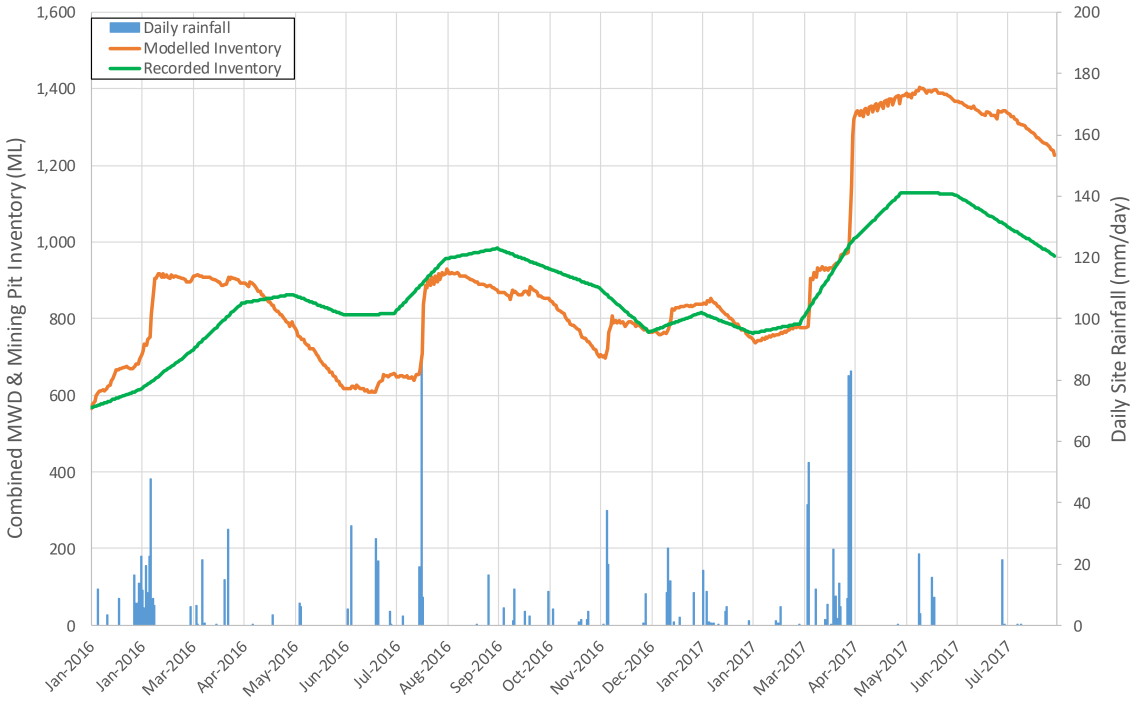


Figure B.10 - Model calibration - combined MWD and mining pit inventory

Appendix C – Existing conditions flood modelling

Contents

C1 Introduction

This appendix outlines the development and calibration of the existing conditions hydrological and hydraulic models that have been developed of Roper Creek and Thirteen Mile Gully at Middlemount Coal Mine. These models have been used to estimate design discharges, flood levels, flood extents and velocities for existing conditions.

The hydrological and hydraulic models are based on the models previously developed for the Stage 1 and Stage 2 Environmental Assessments of Middlemount Coal Mine. These models have been refined to incorporate the Projects mine changes and have been calibrated to surveyed peak water level and rainfall data collected for the January 2013 ex-tropical cyclone Oswald event.

The calibration process used the recorded rainfalls to estimate discharges using the hydrological model. These discharges were then used in the hydraulic model to estimate peak water levels at surveyed water level locations.

C2 Hydrological modelling

C2.1 METHODOLOGY

The Unified River Basin Simulator (URBS) runoff-routing model (Carroll, 2004) was used to estimate flood discharges in the Roper Creek catchment. URBS is a runoff-routing computer model that uses a network of conceptual storages to represent the routing of rainfall excess through a catchment. URBS is used extensively throughout Australia by the Bureau of Meteorology (BoM) for flood forecasting on major river systems.

For this study, the URBS model was used in “split mode”, which enables the simulation of separate catchment and channel routing. Adopted rainfall losses are subtracted from the total rainfall hyetograph to obtain rainfall excess. Rainfall excess is routed through a conceptual storage representing each sub-catchment of the model before being added to the creek or river channel. Routing through the creek or river system uses the Muskingum method.

C2.2 URBS MODEL CONFIGURATION

Figure B.1 shows the configuration of the URBS model. The model extends approximately 11.5 km upstream (west) of the Middlemount Coal Mine lease and consists of 20 sub-catchments. Summary details of sub-catchment areas are given in Table B.1.

Table C.1 – Adopted URBS model sub-catchment areas

Sub-catchment number	Area (km^2)	Sub-catchment number	Area (km^2)
1	46.1	11	8.8
2	26.4	12	8.4
3	26.7	13	7.9
4	8.9	14	4.7
5	36.9	15	9.8
6	59.3	16	3.4
7	29.0	17	1.4
8	20.2	18	4.5
9	24.7	19	2.6
10	18.7	20	8.9

C2.3 URBS MODEL CALIBRATION

C2.3.1 Methodology

The URBS model was calibrated to the recorded data available for the January 2013 ex-tropical cyclone Oswald event. Data was available for one stream gauge at the site; IMPAC1, located downstream of the Middlemount Coal Mine (see Figure B.1) as well as at a number of water level marks that were surveyed after the event. The hydraulic model, described in Section B.3 was used to derive a relationship between recorded water level and discharge at the IMPAC1 gauge.

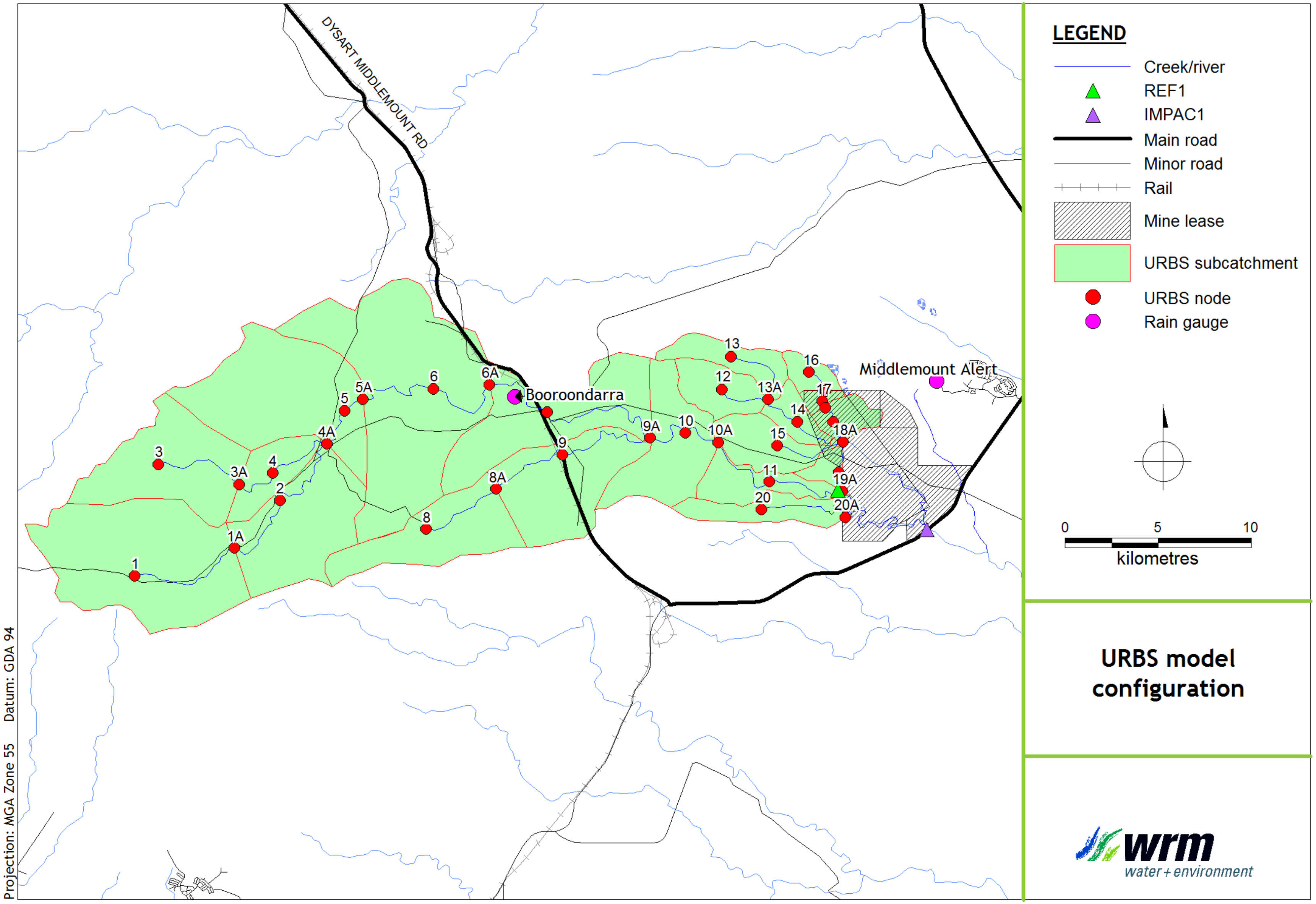


Figure C.1 - Roper Creek URBS model configuration

The calibration attempted to match the predicted and recorded flood peaks and volumes, and also the shape of the recorded and predicted hydrographs with a single (global) set of model parameters for the entire catchment. Each sub-catchment of the model was assigned the rainfall from the nearest rainfall station. A constant loss model (initial loss / continuing loss) was adopted uniformly for all sub-catchments.

C2.3.1 Available rainfall data

Rainfall data for the event was obtained from BoM rainfall stations in the vicinity of the Roper Creek catchment at the locations shown in Figure B.1 and listed in Table B.2.

Table C.2 – Rainfall data available for calibration events

Station no.	Station name	Observation interval	Recorded rainfall 3 days to 0900 hours 27 Jan 2013
035109	Booroondarra	Daily	258.6
534022	Middlemount Alert	Hourly	333.0

The Booroondarra daily rainfall was distributed using the hourly rainfall temporal pattern recorded at the Middlemount Alert station. The Booroondarra rainfall was adopted for the URBS subcatchments 1 to 9 and the Middlemount Alert rainfalls were adopted for the downstream subcatchments 10 to 20.

C2.3.1 URBS model parameters

The calibration of the URBS model was achieved by adjusting global parameters (**α, β** and **m**) and adjusting initial and continuing rainfall losses to obtain the best fit between recorded and predicted discharge hydrographs. The adopted global URBS parameters and the initial and continuing losses for the January 2013 calibration event are shown in Table B.3. The initial loss rate reflects the antecedent conditions in the catchment prior the flood event.

Table C.3 – Adopted URBS model parameters

Parameter	Value
α (channel lag parameter)	0.4
β (catchment lag parameter)	2
m (catchment non-linearity parameter)	0.7
Initial loss (mm)	105
Continuing loss (mm/hr)	3.5

C2.3.2 January 2013 calibration results

Figure B.1 shows a comparison of predicted and recorded flood discharge at the Middlemount Road (IMPAC1) station for the January 2013 calibration event. The magnitude of the peak discharge has been overestimated by the URBS model due to the volume of water that was lost entering the pit, however the timing and shape of the hydrograph are a relatively good fit.

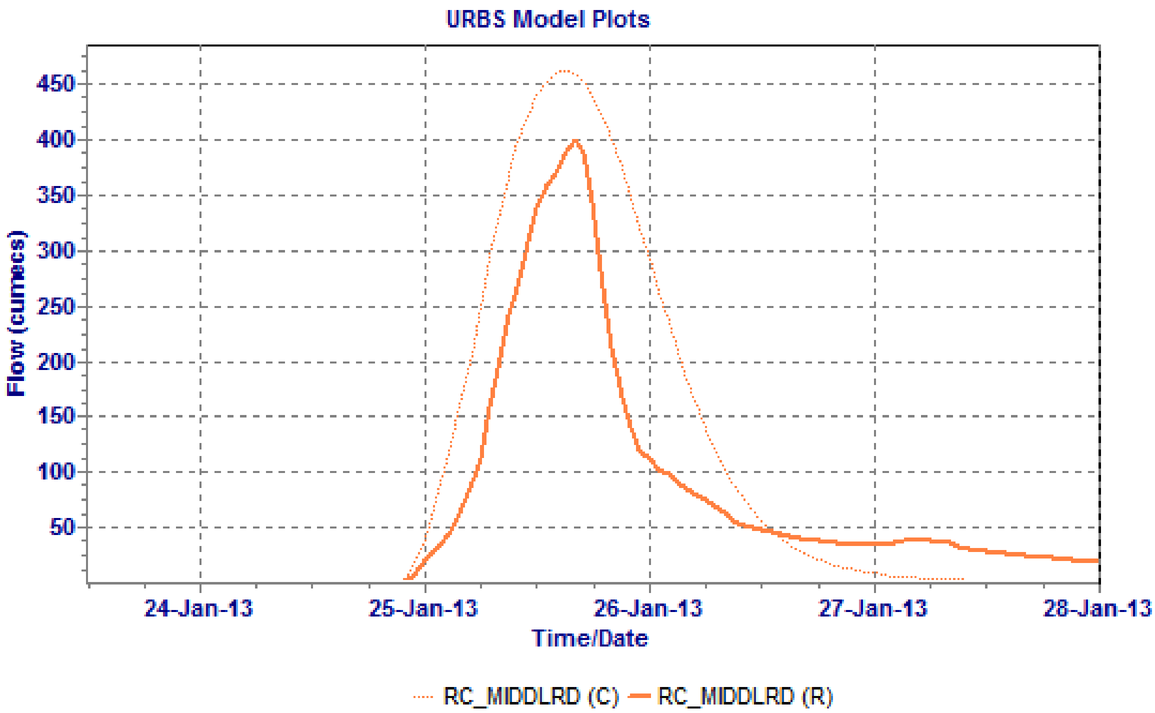


Figure C.2 - Comparison of calculated (C) and recorded (R) discharge hydrographs, Middlemount Road (IMPAC1 gauge), January 2013

C2.4 DESIGN DISCHARGES

The calibrated URBS model was used to estimate design flood discharges in Roper Creek in the vicinity of Middlemount Coal Mine for the 63%, 5%, 2%, 1%, 0.1% AEP events and for the PMF. The ensemble approach described in Australian Rainfall and Runoff (ARR) (Ball et al, 2016) was used to estimate design discharges. This method uses an 'ensemble' of 10 temporal patterns for each storm duration to derive a range of estimated flood peaks for each AEP. The magnitude of the design flood is then estimated from the weighted average of the flood peaks, where the weighting applied to each result reflects the relative likelihood of the selected input occurring. The 10 temporal patterns were obtained from the ARR data hub for events up to the 1% AEP event. Middlemount is located in the East Coast North Temporal Pattern region under the ARR.

For design events rarer than 1% AEP up to PMF, temporal patterns from Revised Generalised Tropical Storm Method (GTSMR) (BoM, 2005) were adopted, in accordance to ARR 2016.

C2.4.1 Design rainfalls

Table B.4 shows the design rainfalls for a range of storm durations for the Roper Creek catchment to Middlemount Coal Mine. Design rainfalls for events up to the 0.1% AEP event were obtained from the BoM. Rainfalls to estimate the PMF were determined using the Revised Generalised Tropical Storm Method (GTSMR) (BoM, 2005). Aerial reduction factors and rainfall losses (IL=49 mm CL=1.7 mm/hr), which were adjusted according to the median pre-burst depths and ratios, were obtained from the ARR data hub.

Table C.4 – Rainfall data available for calibration events

Duration (hours)	Design rainfall (mm)					
	63% AEP	5% AEP	2% AEP	1% AEP	0.1% AEP	PMP
6	57.2	110.4	133.2	150.6		
12	68.6	134.4	163.2	186.0	294.4	780.0
18	77.0	152.1	185.4	212.4	337.8	890.0
24	83.8	166.6	203.8	234.2	364.8	1000.0
36	94.7	189.4	233.3	269.3	416.8	1200.0
48	102.7	207.4	256.3	296.6	457.9	1390.0
72	115.2	234.0	290.2	336.2	514.8	1730.0
96	122.9	252.5	313.0	362.9	550.1	1940.0
120	128.4	265.2	328.8	379.2	571.2	2050.0

C2.4.2 Results

Figure B.3 to B.7 shows the distribution of peak discharges at Middlemount Coal Mine estimated from the ensemble of 10 temporal patterns for each storm duration and for each AEP. The distribution is represented as a box and whisker plot for each duration, which is a standardised way of presenting the distribution of data. For each duration, the rectangle box represents the 25%ile and 75%ile (1st and 3rd quartile, the interquartile range or IQR) bound of the estimate. The black horizontal line (whiskers) represents the upper and lower estimates for 1.5 times of the IQR. The red horizontal line within the box is the median value and the red dot represents the mean value. The peak discharges adopted from the analyses together with the critical duration and the adopted temporal pattern is shown in Table B.5.

Based on these results, the January 2013 event had an AEP of between 5% and 2% AEP.

Table C.5 - Roper Creek Design discharge at Middlemount Coal Mine

Event	Critical duration	Temporal pattern	Discharge (m^3/s)
63% AEP	72	8	65
5% AEP	24	3	374
2% AEP	24	10	550
1% AEP	24	3	689
0.1% AEP	18	7	1,283
PMF	24	3	4,250

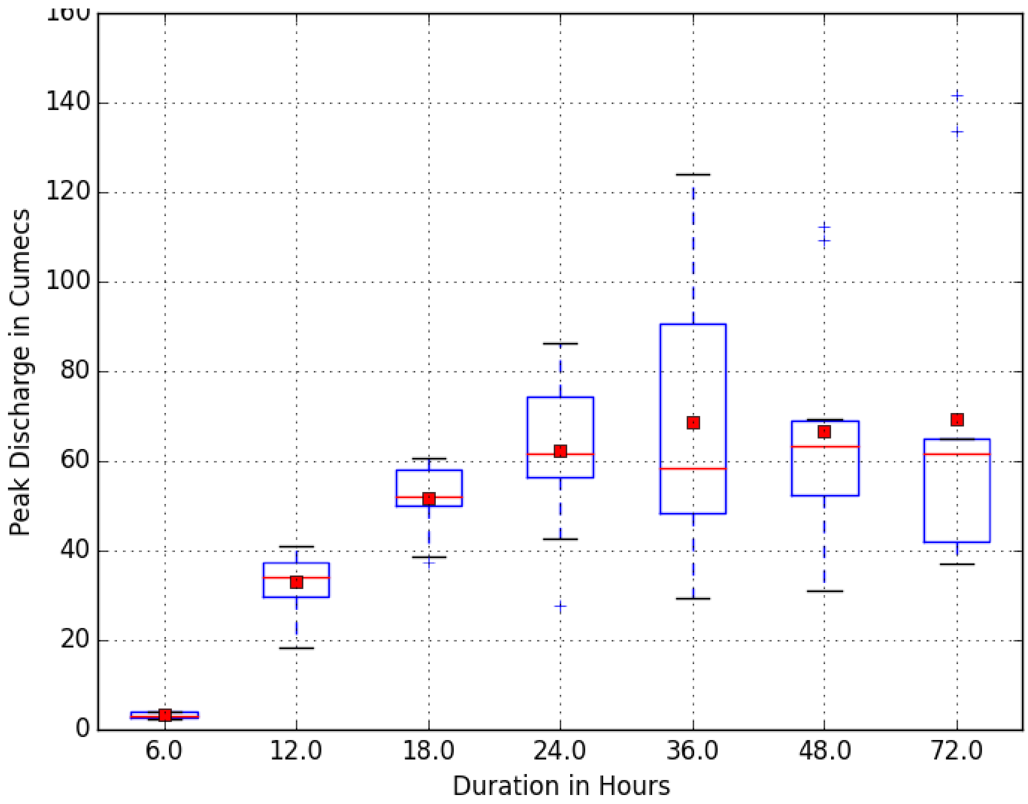


Figure C.3 - Roper Creek discharge box plots at Middlemount Coal Mine, 63% AEP event

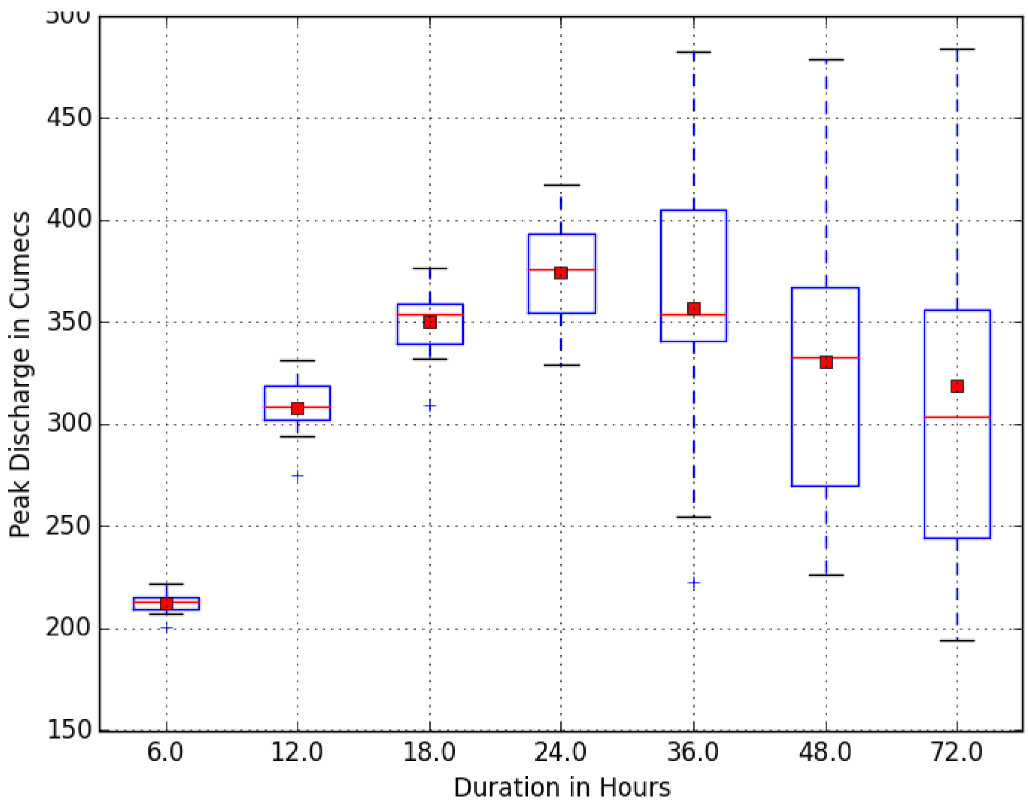


Figure C.4 - Roper Creek discharge box plots at Middlemount Coal Mine, 5% AEP event

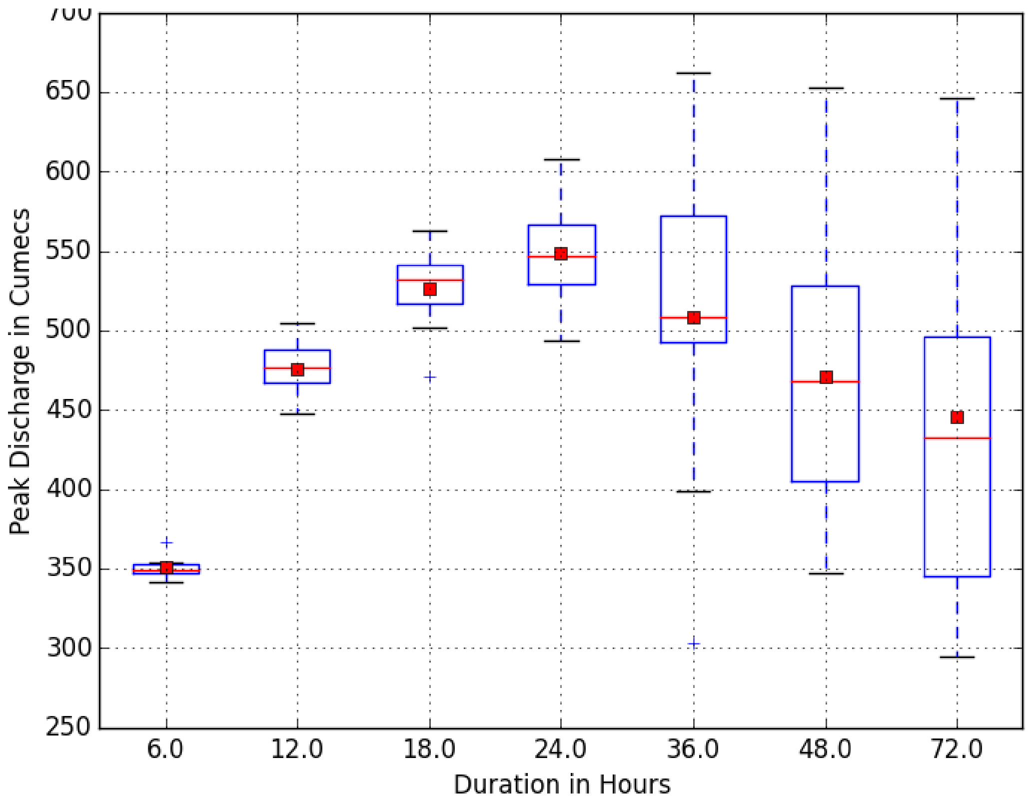


Figure C.5 - Roper Creek discharge box plots at Middlemount Coal Mine, 2% AEP event

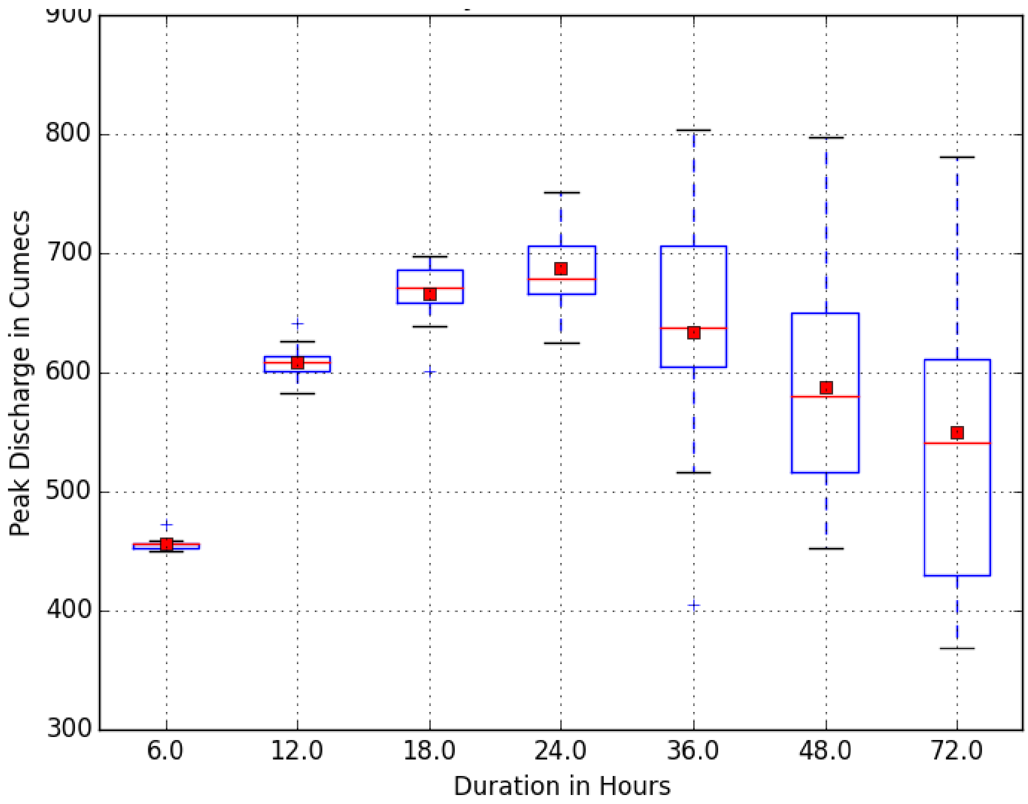


Figure C.6 - Roper Creek discharge box plots at Middlemount Coal Mine, 1% AEP event

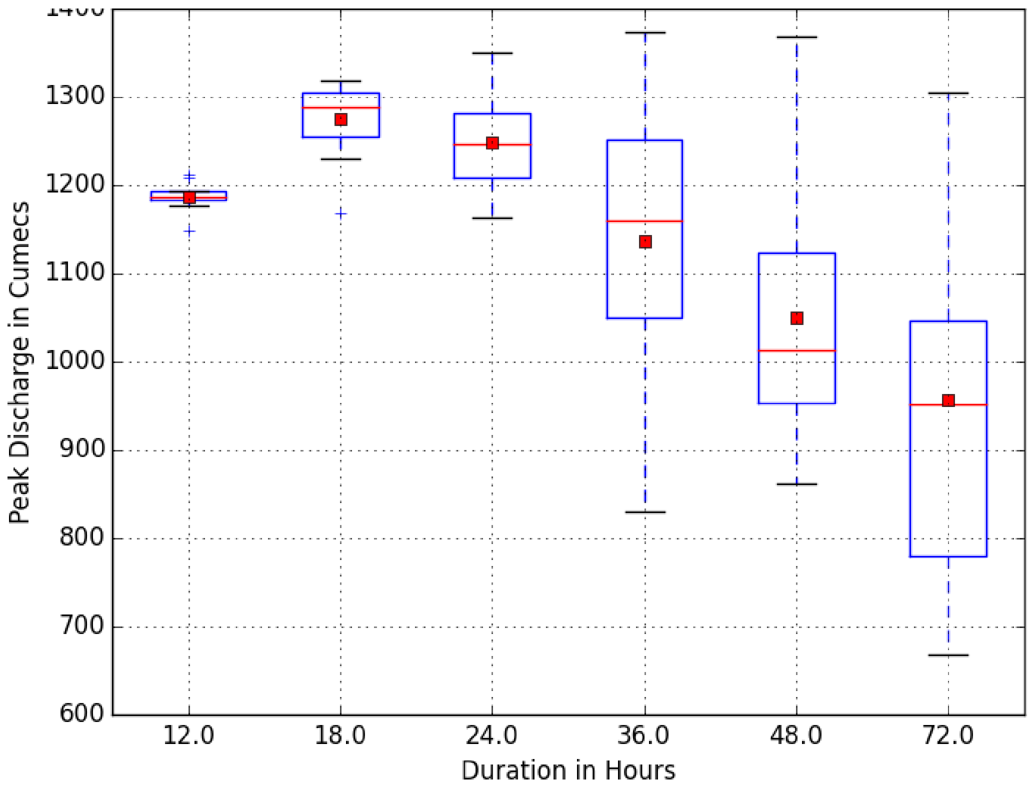


Figure C.7 - Roper Creek discharge box plots at Middlemount Coal Mine, 0.1% AEP event

C3 Hydraulic modelling

C3.1 GENERAL

The TUFLOW hydrodynamic model (WBM, 2016) was used to simulate the flow behaviour of Roper Creek and its tributaries at Middlemount Coal Mine. TUFLOW represents hydraulic conditions on a fixed grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow. The model automatically identifies breakout points and flow directions within the study area.

Modelling was undertaken for existing conditions as well as for the conditions that were in place during the January 2013 ex-tropical cyclone Debbie event. This has been used for model calibration.

C3.2 AVAILABLE TOPOGRAPHIC DATA

Topographic aerial survey data for the study area was provided by Middlemount Coal Pty Ltd. The underlying survey in the model area was performed in May/June 2008 and covers an area of some 90 km^2. Updated survey of the mine lease area was used as the primary ground level information across the mine lease for existing conditions and January 2013 conditions. The existing conditions mine survey was obtained in June 2017 and the January 2013 conditions was obtained in December 2012.

C3.3 MODEL CONFIGURATION

Figure B.8 and Figure B9 shows the extent of the existing conditions and January 2013 (calibration conditions) TUFLOW model. The location of the Roper Creek 1D channel and the location of the 1D and 2D inflow and outflow boundaries are also shown.

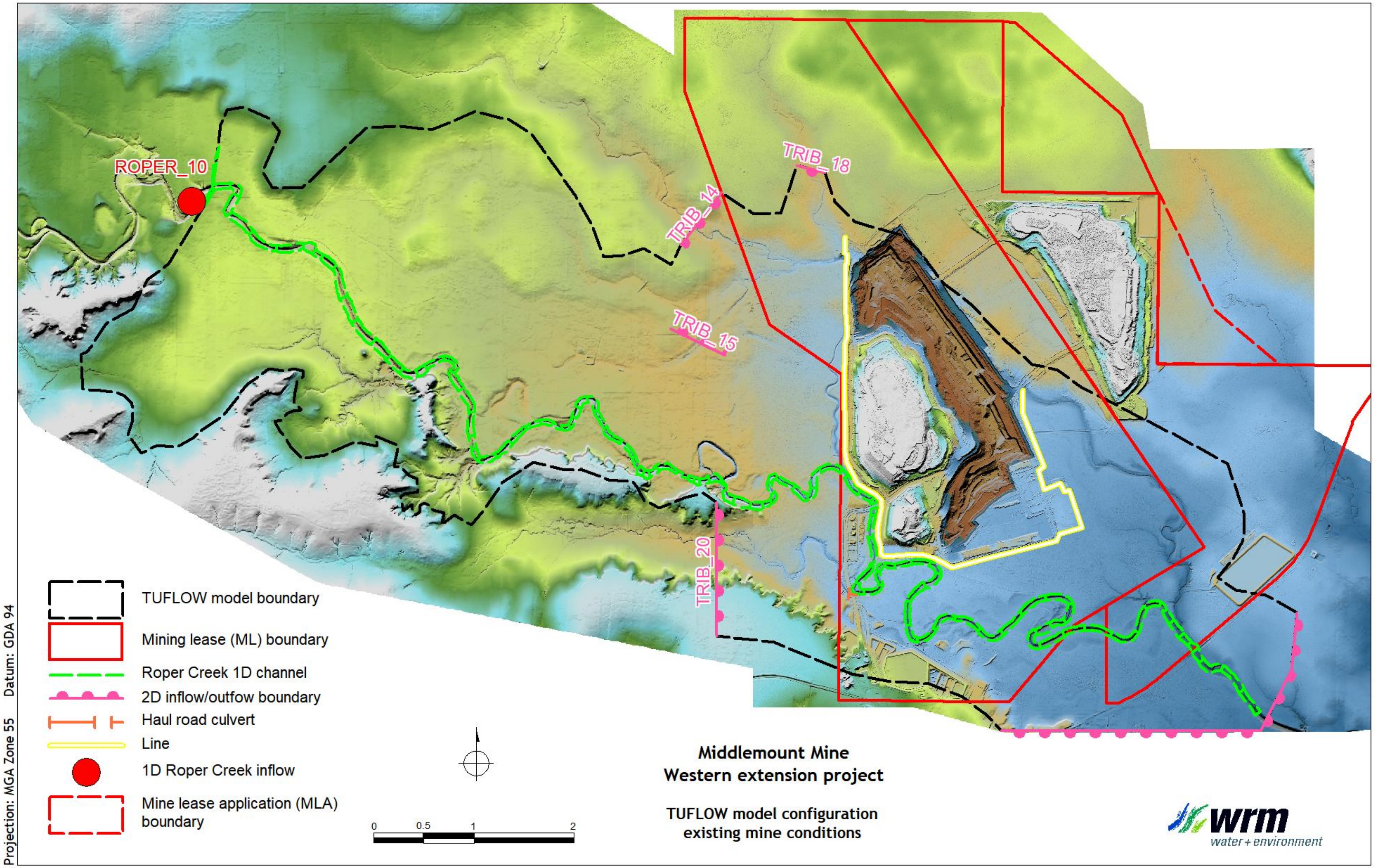


Figure C.8 – Existing Roper Creek TUFLOW model configuration

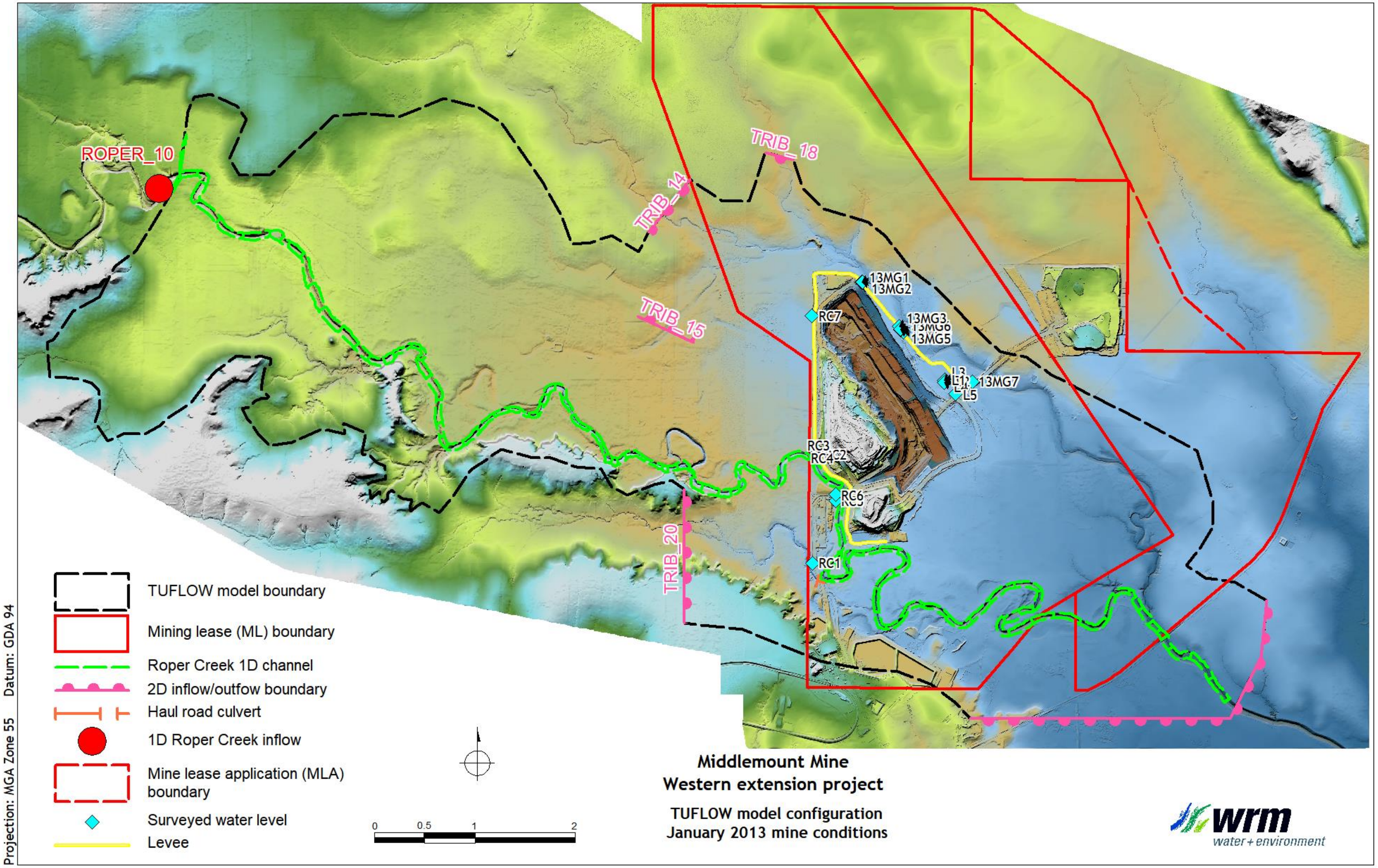


Figure C.9 – January 2013 Roper Creek TUFLOW model configuration

The modelled study area covers approximately 44.5 km^2, commencing approximately 11.5 km upstream of the mine lease area and extends to the east of the mine lease area to Middlemount Road. A 20 m grid size and 5 second time step were adopted for the two dimensional model areas.

C3.3.1 Roper Creek 1D channel

Roper Creek was modelled as a 1D channel carved through the 2D floodplain. Figure B.10 shows a conceptual illustration of the model representation of a typical section of Roper Creek and its floodplain.

The Roper Creek main channel is incised with a width of between 40 m and 80 m. The channel has significant flood capacity, ranging from Q10 to greater than Q100 at some locations. The storage and conveyance of the channel can be represented much more accurately in a 1D model. At some locations, the channel is perched above the floodplain, creating a natural levee along its banks.

A total of 106 cross-sections of the Roper Creek channel were generated from the survey Digital Elevation Model at an average spacing of 250 m. The MIKE 11 hydrodynamic 1D model was used to generate hydraulic information such as storage and conveyance data at each cross section location for input into the ESTRY model.

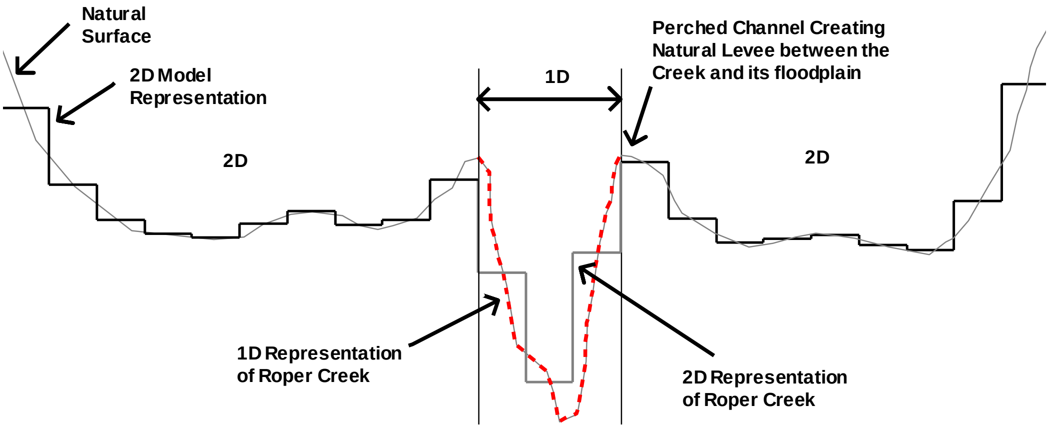


Figure C.10 - Typical cross-section of Roper Creek in 1D and floodplain in 2D (indicative)

C3.3.2 Adopted Manning's 'n' values

The TUFLOW model uses Manning's 'n' values to represent hydraulic resistance (notionally channel or floodplain roughness). Manning's 'n' values were initially selected based on typical published values (for example, those of Chow, 1959) and calibrated using recorded water level data in Roper Creek. The adopted Manning's n values for the TUFLOW model are:

- Roper creek channel: 'n' = 0.045
- Overbank areas: 'n' = 0.06

C3.3.3 Road crossings

The Middlemount Road crossing of Roper Creek downstream of the mine is a bridge which spans the main channel. The bridge forms only a very minor constriction to flood flows and has minimal impact on flow behaviour. Hence, this crossing was not explicitly represented in the TUFLOW model.

The haul road crossing of Roper Creek consists of 4 x 2.5 m diameter corrugated metal pipes and has been represented within the 1D network.

C3.4 MODEL CALIBRATION

The TUFLOW model was calibrated to the recorded water level at the IMPAC1 stream gauge located at Middlemount Road and surveyed flood marks obtained for the January 2013 event. The locations of the gauge and the surveyed flood marks are shown in Figure B.9. Section B.2.3 provides the discharges derived for the event.

Figure B.11 compares the recorded and predicted water level hydrographs at the IMPAC1 gauge and Table B.6 compares the surveyed and predicted peak water levels across the mine. Overall, a good calibration was achieved for the event and is therefore suitable to estimated design flood levels for the various mine Phases.

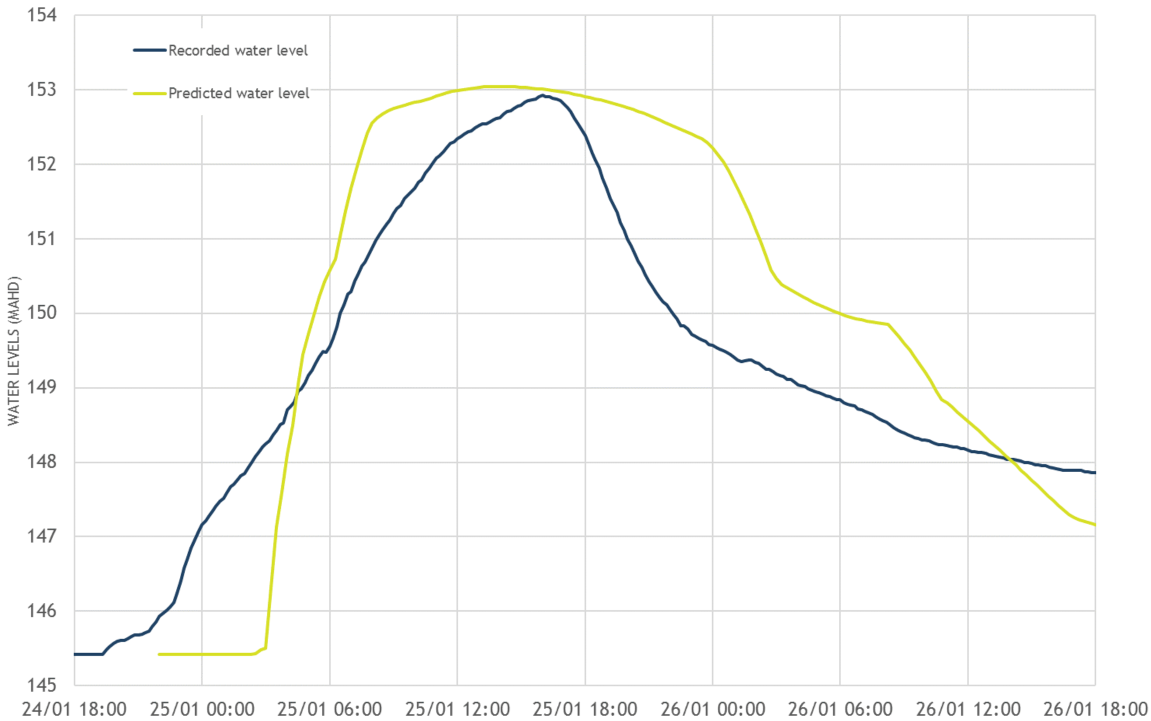


Figure C.11 – Recorded and predicted water level at the IMPAC1 gauge at Middlemount Road, January 2013 event.

Table C.6 – Comparison of surveyed and predicted flood levels, January 2013 event

Location	Surveyed (mAHD)	Predicted (mAHD)	Difference (m)
RC1	162.01	162.13	0.12
RC2	162.66	162.90	0.24
RC3	162.66	162.70	0.04
RC4	162.99	163.04	0.05
RC5	162.25	162.08	-0.17
RC6	162.26	162.32	0.06
RC7	161.79	162.20	0.41
13MG1	161.01	160.90	-0.11
13MG2	161.01	160.90	-0.11
13MG3	160.33	160.33	0.00
13MG4	160.82	160.78	-0.04
13MG5	160.83	160.77	-0.06
13MG6	160.83	160.71	-0.12
L1	160.70	160.76	0.06
L2	160.69	160.76	0.07
L3	160.75	160.76	0.01
L4	160.71	160.76	0.05
L5	160.76	160.76	0.00
13MG7	160.78	160.78	0.00

C3.5 EXISTING CONDITIONS FLOODING

Figure B.12 and Figure B.13 show the existing conditions flood levels depth and extent across the Project area for the 5% and 1% AEP event. The results show that the Roper Creek channel upstream of the Project area has capacity to convey the 5% AEP event. The channel overflows along the western boundary at the Thirteen Mile Gully diversion confluence for this event. The flood investigations undertaken for Stage 2 (WRM, 2010) show that the creek channel overflowed at this location prior to mining. The Roper Creek channel overflows upstream of the Project area for the 1% AEP event. The overflowing floodwater drains into Drainage Line 1, which then flows back to Roper Creek via the Thirteen Mile Gully diversion.

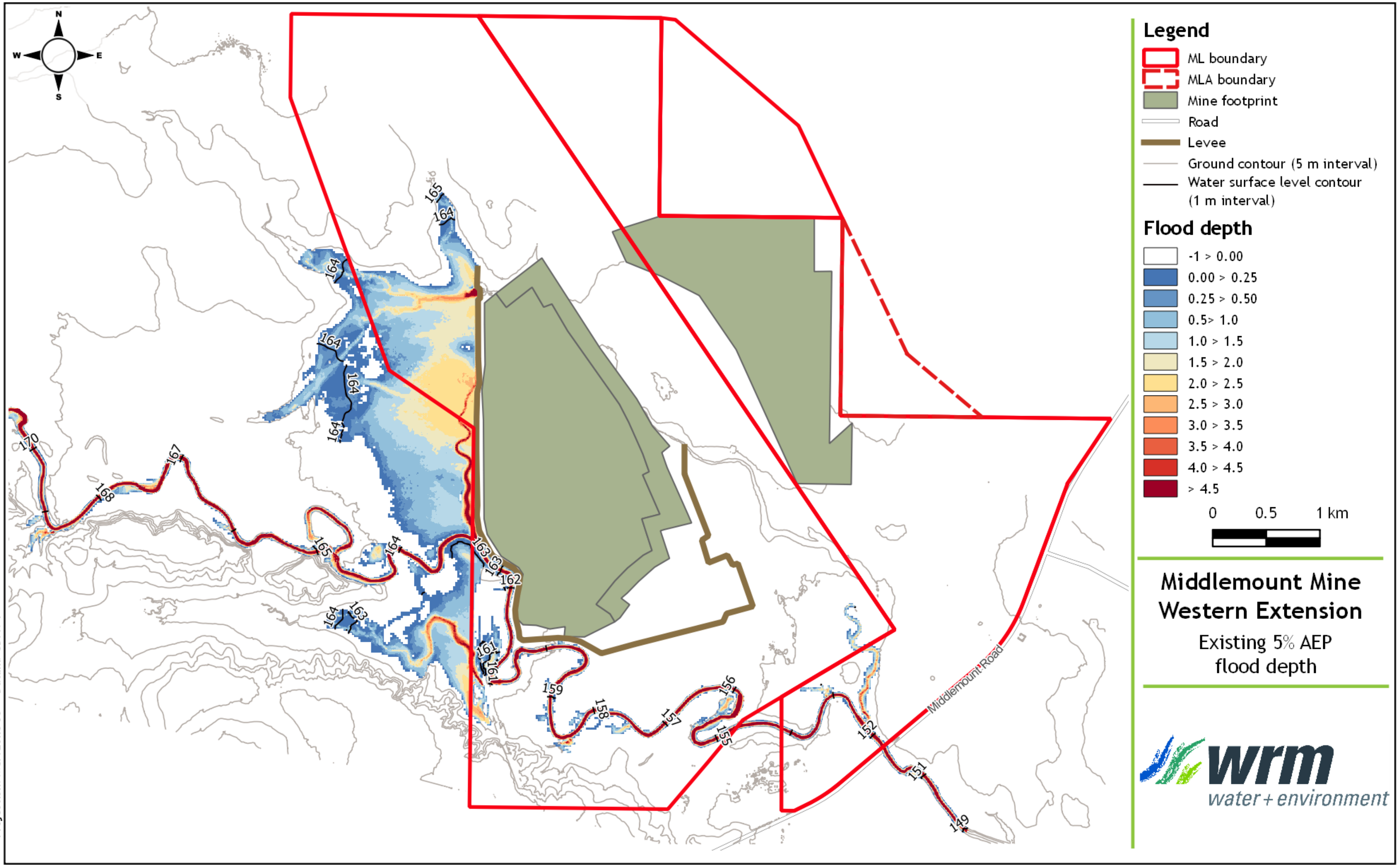


Figure C.12 - Existing conditions flood levels, depths and extent, 5% AEP event.

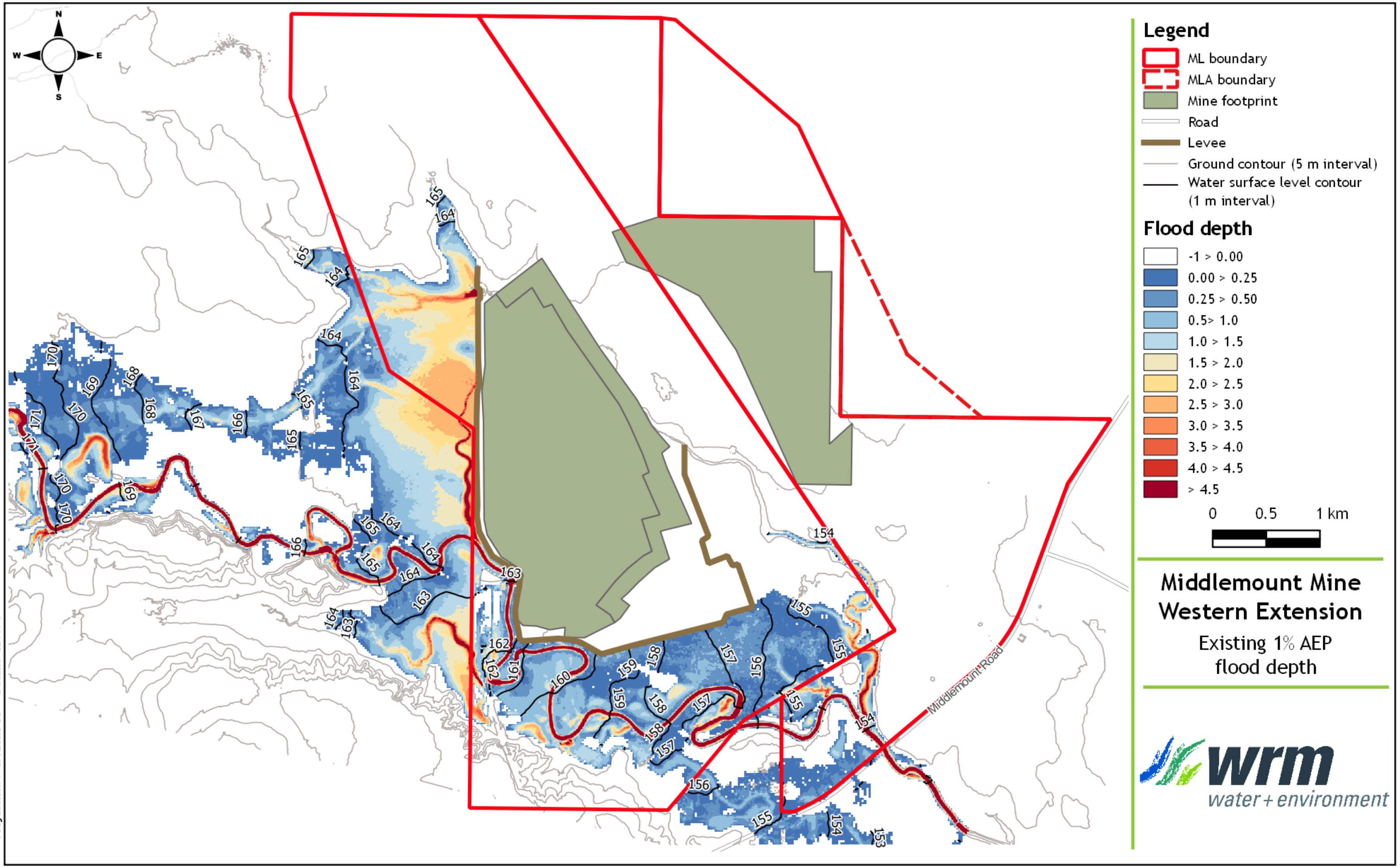


Figure C.13 - Existing conditions flood levels, depths and extent, 1% AEP event.