MIDDLEMOUNT COAL MINE

SOUTHERN EXTENSION PROJECT
Original EPBC Referral Submission 18/03/2021
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EVA Appendix A
Surface Water Assessment

middlemount coal PTY LTD ABN 49 122 348 412

Middlemount Coal Mine

Southern Extension Project
Surface Water Impact Assessment

Middlemount Coal Pty Ltd

0469-29-J4, 3 September 2020

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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).

Minor amendments to the EA were made on 22 August 2017 and 21 May 2018 for various minor changes, including conditions to enable exploration activities in the extended northwest portion of ML 70739. An amendment to the Middlemount Coal Mine EA was granted on 21 March 2019 to extend the open cut pit within ML 70379 to the north-west, increase ROM coal throughput to 5.7 Mtpa and expand the East Dump in ML 700014 and ML 700027 (the Western Extension Project).

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 and ML 700014. Up to 5.7 Mtpa of ROM coal is processed through a coal handling and preparation plant (CHPP) to produce Pulverised Coal Injection (PCI) and coking coal (and small amounts of thermal coal) for the export market. Product coal is transported by rail to the Dalrymple Bay Coal Terminal and Abbot Point Coal Terminal.

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 Southern Extension Project (the Project). The Project involves extension within ML 70379 and ML 70417 to the south and extension of waste rock emplacement areas within ML 70014, ML700027 and ML 70417. The main activities associated with the development of the Project would include:

- extension of the open cut pit to the south within MLs 70379 and 70417;
- 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 (West Dump and East Dump) and within the mined-out void;
- minor extensions to waste rock emplacements footprint;
- progressive development of sediment dams, pipelines and other water management equipment and structures;
- re-positioning of the approved southern flood levee and water management infrastructure;
- re-alignment and extension of the approved (but not yet constructed) eastern diversion of Roper Creek (Roper Creek Diversion 2) inside the MLs;
- 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;
- extension of the approved mine life by approximately seven years (to 2044); and
- a change to the residual landform for the end of the mine life.

The approximate footprint of the Project is shown in Figure 1.2.

The proposed general layout of the Middlemount Coal Mine in 2023, 2028, 2037, 2043 and for the post-mining landform are shown in Figure 1.3 to Figure 1.7.

1.3 REPORT STRUCTURE

This report is structured as follows:

- Section 2 describes the Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development gas information guidelines (IESC, 2018) advice on coal seam gas and large coal mining development proposals and outlines where in the document they have been addressed;
- Section 3 describes the drainage characteristics and environmental values of the regional and local drainage receiving waters;
- Section 4 presents the surface water characteristics of the approved (existing) mine site;
- Section 5 describes the surface water management system including the management objectives and principles;
- Section 6 provides a summary of the water balance model results for the mine water management system;
- Section 7 describes the outcomes from the residual void water assessment;
- Section 8 describes the development and calibration of the flood models developed for the assessment;
- Section 9 describes the proposed Roper Creek Diversion 2 realignment and extension and presents the findings of the flood modelling assessment;
- Section 10 describes the outcomes from the impact assessment for surface water and presents the mitigation and management measures;
- Section 11 summarises the outcomes from the surface water assessment;
- Section 12 gives a list of references;
- Appendix A summarises select recent water quality monitoring data as time-series graphs;
- Appendix B describes the mine water balance model configuration;
- Appendix C presents the flood mapping for pre-mining, approved, proposed and post mining conditions;
- Appendix D presents the flood impact mapping between proposed and post mining conditions compared to approved conditions.

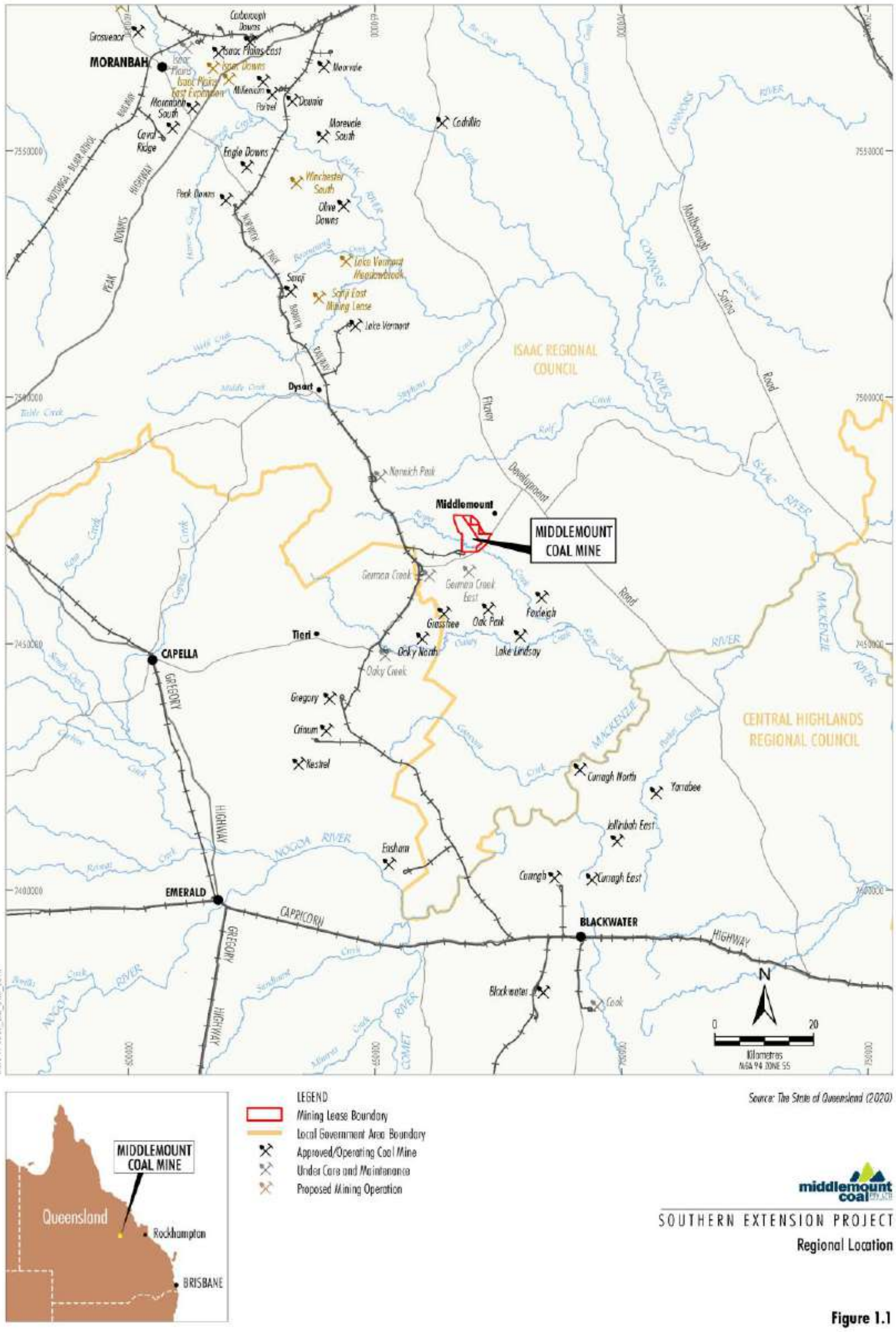

Figure 1.1 – Regional location of Middlemount Coal Mine

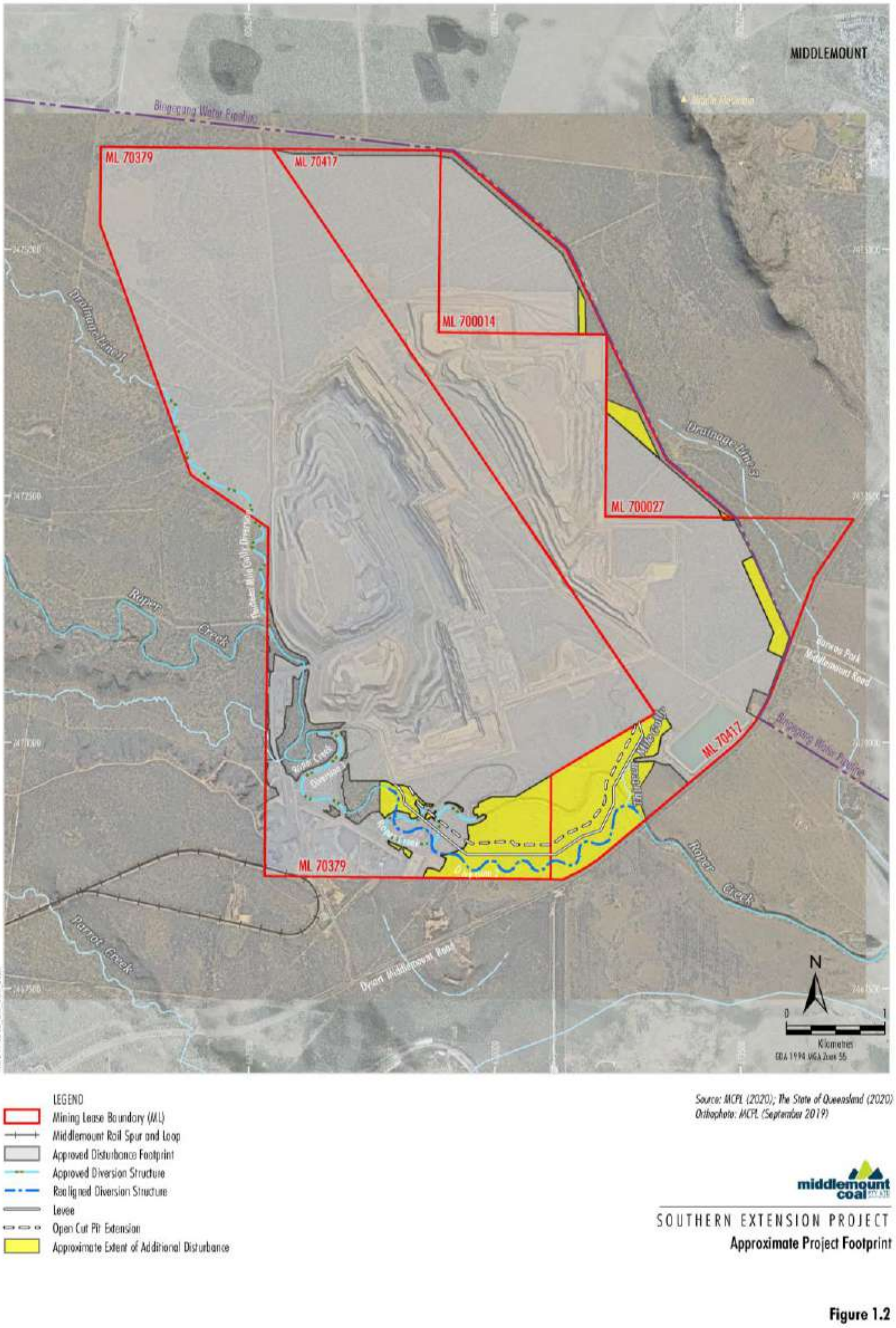

Figure 1.2 – Approximate Project Footprint

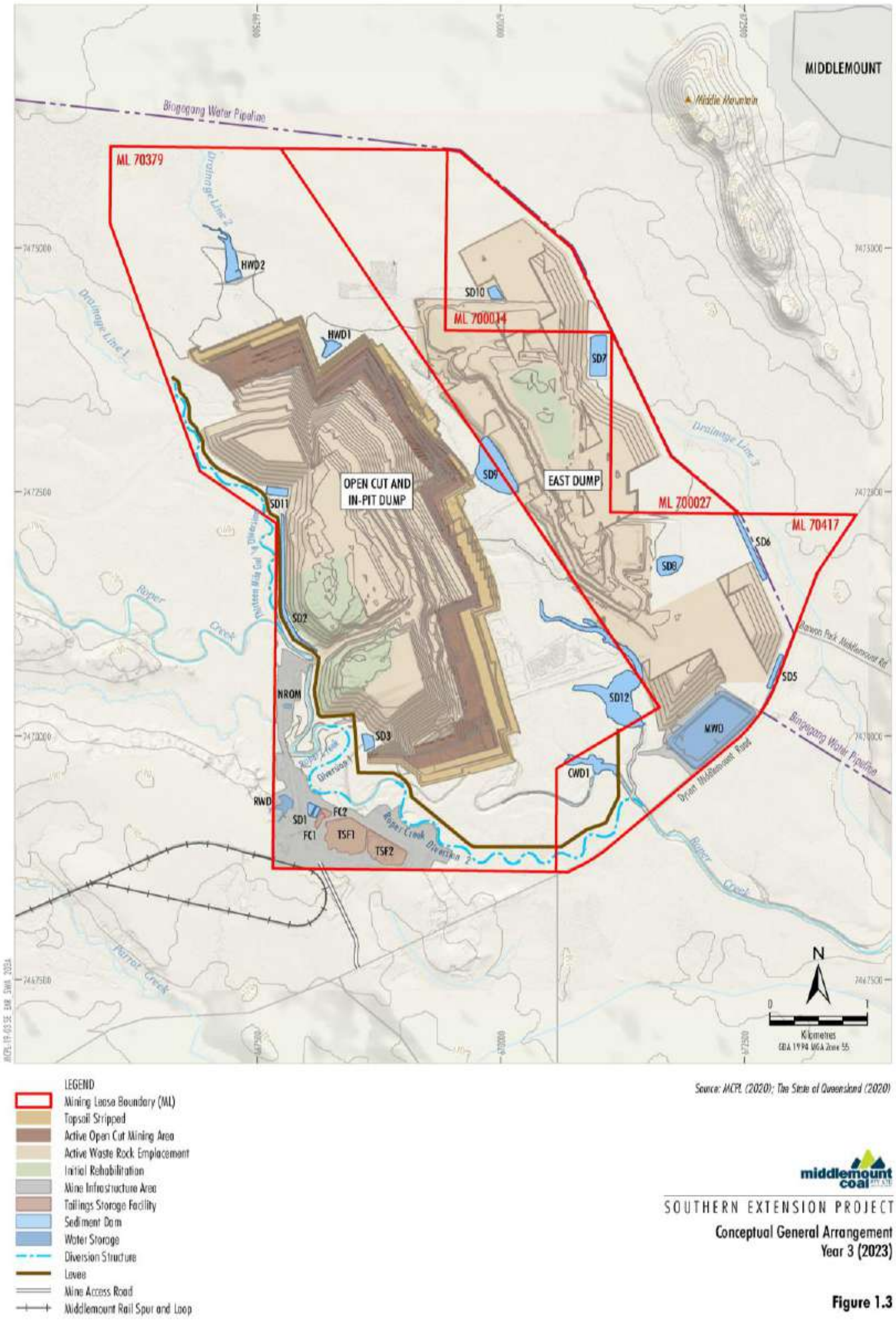

Figure 1.3 – Proposed general layout, Year 3 (2023)

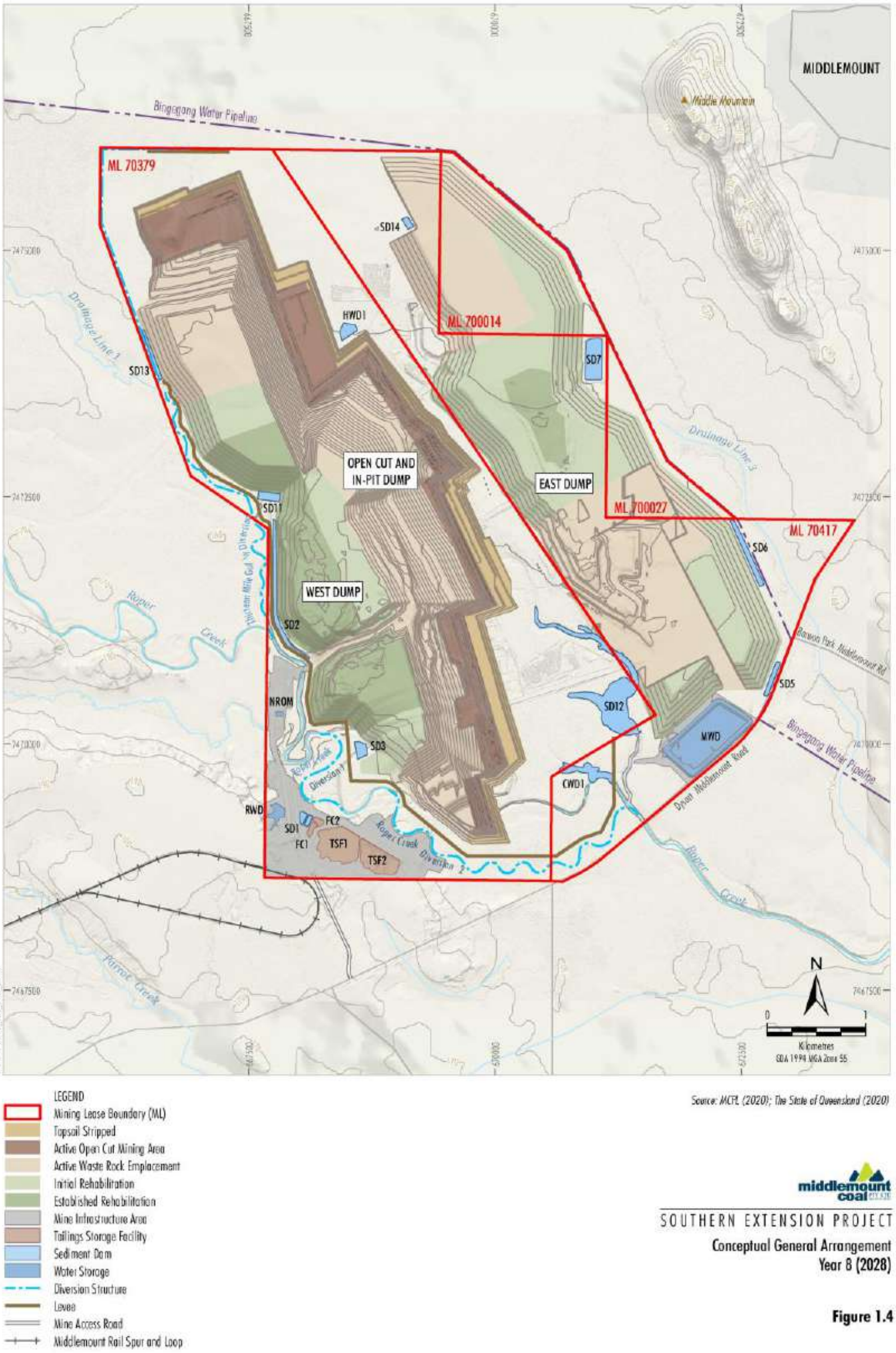

Figure 1.4 – Proposed general layout, Year 8 (2028)

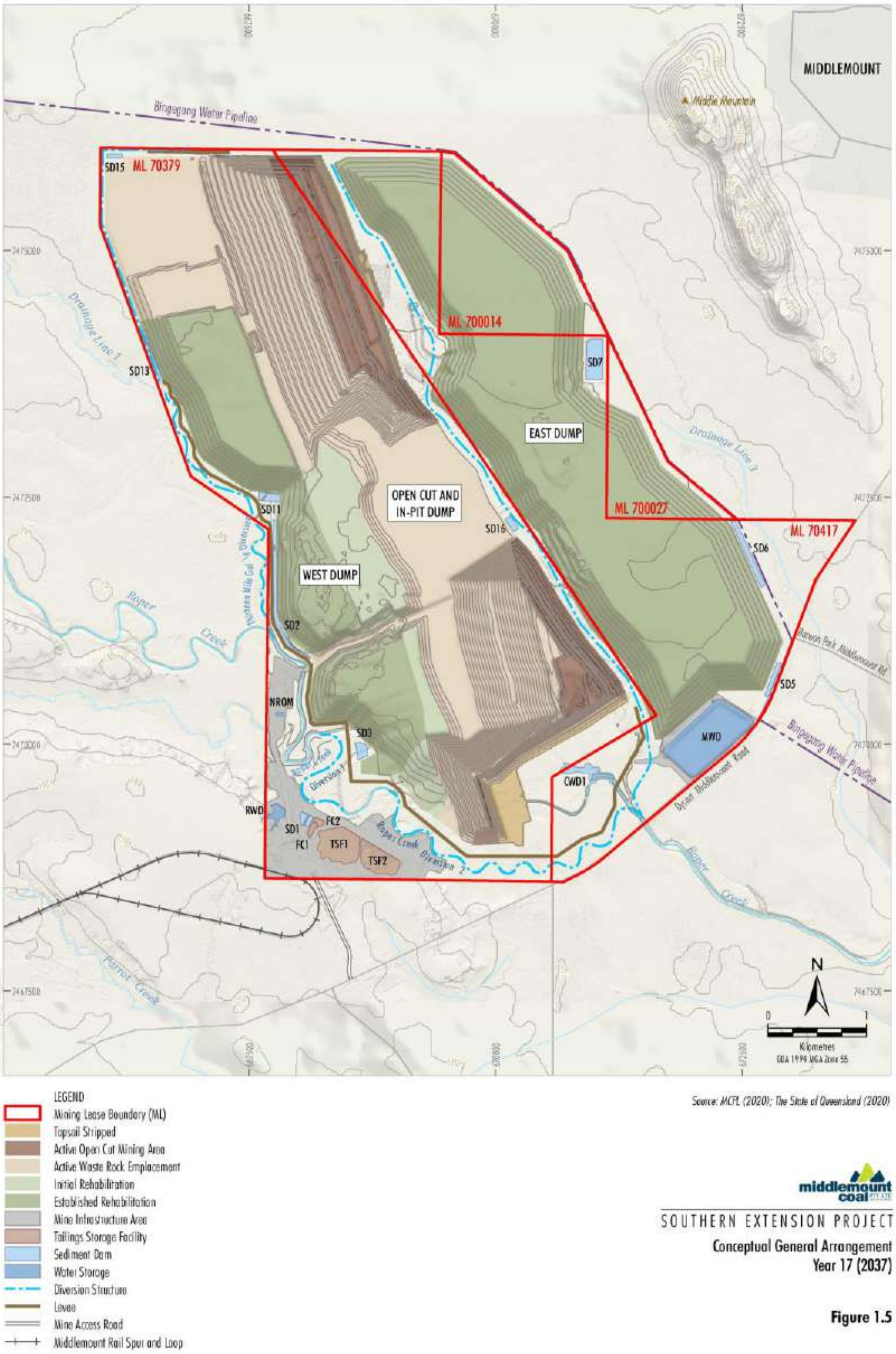

Figure 1.5 – Proposed general layout, Year 17 (2037)

Figure 1.6 – Proposed general layout, Year 23 (2043)

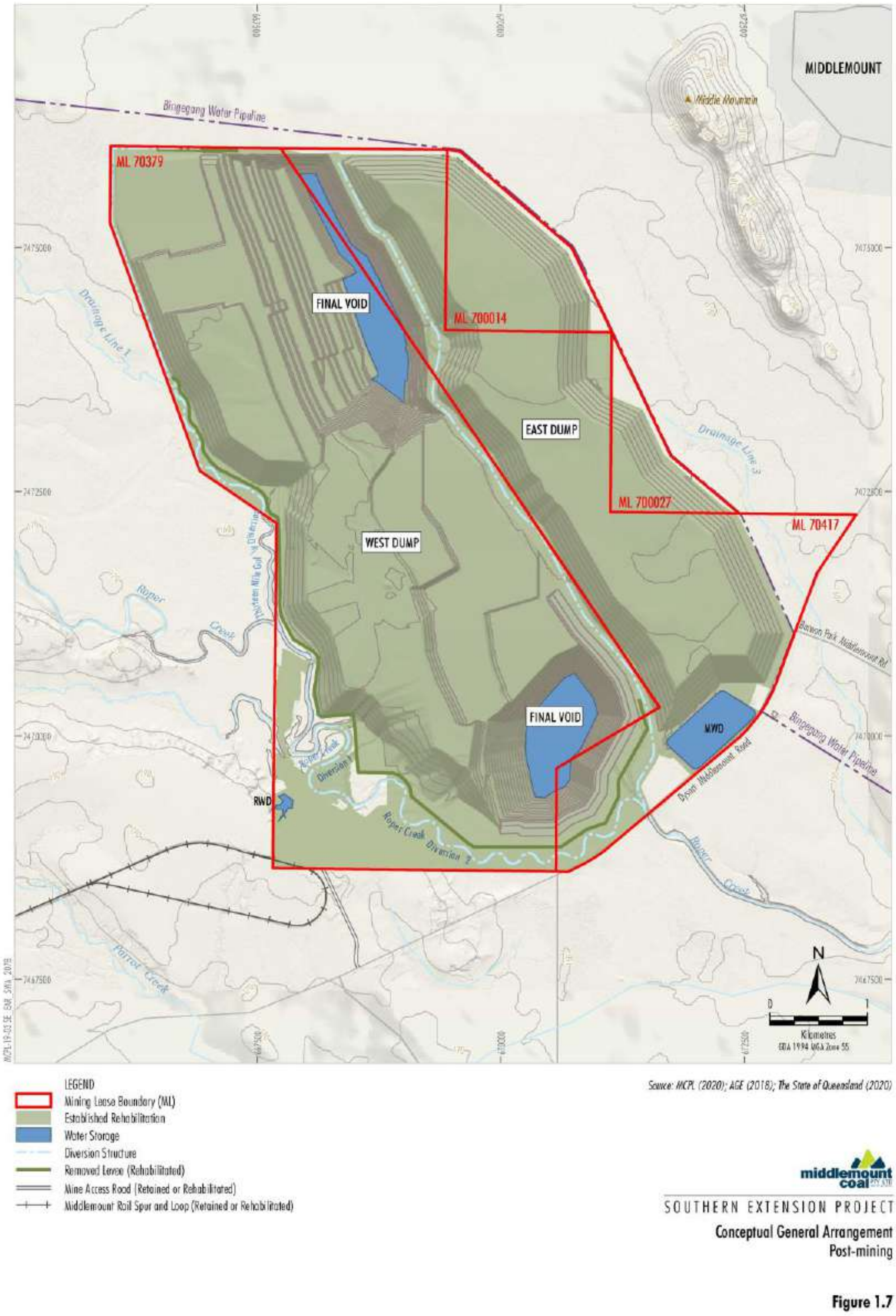

Figure 1.7 – Proposed general layout, Post-mining

2 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) provides assessment consideration 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 2.1.

Table 2.1- 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, 3, 4 & 5
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, 5 & 6
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 3.7 & 3.8
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 3.2, 3.3 & 3.4
• spatial, temporal and seasonal trends in streamflow and/or standing water levels;	Section 3.3
• spatial, temporal and seasonal trends in water quality data (such as turbidity, acidity, salinity, relevant organic chemicals, metals, metalloids and radionuclides); and	Section 3.6
• current stressors on watercourses, including impacts from any currently approved projects.	Section 3.6 & 3.7
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.	Section 8 & Appendix C
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

Project information	Report section
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 B, Appendix C Sections 6 & 8
Use methods in accordance with the most recent publication of *Australian Rainfall and Runoff* (Ball et al. 2016).	Section 8
Develop and describe a program for review and update of the models as more data and information becomes available.	Appendix B1
Describe and justify model assumptions and limitations, and calibrate with appropriate surface water monitoring data.	Section 8.2, 8.4 & Appendix B8
Provide an assessment of the risks and uncertainty inherent in the data used in the modelling, particularly with respect to predicted scenarios.	Section 6.3
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 Section 8.2, 8.4, Appendix B8
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 9 & 10.4
• impacts associated with surface water diversions.	Section 9
• impacts to water quality, including consideration of mixing zones.	Section 6.3 & 0
• 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 6.3 & 0
• 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 7
Discuss existing water quality guidelines, environmental flow objectives and requirements for the surface water catchment(s) within which the development proposal is based.	Section 3.7 & 0
Identify processes to determine surface water guidelines and quantity thresholds which incorporate seasonal variation but provide early indication of potential impacts to assets.	Section 5.5.2
Propose mitigation actions for each identified significant impact.	Section 5, 8 and 10

Project information	Report section
Describe the adequacy of proposed measures to prevent or minimise impacts on water resources and water-dependent assets.	Section 6 & 9
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 10.6
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 9
<u>Surface water – data and monitoring</u>	
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 4.4
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 4.4
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 3.3 & Appendix B2
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. • identify baseline contaminant concentrations and compare these to national guidelines, allowing for local background correction if required.	Section 4.4
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 3.3
Identify dedicated sites to monitor hydrology, water quality, and channel and floodplain geomorphology throughout the life of the proposed project and beyond.	Section 4.4
<u>Water-dependent assets – context and conceptualisation</u>	
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 3.8 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

Project information	Report section
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 3.8
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 5.5.2
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 Ecology Report & 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 3 & 4
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 7
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 6.3.5, 6.3.6 & 0
Assess the overall level of risk to water-dependent assets through combining probability of occurrence with severity of impact.	Section 10
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 5.5.2
Propose mitigation actions for each identified impact, including a description of the adequacy of the proposed measures and how these will be assessed.	Section 10

Project information	Report section
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]).	
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]).	Section 4.4, 5.5.2 and Section 10
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 6 & Appendix B
Describe the water requirements and on-site water management infrastructure, including modelling to demonstrate adequacy under a range of potential climatic conditions.	Section 6 & Appendix B
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 6
Provide salt balance modelling that includes stores and the movement of salt between stores, and takes into account seasonal and long-term variation.	Section 6
Cumulative impacts - context and conceptualisation	
Provide cumulative impact analysis with sufficient geographic and temporal boundaries to include all potentially significant water-related impacts.	Section 10.6
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 10.6

Project information	Report section
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 10
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 • opportunities to work with other water users to avoid, minimise or mitigate potential cumulative impacts.	Section 10.6
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.	Section 10.6
Identify measures to detect and monitor cumulative impacts, pre and post development, and assess the success of mitigation strategies.	
Identify cumulative impact environmental objectives.	
Describe appropriate reporting mechanisms.	
Propose adaptive management measures and management responses.	

Project information	Report section
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.	Section 7
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.	
Assess the probability of overtopping of final voids with variable climate extremes, and management mitigations.	Section 7 & Section 10
Acid-forming materials and other contaminants of concern	
Identify the presence and potential exposure of acid-sulphate soils (including oxidation from groundwater drawdown).	Section 3.4 & 4.4 Refer to Geological Report
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.	
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.	

3 Catchment hydrology and environmental values

3.1 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.

New and revised Default Guideline Values (DGVs) for aquatic ecosystems were published by ANZECC in late 2018. These have been compared against the previous 'trigger values' and updated where appropriate.

3.2 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 – called Drainage line 1 and 2) to Roper Creek;
- Thirteen Mile Gully downstream of the operations; and
- An unnamed tributary of Roper Creek (called Drainage Line 3), 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 3.1 shows the wider locality of the Roper Creek catchment and Figure 3.2 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 other coal mines also exist in the catchment, including the southern extent of Norwich Park Mine, Capcoal Complex, Oaky Creek Coal Mine and Foxleigh Coal Mine (see Figure 1.1).

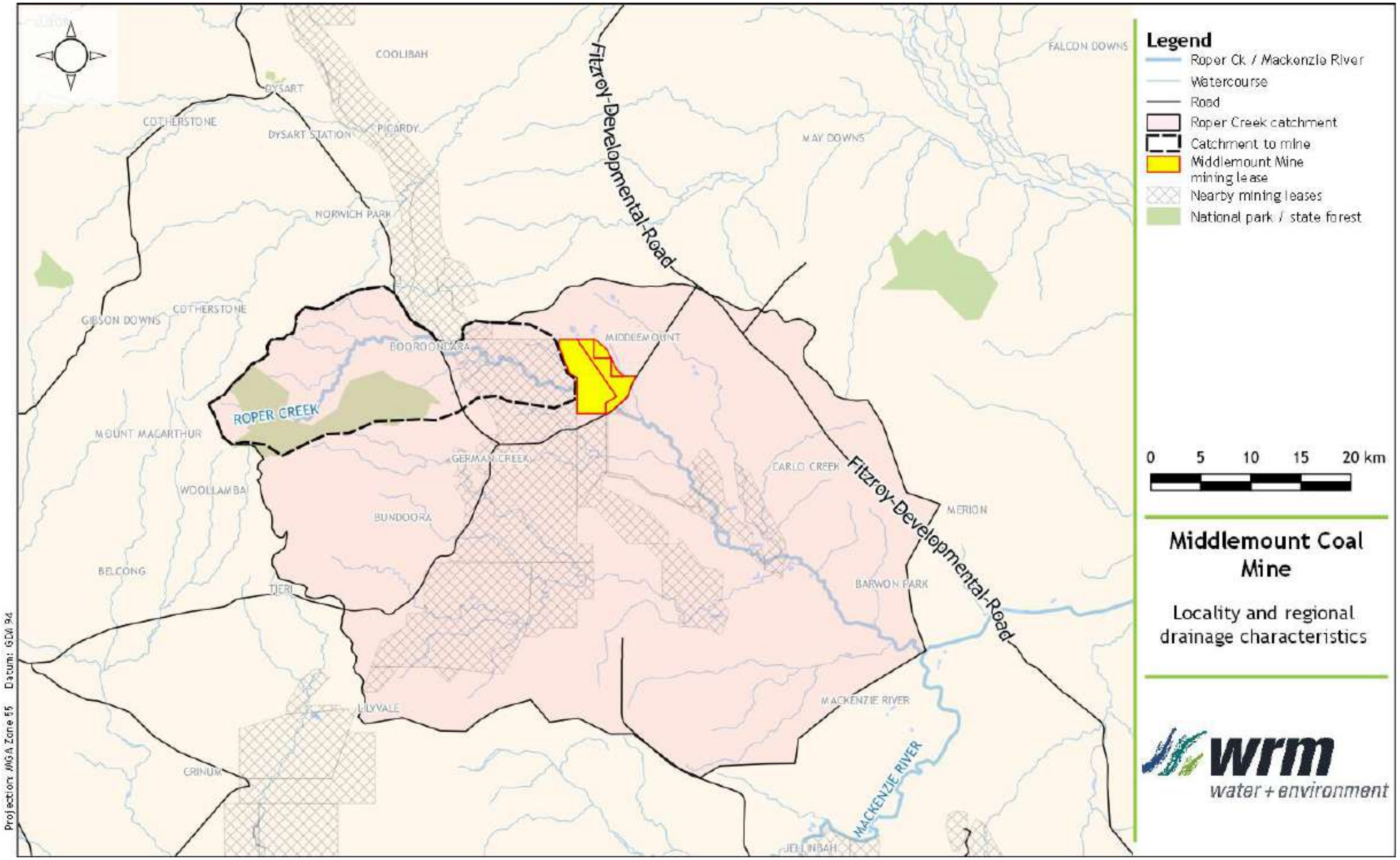

Figure 3.1 – Regional drainage characteristics

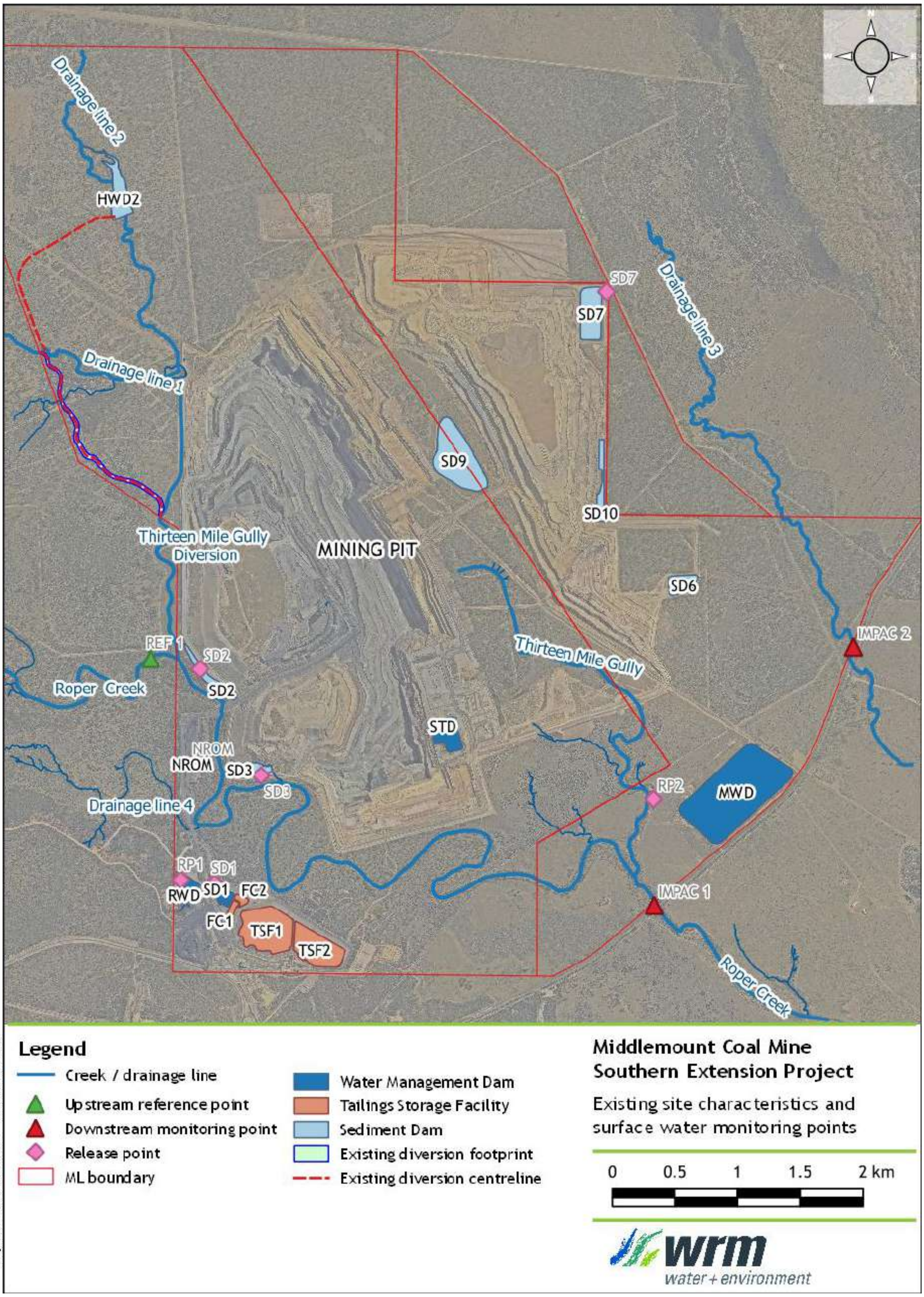

Figure 3.2 – Middlemount Coal Mine existing site characteristics and surface water monitoring locations

Figure 3.2 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. The realignment of the Thirteen Mile Gully Diversion was approved as part of the Western Extension Project and was completed in July 2020.

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). Both of these drainage lines have been redirected around the mine into the Thirteen Mile Gully Diversion.

An unnamed ephemeral tributary of Roper Creek, shown on Figure 3.2 as Drainage Line 3, is located approximately 1 km east and south east of Middlemount Coal Mine. It is poorly defined in some areas upstream of Dysart Middlemount Road, with a channel depth of less than 0.5 m in some locations. The drainage line reappears at Dysart Middlemount Road where it discharges under the road via several box culverts.

Another unnamed ephemeral tributary of Roper Creek, shown on Figure 3.2 as Drainage Line 4, drains into Roper Creek along the western boundary of the mining lease to the north of the mine infrastructure area. It has a catchment area of about 8.7 km^2 and it drains along a relatively well-defined channel. The haul road crosses drainage line 4.

As part of the Southern Extension Project, it is proposed to realign and extend the approved (but not yet constructed) Roper Creek Diversion 2 inside the existing MLs.

3.3 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 3.1 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%.

Figure 3.3 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 3.4 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 20^{th} percentile flow is 200 ML/day.

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.

3.4 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.

Table 3.1 – 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

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.

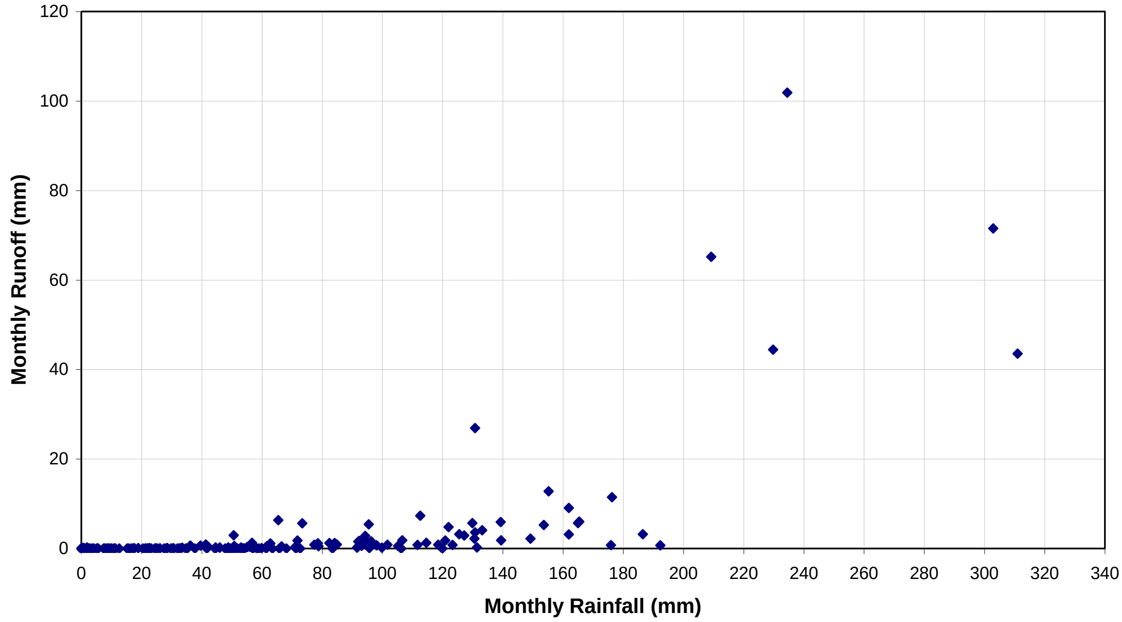

Figure 3.3 – Monthly runoff versus rainfall for Roper Creek at Barwon Park gauging station

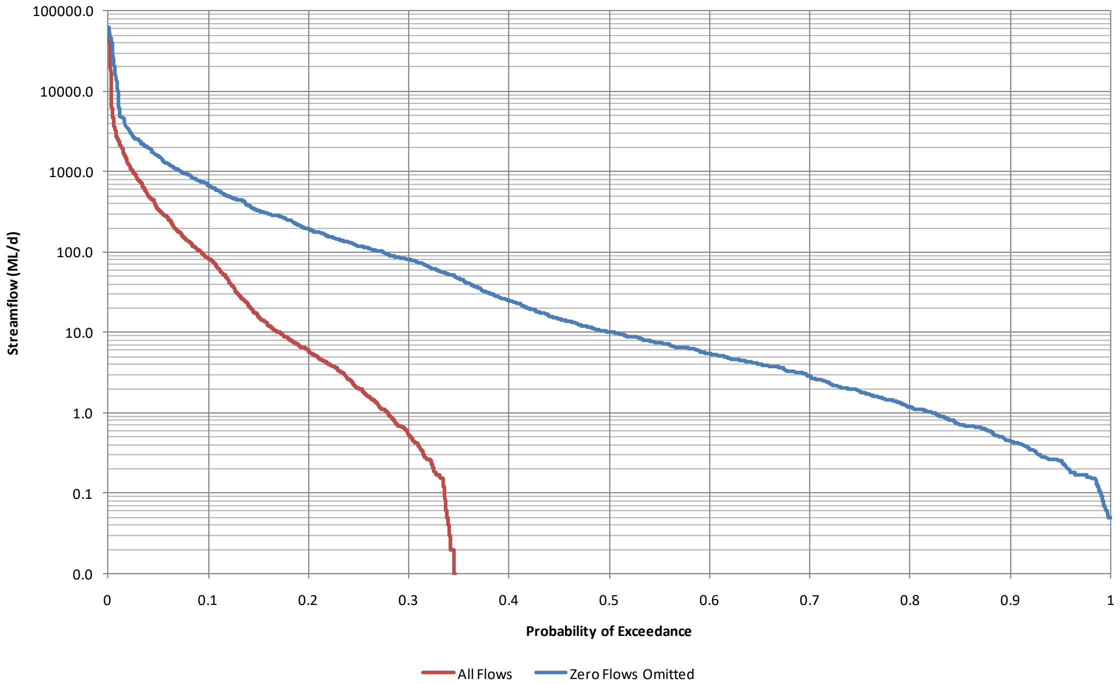

Figure 3.4 – Roper Creek at Barwon Park flow frequency curve, all flows and zero flows omitted

Water quality monitoring in mine affected water storages shows that runoff and seepage from the coal stockpiles, mining pits and tailings storage facilities (TSFs) 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.

3.5 GROUNDWATER

Three hydro-stratigraphic units have been identified by AGE (2020) 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.
    - Bores do not commonly access the Permian aquifer due to the depth of water bearing strata and the typical high salinity of this type of water (AGE, 2020).

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.

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 28.9 mbgl (MW9A), with an average depth of 17.3 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 approximately 19,000 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 approximately 19,000 µS/cm and contains elevated chloride, sodium and TDS.

3.6 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, 2019). Water quality in Roper Creek is characterised by high and variable turbidity, moderate and variable EC and low dissolved oxygen concentrations at times.

The concentrations of most metals were very low within Roper Creek and did not exceed the EA trigger values, with the exception of aluminium and copper (which was recorded at elevated concentrations at upstream and downstream sites), as well as chromium, iron and vanadium (which was recorded at elevated concentrations at the downstream site). As there have been no discharges to Roper Creek since 2014, the elevated metal concentrations at the reference and impact sites are unlikely to be attributable to Middlemount Coal Mine operations.

GHD (2019) (cited in DPM Envirosciences, 2020) found that the macroinvertebrate community of Roper Creek exhibited signs of stress. Given the ephemeral nature of Roper Creek, changes in metrics over time associated with macroinvertebrate communities are to be expected. Given the lack of discharges from Middlemount Coal Mine, there had been no indication of impacts from Middlemount Coal Mine operations on the macroinvertebrate community of Roper Creek.

Table 3.2 shows the water quality at the upstream and downstream surface water monitoring sites. Time series graphs of the historical water quality sampling data of the receiving water contaminant trigger parameters at the upstream and downstream surface water monitoring sites are provided in Appendix A. Given the ephemeral nature of the upstream sub-catchments of Thirteen Mile Gully, no water quality data is available for the minor drainage lines.

3.7 EXISTING WATER USE ENTITLEMENTS

The Queensland Government water entitlement viewer 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.

[1] Excavated within the advancing open cut.

Table 3.2 – Water quality summary, upstream and downstream surface water monitoring sites

Parameter	Units	Middlemount EA conditions		REF1				IMPAC1				IMPAC2			
		End of pipe limit/release contaminant trigger level	Receiving water trigger	No. of samples	10^{th} %ile	Median	90^{th} %ile	No. of samples	10^{th} %ile	Median	90^{th} %ile	No. of samples	10^{th} %ile	Median	90^{th} %ile
pH	-	6.5 - 9.0	6.5 - 8.5	48	7.7	8.1	8.2	45	7.8	7.9	8.1	5	7.0	8.0	8.9
EC	µs/cm	700 - 6,000	700	48	207	674	840	45	290	426	619	5	246	374	455
Suspended solids	mg/L	562 - 1,062	562 - 1,062	53	5	23	494.2	50	33.2	563.5	1168	7	28	39	274
Sulphate ($SO4^{2-}$) (dissolved)	mg/L	250 - 500	250	8	20	47	66	6	22	34	51	4	10	16	25
Turbidity	NTU			50	7	19	507	47	110	845	1718	6	56	220	856
Aluminium (dissolved)	mg/L	0.055	-	15	0.010	0.010	0.140	14	0.010	0.025	0.074	6	0.025	0.055	1.635
Arsenic (dissolved)	mg/L	0.013	-	16	0.001	0.001	0.002	15	0.001	0.001	0.001	7	0.001	0.001	0.004
Cadmium (dissolved)	mg/L	0.0002	-	16	0.0001	0.0001	0.0001	15	0.0001	0.0001	0.0001	7	0.0001	0.0001	0.0001
Chromium (dissolved)	mg/L	0.001		16	0.001	0.001	0.001	15	0.001	0.001	0.001	7	0.001	0.001	0.0074
Copper (dissolved)	mg/L	0.002	-	16	0.001	0.001	0.004	15	0.001	0.002	0.002	7	0.001	0.002	0.005
Iron (dissolved)	mg/L	0.3		15	0.06	0.08	0.30	14	0.05	0.12	0.25	6	0.05	0.06	1.04
Lead (dissolved)	mg/L	0.004	-	16	0.001	0.001	0.001	15	0.001	0.001	0.001	7	0.001	0.001	0.001
Mercury (dissolved)	mg/L	0.0002		15	0.0001	0.0001	0.0001	14	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0001
Nickel (dissolved)	mg/L	0.011	-	16	0.002	0.003	0.003	15	0.002	0.002	0.004	7	0.002	0.002	0.005
Zinc (dissolved)	mg/L	0.008	-	16	0.005	0.005	0.020	13	0.005	0.005	0.006	7	0.005	0.005	0.005
Boron (dissolved)	mg/L	0.37	-	15	0.05	0.07	0.09	14	0.05	0.06	0.08	6	0.05	0.06	0.105
Cobalt (dissolved)	mg/L	0.090	-	15	0.001	0.001	0.001	14	0.001	0.001	0.001	6	0.001	0.001	0.001
Manganese (dissolved)	mg/L	1.9		15	0.001	0.025	0.152	14	0.001	0.001	0.0503	6	0.001	0.0015	0.054
Molybdenum (dissolved)	mg/L	0.034		14	0.001	0.001	0.001	13	0.001	0.002	0.003	5	0.001	0.001	0.011
Selenium (dissolved)	mg/L	0.01		15	0.01	0.01	0.01	14	0.01	0.01	0.01	6	0.01	0.01	0.01
Silver (dissolved)	mg/L	0.001		14	0.001	0.001	0.001	13	0.001	0.001	0.001	5	0.001	0.001	0.001
Uranium (dissolved)	mg/L	0.001		14	0.001	0.001	0.001	11	0.001	0.001	0.001	5	0.001	0.001	0.001
Vanadium (dissolved)	mg/L	0.01		15	0.010	0.010	0.010	12	0.010	0.010	0.010	6	0.010	0.010	0.015
Ammonia (dissolved)	mg/L	0.9		16	0.02	0.06	0.24	15	0.024	0.06	0.112	7	0.046	0.07	0.216
Nitrate	mg/L	1.1		16	0.010	0.010	0.485	15	0.010	0.300	0.448	7	0.006	0.010	0.316
Petroleum hydrocarbons (C6-C9)	µg/L	20		15	20	20	20	15	20	20	20	7	20	20	20
Petroleum hydrocarbons (C10-C36)	µg/L	100		15	50	50	80	15	50	50	50	7	50	50	94
Fluoride	mg/L	2		16	0.1	0.2	0.2	15	0.1	0.2	0.3	7	0.1	0.3	0.4
Sodium (dissolved)	mg/L	TBA		30	10	40	104	23	16	65	91	7	24	36	55

** Shaded values represent an exceedance of the relevant trigger level/DGV*

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.

3.8 ENVIRONMENTAL VALUES

The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP (Water)), which is subordinate legislation to the *Environment Protection Act 1994* (EP Act), provides a framework for identifying environmental values (EVs) for a waterway and deciding water quality objectives (WQOs) to protect or enhance those EVs. 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).

Roper Creek is part of the Mackenzie River catchment in the Fitzroy Basin. The Mackenzie River catchment received a ‘C’ grade (Fair) for aquatic ecosystem health in the *Fitzroy Basin Report Card 2018-19* (Fitzroy Partnership for River Health, 2020).

The environmental values selected for protection include:

- aquatic ecosystem protection (Level 2 – disturbed ecosystems [QWQG - 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.

4 Site characteristics

4.1 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.

4.2 EXISTING SITE OPERATING ACTIVITIES

The major components of the existing Middlemount Coal Mine are shown in Figure 3.2 and include:

- an open cut mining pit;
- out-of-pit spoil dumps;
- 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.

4.3 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.
- '*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.

4.4 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 4.1 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 3.2. Table 4.2 and Table 4.3 summarise the water quality of the tailings and mine affected dams.

Table 4.4 and Table 4.5 show 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. Descriptions of the water quality draining the various areas on the mine site are given in the following sections.

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 for the mine affected water release parameters are provided in Appendix A.

Table 4.1 – Water quality sampling periods

Water storage	ID	Start date	End date (latest sample)
Raw Water Dam	RWD	May 2010	May 2020
Tailings Storage Facility 1	TSF1	October 2010	May 2020
Tailings Storage Facility 2	TSF2	January 2011	March 2020
Mine Water Dam	MWD	January 2015	May 2020
North ROM Dam	NROM	January 2015	April 2020
Mining Pit		July 2015	March 2020*[1]
Sediment Dam 1	SD1	October 2010	May 2020
Sediment Dam 2	SD2	November 2010	May 2020
Sediment Dam 3	SD3	May 2010	May 2020
Sediment Dam 6	SD6	March 2019	January 2020
Sediment Dam 7	SD7	April 2015	June 2019
Sediment Dam 9	SD9	April 2013	June 2019
Sediment Dam 10	SD10	January 2014	January 2020

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

Table 4.2 – Water quality summary, mine affected water storages (1 of 2)

Parameter	Units	Middlemount EA conditions		RWD				TSF 1				TSF 2				Combined TSF 1/2			
		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	No. of samples	10th %ile	Median	90th %ile
pH	-	6.5 – 9.0	6.5 – 8.5	53	6.5	8.5	8.8	43	4.6	8.2	8.7	30	7.6	8.0	8.6	73	7.0	8.1	8.7
EC	µs/cm	700 – 6,000	700	53	1,748	7,400	13,957	43	1,356	8,980	16,228	30	1,687	4,440	15,061	73	1,476	6,570	15,700
Suspended solids	mg/L	562 – 1,062	562 – 1,062	18	5	6	16	11	6	13	61	8	7	65	388	19	6	14	336
Sulphate ($SO4^{2-}$) (dissolved)	mg/L	250 – 500	250	16	254	288	379	15	203	538	822	13	11	235	287	26	211	401	793
Turbidity	NTU			18	3.6	7.8	14.1	11	3.7	12.1	29.0	9	3.2	10.1	225	20	3	12	219
Aluminium (dissolved)	mg/L	0.055	-	12	0.01	0.01	0.01	9	0.010	0.010	0.078	7	0.010	0.010	0.014	16	0.010	0.010	0.050
Arsenic (dissolved)	mg/L	0.013	-	12	0.001	0.001	0.001	9	0.001	0.002	0.002	7	0.001	0.001	0.003	16	0.001	0.002	0.003
Cadmium (dissolved)	mg/L	0.0002	-	11	0.0001	0.0001	0.0001	8	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0002	14	0.0001	0.0001	0.0001
Chromium (dissolved)	mg/L	0.001		10	0.001	0.001	0.001	7	0.001	0.001	0.001	5	0.001	0.001	0.001	12	0.001	0.001	0.001
Copper (dissolved)	mg/L	0.002	-	11	0.001	0.001	0.002	8	0.001	0.001	0.002	6	0.001	0.002	0.002	14	0.001	0.001	0.002
Iron (dissolved)	mg/L	0.3		14	0.05	0.05	0.06	7	0.05	0.05	0.11	5	0.05	0.05	0.05	12	0.050	0.050	0.104
Lead (dissolved)	mg/L	0.004	-	12	0.001	0.001	0.001	8	0.001	0.001	0.001	6	0.001	0.001	0.001	14	0.001	0.001	0.001
Mercury (dissolved)	mg/L	0.0002		14	0.0001	0.0001	0.0001	8	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0001	14	0.0001	0.0001	0.0001
Nickel (dissolved)	mg/L	0.011	-	11	0.007	0.010	0.014	8	0.012	0.013	0.032	6	0.005	0.014	0.018	14	0.009	0.013	0.020
Zinc (dissolved)	mg/L	0.008	-	11	0.005	0.006	0.025	8	0.005	0.006	0.012	6	0.005	0.005	0.018	14	0.005	0.005	0.013
Boron (dissolved)	mg/L	0.37	-	10	0.25	0.35	0.40	6	0.37	0.45	1.97	4	0.181	0.395	0.609	10	0.334	0.405	0.957
Cobalt (dissolved)	mg/L	0.090	-	11	0.001	0.001	0.001	8	0.001	0.004	0.019	6	0.001	0.001	0.006	14	0.001	0.002	0.008
Manganese (dissolved)	mg/L	1.9		8	0.0017	0.003	0.0096	6	0.02	0.03	0.18	4	0.001	0.018	0.103	10	0.001	0.031	0.150
Molybdenum (dissolved)	mg/L	0.034		10	0.0124	0.017	0.024	7	0.019	0.022	0.039	5	0.008	0.012	0.032	12	0.010	0.022	0.034
Selenium (dissolved)	mg/L	0.01		13	0.01	0.01	0.01	6	0.01	0.01	0.01	4	0.01	0.01	0.01	10	0.01	0.01	0.01
Silver (dissolved)	mg/L	0.001		9	0.001	0.001	0.001	7	0.001	0.001	0.001	4	0.001	0.001	0.001	11	0.001	0.001	0.001
Uranium (dissolved)	mg/L	0.001		6	0.004	0.005	0.008	7	0.005	0.009	0.015	5	0.001	0.010	1.204	12	0.001	0.009	0.015
Vanadium (dissolved)	mg/L	0.01		6	0.010	0.010	0.010	7	0.010	0.010	0.010	5	0.010	0.010	0.010	12	0.010	0.010	0.010
Ammonia (dissolved)	mg/L	0.9		10	0.029	0.160	0.324	5	0.10	0.76	2.16	3	0.06	0.14	1.23	8	0.040	0.475	1.974
Nitrate	mg/L	1.1		11	0.01	0.40	0.77	6	0.01	0.39	1.05	4	0.019	0.055	0.42	10	0.010	0.055	0.986
Petroleum hydrocarbons (C6-C9)	µg/L	20		17	20	20	20	9	20	20	60	7	20	20	20	16	20	20	20
Petroleum hydrocarbons (C10-C36)	µg/L	100		17	50	50	54	9	50	50	112	7	50	50	54	16	50	50	95
Fluoride	mg/L	2		36	0.4	0.8	1.0	28	0.3	0.9	1.2	22	0.6	0.8	1.1	50	0.4	0.8	1.2
Sodium (dissolved)	mg/L	TBA		23	883	1,690	2,968	13	974	2,000	3,326	12	556	1,485	3,125	25	614	1,890	3,210

** Shaded values represent an exceedance of the relevant trigger level/DGV*

Table 4.3 – Water quality summary, mine affected water storages (2 of 2)

Parameter	Units	Middlemount EA conditions		MWD				NROM				SD1				Mining Pit				Combined NROM/SD1			
		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	No. of samples	10th %ile	Median	90th %ile
pH	-	6.5 - 9.0	6.5 - 8.5	26	8.7	9.1	9.5	14	8.1	8.6	9.3	38	5.7	8.5	9.1	9	8.3	8.8	9.3	52	6.2	8.6	9.1
EC	µs/cm	700 - 6,000	700	24	7,332	15,370	17,725	13	1,057	2,760	11,066	38	856	6,160	12,606	9	8,084	11,290	13,111	51	934	5,380	12,010
Suspended solids	mg/L	562 - 1,062	562 - 1,062	14	5	8	23	9	5	5	38	14	7	21	56	5	14	22	27	23	5	20	56
Sulphate (SO_4^{2-}) (dissolved)	mg/L	250 - 500	250	-	-	-	-	-	-	-	-	14	120	302	471	1	-	1,240	-	14	120	302	471
Turbidity	NTU			10	3.7	6.2	11.5	8	2.9	14.7	46.6	15	4.2	17.4	45.3	2	5.5	10.7	15.8	23	3	17	46
Aluminium (dissolved)	mg/L	0.055	-	10	0.010	0.010	0.038	6	0.010	0.010	0.015	8	0.010	0.010	0.010	6	0.010	0.010	0.010	14	0.010	0.010	0.010
Arsenic (dissolved)	mg/L	0.013	-	10	0.002	0.004	0.005	6	0.001	0.001	0.002	8	0.001	0.0015	0.002	6	0.001	0.002	0.003	14	0.001	0.001	0.002
Cadmium (dissolved)	mg/L	0.0002	-	10	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0001	7	0.0001	0.0001	0.0001	5	0.0001	0.0001	0.0001	13	0.0001	0.0001	0.0001
Chromium (dissolved)	mg/L	0.001		10	0.0010	0.0010	0.0019	6	0.001	0.001	0.001	6	0.001	0.001	0.001	5	0.001	0.001	0.001	12	0.001	0.001	0.001
Copper (dissolved)	mg/L	0.002	-	10	0.001	0.001	0.002	6	0.001	0.001	0.002	7	0.001	0.001	0.002	5	0.0010	0.0010	0.0016	13	0.001	0.001	0.002
Iron (dissolved)	mg/L	0.3		12	0.05	0.05	0.05	6	0.05	0.05	0.05	6	0.05	0.05	0.09	6	0.050	0.050	0.165	12	0.05	0.05	0.05
Lead (dissolved)	mg/L	0.004	-	10	0.001	0.001	0.001	6	0.001	0.001	0.001	7	0.001	0.001	0.001	5	0.001	0.001	0.001	13	0.001	0.001	0.001
Mercury (dissolved)	mg/L	0.0002		12	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0001	7	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0001	13	0.0001	0.0001	0.0001
Nickel (dissolved)	mg/L	0.011	-	10	0.006	0.007	0.009	6	0.001	0.002	0.007	7	0.003	0.006	0.026	5	0.003	0.008	0.011	13	0.001	0.004	0.010
Zinc (dissolved)	mg/L	0.008	-	10	0.005	0.005	0.005	5	0.005	0.005	0.007	7	0.005	0.006	0.031	5	0.005	0.005	0.005	12	0.005	0.005	0.018
Boron (dissolved)	mg/L	0.37	-	10	0.330	0.425	0.452	6	0.05	0.05	0.38	6	0.12	0.24	0.47	5	0.256	0.340	0.382	12	0.05	0.16	0.58
Cobalt (dissolved)	mg/L	0.090	-	10	0.001	0.001	0.001	6	0.0010	0.0010	0.0025	7	0.001	0.001	0.011	5	0.001	0.001	0.001	13	0.001	0.001	0.003
Manganese (dissolved)	mg/L	1.9		8	0.0010	0.0015	0.0204	4	0.001	0.002	0.002	5	0.0014	0.0050	0.0326	4	0.001	0.001	0.021	9	0.001	0.002	0.016
Molybdenum (dissolved)	mg/L	0.034		10	0.0157	0.0185	0.0204	6	0.005	0.009	0.017	6	0.003	0.011	0.017	6	0.009	0.017	0.022	12	0.004	0.010	0.020
Selenium (dissolved)	mg/L	0.01		12	0.01	0.01	0.01	6	0.01	0.01	0.01	6	0.01	0.01	0.01	6	0.01	0.01	0.01	12	0.01	0.01	0.01
Silver (dissolved)	mg/L	0.001		7	0.001	0.001	0.001	6	0.001	0.001	0.001	6	0.001	0.001	0.001	2	0.001	0.001	0.001	12	0.001	0.001	0.001
Uranium (dissolved)	mg/L	0.001		5	0.003	0.004	0.004	4	0.0010	0.0015	0.0055	6	0.001	0.001	0.006	1	-	0.003	-	10	0.001	0.001	0.007
Vanadium (dissolved)	mg/L	0.01		5	0.010	0.010	0.010	4	0.010	0.010	0.010	6	0.010	0.010	0.010	1	-	0.01	-	10	0.010	0.010	0.010
Ammonia (dissolved)	mg/L	0.9		10	0.019	0.055	0.297	6	0.01	0.03	0.42	6	0.02	0.115	0.76	5	0.02	0.03	0.04	12	0.01	0.05	0.71
Nitrate	mg/L	1.1		9	0.01	0.52	2.12	6	0.01	0.04	2.20	7	0.01	0.01	0.124	5	0.01	0.43	3.87	13	0.01	0.01	0.15
Petroleum hydrocarbons (C6-C9)	µg/L	20		11	20	20	20	6	20	20	20	8	20	20	20	5	20	20	20	14	20	20	20
Petroleum hydrocarbons (C10-C36)	µg/L	100		12	50	50	50	6	50	50	55	8	50	50	50	6	50	50	50	14	50	50	50
Fluoride	mg/L	2		14	0.8	0.9	1.2	9	0.4	0.9	2.8	29	0.3	0.7	1.2	5	0.6	1.0	1.1	38	0.3	0.75	1.5
Sodium (dissolved)	mg/L	TBA		13	1,000	1,920	3,560	8	147	462	1,595	14	524	1,060	2,154	5	1,448	2,240	3,866	22	203	1,015	2,158

** Shaded values represent an exceedance of the relevant trigger level/DGV*

Table 4.4 – Water quality summary, on-site stormwater storages (1 of 2)

Parameter	Units	Middlemount EA conditions		SD2				SD3 (from Jan-16 onwards)				SD6			
		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	44	4.2	8.2	9.5	13	7.4	8.7	9.2	5	8.1	8.5	9.4
EC	µs/cm	700 – 6,000	700	42	593	979	2,199	13	1020	1400	6,104	5	271	328	862
Suspended solids	mg/L	562 – 1,062	562 – 1,062	11	8	31	54	5	12	24	63	2	74	138	202
Sulphate ($SO4^{2-}$) (dissolved)	mg/L	250 – 500	250	13	100	158	320	6	83	116	279	-	-	-	-
Turbidity	NTU			19	25	58	343	5	15	57	168	2	2,454	3,150	3,846
Aluminium (dissolved)	mg/L	0.055	-	6	0.01	0.01	0.01	5	0.010	0.010	0.042	2	0.961	1.565	2.169
Arsenic (dissolved)	mg/L	0.013	-	6	0.0010	0.0010	0.0035	5	0.0010	0.0010	0.0016	2	0.001	0.001	0.001
Cadmium (dissolved)	mg/L	0.0002	-	5	0.0001	0.0001	0.0001	5	0.0001	0.0001	0.0001	2	0.0001	0.0001	0.0001
Chromium (dissolved)	mg/L	0.001		4	0.001	0.001	0.001	5	0.001	0.001	0.001	2	0.0011	0.0015	0.0019
Copper (dissolved)	mg/L	0.002	-	5	0.0010	0.0020	0.0036	5	0.001	0.002	0.002	2	0.002	0.002	0.002
Iron (dissolved)	mg/L	0.3		4	0.05	0.05	0.05	6	0.050	0.050	0.050	2	0.351	0.635	0.919
Lead (dissolved)	mg/L	0.004	-	5	0.001	0.001	0.001	5	0.001	0.001	0.001	2	0.001	0.001	0.001
Mercury (dissolved)	mg/L	0.0002		5	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0001	2	0.0001	0.0001	0.0001
Nickel (dissolved)	mg/L	0.011	-	5	0.0010	0.0010	0.0034	5	0.001	0.001	0.001	2	0.002	0.003	0.003
Zinc (dissolved)	mg/L	0.008	-	5	0.005	0.005	0.006	5	0.005	0.005	0.006	2	0.007	0.016	0.024
Boron (dissolved)	mg/L	0.37	-	4	0.050	0.085	0.176	5	0.074	0.11	0.17	2	0.085	0.145	0.205
Cobalt (dissolved)	mg/L	0.090	-	5	0.0010	0.0010	0.0016	5	0.001	0.001	0.001	2	0.001	0.001	0.001
Manganese (dissolved)	mg/L	1.9		3	0.001	0.001	0.001	4	0.0010	0.0015	0.0041	2	0.003	0.003	0.003
Molybdenum (dissolved)	mg/L	0.034		4	0.004	0.008	0.009	5	0.003	0.006	0.006	2	0.001	0.001	0.001
Selenium (dissolved)	mg/L	0.01		4	0.01	0.01	0.01	6	0.01	0.01	0.01	2	0.01	0.01	0.01
Silver (dissolved)	mg/L	0.001		4	0.001	0.001	0.001	5	0.001	0.001	0.001	2	0.001	0.001	0.001
Uranium (dissolved)	mg/L	0.001		4	0.001	0.001	0.001	4	0.001	0.001	0.001	2	0.001	0.001	0.001
Vanadium (dissolved)	mg/L	0.01		4	0.01	0.01	0.01	4	0.01	0.01	0.01	2	0.01	0.01	0.01
Ammonia (dissolved)	mg/L	0.9		4	0.013	0.080	0.175	5	0.010	0.080	0.886	2	0.071	0.075	0.079
Nitrate	mg/L	1.1		5	0.01	0.01	0.57	5	0.01	0.01	0.114	2	0.107	0.215	0.323
Petroleum hydrocarbons (C6-C9)	µg/L	20		7	20	20	20	6	20	20	20	2	20	20	20
Petroleum hydrocarbons (C10-C36)	µg/L	100		7	50	50	90	6	50	50	50	2	50	50	50
Fluoride	mg/L	2		25	0.2	0.8	1.6	5	1.1	1.2	1.3	2	0.4	0.4	0.4
Sodium (dissolved)	mg/L	TBA		13	121	260	515	6	164	212	824	1	63	63	63

** Shaded values represent an exceedance of the relevant trigger level/DGV*

Table 4.5 – Water quality summary, on-site stormwater storages (2 of 2)

Parameter	Units	Middlemount EA conditions		SD7				SD9				SD10				Combined SD2/SD6/SD9/SD10/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	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	9.0	9.7	9.8	11	8.1	8.4	9.1	15	8.2	8.9	9.9	91	5.6	8.6	9.7
EC	µs/cm	700 – 6,000	700	8	586	918	4,063	11	368	526	2,080	16	380	664	1,328	90	469	961	2,385
Suspended solids	mg/L	562 – 1,062	562 – 1,062	6	15	26	114	2	13	27	41	5	26	37	83	29	10	30	89
Sulphate (SO_4^{2-}) (dissolved)	mg/L	250 – 500	250	-	-	-	-	-	-	-	-	-	-	-	-	13	100	158	320
Turbidity	NTU			6	17	37	147	3	57	229	275	7	215	409	2,358	40	18	85	556
Aluminium (dissolved)	mg/L	0.055	-	3	0.014	0.030	0.038	3	0.24	1.18	4.22	2	0.221	0.265	0.309	19	0.010	0.010	0.492
Arsenic (dissolved)	mg/L	0.013	-	2	0.001	0.002	0.003	3	0.001	0.001	0.001	2	0.001	0.001	0.001	18	0.001	0.001	0.003
Cadmium (dissolved)	mg/L	0.0002	-	2	0.0001	0.0001	0.0001	2	0.0001	0.0001	0.0001	2	0.0001	0.0001	0.0001	16	0.0001	0.0001	0.0001
Chromium (dissolved)	mg/L	0.001		2	0.001	0.001	0.001	1	0.001	0.001	0.001	2	0.0011	0.0015	0.0019	14	0.001	0.001	0.001
Copper (dissolved)	mg/L	0.002	-	3	0.001	0.002	0.003	2	0.0023	0.0035	0.005	2	0.001	0.001	0.001	17	0.001	0.002	0.003
Iron (dissolved)	mg/L	0.3		2	0.05	0.05	0.05	1	0.05	0.05	0.05	2	0.121	0.125	0.129	15	0.05	0.05	0.092
Lead (dissolved)	mg/L	0.004	-	2	0.001	0.001	0.001	2	0.001	0.003	0.005	2	0.001	0.001	0.001	16	0.001	0.001	0.001
Mercury (dissolved)	mg/L	0.0002		2	0.0001	0.0001	0.0001	1	0.0001	0.0001	0.0001	2	0.0001	0.0001	0.0001	16	0.0001	0.0001	0.0001
Nickel (dissolved)	mg/L	0.011	-	3	0.001	0.001	0.002	2	0.003	0.004	0.004	2	0.001	0.002	0.002	17	0.001	0.001	0.003
Zinc (dissolved)	mg/L	0.008	-	2	0.005	0.006	0.007	2	0.010	0.012	0.013	2	0.006	0.012	0.018	16	0.005	0.005	0.012
Boron (dissolved)	mg/L	0.37	-	3	0.204	0.220	0.412	1	0.15	0.15	0.15	2	0.18	0.18	0.18	15	0.05	0.15	0.22
Cobalt (dissolved)	mg/L	0.090	-	2	0.001	0.001	0.001	2	0.001	0.003	0.005	2	0.001	0.001	0.001	16	0.001	0.001	0.002
Manganese (dissolved)	mg/L	1.9		2	0.001	0.001	0.001	1	0.001	0.001	0.001	2	0.0011	0.0015	0.0019	12	0.001	0.001	0.002
Molybdenum (dissolved)	mg/L	0.034		3	0.002	0.003	0.004	1	0.004	0.004	0.004	2	0.0031	0.0035	0.0039	15	0.003	0.004	0.008
Selenium (dissolved)	mg/L	0.01		2	0.01	0.01	0.01	1	0.01	0.01	0.01	2	0.01	0.01	0.01	15	0.01	0.01	0.01
Silver (dissolved)	mg/L	0.001		2	0.001	0.001	0.001	1	0.001	0.001	0.001	2	0.001	0.001	0.001	14	0.001	0.001	0.001
Uranium (dissolved)	mg/L	0.001		2	0.001	0.001	0.001	1	0.001	0.001	0.001	2	0.001	0.001	0.001	13	0.001	0.001	0.001
Vanadium (dissolved)	mg/L	0.01		2	0.01	0.01	0.01	1	0.01	0.01	0.01	2	0.01	0.01	0.01	13	0.01	0.01	0.01
Ammonia (dissolved)	mg/L	0.9		2	0.101	0.145	0.189	1	0.01	0.01	0.01	2	0.014	0.030	0.046	14	0.01	0.065	0.197
Nitrate	mg/L	1.1		2	0.01	0.01	0.01	1	0.01	0.01	0.01	2	0.01	0.01	0.01	15	0.01	0.01	0.114
Petroleum hydrocarbons (C6-C9)	µg/L	20		2	20	20	20	4	20	20	20	2	20	20	20	21	20	20	20
Petroleum hydrocarbons (C10-C36)	µg/L	100		2	64	120	176	4	50	50	120	2	50	50	50	21	50	50	150
Fluoride	mg/L	2		6	1.1	1.4	2.7	4	0.2	0.4	0.9	6	0.8	1.2	1.8	46	0.2	1.0	1.7
Sodium (dissolved)	mg/L	TBA		6	104	194	832	4	32	47	291	6	64	122	213	35	62	202	503

** Shaded values represent an exceedance of the relevant trigger level/DGV*

4.4.1 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 4.2) indicates that the stored water exceeds the *EPP Water WQOs* and has the following characteristics:

- Brackish with a median EC of 6,570 µS/cm and 10% exceeding 15,700 µS/cm;
- Moderate sulphate with a median of 400 mg/l and 10% exceeding 795 mg/l;
- Generally slightly alkaline, with a median pH of 8.1, 10% exceeding 8.7 and 10% less than 7.0; and
- Metals (dissolved) less than the default trigger values with the exception of median values of nickel, boron and uranium and 90^{th} percentile values of aluminium, zinc and molybdenum.

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

4.4.2 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 4.2 and Table 4.3 indicates that the stored water has the following characteristics:

- Brackish with a median EC of 5,380 µS/cm and 10% exceeding 12,010 µS/cm;
- Moderate sulphate with a median of 300 mg/l and 10% exceeding 470 mg/l;
- Generally slightly alkaline, with a median pH of 8.6, 10% exceeding 9.1 and 10% less than 6.2; and
- Metals (dissolved) generally below the default trigger values with the exception of 90^{th} percentile values of boron, uranium and zinc.

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 5.

Refer to Section 4.4.5 for a summary of the water quality of the external water supply from German Creek Mine.

4.4.3 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, 2019a). Water quality monitoring of sediment dams (that have not been historically affected by mine water (SD2, SD3, SD6, SD7, SD9 and SD10)) since April 2013 indicates that the collected runoff has the following characteristics (Table 4.4 and Table 4.5):

- Fresh to brackish with a median EC of 960 µS/cm and 10% exceeding 2,385 µS/cm;
- Moderate sulphate with a median of 158 mg/l and 10% exceeding 320 mg/l;
- Moderate suspended solids with a median of 30 mg/l and 10% exceeding 89 mg/l; and
- Moderately alkaline, with a median pH of 8.6, 10% exceeding 9.7 and 10% less than 5.6.

Review of Table 4.4 and Table 4.5 shows that the metals (dissolved) are generally below the release contaminant trigger levels, with the exception of:

- Aluminium and zinc readings in SD6, SD9 and SD10;
- Chromium readings in SD6 and SD10;
- Copper readings in SD2, SD7 and SD9;
- Iron readings in SD6;
- Lead in SD9;
- Zinc in SD6, SD9 and SD10; and
- Boron readings in SD7.

A further review of the on-site stormwater storage's 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 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 on-site stormwater storages could be greater than recorded values to date.

Mine affected water has historically been pumped to SD3. SD3 also temporarily received de-sludged 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.

Water quality monitoring of three release events from on-site stormwater storages has occurred in the months:

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

Investigations into all three release events were completed by MCPL to ensure compliance with the EA conditions. The water quality results showed that all parameters were within the release limits and trigger investigation limits, with the exception of copper and zinc during the February 2014 release from SD2. 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 (MCPL, 2014b).

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 (233 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 5.7.

4.4.4 Contaminated water

Water collected in sumps, service bays and fuel storage areas is not currently monitored given the small volumes. The water is contained and managed accordingly as it is expected to come into contact with petroleum hydrocarbons. Details of the contaminated water management system is provided in Section 5.6.

4.4.5 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 on an 'as needed' basis and placed in the RWD, STD 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 used in preference to the German Creek water.

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

- Brackish with a median EC of 7,870 µS/cm and 10% exceeding 9,515 µS/cm;
- Moderate to high sulphate with a median of 1,845 mg/l;
- Moderately alkaline with pH ranging from 8.2 to 8.7; and
- Metals (total) generally below the default trigger values with the exception of nickel.

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

5 Existing surface water management system

5.1 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, 2018);
- Water Management Plan (WRM, 2019b);
- Water Management Site Practice (MCPL, 2014a);
- Site Water Balance (WRM, 2019c);
- Regulated Structures Operational Plan (MCPL, 2019);
- Receiving Environment Monitoring Program – Design Document (DPM Envirosciences, 2019);
- Erosion and Sediment Control Plan (WRM, 2019a); and
- Severe Weather Site Practice (MCPL, 2013a).

The locations of the existing mine water management infrastructure are shown Figure 3.2, and shown schematically in Figure 5.1. 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.

5.2 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).

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.

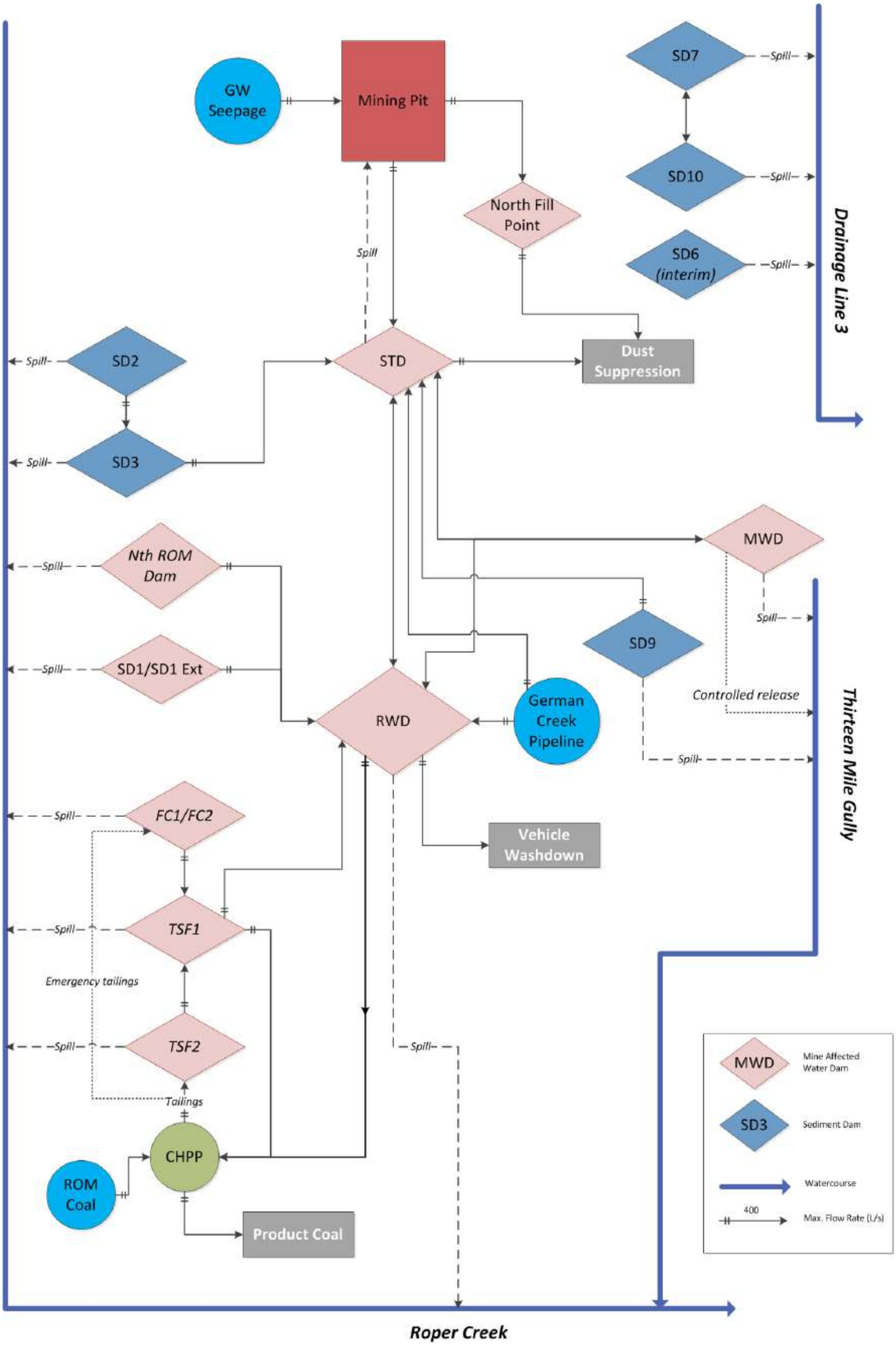

Figure 5.1 – Existing water management system schematic

5.3 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% annual exceedance probability (AEP) immunity from Thirteen Mile Gully and Roper Creek floods.

5.4 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 3.2 and Figure 5.1 for the locality and configuration of the tailings circuit.

5.5 MINE AFFECTED WATER MANAGEMENT

The mine affected water management system is managed in accordance with the Regulated Structures Operational Plan (MCPL, 2019).

The layout of the mine water management system is shown in Figure 3.2, and shown schematically in Figure 5.1. Mine affected water is managed as follows:

- There are two main mine water management storages: RWD and MWD. Mine affected water in excess of the RWD capacity is stored in the MWD.

- STD is operated as a transfer dam adjacent the mining pit to transfer mine affected water to RWD or MWD and as a source of water for dust suppression. STD has no external catchment area.
- Water captured in the mining pit may also be pumped directly to RWD or MWD (via STD).
- 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 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 risk of uncontrolled releases during rain events.
- Runoff from the northern ROM stockpile and hardstand area is captured in NROM and transferred to RWD for reuse in the CHPP.
- Controlled releases can be made from RWD, MWD and SD1 subject to the relevant EA conditions.

5.5.1 Mine affected water management storages

Figure 3.2 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 5.1.

Table 5.1 – Existing mine affected water management storages

Dam Name	Full supply volume (ML)	Surface area at FSL (ha)	Maximum water depth (m)	Catchment area (ha)	Overflows to
Raw Water Dam (RWD)	191	2.7	6.2	25.5	Roper Creek
Mine Water Dam (MWD)	1,928	28.6	8.1	36	Thirteen Mile Gully
Sediment Dam 1 (SD1)	60	0.7	3.8	16.2	Roper Creek
South Transfer Dam (STD)	26	1.5	1.6	28.7	Mining Pit
North ROM Dam (NROM)	4	0.2	1.2	5.5	Roper Creek
Tailings Storage Facility 1 (TSF1)	187#	14.3	12.8	15.5	Roper Creek*
Tailings Storage Facility 2/In-line Flocc cells (TSF2)	535#	9.1	8.9	9.7	Roper Creek*
Emergency Flocc cells (FC1/FC2)	52	1.4	7.1	9.7	Roper Creek*
Mining Pit	24,500	104.5	68.0	463.5	-

Excludes volume of tailings placed within storage.
* No releases are expected to occur from either of the TSFs or FC1/FC2.
FSL = full supply level.

5.5.2 Environmental Authority (EA) - release conditions

The current Middlemount Coal Mine EA (EPML00716913) took effect on 26 February 2020. 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 5.2 lists all the mine affected water release points and associated receiving water for the current water management system (Table C1 in the EA). The locations of the release points are shown in Figure 3.2.

Table 5.3 shows the mine affected water release limits given in the Middlemount Coal Mine 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 5.4. Further, Condition C10 requires that the release of mine affected water must not exceed the EC and sulphate release limits specified in Table 5.4.

Table 5.2 - 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 5.3 - Mine affected water release limits (EA Table C2)

Quality characteristic	Units	Minimum	Maximum
EC	μs/cm	See Table 5.4	
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 5.4	

Table 5.4 - 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)	Release limit 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

5.6 CONTAMINATED WATER MANAGEMENT SYSTEM

5.6.1 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 onsite for all chemicals. Where appropriate, safety data sheets will be kept in storage areas or accessed online, as required.

5.6.2 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.

5.6.3 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.

5.7 ON-SITE STORMWATER MANAGEMENT SYSTEM

5.7.1 Overview

On-site stormwater runoff from the overburden dumps and haul roads is managed in accordance with the ESCP (WRM, 2019a).

The ESCP would be reviewed and updated to incorporate the Project.

5.7.2 Sediment dam sizing

Sediment dams capture runoff from overburden dumps in accordance with the ESCP (WRM, 2019a). 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 5.5 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 1.6.

Table 5.5 - 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)	
SD3	70.9	13.9	7.0	20.9	Roper Creek (pumped)
SD5	110.0	21.6	10.8	32.4	Drainage Line 3
SD6	256.0	50.3	25.2	75.5	Drainage Line 3
SD10	64.4	12.7	6.3	19.0	SD7 (pumped)
SD11	109.9	21.6	10.8	32.4	Thirteen Mile Gully Diversion (pumped)
SD12	666.5	131.0	65.5	196.5	Thirteen Mile Gully
SD13	92.9	18.3	9.1	27.4	Unnamed Diversion
SD14	38.7	7.6	3.8	11.4	SD7 (pumped)
SD15	39.1	7.7	3.8	11.5	Unnamed Diversion
SD16	50.9	10.0	5.0	15.0	Thirteen Mile Gully
SD17	60.8	11.9	6.0	17.9	Roper Creek (pumped)

Six new sediment dams (SD3, SD5, SD6, SD10[2], SD11 and SD12[3]) would be constructed by 2023 to capture runoff from the expanding overburden dump. Note that SD3 is an existing dam but would be moved and redesigned by 2023 to the location shown on Figure 1.3. By 2028, the existing sediment dams SD8 and SD9, as well as the proposed dam SD10 would be removed due to the expanding open cut and waste dump footprints. In addition, proposed dams SD13 and SD14 would be required by 2028. By 2037, proposed dams SD12 and SD14 would be removed and proposed dams SD15 and SD16 would be introduced. By 2043, proposed sediment dam SD17 would be introduced.

5.8 CATCHMENT RUNOFF WATER MANAGEMENT SYSTEM

5.8.1 Flood protection levees

Flood levees are used across Middlemount Coal Mine to prevent up-catchment floodwater from Roper Creek and the drainage lines from entering the water management system. The location of the existing levee is shown in Figure 5.2. These levees have been progressively constructed since 2008 and are regulated structures under the EP Act.

The approved Western Extension Project allowed mining of the western extension area, which required a realignment of the Thirteen Mile Gully levee and diversion (see Figure 5.2). The realigned diversion and levee were completed in July 2020.

The levees are regulated structures under the EP Act and are therefore required to have a crest above the 0.1% AEP event. The levees at Middlemount Coal Mine are operated and maintained in accordance with *Regulated Structures Operational Plan* (MCPL, 2019).

The Project proposes to realign the levee approved under the Western Extension Project to allow mining of the southern extension area. The location of the proposed levee change is shown in Figure 1.2. 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 9.6.

5.8.2 Waterway diversions

Three waterway diversions have been approved at Middlemount Coal Mine; two diversions of Roper Creek (Roper Creek Diversions 1 [western diversion] and 2 [eastern diversion]) and a diversion of Thirteen Mile Gully into Roper Creek along the eastern boundary of ML 70730.

The Thirteen Mile Gully diversion has been constructed and its location is shown in Figure 5.2. Approval to realign Thirteen Mile Gully diversion was granted as part of the Western Extension Project. The diversion will 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 as shown in Figure 5.2. The diversion was completed in July 2020.

The approved locations of the Roper Creek diversions are shown in Figure 5.2. The conditions of approval for the two diversions are given in the current EA.

Detailed design of the Roper Creek Diversion 1 has been completed (Engeny, 2020) and is planned for construction in 2020.

As part of the Project, it is proposed to realign the approved (but not yet constructed) Roper Creek Diversion 2 inside the existing MLs.

2 Would adopt the name ‘SD10’ following the decommissioning of existing dam SD10.
3 SD12 is associated with a natural depression from the diverted alignment of Thirteen Mile Gully.

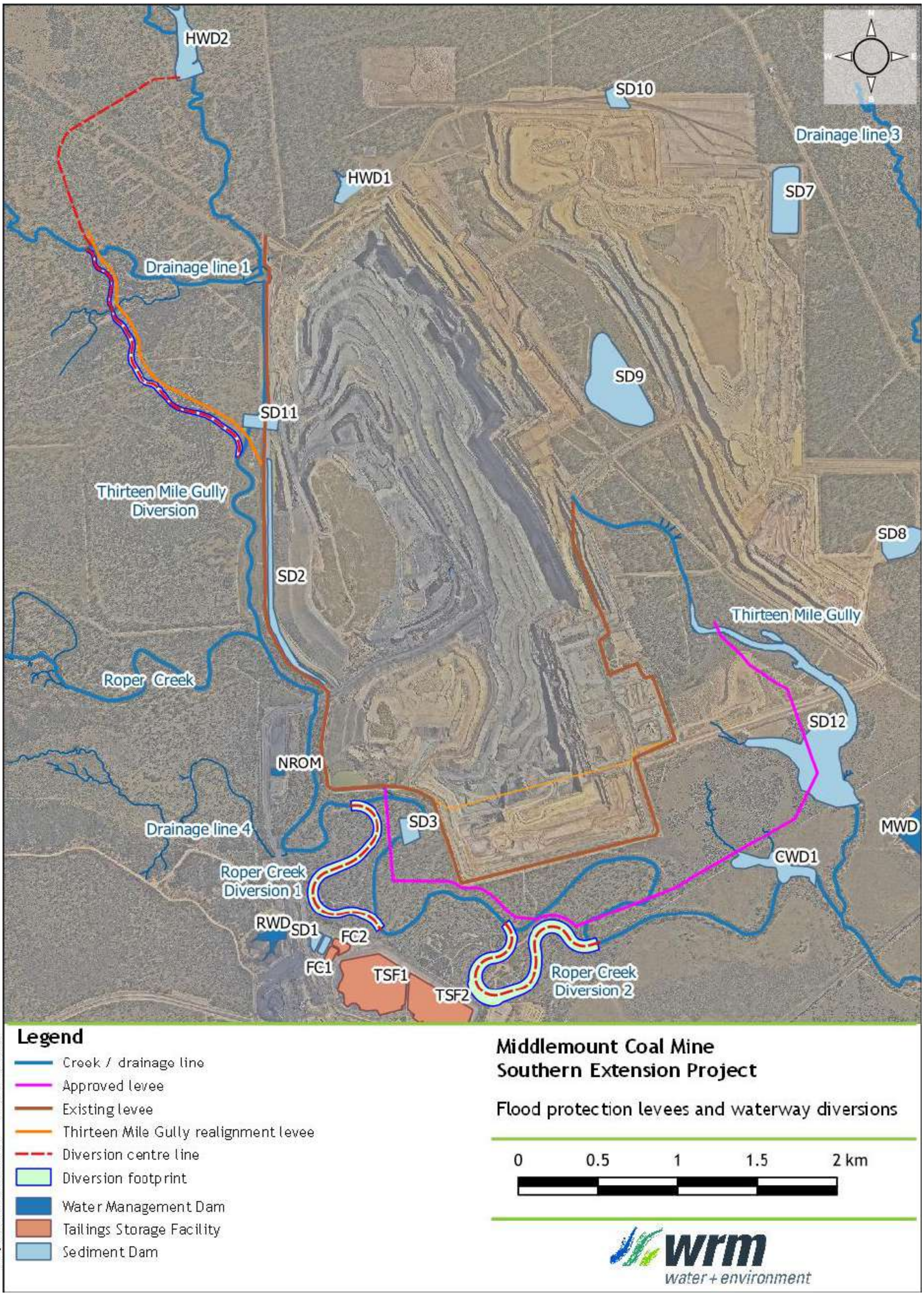

Figure 5.2 – Existing and approved flood protection levees and waterway diversions

5.8.3 Up-catchment runoff water diversions

A series of up-catchment water drains and temporary water storages have been or are proposed to be constructed to capture and divert catchment runoff water around the mining areas. The locations of the temporary water storages are shown in Figure 5.2. Descriptions of the temporary water storages are as follows:

- High Wall Dam 2 (HWD2) has been constructed to the north of the mining areas to capture overland flows from drainage line 2. The captured overland flows are drained to the Thirteen Mile Gully diversion.
- High Wall Dam 1 (HWD1) will be constructed towards the end of 2020 to the north of the mining areas to capture overland flows. The captured overland flows will be pumped to HWD2. This structure is currently in the detailed design phase.

5.9 EXTERNAL WATER SUPPLY

MCPL have an arrangement with Anglo American plc 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 6.3.4 show that the current agreement with Anglo American is sufficient to meet the mines external water supply requirements under all but the driest climatic conditions.

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

6 Water management system assessment

6.1 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 model represents five different representative stages of the mine life. The adopted model stages are summarised in Table B.3.

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 rainfall sequences (Section 6.3.1);
- mine water inventory and salinity – the risk of accumulation (or reduction) of the overall mine water inventory and associated water quality (Section 6.3.2);
- in-pit storage - the risk of accumulation of water in the mining pit, and the associated water volumes (Section 6.3.3);
- external water demand – the risk and associated volumes of requiring imported external water (via the Anglo pipeline) to supplement site mine water supplies (Section 6.3.4);
- uncontrolled spillway discharges – the risk of uncontrolled discharge from the mine affected water storages to the receiving environment (Section 6.3.5); and
- controlled releases – the risk and associated volumes of controlled release of mine affected water to the receiving environment (Section 6.3.6).

6.2 INTERPRETATION OF RESULTS

In order to undertake forecasting simulations of the behaviour of the water management system over the future 24 years of mine operations, for a range of climatic conditions, the calibrated water balance model was configured to run 107 simulations of a 24 year (mine life) period, using the 131 years of available SILO Data Drill historic climate data. The 24 year forecast simulation period commences on 1 January 2021 and ends on 31 December 2044.

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.

6.3 WATER BALANCE MODEL RESULTS

6.3.1 Overall water balance

Water balance results for all of the 107 modelled realisations are presented in Table 6.1, over each model Stage. The results presented in Table 6.1 are the average of all realisations and will include wet and dry periods distributed throughout the mine life. Rainfall yield and evaporation for each Stage is affected by the variation in climatic conditions within the adopted climate sequence.

Table 6.1 - Annual water balance - all realisations

Component	Process	Average annual volume (ML/year) per model Stage			
		Stage 1	Stage 2	Stage 3	Stage 4
Inflows	Catchment runoff & direct rainfall	1,962	1,871	1,678	1,580
	Groundwater inflows	827	801	903	463
	External supply	870	707	561	660
	Total inflows	**3,659**	**3,379**	**3,142**	**2,704**
Outflows	Evaporation	1,189	1,034	878	873
	Dust suppression	1,187	1,187	1,187	1,187
	Net CHPP demand	929	928	841	471
	Controlled releases	0	0	0	0
	Spillway overflows - mine water dams	0	0	0	0
	Spillway overflows - sediment dams	250	214	178	209
	Spillway overflows - catchment runoff dams	33	21	19	0
	Total outflows	**3,588**	**3,385**	**3,102**	**2,739**
	Change in volume	**71**	**-6**	**40**	**-36**

Table 6.1 provides an indication of the long-term average annual inflows and outflows. Key outcomes from the overall water balance are as follows:

- During each Stage the overall mine system alternates between generating a net gain or loss of water;
- The groundwater inflows (which are based on the calibrated model predictions by AGE [2020]) are generally consistent between Stage 1 and Stage 3, with a reduction towards the end of the Project in Stage 4;

- Average annual external water supply requirements vary between 560 to 870 ML/year over the life of the Project;
- The net CHPP demand (based upon forecast CHPP output numbers) is generally consistent between Stage 1 and Stage 3, with a reduction towards the end of the Project in Stage 4;
- On average, there are no spills to the environment from mine water dams; and
- External supply requirements are greatest in Stage 1, decreasing to Stage 3 and slightly increasing in Stage 4.

6.3.2 Mine site storage inventory and salinity

Figure 6.1 shows the modelled behaviour of the MWD over the 24-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 volume falls below 1,200 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 MWD does not spill under any of the realisations, with its maximum operating volume staying below 1,910 ML under all realisations.

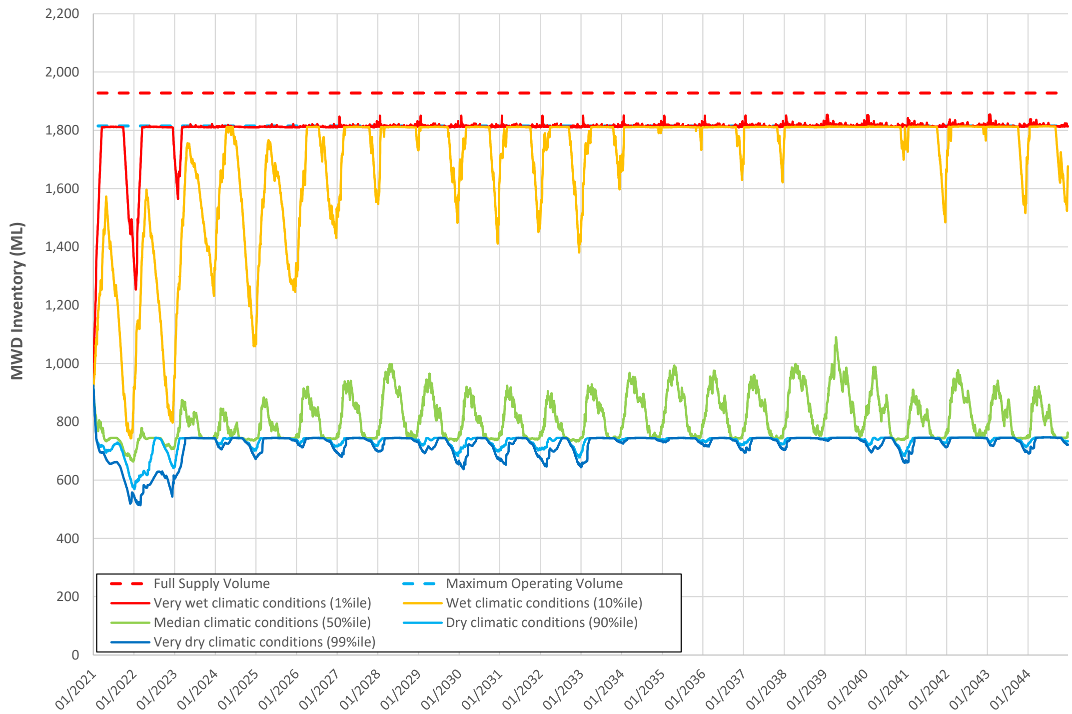

Figure 6.1 – Forecast MWD inventory

Figure 6.2 shows the modelled salinity of the MWD over the 24-year simulation period. The following is of note:

- The initial modelled salinity of 17,270 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 13,000 to 16,000 µS/cm. This is due to the greater reliance on the water supply from the Anglo pipeline, which has a modelled salinity of 8,000 µS/cm, as well as the lower overall inventory in the MWD.
- During median climatic conditions, the salinity of MWD is expected to be around 11,000 to 14,000 µS/cm.
- During wetter climatic sequences, the salinity of MWD is expected to reduce to around 6,000 to 9,000 µs/cm. This is due to the reduced reliance on the water supply from the Anglo pipeline and the higher overall inventory in MWD.

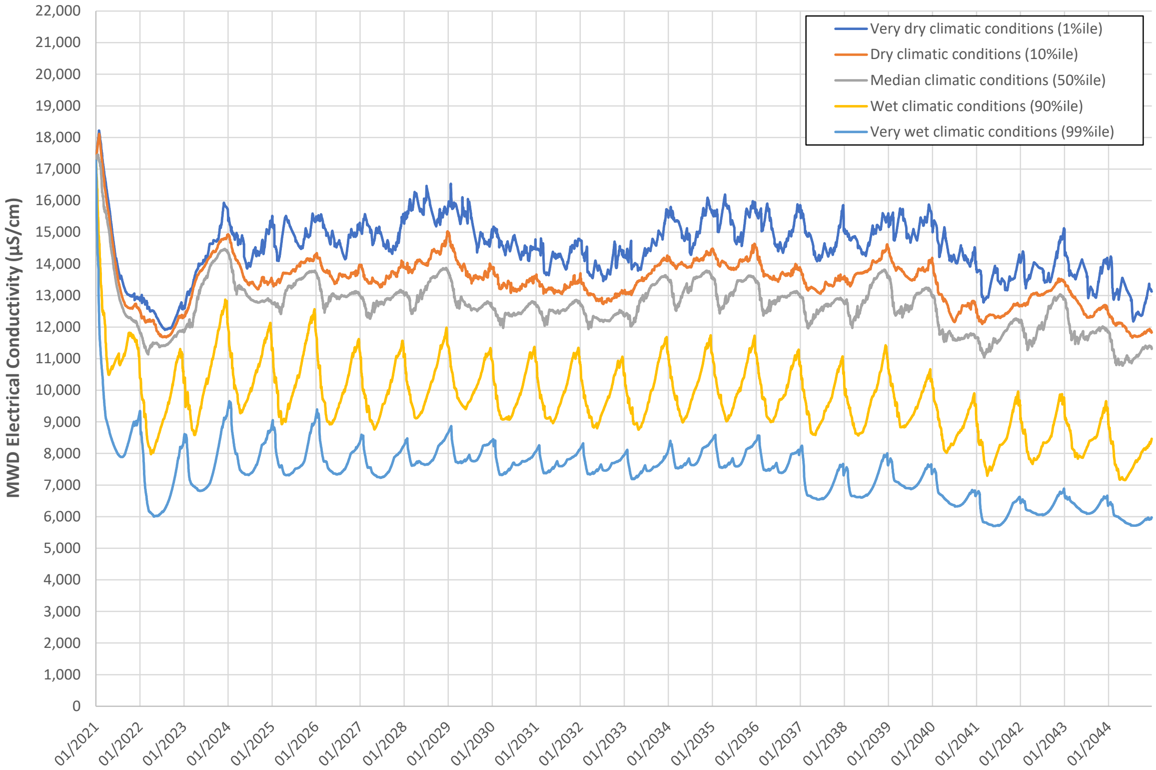

Figure 6.2 – Forecast MWD salinity

6.3.3 Pit inundation characteristics

Figure 6.3 shows the modelled behaviour of the mining pit over the 24-year simulation period.

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 over the Project life, with the 1%ile (very wet conditions) peaking at approximately 2,850 ML.
- Under 10%ile (wet) conditions the pit inventory will not increase over 1,000 ML over the Project life.
- The pit inventory does not increase above 30 ML over the Project life under 50%ile conditions.

These modelling results indicate that the risk of excessive pit inundation is relatively low due to the storage capacity available in the MWD and the existing pit pump capacity.

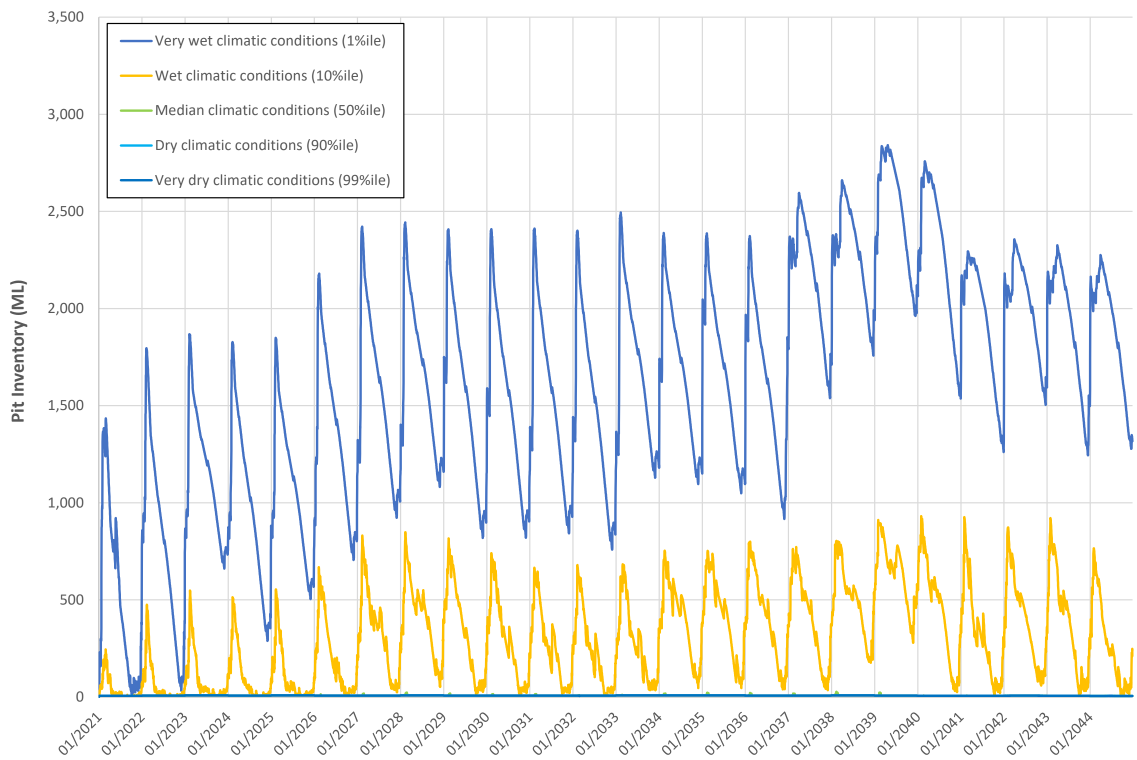

Figure 6.3 - Forecast mining pit inventory

6.3.4 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 24-year Project life. Further to this, the modelling indicates that:

- an external water supply source is required in almost all years to satisfy demand;
- under 50th %ile conditions there is a requirement for between 460 ML/yr to 1,330 ML/yr over the Project life; and
- there is <1% chance that the Project would require more than 1,800 ML/yr of external water (i.e. greater than the maximum 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) would be sufficient for the vast majority of climatic cases.

6.3.5 Uncontrolled discharges

The water balance model shows that there is less than a 1% chance of uncontrolled spills to the environment from the Project mine water dams. 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.

The model results indicate that 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.

6.3.6 Controlled releases

The water balance model simulates that no controlled releases from the MWD to Roper Creek would occur based on the conditions of the EA. This is due to the high initial salinity of the MWD and the high salinity of the groundwater, runoff parameters and from the external water supply pipeline.

Although controlled releases can be made from other storages, it is only made from the MWD under the current mine affected water management system.

7 Residual void behaviour

7.1 OVERVIEW

Water levels in the residual 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 residual voids. The historical rainfall and evaporation sequences (131 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.

7.2 RESIDUAL VOID CONFIGURATION

The residual void configuration and contributing catchment areas are shown in Figure 7.1 and Table 7.1. The final catchment draining to the voids will be minimised using upslope diversion drains, as shown in Figure 7.1. The total catchment draining to the two residual voids is less than the total catchment of the approved residual voids. A depth varying storage evaporation factor has been applied to each void to simulate the expected 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 - 0.9
- Top of void - 1.0

Table 7.1 - Contributing catchment to residual void

Residual void	Contributing catchment (ha)
North Void	440.4
South Void	240.8

7.3 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 residual voids are summarised in Table 7.2.

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 metres Australian height datum (mAHD).

Table 7.2 - Modelled residual void geometry

Residual void	Depth (m)	Top surface area (ha)	Full supply volume (ML)
North Void	235	358	285,870
South Void	199	163	157,960

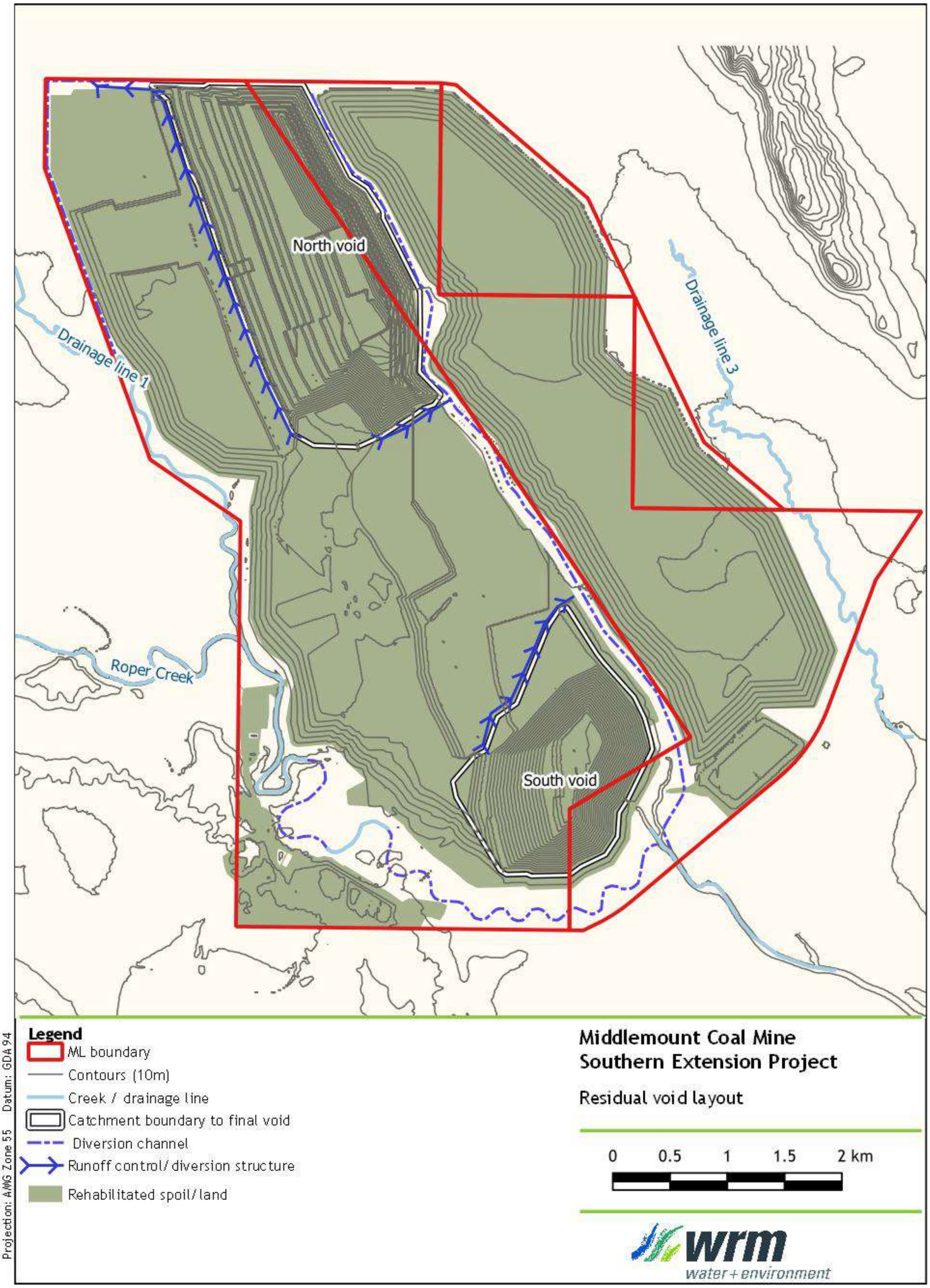

Figure 7.1 – Residual void catchment plan

7.4 GROUNDWATER INFLOWS

Groundwater inflows to the north and south void have been predicted by AGE (2020). 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 residual void water level behaviour given that the predicted groundwater inflows to the residual void are relatively small (Age, 2020).

7.5 WATER QUALITY

Weathering processes on the mine spoil will result in the dissolution of soluble minerals, partial dissolution of lower solubility minerals (mineral weathering), cation exchange, and reaction. Mining activities increase the hydraulic conductivity and surface area of naturally occurring materials resulting in a body of spoil more prone to leaching. The salts released are mainly chlorides of Na, Ca and Mg, and to a lesser extent, sulphates and carbonates.

As a result, the GOLDSIM site water balance model has been developed using Total Dissolved Solids (TDS) as an indicator of water quality in the residual voids. There is insufficient quality data available to develop a site-specific relationship between EC and TDS at Middlemount Coal Mine. Therefore, the following relationship has been adopted for Middlemount Coal Mine: TDS (mg/L) = 0.6 x EC (µS/cm)

Salts will enter the residual void via:

- Surface runoff from the rehabilitated spoil;
- Groundwater inflows.

Based on a combination of past experience on similar sites, and water quality data collected at Middlemount Coal Mine operation, the TDS values shown in Table 7.3 have been adopted for this study. The adopted groundwater salinity is consistent with the outcomes presented in the AGE groundwater assessment for the Southern Extension Project (AGE, 2020) which indicated that the average TDS for inflows from the Permian aquifers was around 10,000 mg/L.

Table 7.3 - Indicative contaminant concentrations of runoff

Contaminant source	Adopted TDS (mg/L)	EC (µs/cm)
Rehabilitated spoil	300	500
Groundwater	10,000	16,666

The adopted runoff salinity for the residual void assessment is applied at a fixed concentration and does not include any allowance for decay in runoff salinity over time (and hence is likely to overstate the rate of salinity level increase).

Prior to mine closure, the spoil surface will be regraded, topsoiled and revegetated. These changes should result in improved surface runoff quality. In the long-term, leaching of salts, should result in runoff salinities reducing to background levels.

7.6 MODEL RESULTS

7.6.1 Long-term water level behaviour

Figure 7.2 to Figure 7.5 show the simulated long-term water levels and volumes in the North and South voids. Table 7.4 shows a summary of the storage details of the residual voids and the results of the water balance modelling.

Table 7.4 – Residual void modelling results summary

Void	Elevation (mAHD)			
	Floor level	Pre-mining groundwater level	Overflow level	Modelled average long-term water level
North Void	-72	140	163	10.5
South Void	-40	130	159	35.1

The model results show the following:

- North Void (Figure 7.2 and Figure 7.3)
    - The water level reaches equilibrium between 6.5 mAHD and 13 mAHD after around 200 years, and generally varies between these levels throughout the remaining 300 years of the simulation.
    - The maximum modelled water level is around 150 m below the North Void full supply level and around 127 m below the pre-mining groundwater level.
- South Void (Figure 7.4 and Figure 7.5)
    - The water level reaches equilibrium between 32 mAHD and 37 mAHD after around 200 years, and generally varies between these levels throughout the remaining 300 years of the simulation.
    - The maximum modelled water level is around 122 m below the South Void full supply level and around 93 m below the pre-mining groundwater level.

The residual 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, 2020).

The water balance modelling indicates that there would be no interaction between the long-term surface water levels within North Void and South Void. Due to the different floor elevations and predicted water levels in the voids, a groundwater flow gradient from the South Void into the North Void through the spoil backfill would occur (AGE, 2020).

7.6.2 Long-term salinity

The predicted long-term void water levels do not exceed the current regional groundwater level. Therefore, there is no mechanism to lose salt within the closed void system, the voids continually accumulate salt over time and become hypersaline (around 33,000 mg/L) within the first 200-300 years of the simulation.

Figure 7.2 and Figure 7.3 shows the North Void salt accumulation and salt concentration over the first 500 years of simulation. Figure 7.4 and Figure 7.5 shows the South Void salt accumulation and salt concentration of the first 500 years of simulation.

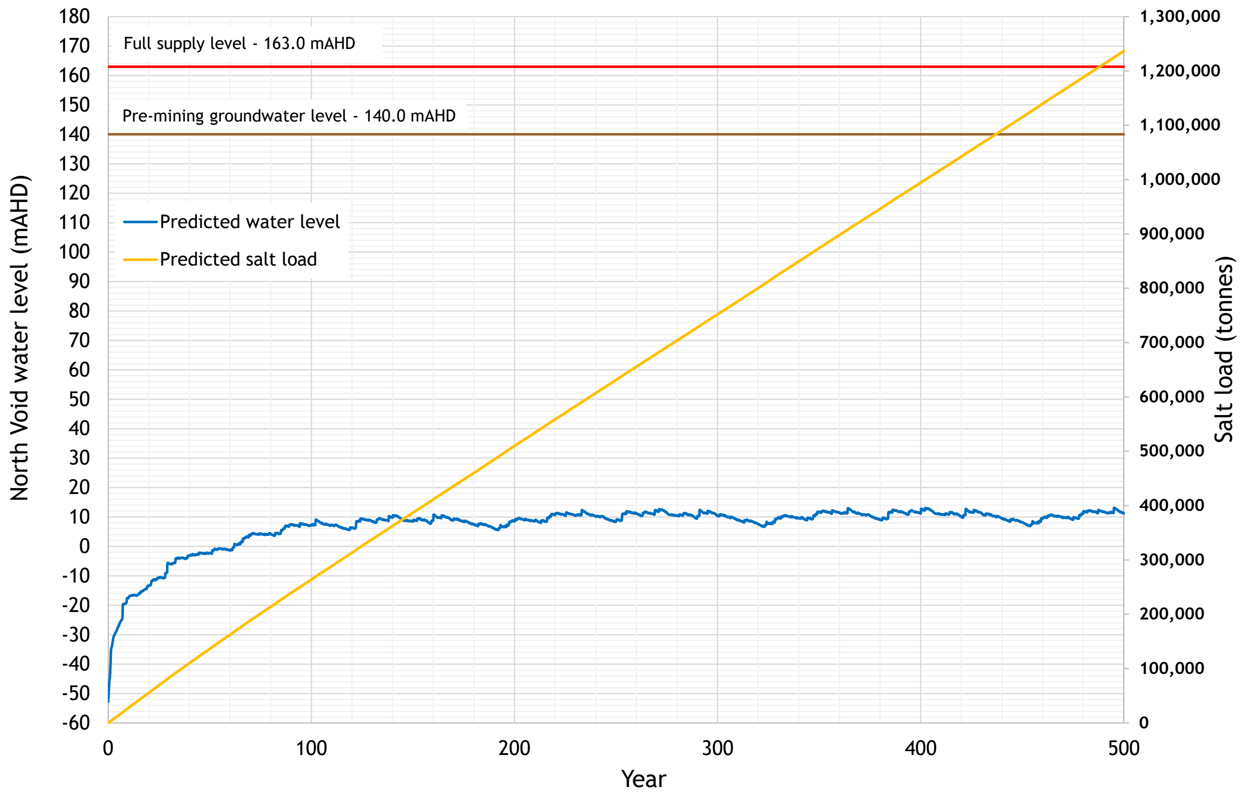

Figure 7.2 - Residual void water levels and salt load - North Void

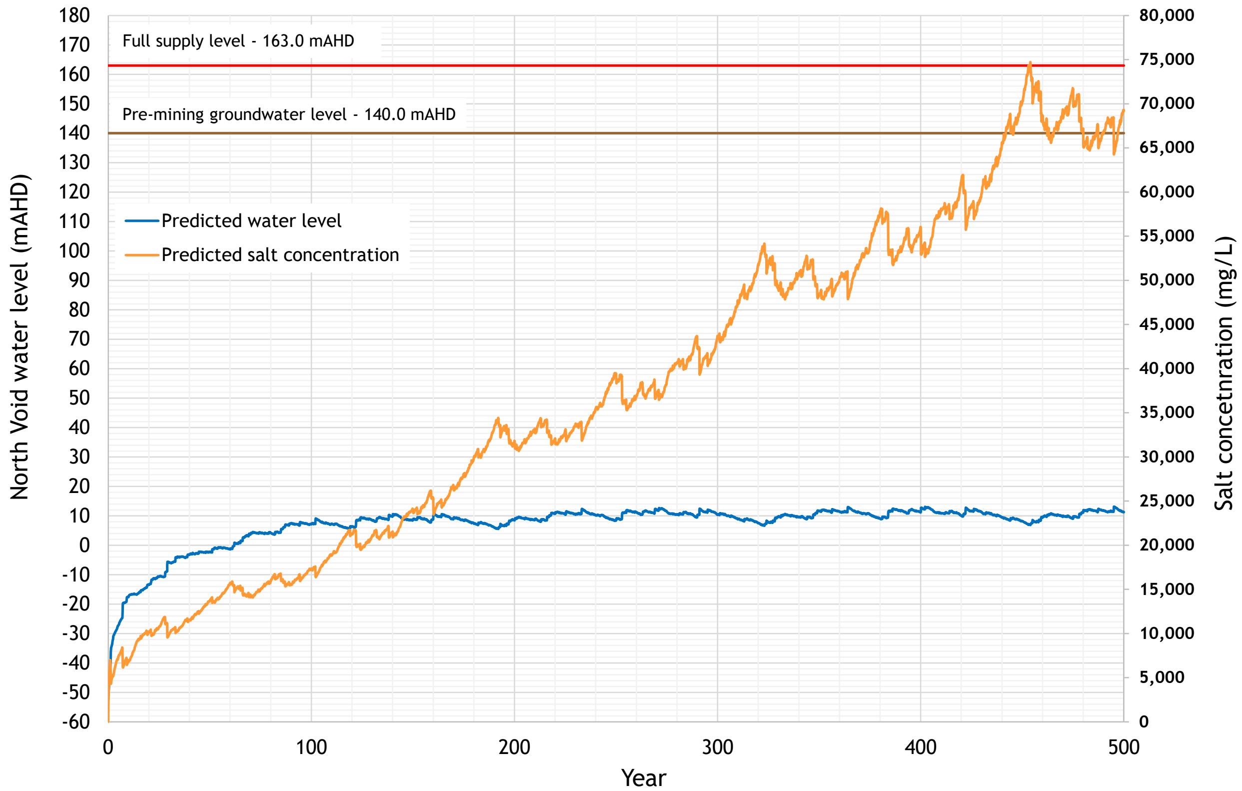

Figure 7.3 - Residual void water levels and salt concentration - North Void

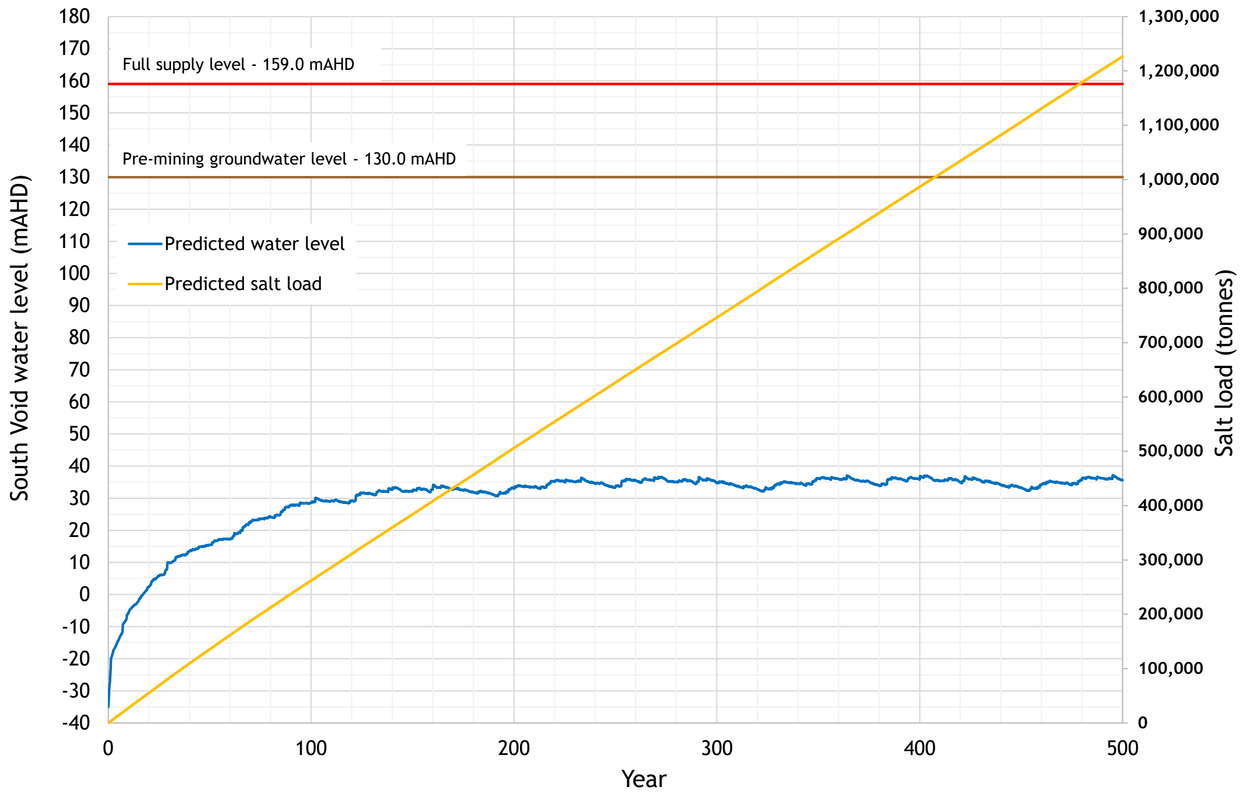

Figure 7.4 - Residual void water level and salt load - South Void

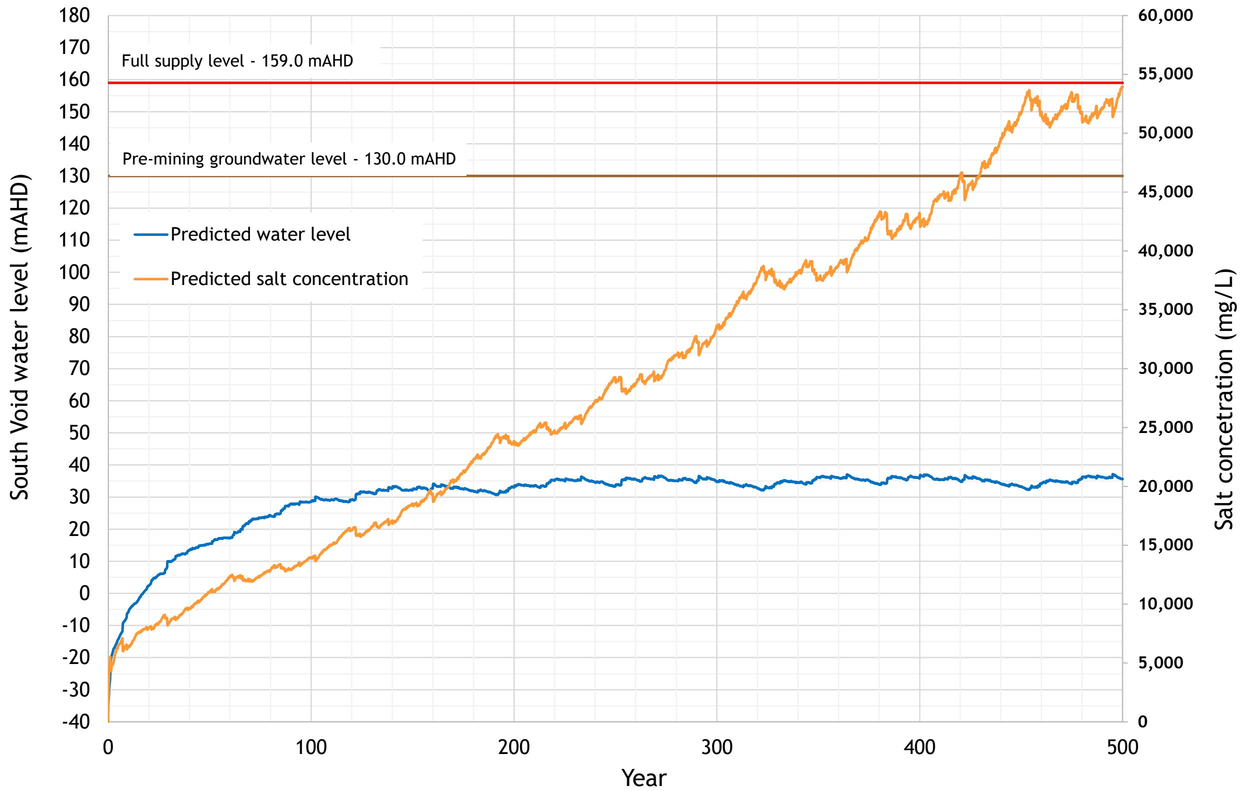

Figure 7.5 - Residual void water level and salt concentration - South Void

The model results show the following:

- North Void (Figure 7.2 and Figure 7.3)
  - In the first 500 years, the modelled salinity reaches a peak concentration of 74,700 mg/L;
  - Salt accumulates within the North void at an average rate of around 2,470 tonnes per year; and
- South Void (Figure 7.4 and Figure 7.5)
  - In the first 500 years, the modelled salinity reaches a peak concentration of 53,950 mg/L;
  - Salt accumulates within the South void at an average rate of around 2,450 tonnes per year; and

It is noted that the driving head of groundwater inflow from the surrounding groundwater table towards the void (i.e. sink effect) would be expected to overcome any density-driven groundwater flow within the void lake itself. Therefore, the residual voids would not result in an increase in groundwater salinity concentrations beyond the extent of the residual voids.

7.7 STORM EVENT BEHAVIOUR

7.7.1 Overview

An assessment of the impact of storm events on the water level in the residual voids has been undertaken. The potential for discharge of void water has been assessed for the following design rainfall events using 72-hour (3 day) rainfall depths:

- 1 in 100 AEP;
- 1in 1,000 AEP.

7.7.2 Initial conditions

The maximum water level simulated in the base case water balance modelling were adopted as the initial conditions for the storm event analysis. The following values were adopted for each void:

- North Void – Initial volume of 19,100 ML (13.2 mAHD).
- South Void - Initial volume of 23,650 ML (37.2 mAHD).

7.7.3 Design rainfall depths

Design rainfall depths for the 1 in 100 AEP, 1 in 1,000 AEP rainfall events were estimated using standard procedures in Australian Rainfall and Runoff (ARR) (Ball et al., 2016).

7.7.4 Assessment outcomes

Runoff volumes were calculated assuming no losses from the total catchment areas adopted in the water balance model. Table 7.5 show the results of the storm event analysis for the North and South voids respectively.

The results show that even during storm events with rainfall depths equivalent to the 1 in 1,000 AEP design event, there would be minimal impact on the level of water in the voids. The 1 in 1,000 AEP design event final water level is approximately 146 m and 120 m below spillway level for the North and South voids, respectively.

Table 7.5 - Storm event behaviour - North Void and South Void

Storm event (AE)	Rainfall depth (mm)	Runoff volume (ML)	Final volume (ML)	Change in water level (m)	Final water level (mAHD)
North Void					
1 in 100	335	1,475	20,541	2.2	15.4
1 in 1000	519	2,286	21,351	3.4	16.6
South Void					
1 in 100	335	807	24,458	1.3	38.5
1 in 1000	519	1,250	24,902	2.1	39.2

7.8 POST-MINING POTENTIAL CHANGED CLIMATE ASSESSMENT

7.8.1 Methodology and sensitivity parameters

The potential changes to climate post-mining were assessed using the projections and methodologies given in the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Commonwealth Bureau of Meteorology (BoM) report entitled "Climate Change in Australia Technical Report" (CSIRO, 2015). This report provides guidance on the possible projections of future climate for the Australian East Coast based on a current understanding of the climate system, historical trends and model simulations of the climate response to changing greenhouse gas and decreasing aerosol emissions.

Projections are given for a number of climatic variables including (but not limited to) temperature, rainfall, wind speed and potential evapotranspiration. CSIRO (2015) presents a number of possible approaches to quantify risks associated with climate change impacts.

For this assessment, the Representative Concentration Pathway 4.5 (RCP4.5) emissions scenario has been adopted. The year 2090 was selected as the representative year, being approximately 50 years post-mine closure. Potential changes in climate have been obtained using the projection builder tool provided in the Climate Change Australia website. Climate variable inputs for the 'best case', 'maximum consensus' case 'and 'worst case' RCP4.5 climate change scenarios are provided in Table 7.6.

Rainfall is expected to change by between plus 4.4% and minus 19.8% and evapotranspiration is expected to increase by between 5.5% and 7.8%. The climate variable inputs (rainfall and evaporation) to the water balance model were adjusted to undertake the climate change impact assessment. All three scenarios have been assessed for the proposed residual voids.

Table 7.6 - Projections of changes to climate - Year 2090

Scenario	Climate model	Annual change (%)	
		Rainfall	Evapotranspiration
Best case	GFDL-ESM2M	-19.8%	6.9%
Maximum consensus	NorESM1-M	-10.1%	5.5%
Worst case	ACCESS1-0	4.4%	7.8%

7.8.2 Potential climate change impacts

7.8.2.1 Overview

Potential climate change impacts to the residual void water balance were assessed by simulating the 'best' case, 'maximum consensus case' and 'worst' case climate scenarios for the Year 2090 climate changes projection. The water balance model climate inputs (rainfall and evaporation) were factored by the values given in Table 7.6.

7.8.2.2 Potential impacts on residual void water levels

The impact of the potential changes in rainfall and evapotranspiration for the proposed residual voids are presented in Figure 7.6 and Figure 7.7. The results show the following (with the baseline results shown for reference):

- For the 'best' case climate scenario:
    - *North Void*: The equilibrium and peak water level are around 12 to 13 m lower than under baseline climate conditions.
    - *South Void*: The equilibrium and peak water level are around 14 to 15 m lower than under baseline climate conditions.
- For the 'maximum consensus' case climate scenario:
    - *North Void*: The equilibrium and peak water level are around 7 to 9 m lower than under baseline climate conditions.
    - *South Void*: The equilibrium and peak water level are around 9 to 10 m lower than under baseline climate conditions.
- For the 'worst' case climate scenario:
    - *North Void*: The equilibrium and peak water level are around 3 to 4 m lower than under baseline climate conditions.
    - *South Void*: The equilibrium and peak water level are around 3 to 4 m lower than under baseline climate conditions.

Under all three modelled climate changes scenarios, the water balance modelling results show that the residual voids will remain a groundwater sink in perpetuity, with no leakage of stored void water.

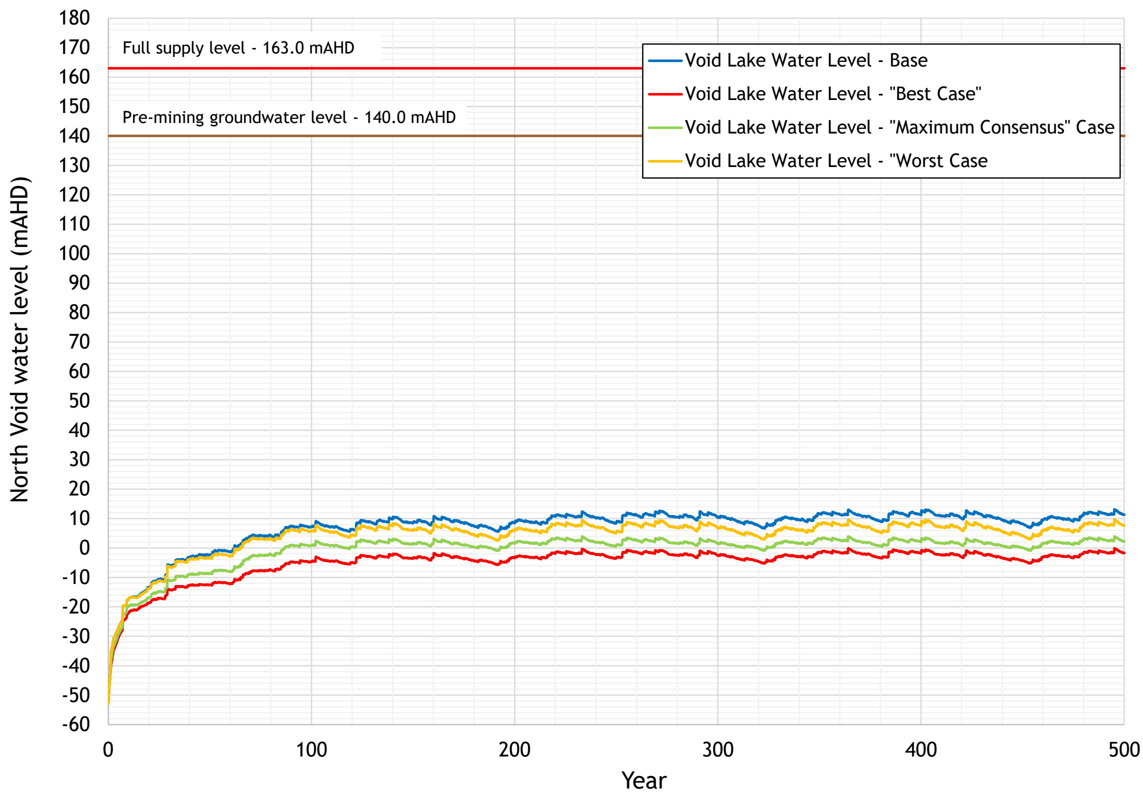

Figure 7.6 – North Void water level – climate change assessment

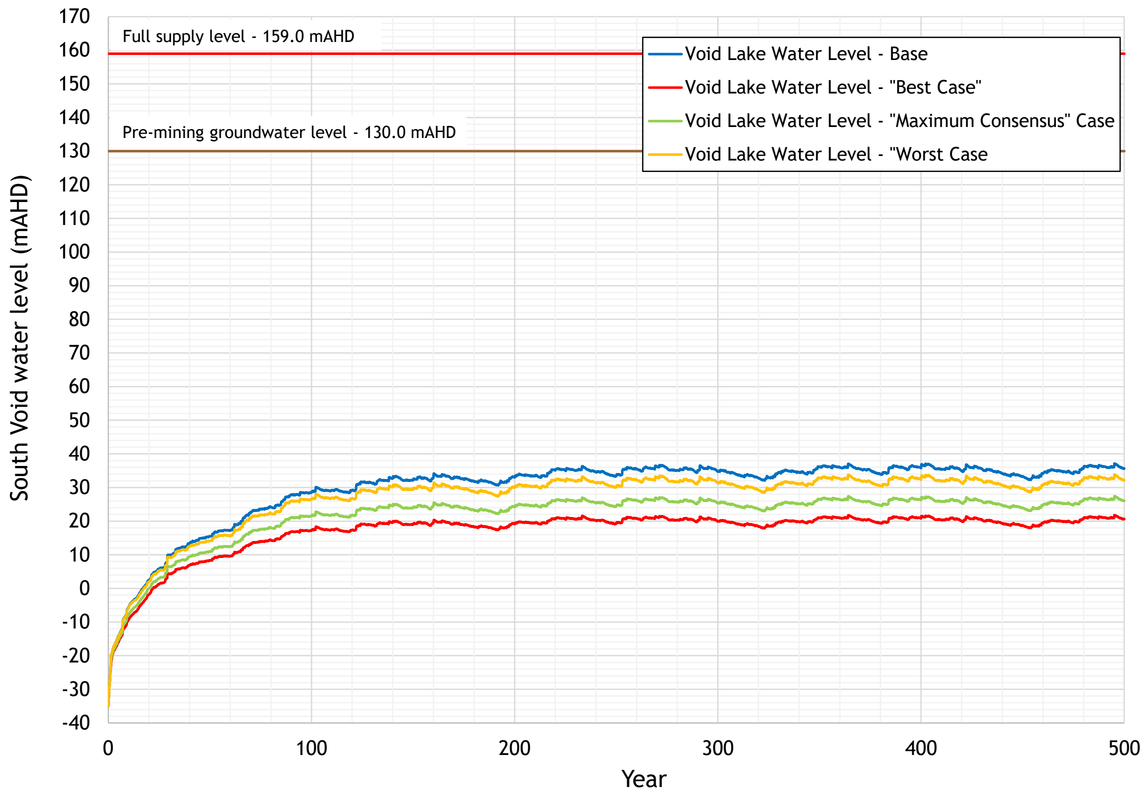

Figure 7.7 – South Void water level – climate change assessment

8 Flood model development and calibration

8.1 OVERVIEW

Flood models were developed to derive peak flood levels, extents and depths for a range of design flood events to assess the flood impacts of the Project, to define the proposed modified levee crest heights for the operational and final landform phase, and assess the proposed re-alignment to the approved Roper Creek Diversion 2.

The Unified River Basin Simulator (URBS) hydrological model (Carroll, 2004) was used to estimate stream flows (discharges) and the TUFLOW two-dimensional hydraulic model (BMT, 2018) was used to define flood levels and assess the impact 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. The calibrated models were then modified to represent the following development scenarios:

- Pre-mining conditions;
- Approved conditions (in accordance with the existing Environmental Approval);
- proposed year 23 end-of-mine conditions (proposed); and
- final landform conditions (post-mine).

This section outlines the development and calibration of the Pre-mining and approved conditions models. The subsequent sections present the assessment of the proposed and final landform conditions.

8.2 HYDROLOGICAL MODELLING

8.2.1 Methodology

The 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.

8.2.2 URBS model configuration

Figure 8.1 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 8.1.

8.2.3 URBS model calibration

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 8.1) as well as at a number of water level marks that were surveyed after the event. The hydraulic model, described in Section 8.4 was used to derive a relationship between recorded water level and discharge at the IMPAC1 gauge.

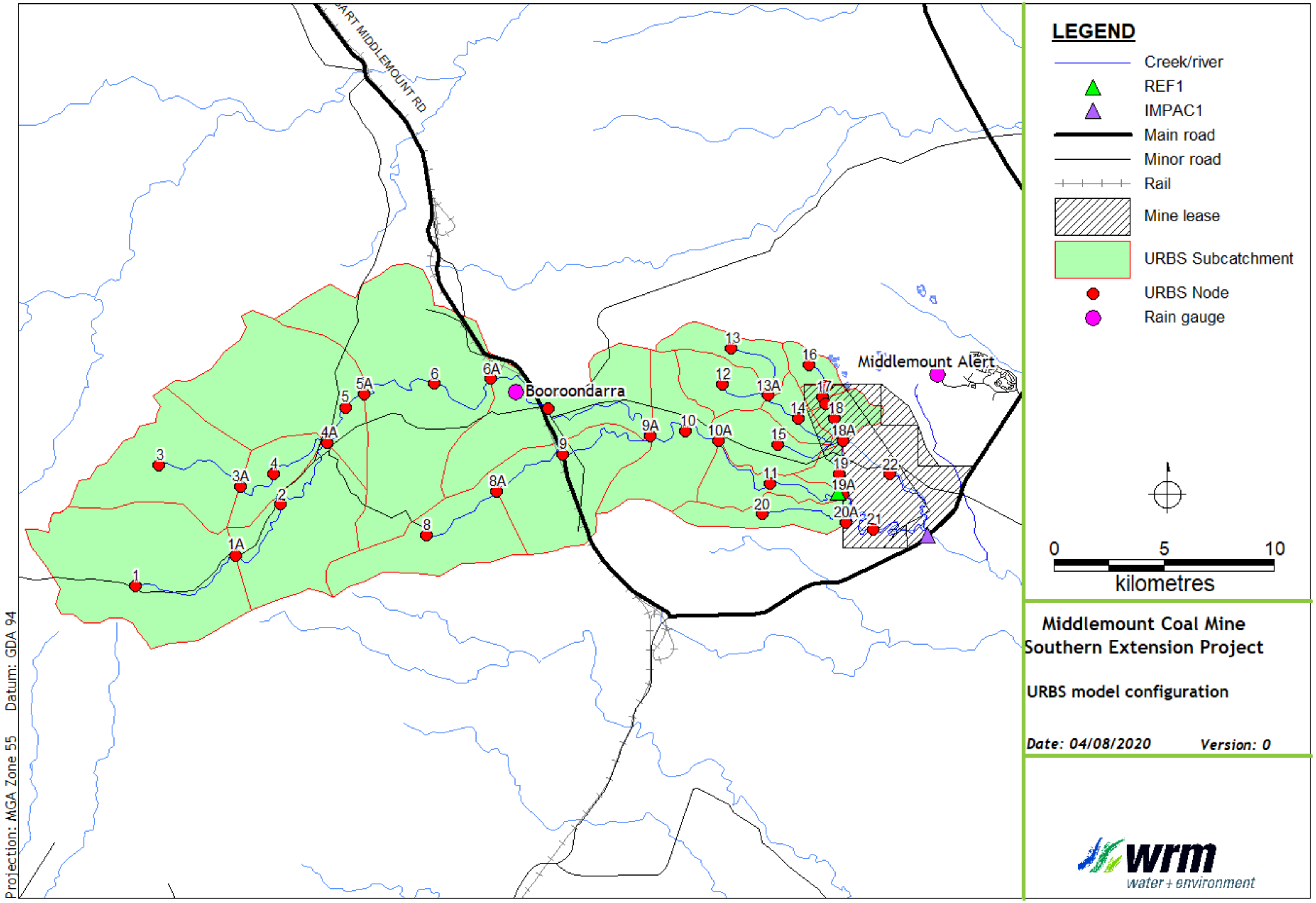

Figure 8.1 – URBS model configuration

Table 8.1 - 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

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.

8.2.4 Calibration event 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 8.1 and listed in Table 8.2.

Table 8.2 - 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.

8.2.5 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 8.3. The initial loss rate reflects the very dry antecedent conditions in the catchment prior the flood event.

Table 8.3 – 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)	1.7

8.2.6 January 2013 calibration results

Figure 8.2 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.

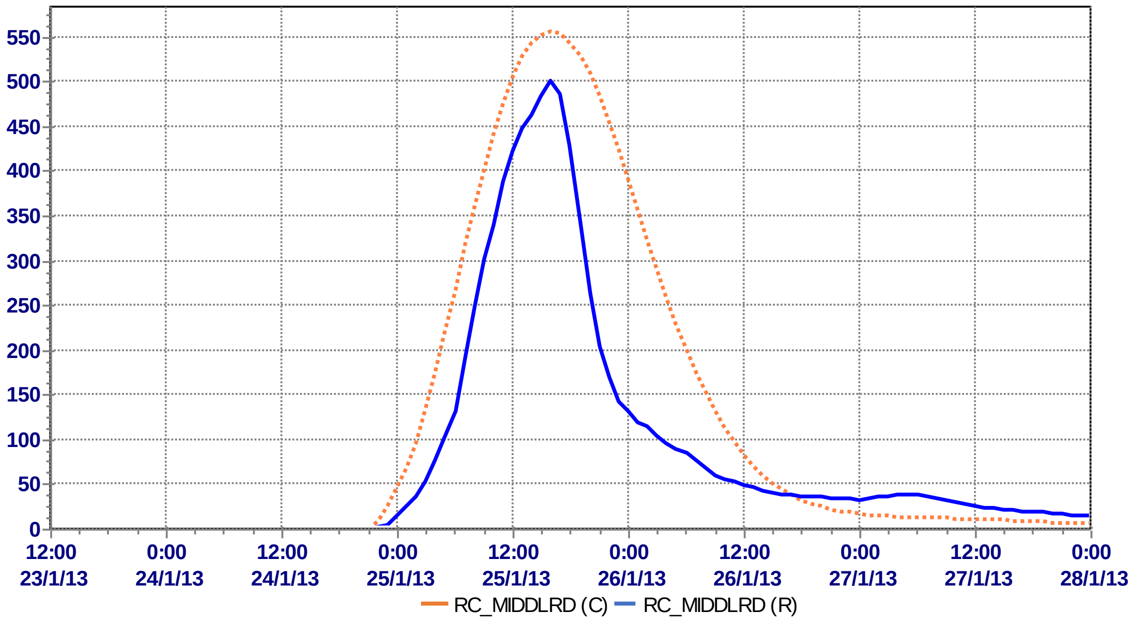

Figure 8.2 - Comparison of calculated (C) and recorded (R) discharge hydrographs, Middlemount Road (IMPAC1 gauge), January 2013

8.3 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 50%, 5%, 2%, 1%, 0.1% AEP events and for the probable maximum flood (PMF). The ensemble approach described in Australian Rainfall and Runoff (ARR) (Ball et al, 2019) 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 (Geoscience Australia, 2019) 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, design rainfalls and temporal patterns from Revised Generalised Tropical Storm Method (GTSMR) (BoM, 2005) were adopted, in accordance with ARR.

8.3.1 Design rainfalls

Table 8.4 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 (2016). Rainfalls to estimate the PMF were determined using the GTSMR (BoM, 2005). Areal 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 (Geoscience Australia, 2019).

Table 8.4 - Design rainfalls depths - Roper Creek catchment

Duration (hours)	Design rainfall (mm)					
	50% AEP	5% AEP	2% AEP	1% AEP	0.1% AEP	Probable Maximum Precipitation
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

8.3.2 Results

Figure 8.3 to Figure 8.7 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 8.5. Based on these results, the January 2013 event had an AEP of between 5% and 2% AEP.

Table 8.5 - Roper Creek design discharge at Middlemount Coal Mine

Event	Critical duration	Temporal pattern	Discharge (m^3/s)
50% 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

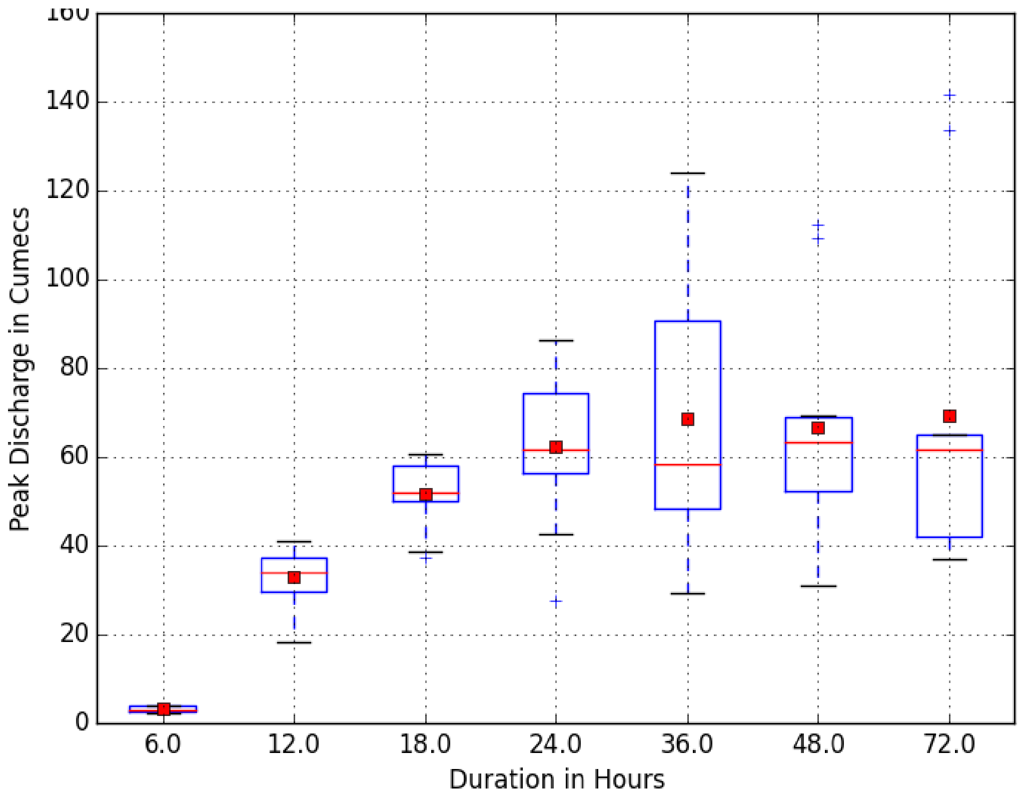

Figure 8.3 - Roper Creek discharge box plots at Middlemount Coal Mine, 50% AEP event

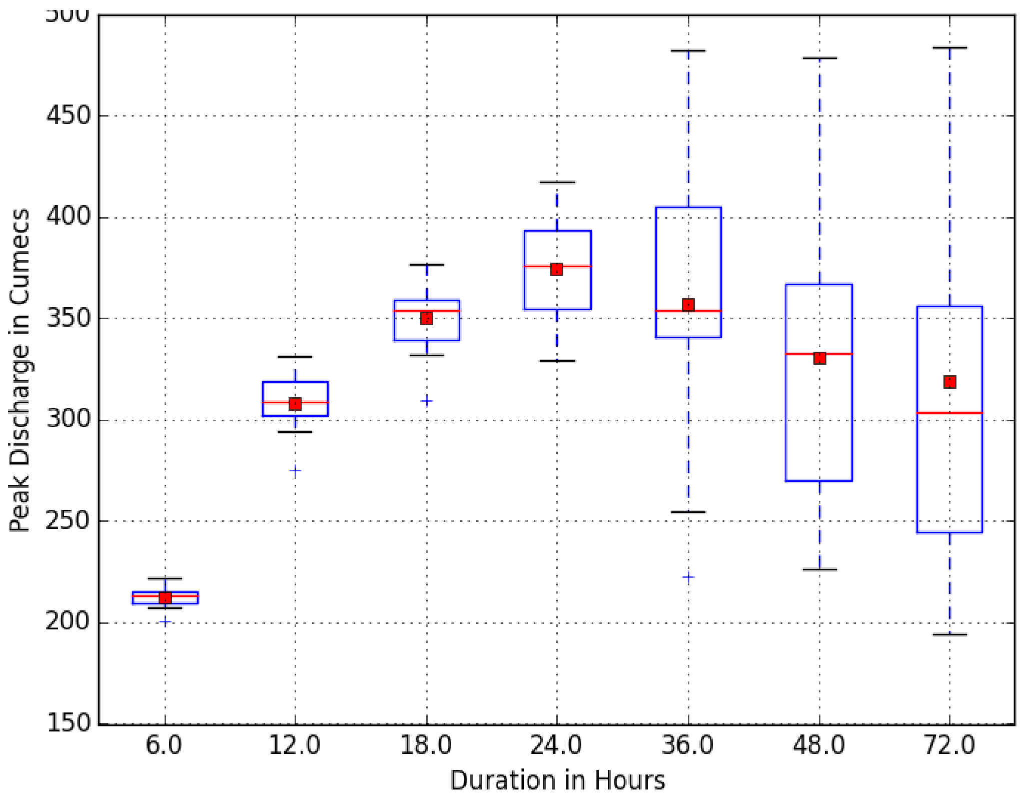

Figure 8.4 - Roper Creek discharge box plots at Middlemount Coal Mine, 5% AEP event

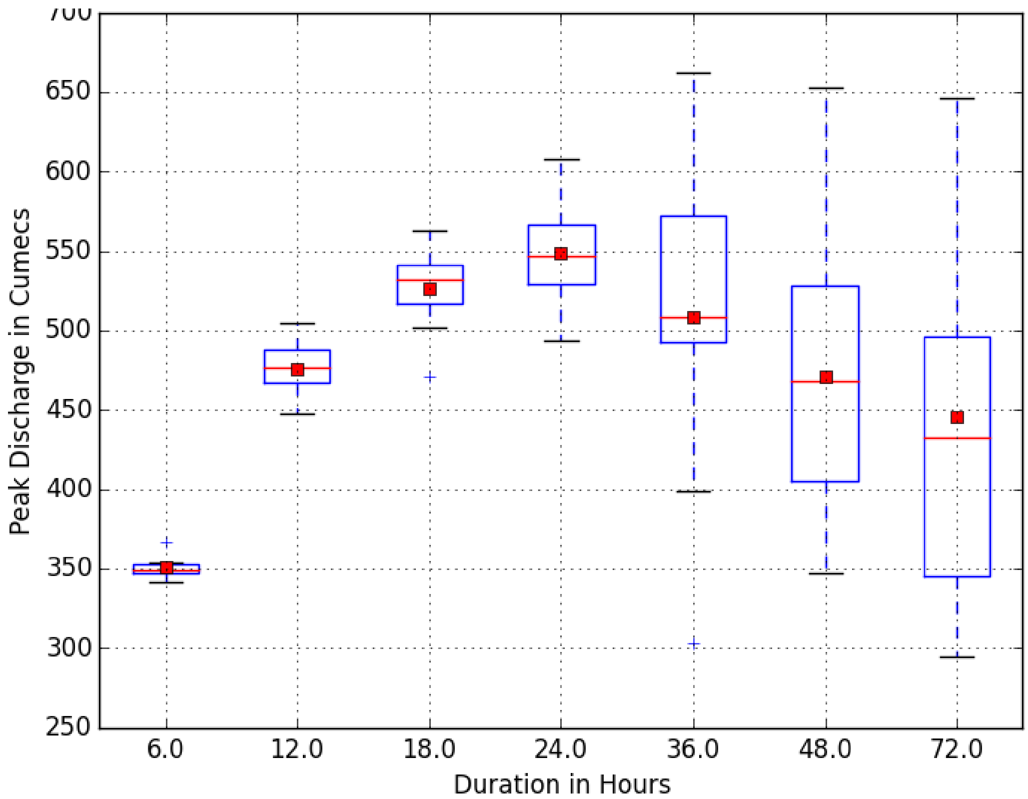

Figure 8.5 – Roper Creek discharge box plots at Middlemount Coal Mine, 2% AEP event

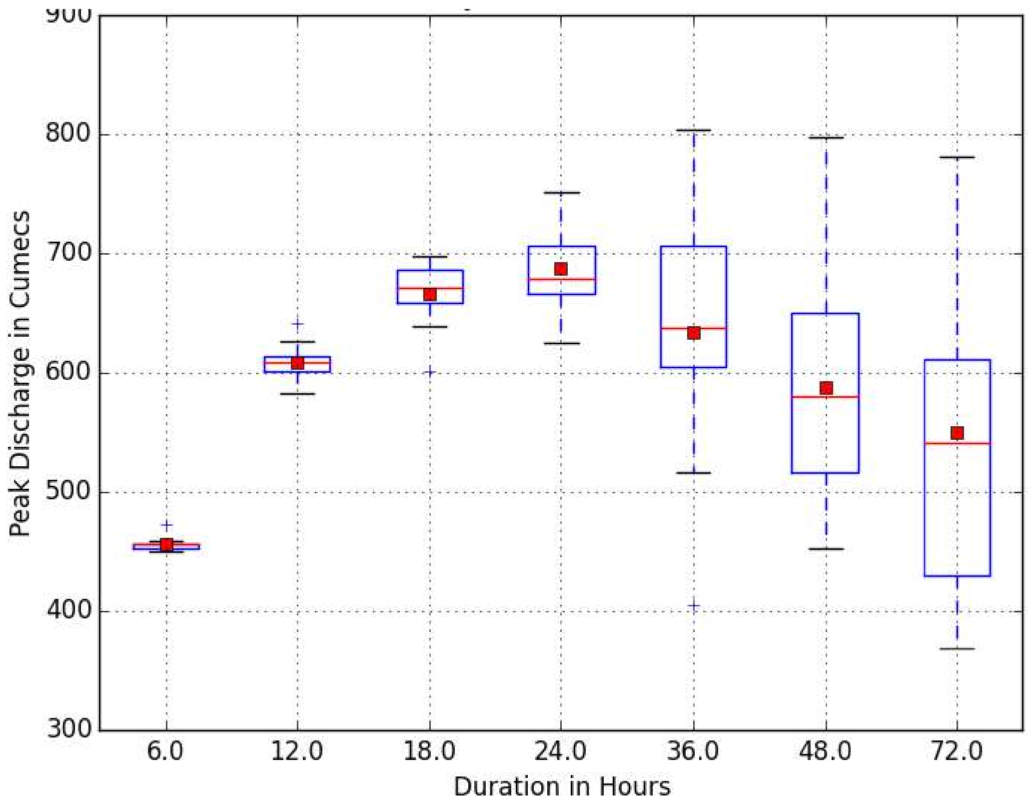

Figure 8.6 – Roper Creek discharge box plots at Middlemount Coal Mine, 1% AEP event

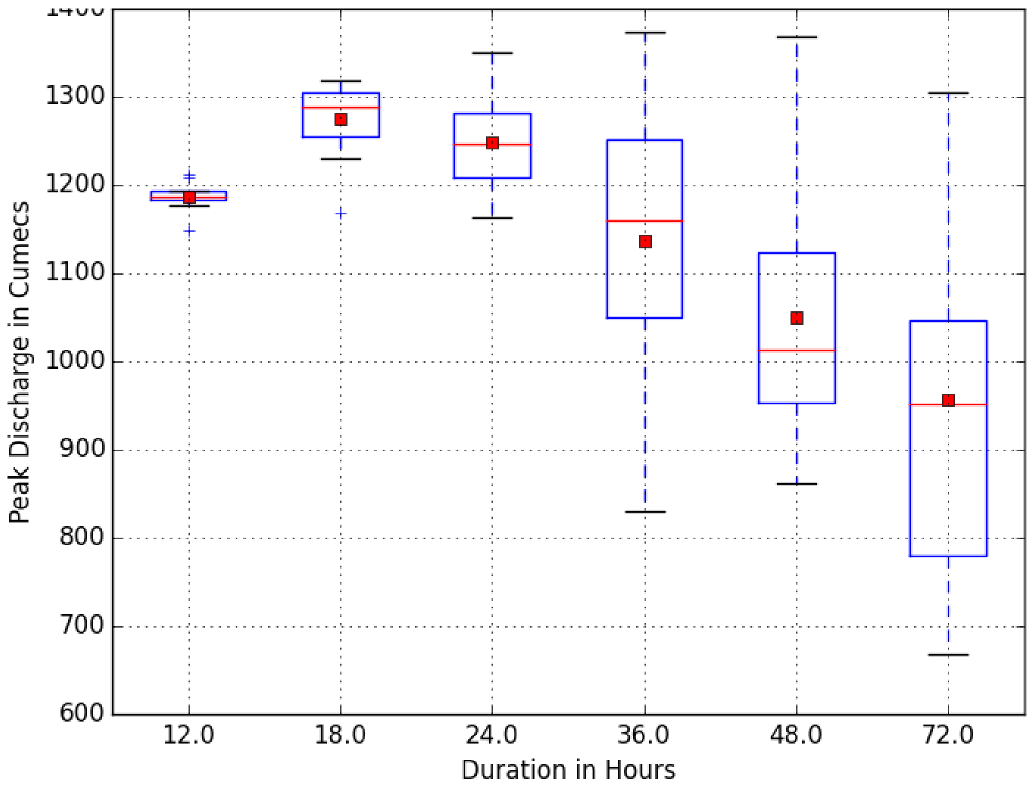

Figure 8.7 - Roper Creek discharge box plots at Middlemount Coal Mine, 0.1% AEP event

8.4 HYDRAULIC MODELLING

8.4.1 General

The two-dimensional unsteady flow (TUFLOW) hydrodynamic model (Version 2020-01-AB-iSP-w64) (BMT, 2018) 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.

8.4.2 Calibration model configuration

Figure 8.8 shows the extent of the January 2013 (calibration conditions) TUFLOW model. The locations of the inflow and outflow boundaries are also shown.

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 5 m grid size was adopted for the two-dimensional model area.

8.4.3 Available topographic data

Topographic aerial survey data for the study area was provided by MCPL. 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 obtained in December 2012 was used as the primary ground level information for the January 2013 event.

MCPL provided additional ground survey of the area to the south of Middlemount Road in 2019.

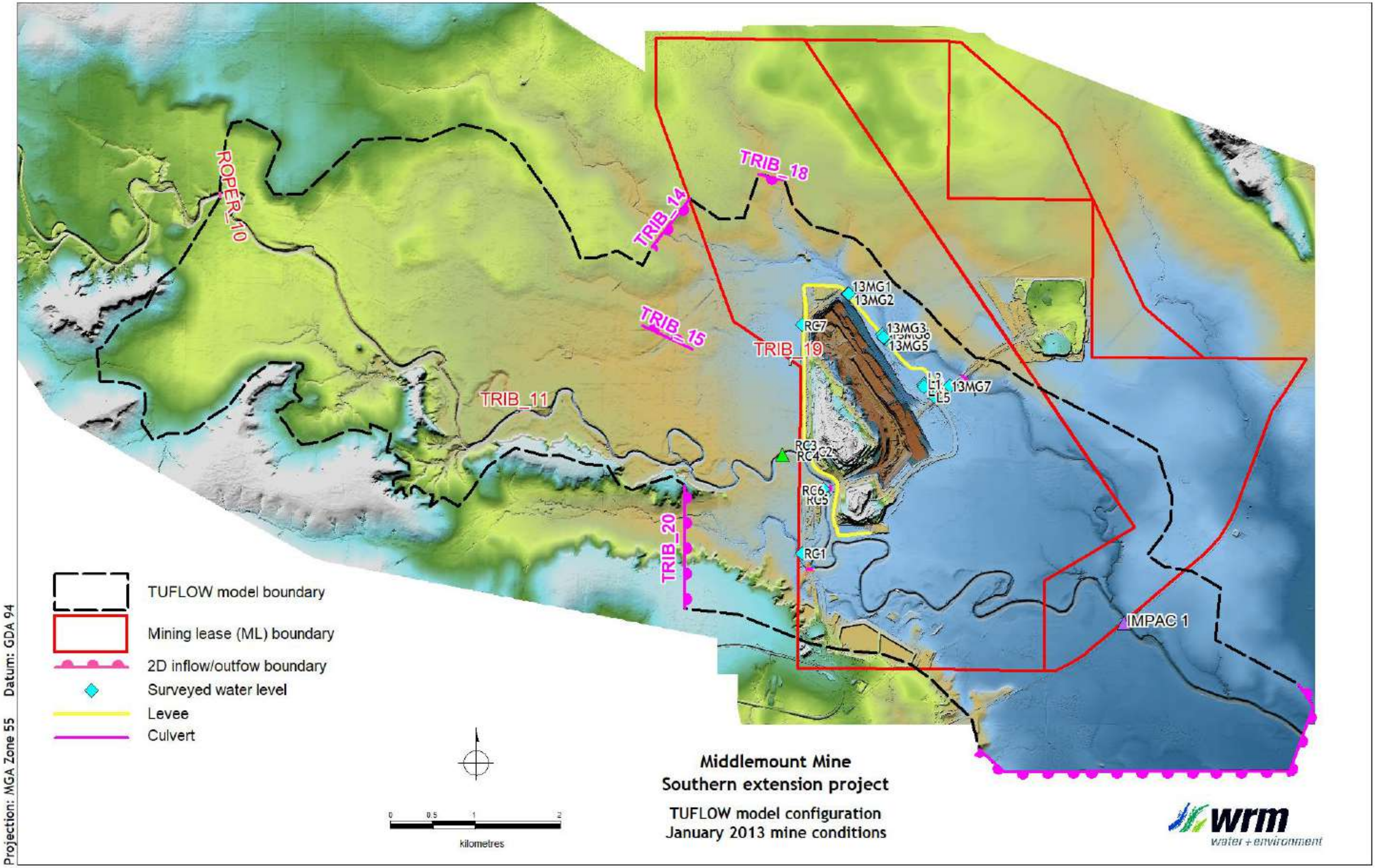

Figure 8.8 – January 2013 Roper Creek TUFLOW model configuration

8.4.4 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 for the January 2013 event. The adopted Manning's n values for the TUFLOW model are:

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

8.4.5 Road crossings

The Middlemount Road crossing of Roper Creek downstream of the mine is a bridge which spans the main channel. The bridge was represented in the TUFLOW model as a layered flow constriction with a 1.2 m thick superstructure and a road deck level of 152.5 mAHD. The bridge piers below the superstructure were represented by applying a 10% blockage below the superstructure.

Table 8.6 shows details of the haul road crossings of the various waterways. The locations of the haul road crossings are shown in Figure 8.8.

Table 8.6 – Haul Road crossing details

Location ID (see Figure 8.8)	Location	Details
1	Roper Creek	2 x 2.4 m diameter CMP* 2 x 2.6 m diameter CMP
2	Unnamed Roper Creek tributary	2 x 2.1 m diameter CMP
3	Thirteen Mile Gully	2 x 0.9 m diameter CMP

CMP – Corrugated metal pipe

8.4.6 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 8.8.

Figure 8.9 compares the recorded and predicted water level hydrographs at the IMPAC1 gauge and Table 8.7 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.

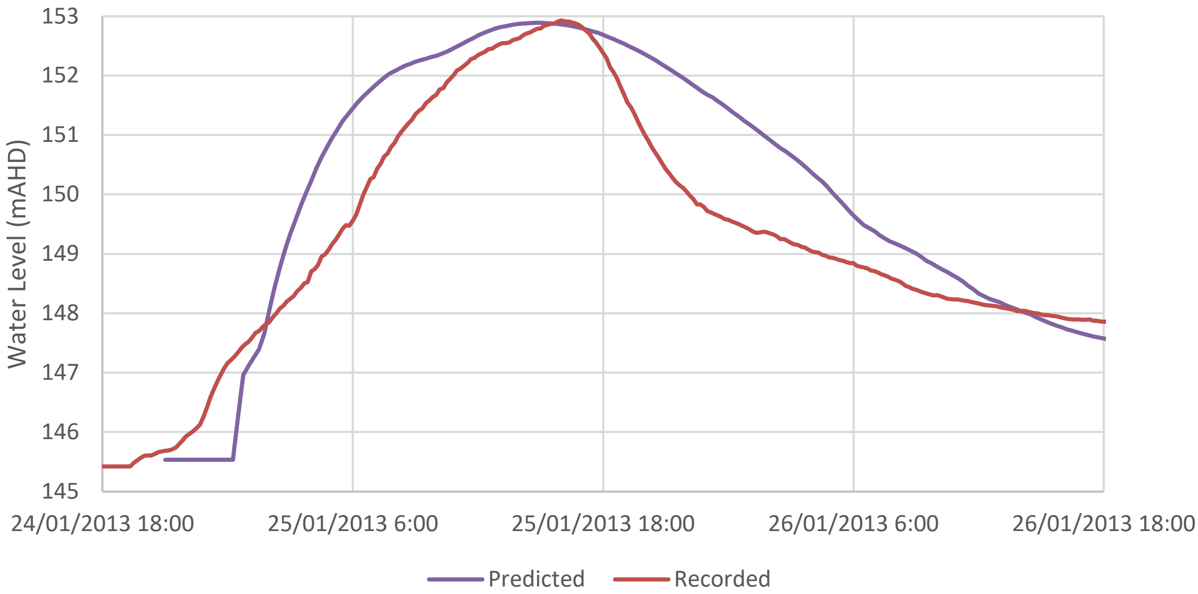

Figure 8.9- Recorded and predicted water level at the IMPAC1 gauge at Middlemount Road, January 2013 event.

Table 8.7 - Comparison of surveyed and predicted flood levels, January 2013 event

Location	Surveyed (mAHD)	Predicted (mAHD)	Difference (m)
RC1	162.01	163.04	1.03
RC2	162.66	163.09	0.43
RC3	162.66	162.92	0.26
RC4	162.99	163.15	0.16
RC5	162.25	161.98	-0.27
RC6	162.26	162.47	0.21
RC7	161.79	162.36	0.57
13MG1	161.01	161.13	0.12
13MG2	161.01	161.13	0.12
13MG3	160.33	161.05	0.72
13MG4	160.82	161.04	0.22
13MG5	160.83	161.01	0.17
13MG6	160.83	161.01	0.18
L1	160.70	161.04	0.34
L2	160.69	161.04	0.35
L3	160.75	161.04	0.29
L4	160.71	161.04	0.33
L5	160.76	161.04	0.28
13MG7	160.78	161.04	0.26

8.5 PRE-MINING CONDITIONS FLOODING

8.5.1 Model changes

Figure 8.10 shows the configuration and topography of pre-mining conditions. Pre mining conditions uses the underlying survey from May/June 2008 (prior to mining). Ground levels along the Roper Creek channel were updated using Lidar data flown in July 2018. Hydrology model inflows remained unchanged from the model calibration conditions. Note that mining catchments were not included in the hydrology model for consistency across all scenarios.

8.5.2 Flood depths and velocities

Figure 8.11 show the pre-mining conditions flood levels, depth and extent within the vicinity of the Project and Figure 8.12 show the pre-mining conditions flood velocities for the 1% AEP event. Peak flood depths and velocities for the 50%, 5%, 2% and 0.1% AEP events are given in Appendix C. The results show the following:

- The 50% AEP flood would not exceed the capacities of the Roper Creek or Thirteen Mile Gully channels. The overbank flooding shown on the figure is due to local catchment runoff that drains the floodplain. Roper Creek channel velocities average 1.1 m/s.
- The 5% AEP flood would be confined to the main Roper Creek channel upstream of the mine but would break out of the main channel near the mine lease boundary. The overflowing floodwater would drain in an easterly direction to Thirteen Mile Gully or back to Roper Creek near the Thirteen Mile Gully confluence. Floodwater would also overflow to the south before draining back into Roper Creek immediately downstream of the Mine lease boundary. Roper Creek channel velocities average 1.6 m/s and overbank velocities would be generally less than 0.3 m/s.
- The 2% and 1% AEP flood events would overflow the Roper Creek channel both upstream of the mine and near the mine lease boundary. The Roper Creek channel is 'perched' above the floodplain both upstream and within the mine with overbank floodwater draining along independent flow paths. Two of these independent flow paths drain to Thirteen Mile Gully to the east (eastern flow paths). A third independent flow path drains to the south of Roper Creek (southern flow path) along a remnant flood channel and across Middlemount Road. Roper Creek channel velocities average 1.7 to 1.8 m/s and overbank velocities are generally less than 0.5 m/s.
- The 0.1% AEP event would inundate much of the floodplain between Roper Creek and Thirteen Mile Gully.

8.6 APPROVED FINAL LANDFORM CONDITIONS FLOODING

8.6.1 Model changes

The following changes have occurred or are approved to be constructed from pre-mining conditions:

- The approved flood protection levees that extend around the western and southern areas of the mine.
- Existing mine infrastructure within the Roper Creek floodplain as defined by the 2018 LiDAR information including:
    - the haul road and culvert crossings;
    - North ROM; and
    - topsoil stockpiles.
- The two approved (not constructed) Roper Creek diversions (WRM, 2020).

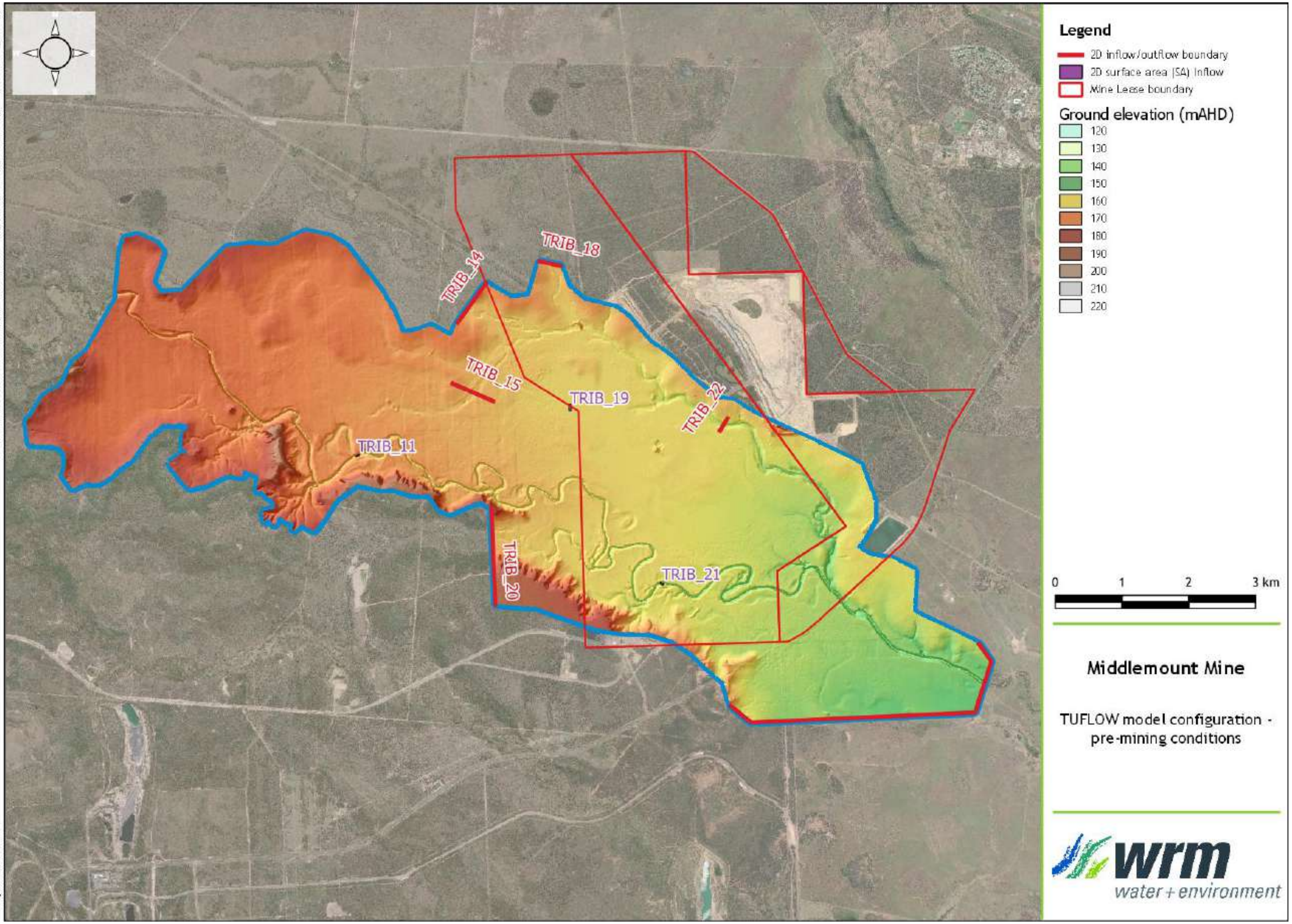

Figure 8.10 – Pre-mining Roper Creek TUFLOW model configuration

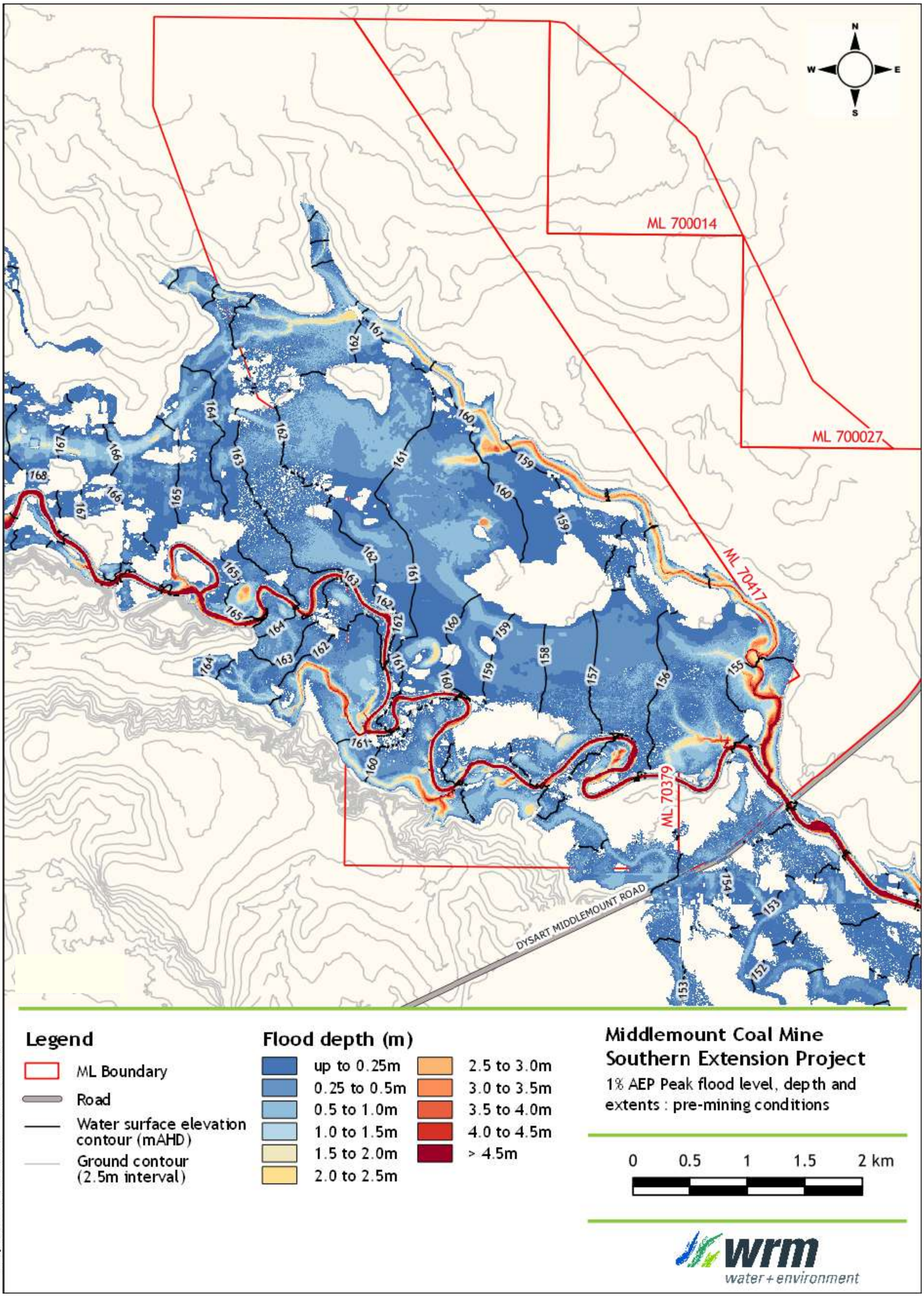

Figure 8.11 – Pre-mining conditions flood levels, depths and extent, 1% AEP event.

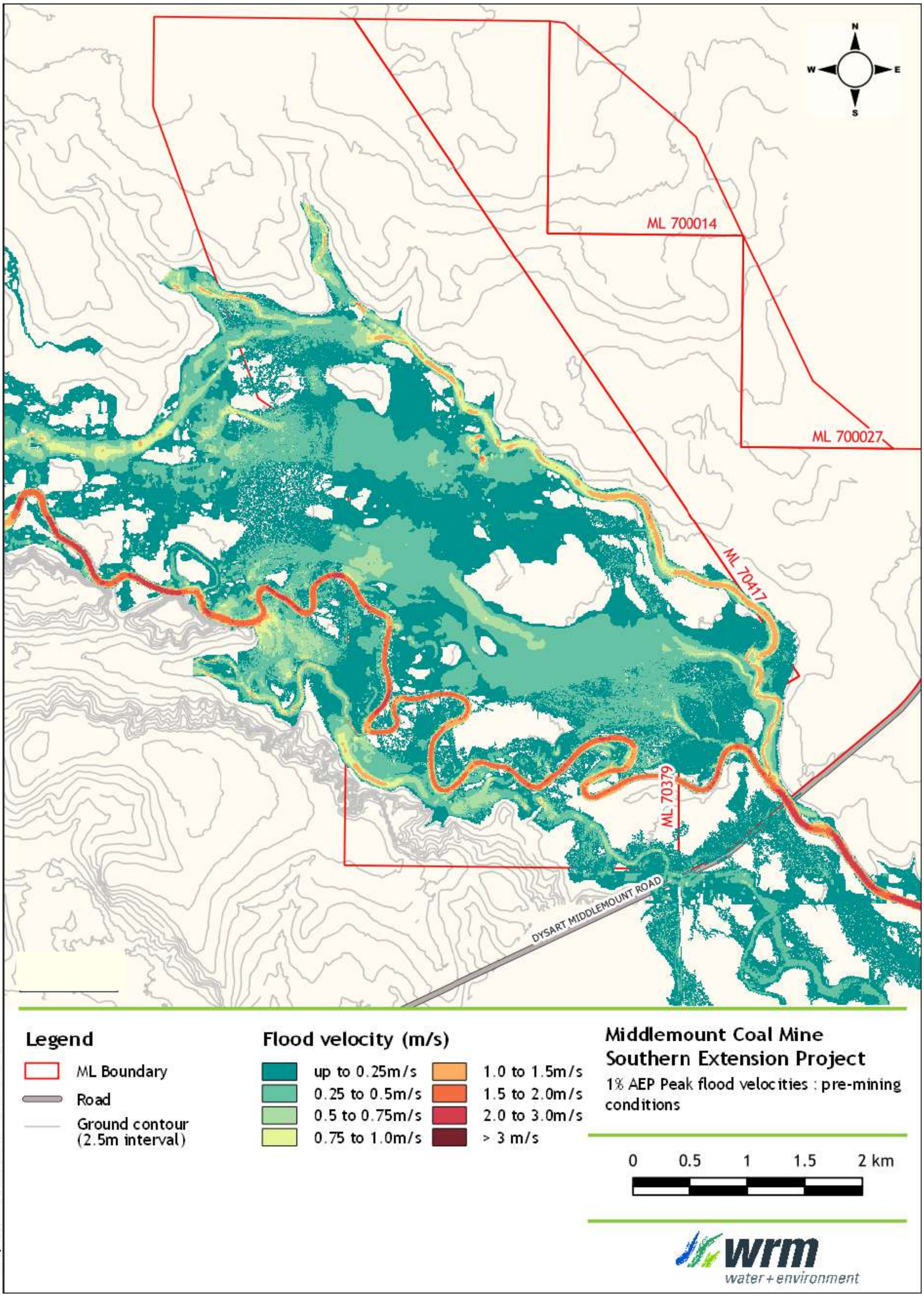

Figure 8.12 – Pre-mining conditions flood velocities, 1% AEP event.

Descriptions of the approved diversions and the levee are given in Section 5.8. The Roper Creek diversions were designed within the 12D software using the cross sections shown in Section 4.8 as a template. The 12D tins were then converted to digital elevation model (DEM) files to override the pre-mining conditions ground levels. The floodplain modifications were defined using a Zshape file inbuilt within TUFLOW.

The flood levee was modelled as a high wall to ensure it provided flood immunity for all design floods. No other changes were made to the pre-mining TUFLOW model.

8.6.2 Flood depths and velocities

Figure 8.13 show the flood levels, depths and extent within the vicinity of the Project and Figure 8.14 show the peak flood velocities for the 1% AEP event. Flood maps for the 50%, 5% AEP, 2% and 0.1% AEP events for the approved conditions are provided in Appendix C. The results show the following:

- The 50% AEP flood would not exceed the capacities of the Roper Creek or Thirteen Mile Gully diversion channels in a similar manning to pre-mining conditions. Roper Creek channel velocities would remain at around 1.1 m/s.
- For the 5% AEP event, floodwater would break out of the Roper Creek channel near the upstream boundary of the mine (in a similar location to the pre-mining conditions) to pond along the Thirteen Mile Gully diversion and upstream of the haul road from the mine infrastructure area. Overbank ponding depths exceed 2.5 m. The flood protection levees and Thirteen Mile Gully Diversion divert the eastern flow paths and Thirteen Mile Gully flows to Roper Creek. The haul road and mine infrastructure would obstruct the southern overland flow path back to Roper Creek. Flows are generally confined to the Roper Creek channel and the two diversion channels across the mining area. Roper Creek channel velocities average 1.6 m/s.
- The 2% and 1% AEP flood events pond upstream of the Thirteen Mile Gully Levees and upstream of the haul road to the south of Roper Creek to depths exceeding 3 m. Floodwater also overflows to the south of the mine and drains across Middlemount Road in a similar manner to pre-mining conditions.
- The 0.1% AEP event inundates much of the floodplain behind the flood protection levees.

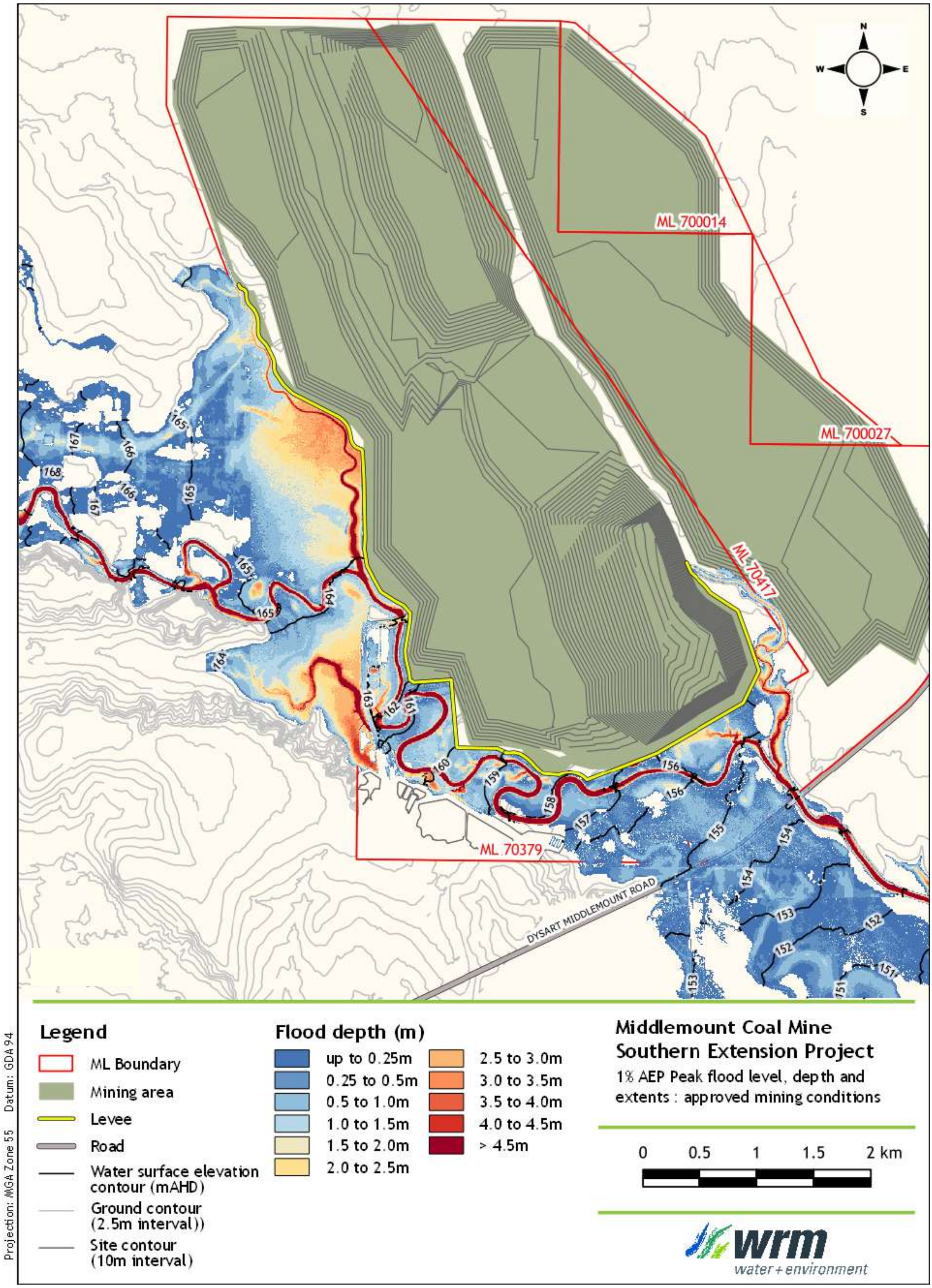

Figure 8.13 – Approved conditions flood levels, depths and extent, 1% AEP event.

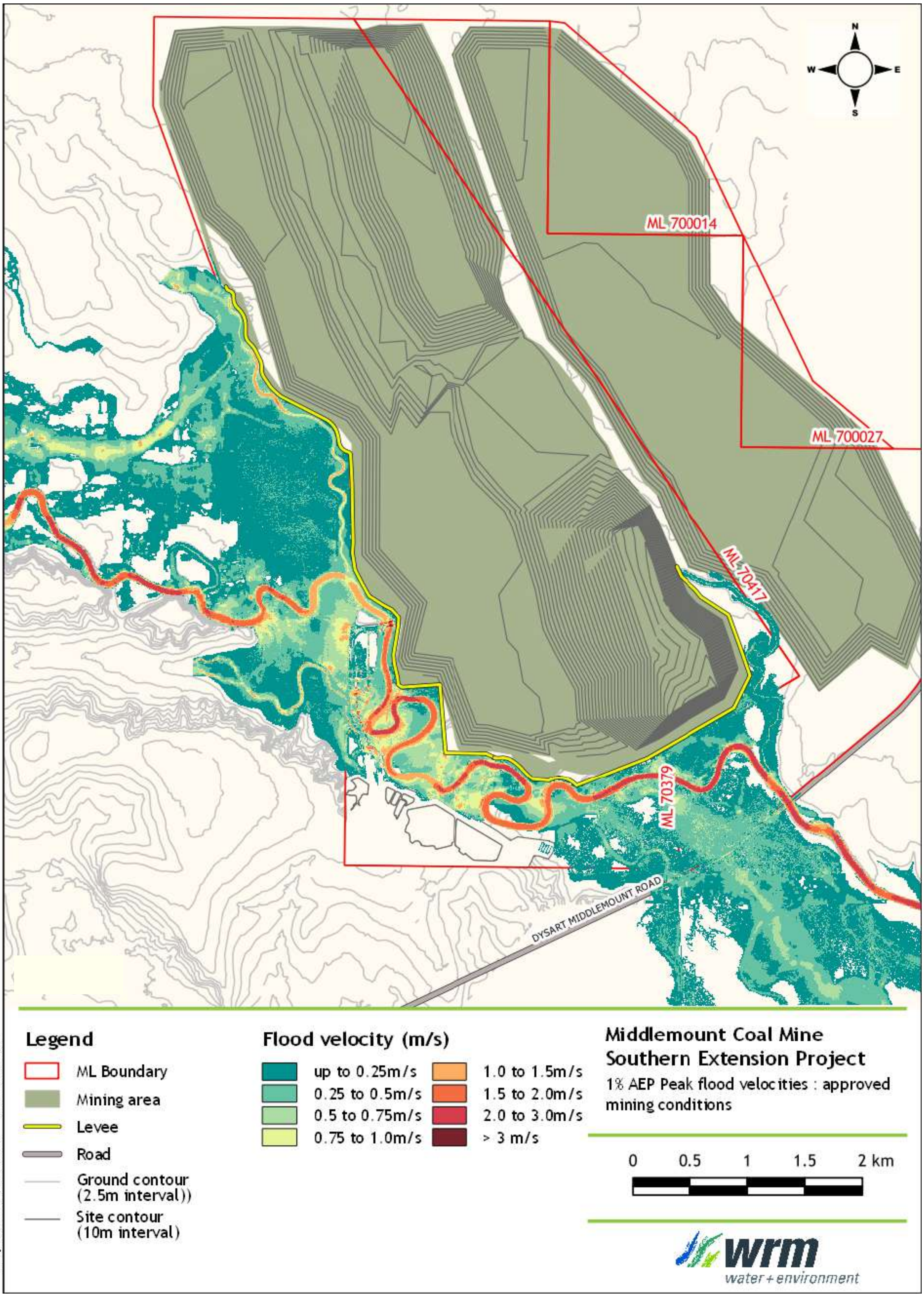

Figure 8.14 – Approved conditions flood velocities, 1% AEP event.

9 Flood modelling assessment

9.1 OVERVIEW

The flood models were updated to derive peak food levels, extents and depths for a range of design flood events to assess flood impacts of the Project. The models were also used to assess the performance of:

- the proposed Roper Creek diversion against the Guideline: *Works that interfere with water in a watercourse — watercourse diversions* (DNRM, September 2014);
- define the proposed modified levee crest heights to satisfy the flood immunity requirements for regulated levees in accordance with the 'Manual for Assessment Consequence Categories and Hydraulic Performance of Structures' (Structures Manual) (DES, 2016); and
- the post mining conditions landform to confirm that the open void will not be inundated for a probable maximum flood (PMF).

The assessment was undertaken for the:

- proposed year 23 end-of-mine conditions (proposed); and
- final landform conditions (post-mine).

9.2 ROPER CREEK DIVERSION

The Proponent has approval to divert Roper Creek in two locations (see Figure 5.2). The upstream diversion (Diversion 1) is in the process of being constructed. The downstream diversion (Diversion 2) is proposed to be modified as part of the project. The new alignment is shown in Figure 9.1 and will be constructed prior to 2023. The diversion will drain along a confined floodplain during the operational phase of the project. At the completion of mining, the floodplain will be widened to improve flood conveyance (refer revised location shown on Figure 9.2). No changes are proposed to the diversion channel post mining.

The Guideline: *Works that interfere with water in a watercourse — watercourse diversions* (DNRM, September 2014) provides guidance to proponents seeking approval to divert a watercourse as part of a new or amended environmental application. It includes guidance on watercourse diversion design and operation including maintenance, monitoring and revegetation. The guideline sets out key design principles and requirements for the functional designs of permanent diversions.

A contemporary version of this guideline has been prepared for stream diversions authorised under the Water Act (DNRME, 2019) (guideline). Updated guidelines for EP Act authorisations have not yet been prepared and therefore this assessment has been developed in consideration of the guideline for watercourse diversions authorised under the Water Act.

Design of the proposed Roper Creek Diversion 2 is generally in accordance with both guideline requirements. Details of how they have been addressed are provided below.

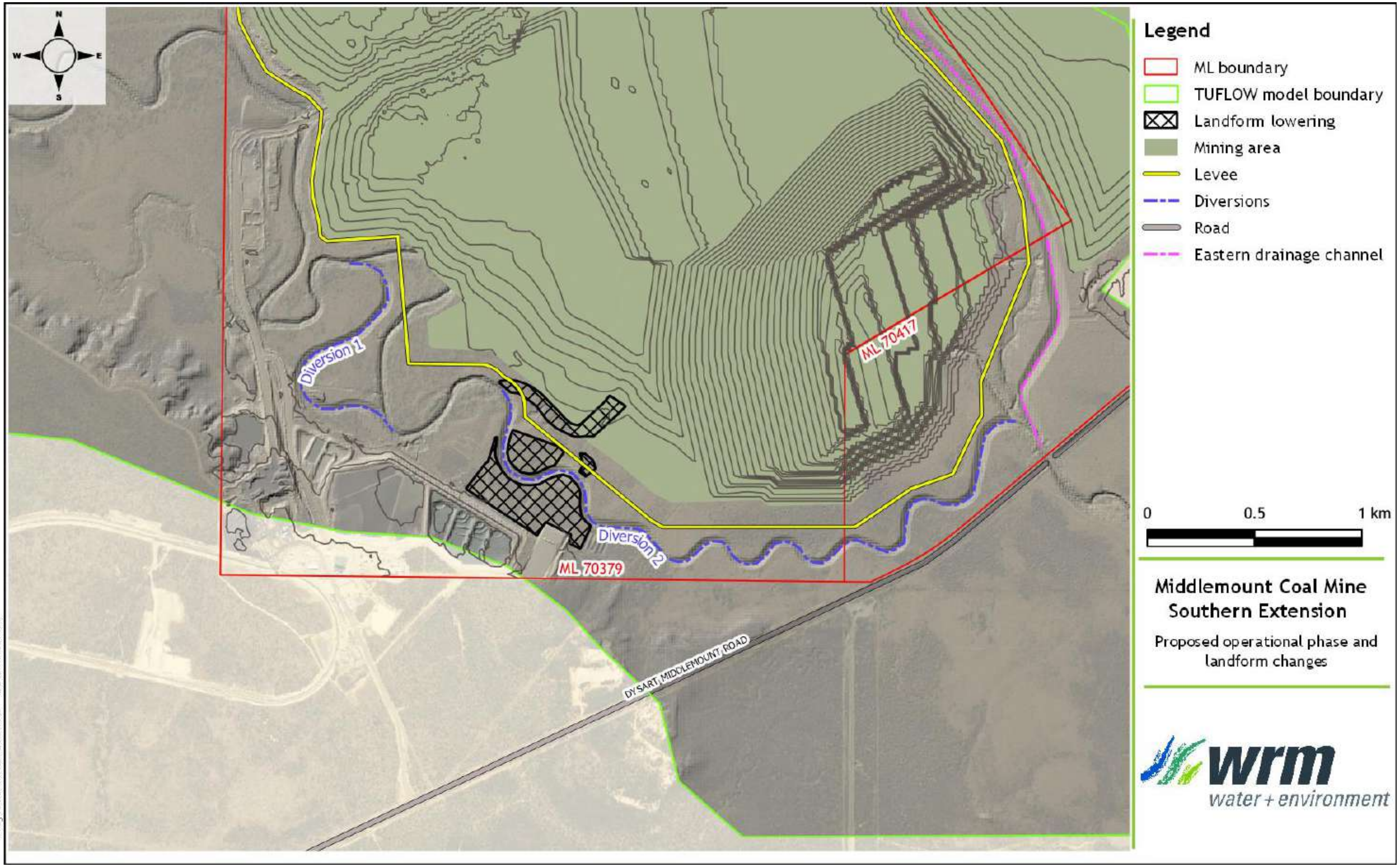

Figure 9.1 – Middlemount Mine Operational Phase (Year 2043 conditions)

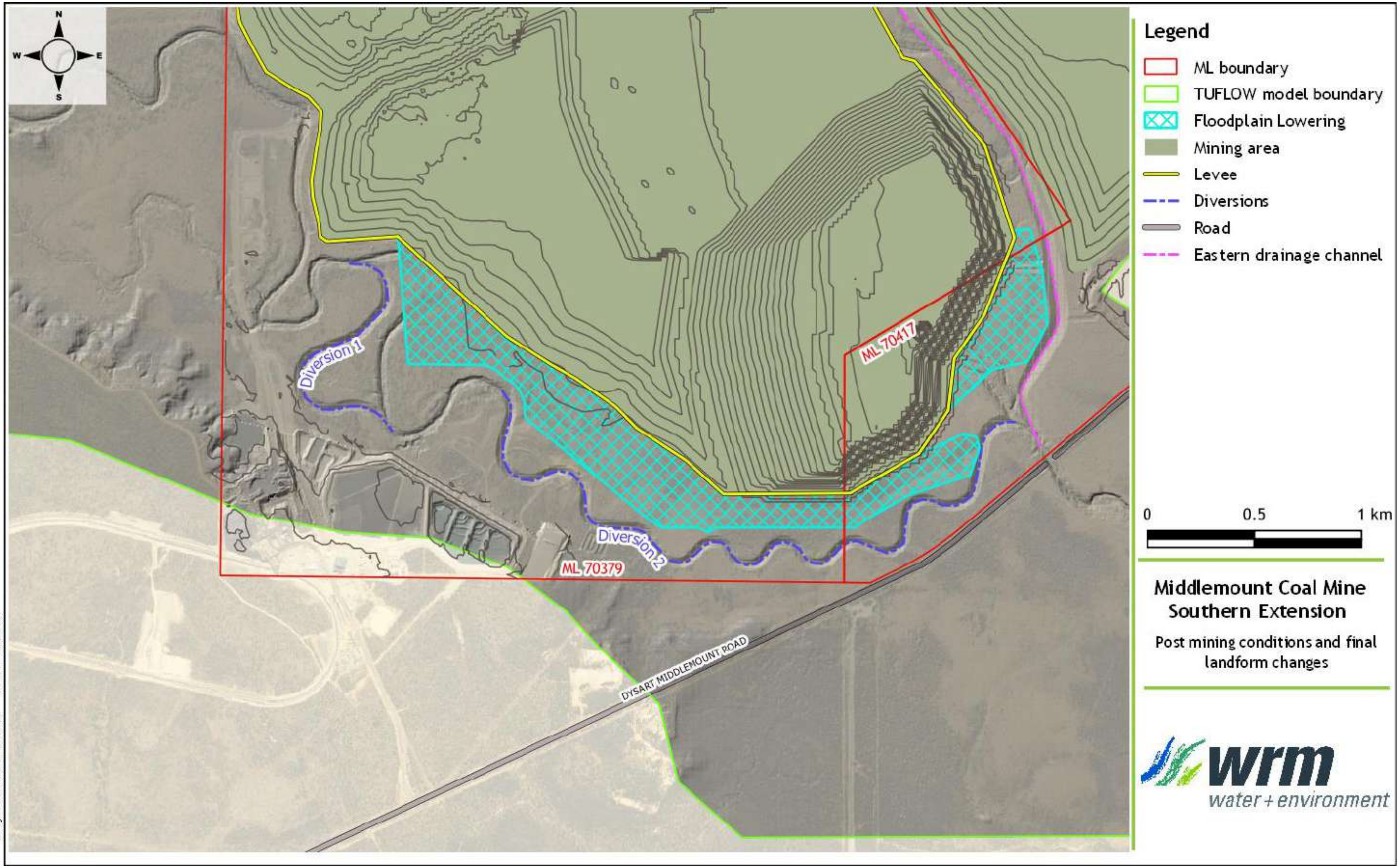

Figure 9.2 – Middlemount Mine Final Landform configuration

9.2.1 Roper Creek Diversion Design objectives

The proposed Roper Creek Diversion 2 aims to achieve the following key objectives:

- be self-sustaining and include geomorphic and vegetation features of regional watercourses and the surrounding landscape;
- where possible, positively contribute to river health values for the system; and
- not impose liability on the State, the proponent or the community to maintain the watercourse diversion and its associated components.

9.2.2 Adopted design approach

9.2.2.1 Guideline outcomes

The proposed diversions will need to satisfy the following outcomes:

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.

9.2.2.2 Design hydraulic criteria

The Guideline has been developed using the results of the Australian Coal Association Research Program (ACARP) stream diversion project (Fisher Stewart, 2002). The Fisher Stewart study investigated the hydraulic characteristics of a number of natural streams in the area of the Project. The performance and design faults of existing stream diversions within the Bowen Basin were also assessed as part of the Fisher Stewart study.

Table 9.1 shows the design criteria given in the Guideline. Stream power, stream velocity and shear stress are the main hydraulic characteristics of interest:

- Stream power is a function of discharge, hydraulic gradient and flow width. It represents the energy that is available to do work in and on the channel. High stream powers are indicative of elevated erosion potential.
- The velocity criteria have been selected to minimise the potential for damage to the channel through erosion associated with high flow velocities. Where calculated velocities exceed the adopted velocity criteria, additional bank protection (increased vegetation density or rock protection) will be required. Note there is no direct relationship between velocity and the force exerted on soil particles at the boundary and thus stream power and shear stress are used as more reliable indicators of erosion potential.
- The shear stress provides a measure of the tractive force acting on sediment particles at the boundary of the stream, and is used to determine the threshold of motion for bed material. It provides an indication of the potential for erosion of cohesive sediments or movement of non-cohesive sediments at the channel boundary.

Table 9.1 – Guideline design criteria for Bowen Basin stream diversions

Scenario	Stream Power (W/m^2)	Velocity (m/s)	Shear Stress (N/m^2)
50% AEP event without vegetation	<35	<1.0	<40
50% AEP event with vegetation	<60	<1.5	<40
2% AEP event with vegetation	<150	<2.5	<50

The Guideline design criteria are based on an incised channel with confinement of flows up to and including the 5% AEP design event. The Guideline hydraulic parameters were derived in the Fisher Stewart (2002) study from depth averaged channel cross sections using the HEC-RAS one dimensional hydraulic model. The Fisher Stewart study also derived the small event values for the 2 year average recurrence interval (ARI) event and not the 50% AEP event, which is slightly larger. The difference is expected to be minor.

The 50% AEP event (an approximation of the 2 Year ARI event) represents the behaviour of the main channel of the creek and proposed diversion at bank full flow conditions. In geomorphologic assessments, 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.

An assessment of the 2% AEP (50 Year ARI) design flood represents the behaviour of Roper Creek and the diversion during a representative large flood. It can be used to identify whether the changed out of bank flood behaviour could inadvertently cause an avulsion of the channel.

9.2.2.3 Current research design guidelines

ACARP engaged consultants to review the success or otherwise of diversions constructed using the ACARP design criteria and to update the design criteria based on the outcomes of this research and other recent research (project C20017) (Alluvium, 2014).

The study found that constructed diversions in Central Queensland comprise elements of both alluvial and threshold channel design. A description of these design processes is given below.

Alluvial channel design

For alluvial channel design, the study found that sediment supply and bed load transport were a critical factor in the performance of the diversions assessed, particularly new diversions that had applied the above Guideline criteria. The volume of bed load sediment transported by a watercourse system is controlled by both the amount of sediment delivered to the watercourse and the capacity of the watercourse to transport sediment. Bed load transport in a watercourse can be broadly described as being either supply limited (can transport more sediment than is available) or transport limited (sediment supply exceeds transport capacity). Given the sediment loads currently within the bed of Roper Creek, it would be a transport limited stream.

The outcome of the study was the development of a modified approach to diversion design based on the systems with high and low sediment supply to the constructed watercourse using stream power as a surrogate for sediment transport. The revised alluvial channel design parameters are given in Table 9.2.

In addition, the guidelines suggest the following for stream power:

- Cross sections within a constructed waterway are not to vary by greater than 50% of the mean reach stream power; and
- The 25th and 75th percentile range of stream power is to be within the range shown in Table 9.2. No stream power value shall be more than 30% greater than the maximum value shown in Table 9.2.

Table 9.2 - Revised ACARP design criteria for Bowen Basin stream diversions

Stream Type	Sediment Transport group	Stream Power (W/m^2)	
		2 year ARI	50 year ARI
Alluvial	Supply limited	15-35	50-100
	Transport limited	35-60	80-150
Bedrock controlled	n/a	50-100	100-350

Threshold channel design

Threshold channel design focusses on maintaining stability up to a design flow event. It uses shear stress to define the threshold to:

- achieve an acceptable level of success over the vegetation establishment phase; and
- protect the stream and mine infrastructure against stream flow events.

The adopted shear stress thresholds for typical vegetation types in the Bowen Basin is given Table 9.3.

Table 9.3 - Shear stress thresholds for vegetation

Vegetation Types	Design shear stresses (N/m^2) for constructed waterways in the Bowen Basin
Buffel Grass	40
Structurally diverse suite of established native vegetation	120

The recommended design events for long term stability against extreme floods is given in Table 9.4.

Table 9.4 - Design flood events for long term performance

Consequence of channel scour	Proposed design event	
	During mine life	Post mining
Scour that threatens mine infrastructure	To be determined by mine operator	n/a
Scour that threatens public infrastructure	To be determined in consultation with relevant stakeholder (asset owner)	To be determined in consultation with relevant stakeholder (asset owner)
Scour that threatens capture of watercourse into the open cut pit.	1 in 1000 AEP	Probable Maximum flood

9.2.3 Diversion 2 characteristics

9.2.3.1 Channel characteristics

The proposed Roper Creek diversion has been designed to replicate as close as possible the Roper Creek sections that they replace and be constructible. Figure 9.3 shows a typical cross-section of the proposed Diversion 2 superimposed on thirty cross sections of the existing Roper Creek in the vicinity of the proposed diversion.

The following is of note with respect to the concept design of the channel diversion:

- The channel will have a base width of 4 m with batter slopes of 1V:3H.
- The confluence of the proposed diversions and Roper Creek will be designed with consideration to:
    - minimising the disruption to existing bank vegetation;
    - ensuring the diversion outflows are not directed onto the banks of Roper Creek; and
    - ensuring that the bed elevation at the downstream end of the diversion is the same as the Roper Creek bed elevation so drop structures would not be required.
- Depending upon the substrate material encountered, the base of the channel will be layered with sand (the depth to be determined during detailed design).

Further work will be undertaken on the channel design during detailed design to enhance the in-stream channel form. Note that the existing channel has bank batter slopes of often less than 1V:2H. During the design of Diversion 1, it was advised that a constructed channel would not be stable at these slopes. The adopted bank batter slopes of 1V:3H are expected to behave in a similar manner.

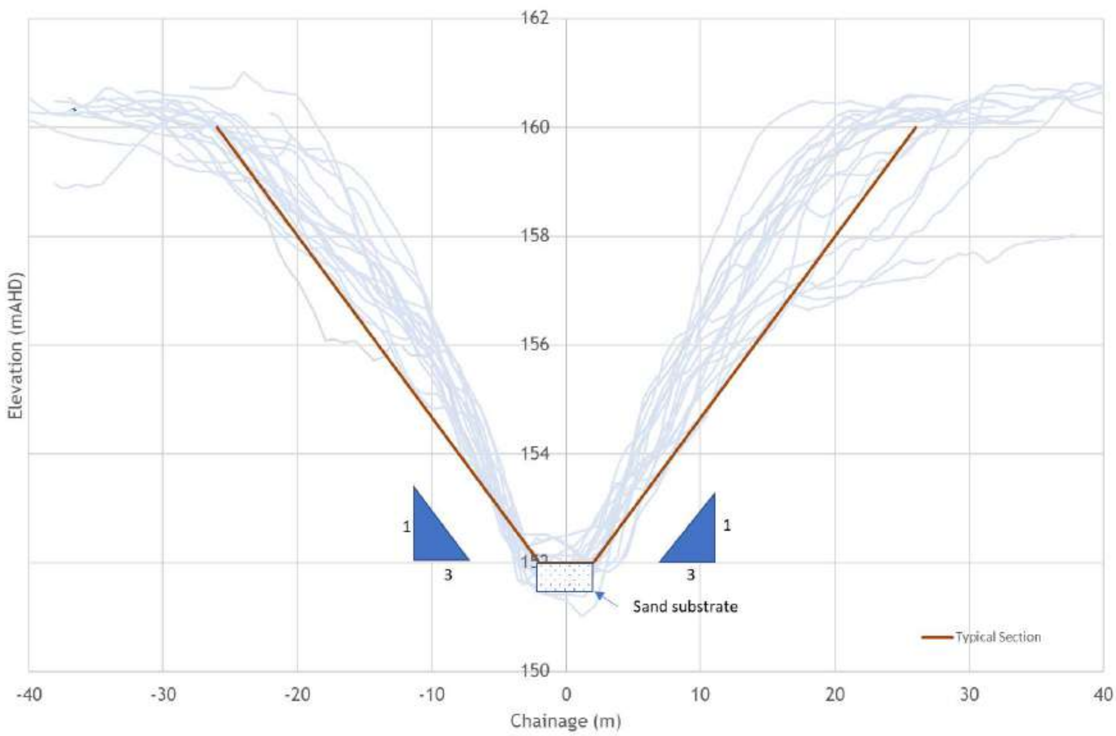

Figure 9.3 - Proposed Roper Creek Diversion cross-sections for the straight and meander sections

9.2.3.2 Floodplain modifications

Ground levels between the TSF and Diversion 2 will be modified to increase the conveyance of the floodplain at this location. There is currently a topographical ridge that is about 5 m above the adjacent floodplain, which will be lowered to match the surrounding ground levels of 158.2 m AHD on the upstream side and 155.25 mAHD on the downstream side. The location of the land to be lowered is shown in Figure 9.1.

At the completion of mining, the northern floodplain of Roper Creek will be rehabilitated back to an active floodplain. The operational phase levee will be relocated some 150 m to 300 m further to the north and the floodplain shaped to drain local catchment runoff from the floodplain back to the Roper Creek channel (see Figure 9.2).

Figure 9.4 shows a typical cross section of the Roper Creek diversion and the final landform floodplain. The location of the cross section is shown in Figure 9.2. The conceptual design of the reinstated floodplain consists of side slopes varying from 1 in 200 at the upstream end to 1 in 12 as it drains back into Roper Creek. The floodplain will fall at a gradient varying from 0.45% to 0.26%. In effect, the rehabilitated floodplain will mimic adjacent inflow channels that drain the pre-mine Roper Creek floodplain.

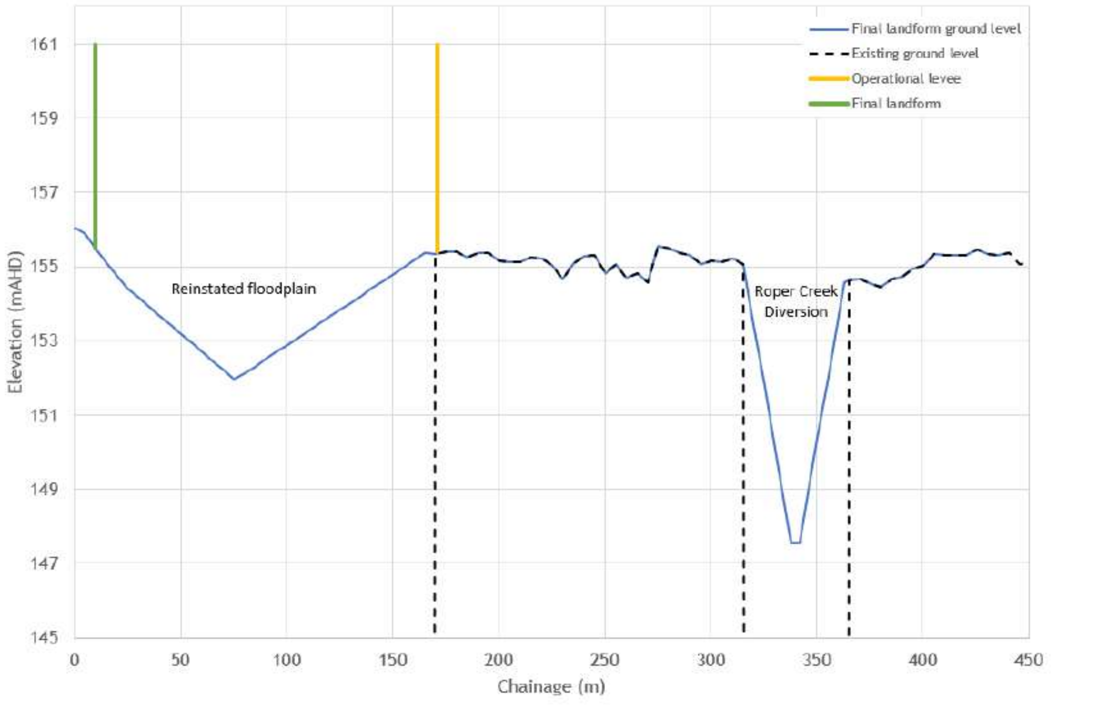

Figure 9.4 – Typical cross section of the Roper Creek diversion and final landform floodplain

9.2.3.3 Revegetation

The establishment and maintenance of riparian vegetation is essential for bank stability. Root systems from trees and shrubs provide much of the erosion resistance for channel widening from the shear stresses of flowing water and grasses protect the soil surface from raindrop splash erosion and overland flows.

Tree and shrub root systems take time to establish and grass root systems cannot provide sufficient depth and strength to provide the necessary erosion protection. The revegetation design must therefore provide for the rapid establishment of high strength, deep root systems to protect the soil surface from raindrop splash and overland flows and provide for long term erosion protection and ecological function. Revegetation will be undertaken in accordance with the Middlemount Mine Rehabilitation Management Plan required by EA EPML00716913.

9.2.4 Geomorphic channel parameter comparison

Table 9.5 shows comparisons of the geomorphic characteristics between the pre-mining/existing Roper Creek channel and the proposed Diversion 2. Diversion 2 replicates the geometric properties of the channel and bed grade of the existing Roper Creek channel. However, due to restrictions within the floodplain, Diversion 2 is about 13% shorter than the existing channel and the meander geometry cannot be fully replicated.

Table 9.5 – Roper Creek and Drainage Line 2 hydraulic and geomorphic characteristics

Parameter	Existing Roper Creek	Proposed Diversion 2
Length (km)	4,400	3,840
Bed grade (%)	0.111	0.114
Bed width (m)	7 to 9	4
Mean Top Width (m)	49	50
Depth to Floodplain (m)	7 – 8	7 - 8
Meander Radius (m)	80 to 550	85 to 150
Meander Sinuosity Index	1.77	1.54
Meander Wavelength (m)	400 to 1,000	300 to 500
Meander Amplitude (m)	250 to 600	150

9.3 PROPOSED CONDITIONS FLOODING AND FLOOD IMPACTS

9.3.1 Model changes

The following changes from approved mining conditions have been undertaken to the model to represent the proposed conditions:

- The revised Roper Creek Diversion 2, as described in Section 9.2.
- The proposed floodplain changes to remove the high ground around the upstream end of Diversion 2.
- The proposed final landform; and
- The proposed drainage channel between the active mining area and the eastern dump.

The Roper Creek Diversion 2 was designed within the 12D software using the cross sections shown in Figure 9.3 as a template. The 12D tin was then converted to digital elevation model (DEM) files to override the 2018 lidar ground levels. The floodplain modifications were defined using a Zshape file inbuilt within TUFLOW. Further work will be undertaken to refine the ground level changes as part of the final design of Diversion 2.

The flood levee was modelled as a high wall to ensure it provided flood immunity for all design floods. No other changes were made from the approved conditions TUFLOW model.

9.3.2 Flood depths and velocities

Figure 9.5 show the flood levels, depths and extents and Figure 9.6 show the flood velocities across the Project area for the 1% AEP events under proposed conditions. The 50%, 2% and 0.1% AEP flood depths and velocities are given in Appendix C. The change in flood level and velocity between proposed and approved conditions are given in Figure 9.7 and Figure 9.8 respectively for the 1% AEP event and in Appendix D for the other events.

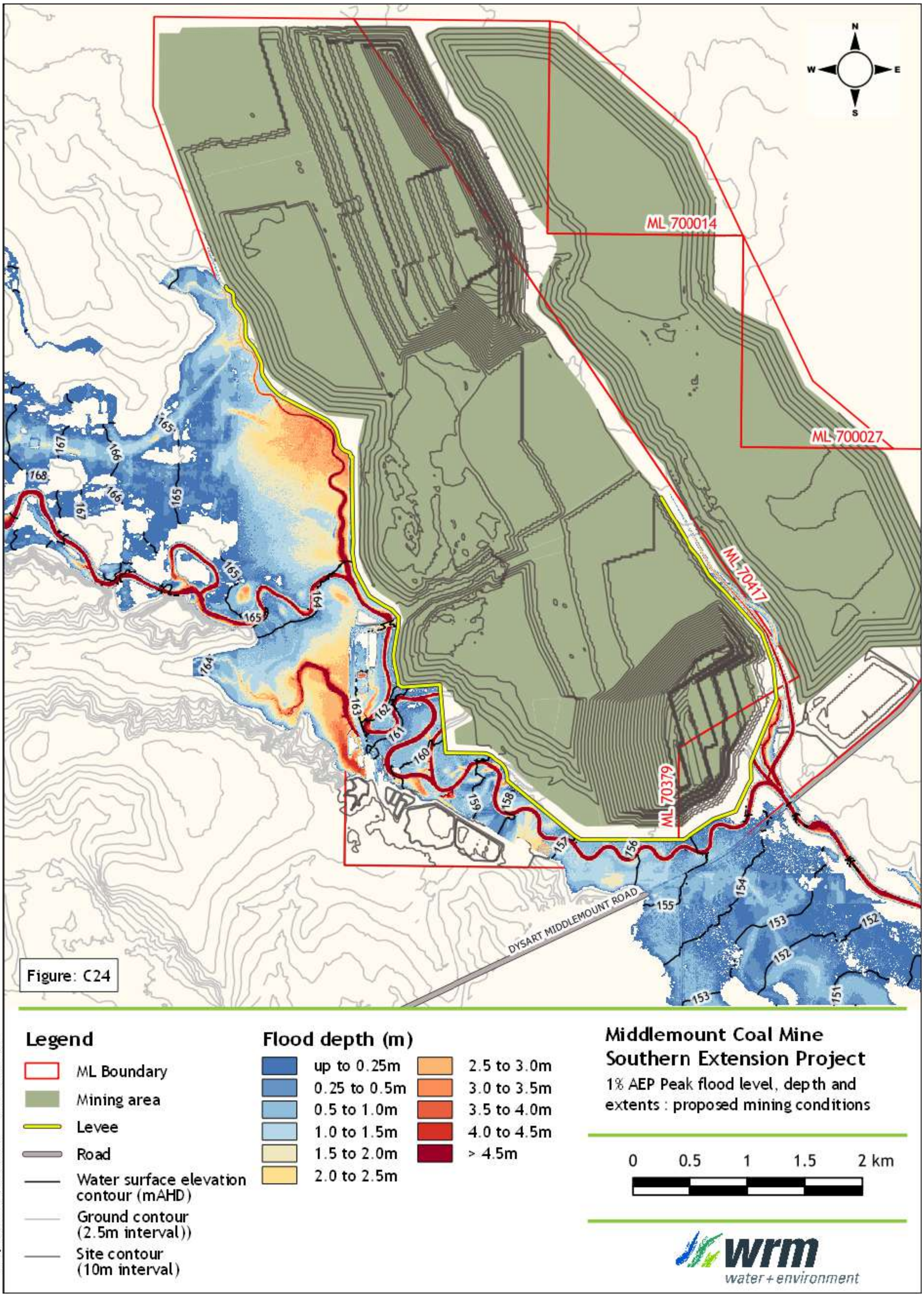

Figure 9.5 – Flood depths and extent, proposed conditions, 1% AEP

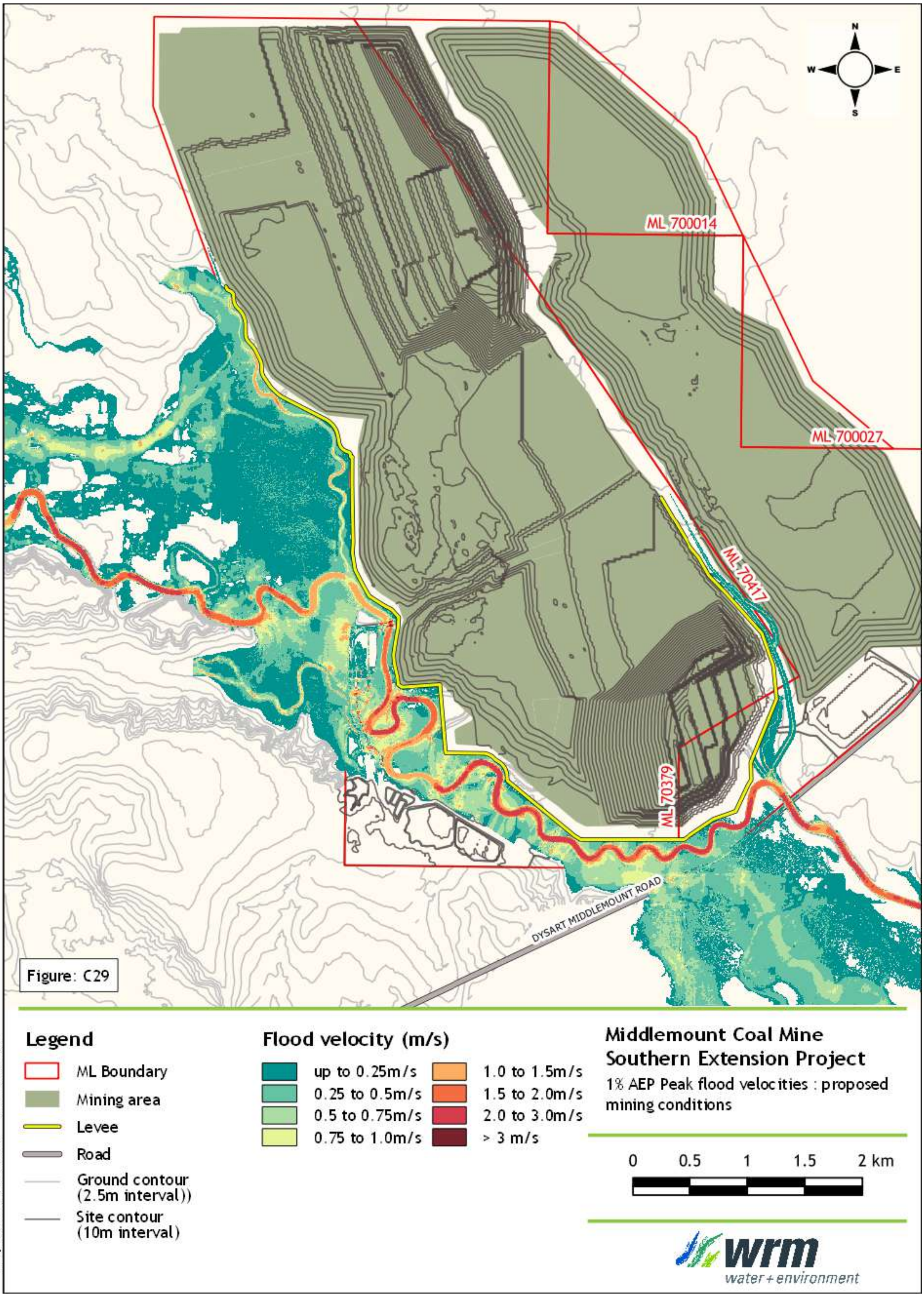

Figure 9.6 – Flood velocities, proposed conditions, 1% AEP

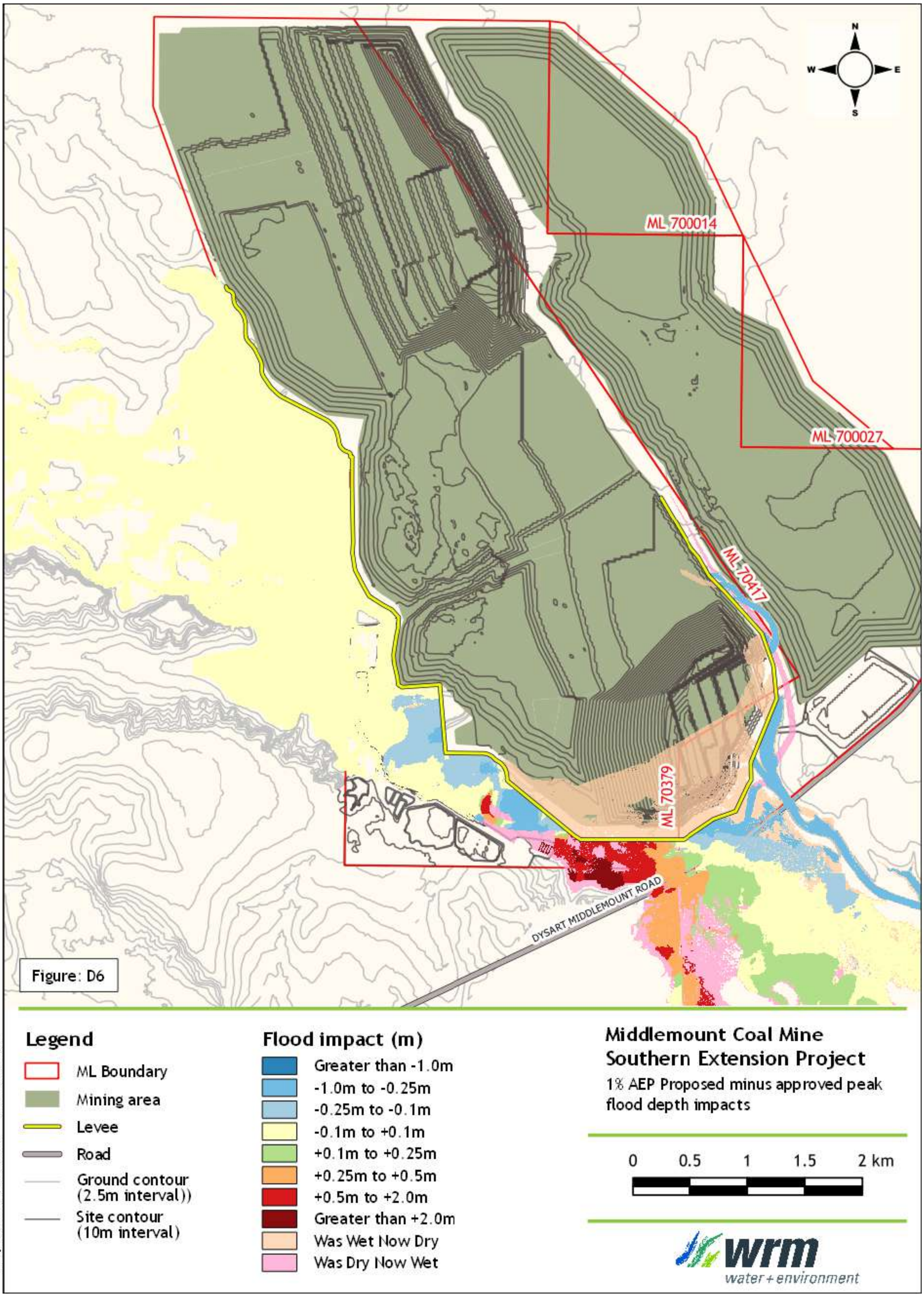

Figure 9.7 – Proposed minus approved conditions flood level impacts, 1% AEP

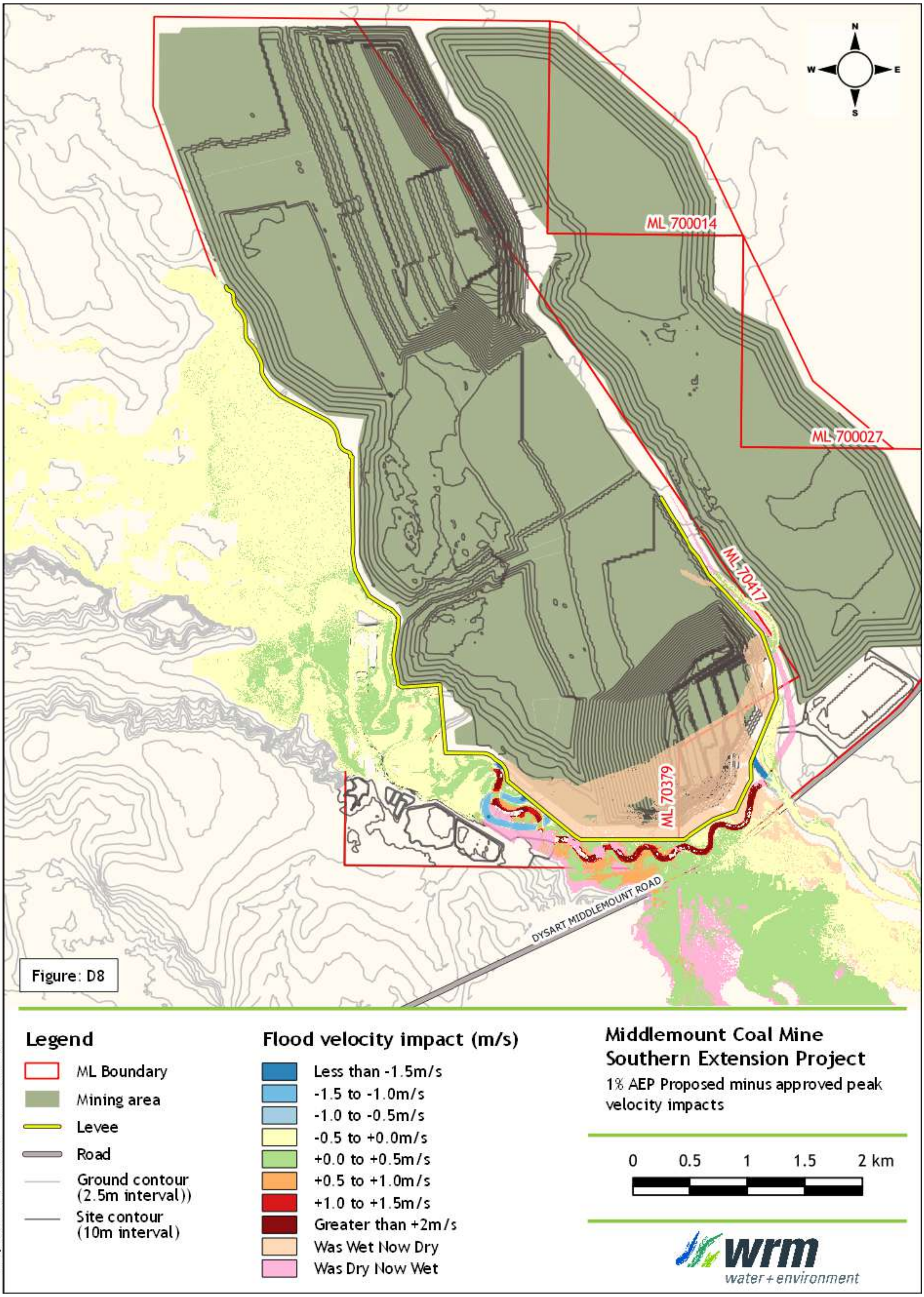

Figure 9.8 – Proposed minus approved conditions flood velocity impacts, 1% AEP

The results show the following:

- There are no significant changes to flood levels and velocities from approved conditions for the 50% AEP event with the exception of the change due to Diversion 2 relocation.
- The 5% AEP event flood levels would be unchanged from approved conditions upstream of Diversion 1 and moderately reduce peak flood levels within Diversion 1. Diversion 2 would overflow and drain across Middlemount Road for this event, which is not predicted to occur for pre-mining or approved conditions. The depth of flooding on Middlemount Road for this event is predicted to be 0.4 m and therefore likely impassable. The floodwater is confined to the old flood channel downstream of Middlemount Road.
- The 2% and 1% AEP peak flood levels are generally unchanged upstream of Diversion 2. The Project will increase flows on Middlemount Road and further downstream above approved and pre mining conditions. Peak flood levels (and flows) would reduce within the Roper Creek channel. The impact extent goes beyond the available topographic data. However, a review of the aerial imagery shows the flood channel that conveys this floodwater drains back into Roper Creek about 4.6 km downstream of Middlemount Road. The impact is not expected to extend further downstream of this location.

9.4 POST MINING CONDITIONS FLOODING AND FLOOD IMPACTS

9.4.1 Model changes

The following changes are proposed as part of the final post mining conditions from proposed mining conditions:

- The ground levels between the proposed conditions levee and the toe of the final landform around the southern void were lowered and reshaped back to an active floodplain.
- The proposed conditions levee was removed such that the toe of the proposed final landform around the southern void formed the edge of the floodplain.
- The haul road, North ROM and associated infrastructure between the mine infrastructure area and the mining areas were removed back to pre-mining ground levels.
- Minimal works are proposed along the Operational phase floodplain and Diversion 1 and Diversion 2 channels. Minor break out channels will be incorporated (at existing break out locations) to encourage more overbank flow into the newly created floodplain to mitigate the flooding on Middlemount Road.

The floodplain modifications were defined using a Zshape file inbuilt within TUFLOW. Further work will be undertaken to refine the ground level changes as part of the final design of the floodplain modifications.

The toe of the final landform was modelled as a high wall to ensure it provided flood immunity for all design floods. No other changes were made from the proposed conditions TUFLOW model.

9.4.2 Flood depths and velocities

Figure 9.9 show the flood levels, depths and extents and Figure 9.10 show the flood velocities across the Project area for the 1% AEP events under the post mining final landform conditions. The 50%, 2% and 0.1% AEP flood depths and velocities are given in Appendix C. The flood level and velocity impacts between proposed and approved conditions are given in Figure 9.11 and Figure 9.12 respectively for the 1% AEP event and in Appendix D for the other events.

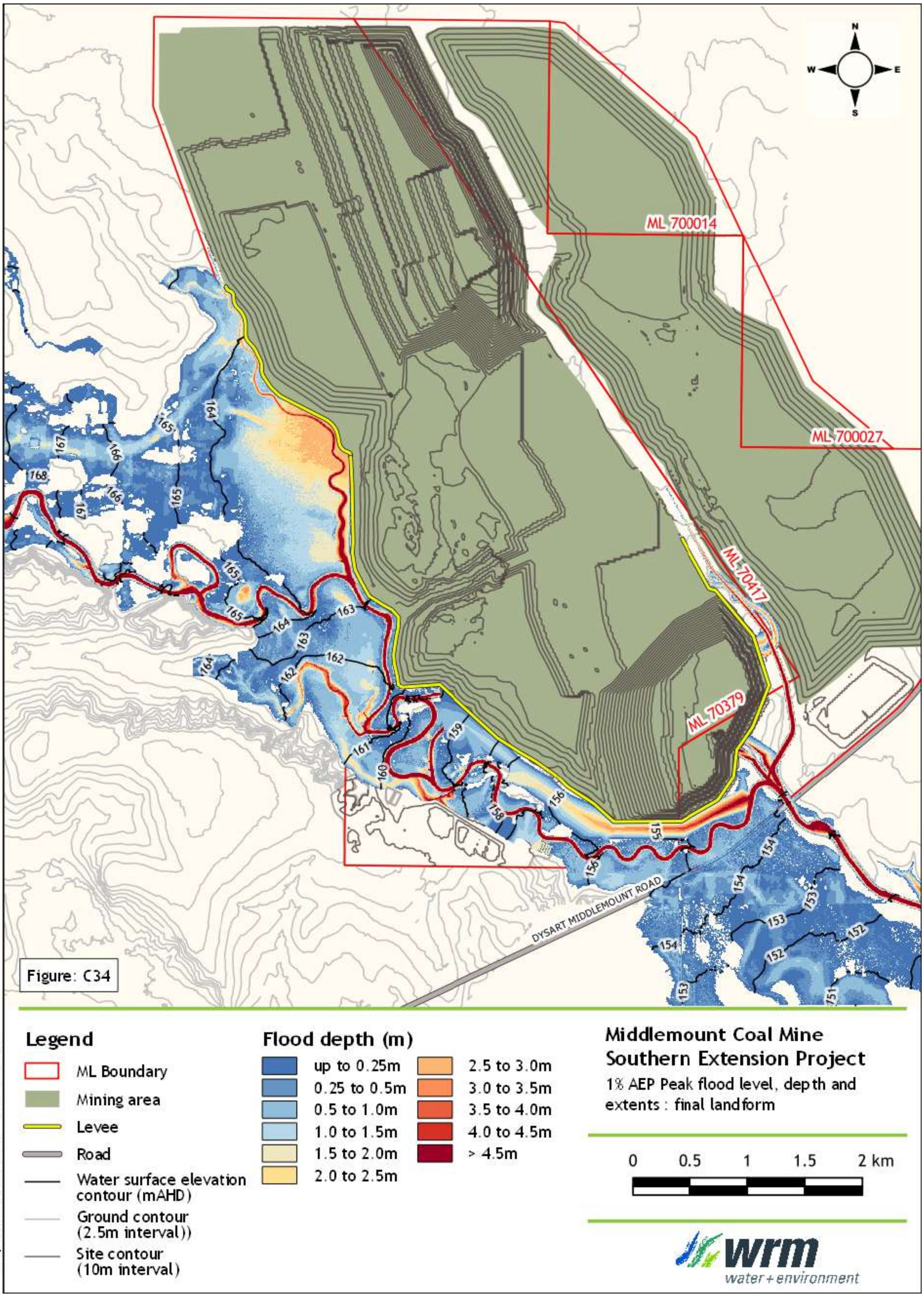

Figure 9.9 – Flood depths and extent, Post mining conditions, 1% AEP

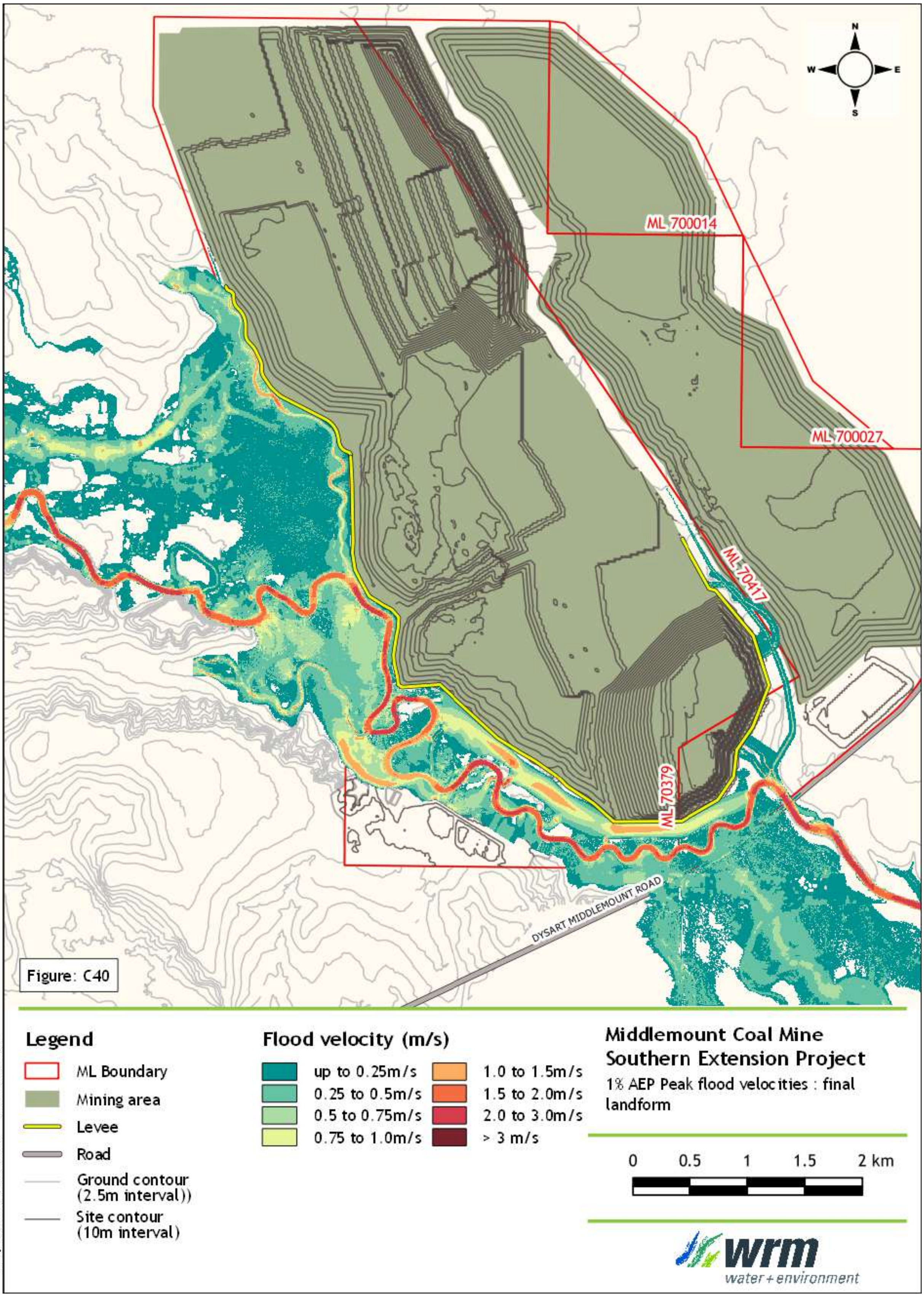

Figure 9.10 – Flood velocities, Post mining conditions, 1% AEP

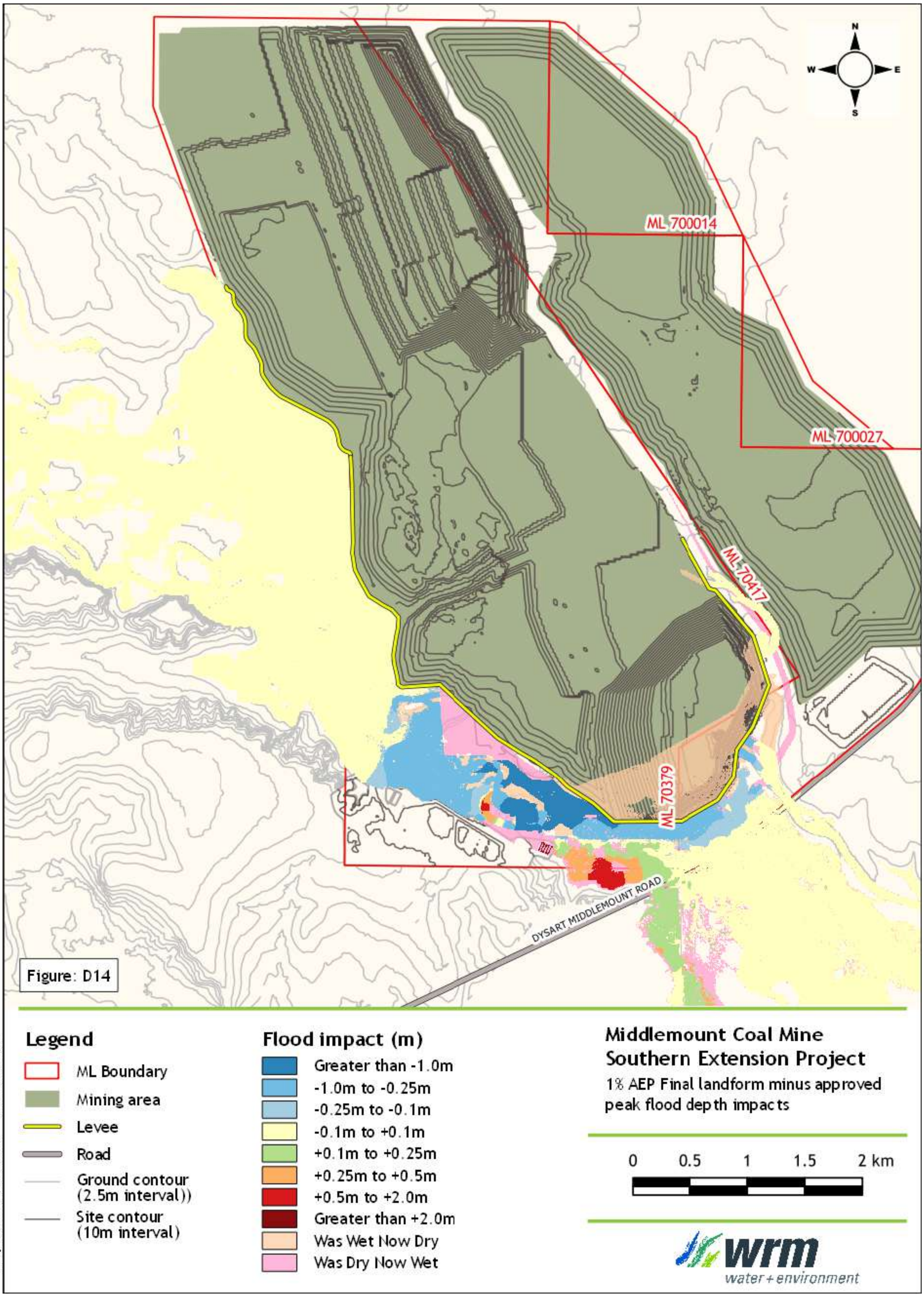

Figure 9.11 – Post mining minus approved conditions flood level impacts, 1% AEP

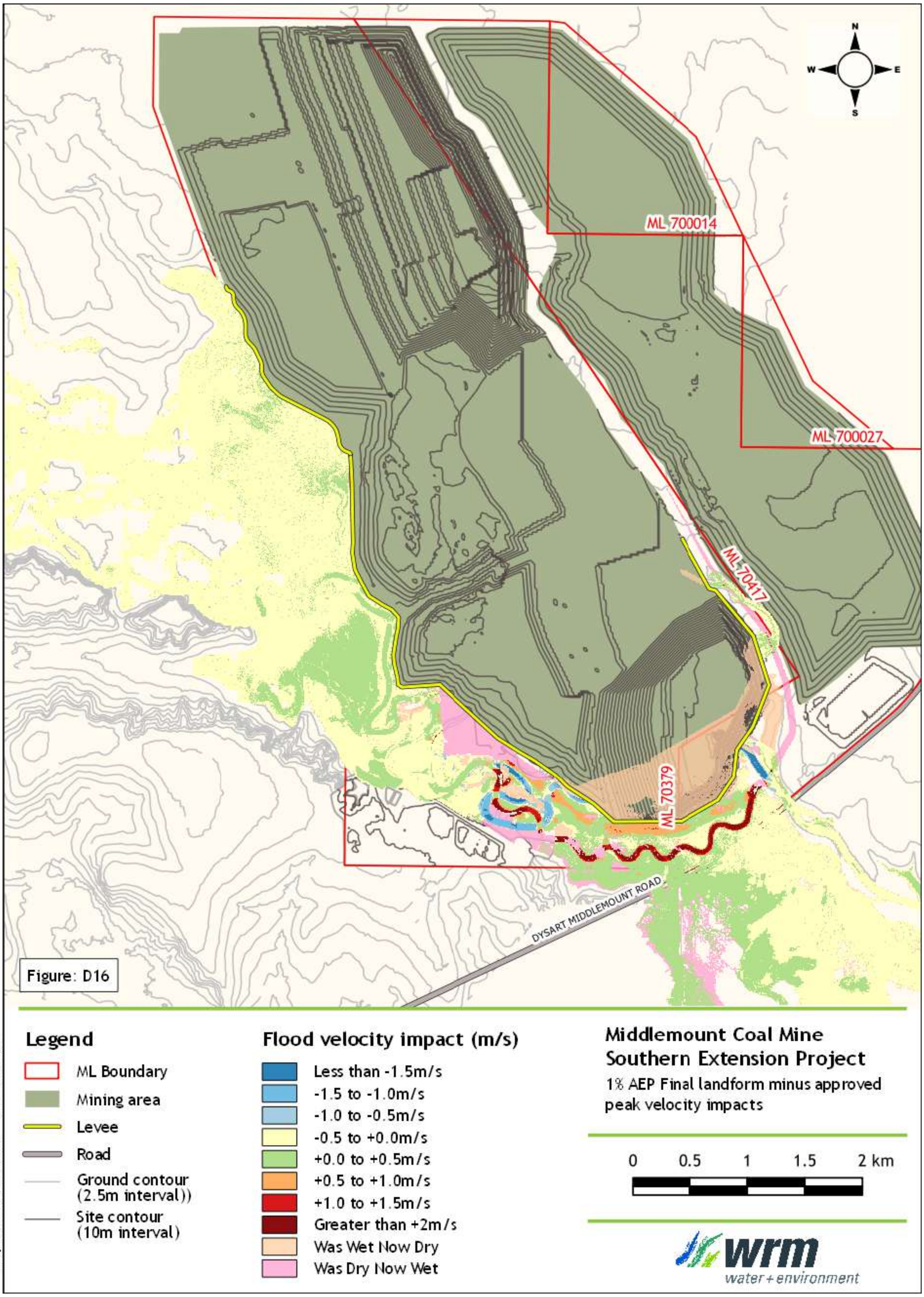

Figure 9.12 – Post mining minus approved conditions flood velocity impacts, 1% AEP

The results show the following:

- There would be a minor increase in flood levels and velocities from proposed conditions for the 50% AEP event due to the removal of the detention effects of the haul road.
- For the 5% AEP event, the removal of the haul road would re-activate flows along the southern flood channel adjacent to the mine infrastructure area. The rehabilitated floodplain adjacent to the South Void would also convey flood flows, which in turn would reduce the flows overtopping Diversion 2 that were predicted to flow across Middlemount Road for approved conditions. Middlemount Road would be trafficable for this event under final landform conditions. Peak velocities on the rehabilitated floodplain would not exceed 0.8 m/s.
- For the 2% and 1% AEP events, peak flood levels along Diversion 1 and 2 would reduce from approved conditions due to the additional conveyance capacity of the rehabilitated floodplain. This in turn would minimise the change in flooding behaviour downstream of Middlemount Road from approved conditions.

9.5 ROPER CREEK DIVERSION ASSESSMENT

9.5.1 Alluvial channel design criteria

Table 9.6 shows the hydraulic parameters (stream power, bed shear and velocity) of the Roper Creek channel for pre-mining conditions and compares them to the hydraulic parameters along Diversion 2 for the proposed operational and post mining conditions. Results are provided for the 50% and 2% AEP floods to compare the results to the Guideline values in Table 9.1 and the revised ACARP criteria given in Table 9.2.

Results have been provided for stream power, bed shear and channel velocity ranging from 25%ile (low) to 95%ile (high). To replicate the Guideline and ACARP criteria, which was derived using the HEC-RAS model, the following process was used:

- Standard 50 m wide cross sections (the approximate top width of the channel) were generated at 50 m increments along the channel;
- At 1 m increments along each cross section, the flow depth and velocity were extracted from the TUFLOW depth and velocity grids generated for each scenario; and
- The data at each cross section was used to generate a depth averaged channel velocity, hydraulic radius, flow and slope, which was then used to calculate bed shear stress and stream power.

Shear stress was calculated as follows:

Shear stress = ρ g R S

where ρ = water density, g = gravitational acceleration, R = hydraulic radius, S = hydraulic gradient

Stream power was calculated by multiplying shear stress with the depth averaged channel velocity.

Along the proposed Diversion 2, the results show the following:

- For the 50% AEP event, the 75%ile values for stream power, shear stress and velocity are below the guideline values and revised ACARP criteria for both proposed operational and post mining conditions. The values are moderately above the pre mining conditions values due to the approved diversion of Thirteen Mile Gully into Roper Creek. The 95%ile stream power is less than 50% of the mean stream power within the reach.

Table 9.6 – Roper Creek hydraulic and geomorphic characteristics, pre-mine (full reach and Diversion 2 reach) and proposed operational conditions along Diversion 2

Parameter	Stream Power (N/m s)	Bed Shear Stress (N/m^2)	Velocity (m/s)	Stream Power (N/m s)	Bed Shear Stress (N/m^2)	Velocity (m/s)
	50% AEP			2% AEP		
Guideline and ACARP criteria	35-60	<40	<1.5	80-150	<50	<2.5
Pre-mining (full reach)						
25%	14.6	15.0	1.0	48.0	29.8	1.6
Mean	20.8	18.8	1.1	65.7	36.2	1.7
75%	24.3	21.4	1.2	80.5	42.3	1.9
95%	37.7	28.6	1.3	113.1	53.0	2.1
Pre-mining (Diversion 2 reach)						
25%	14.2	14.7	1.0	49.2	30.1	1.6
Mean	20.2	18.4	1.1	63.8	35.5	1.8
75%	23.3	20.6	1.1	80.0	41.8	1.9
95%	35.8	27.9	1.3	90.0	45.8	2.0
Proposed Operational Phase (Diversion 2 reach)						
25%	23.6	21.1	1.1	81.2	42.5	1.9
Mean	26.7	22.9	1.2	98.0	47.5	2.0
75%	28.7	24.3	1.2	111.8	51.8	2.1
95%	36.3	28.3	1.3	127.5	57.4	2.2
Post mining (Diversion 2 reach)						
25%	24.7	21.7	1.1	74.5	40.2	1.9
Mean	28.0	23.6	1.2	84.0	43.1	1.9
75%	30.0	24.9	1.2	85.1	44.0	1.9
95%	38.0	29.1	1.3	130.7	58.6	2.2

- For the 2% AEP event under proposed operational conditions;
    - The mean and 75%ile stream power are below the guideline value and revised ACARP criteria but exceeds the pre-mining conditions value by 40% to 50%;
    - The 95%ile stream power within the reach does not exceed the mean stream power by more than 50%.
    - The mean bed shear stress is below the vegetated channel guideline value but above the unvegetated channel guideline value. Both values exceed the pre-mining conditions by 20% to 30%.
    - Velocities are generally consistent with the guideline values and pre-mining conditions.
- For the 2% AEP event under proposed post mining conditions;

- The 75%ile stream power remains below the guideline value and revised ACARP criteria and has reduced to be only be 6% above the pre-mining conditions;
- The 75%ile bed shear stress remains below the guideline values (assuming it has been vegetated) and within 5% of the pre-mining conditions bed shear.
- Velocities are generally consistent with the guideline values and pre-mining conditions.

The results suggest that the proposed operational phase Diversion 2 would generally satisfy the guideline alluvial channel hydraulic criteria. The results are higher than pre-mining conditions, which are potentially more relevant for the assessment of long-term sustainability. The proposed post mining final landform floodplain changes would reduce all of the key hydraulic criteria to be close to the pre-mining conditions and therefore be more sustainable.

9.5.2 Threshold channel design criteria

Figure 9.13 shows the 0.01% AEP (1 in 1,000) bed shear stress calculated by TUFLOW along the Roper Creek Diversion 2 for the proposed and post mining conditions. The key threshold criteria for the various vegetation characteristics is given in Table 9.3.

For the proposed conditions, the results suggest the channel bed shear would vary from 40 to 120 Pa. The majority of the floodplain bed shear is below 40 Pa. There would be minor areas of bed shear greater than 120 Pa. However, any scour at these locations would not threaten to capture the watercourse into the open cut pit. The channel is proposed to be vegetated with a structurally diverse suite of established native vegetation and therefore should withstand the elevated bed shear values.

For the post mining conditions, channel and floodplain bed shear would significantly reduce, with most of the channel with bed shear below 60 Pa and the undisturbed sections of the floodplain below 20 Pa. Higher bed shear within the rehabilitated floodplain would range from 20 Pa to 65 Pa. It is expected that further refinement of the floodplain during detailed design (to remove the sharp changes in shape that are present in the conceptual design) would further reduce the bed shear in the over bank areas. Notwithstanding, the rehabilitated floodplain will be vegetated with a structurally diverse suite of established native vegetation and therefore should withstand the elevated bed shear values without threatening to capture the watercourse in the open cut pit (residual void).

9.5.3 Outcome assessment

An assessment of the proposed diversion against the outcomes in the Queensland watercourse diversion guidelines (see Section 9.2.2.1) is as follows:

9.5.3.1 Outcome 1

The watercourse diversion incorporates natural features (including geomorphic and vegetation) present in the regional landscape and associated local watercourses.

Table 9.5 shows that the proposed Diversion 2 channel would replicate the geomorphic features of the existing Roper Creek channel. Due to restrictions within the floodplain, Diversion 2 is about 13% shorter than the existing channel and the meander geometry cannot be fully replicated. The channel depths to the adjacent floodplain and channels shape would be similar to the pre-mining conditions channel. The widening of the floodplain post mining would provide independent overbank flood channels in a similar manner to pre-mining conditions.

A revegetation plan will be developed as part of the detailed design that will use vegetation characteristics seen in the Existing Roper Creek channel.

On this basis, the proposed diversion would satisfy Outcome 1.

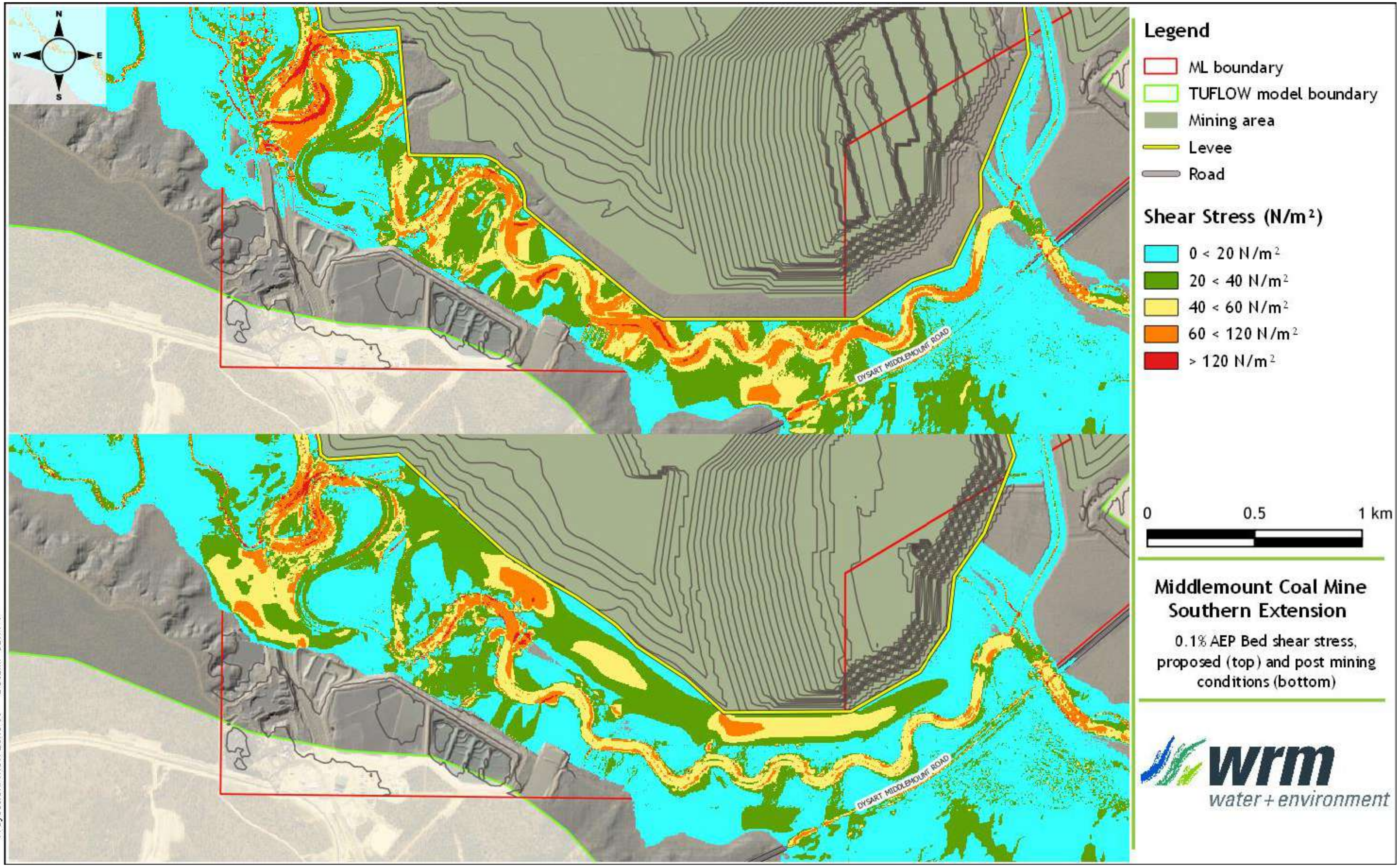

Figure 9.13 – 1 in 1000 AEP bed shear stress, proposed and post mining conditions

9.5.3.2 Outcome 2

The watercourse diversion maintains the existing hydrologic characteristics of surface water and groundwater systems.

The proposed diversion will convey the same upstream catchment as the approved diversion because the catchment area has not changed. Peak discharges for the range of events assessed has not changed from approved conditions.

The diversions will also maintain the same groundwater characteristics as it will intercept the same sandy alluvial substrate material experienced across the floodplain. Further groundwater investigations will be undertaken during detailed design as part of the geotechnical investigations to confirm this.

On this basis, the proposed diversion would satisfy Outcome 2.

9.5.3.3 Outcome 3

The hydraulic characteristics of the watercourse diversion are comparable with other local watercourses and suitable for the region in which the diversion is located.

The proposed diversions will replicate the hydraulic characteristics of the existing Roper Creek channel in which they replace (see Section 9.5.1) and would therefore satisfy Outcome 3.

9.5.3.4 Outcome 4

A sediment transport regime that allows the watercourse diversion to be self-sustaining and not result in material or serious environmental harm on upstream and downstream reaches.

The hydraulic analysis shows that channel stream powers, which can be used as a surrogate for sediment transport, within the proposed diversion would mimic the Roper Creek channel stream power for the 50% AEP (in channel) event. The post mining stream power is within 6% of pre-mining conditions stream power. On this basis, the sediment transport regime of the diversion should be self-sustaining and would satisfy Outcome 4.

9.5.3.5 Outcome 5

The watercourse diversion and associated structures maintain stability and functionality and are appropriate for all substrate conditions they encounter.

Parsons Brinckerhoff and Landloch have undertaken preliminary sampling of agronomic and erosion parameters of surface soils for the approved diversion. The soil analysis demonstrates a considerable variation in the erosion risk and revegetation risk across the site. The erosion risk comes from the presence or dispersive and/or sodic soils that erode chemically in the presence of water.

The soils also have high magnesium levels (magnesic). The very weak ionic bonding within the soil particles creates a similar effect to dispersion. The sandy texture of some of the soils also allows erosion at low flow velocities. The soil chemical and physical constraints provide an extreme erosion risk in many circumstances. The high electrical conductivity, sodium and magnesium levels, poor calcium to magnesium ratio, moderate to strong alkalinity and low organic carbon levels provide significant constraints to vegetation establishment and growth. It will be necessary to ameliorate and modify the soils to allow the vegetation growth necessary to control creek bed and channel erosion (Landloch, 2012).

Geotechnical investigations were undertaken for the approved diversions to determine the engineering design parameters relevant for the proposed works (Parsons Brinkerhoff, 2013). These investigations were based on detailed bore logs along the proposed alignment. A sensitivity analysis was also undertaken should less favourable subsurface conditions be encountered.

No free groundwater was observed within the substrate materials encountered. However, sand lenses were evident within the profile, which are likely to convey shallow groundwater when soils are saturated. It is expected that the proposed diversion would intercept the same sand lenses as the existing channel.

Given that the proposed diversion will be located along the same floodplain with likely similar substrate conditions as the approved diversion, it is expected the same geotechnical design parameters will be acceptable.

9.6 OPERATIONAL PHASE FLOOD LEVEE ASSESSMENT

The proposed realigned flood protection levee along the southern 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 Appendix C Figure C25.

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.

9.7 FINAL LANDFORM ASSESSMENT

Figure C36 in Appendix C shows the final landform and the extent of the PMF from Roper Creek. The proposed final landform for the Project will include two residual voids. The southern void is located on the pre-mine Roper Creek floodplain. The final landform around the southern void will be constructed to prevent floodwater from entering. This landform feature will be constructed to be up to 100 m wide at the crest, have a crest height above the PMF level from Roper Creek and be incorporated into the rehabilitated landform to form a self-sustaining final landform. The PMF is defined as the largest flood that could conceivably occur at a particular location and is estimated from probable maximum precipitation (PMP).

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 residual void, which is more than adequate to prevent floodwater from entering the residual voids.

Figure 9.14 shows a longitudinal profile of bed shear for the 0.1% AEP measured approximately 10 m from the toe of the proposed southern extension final landform. The section commences near the Roper Creek Diversion 1 and extends to the existing Roper Creek channel. The vegetation thresholds that would protect against scour, as described in Section 9.5.2 are also shown for comparison. The results show that bed shear against the toe of the landform remains below the native vegetation threshold at all locations for the 0.1% AEP event.

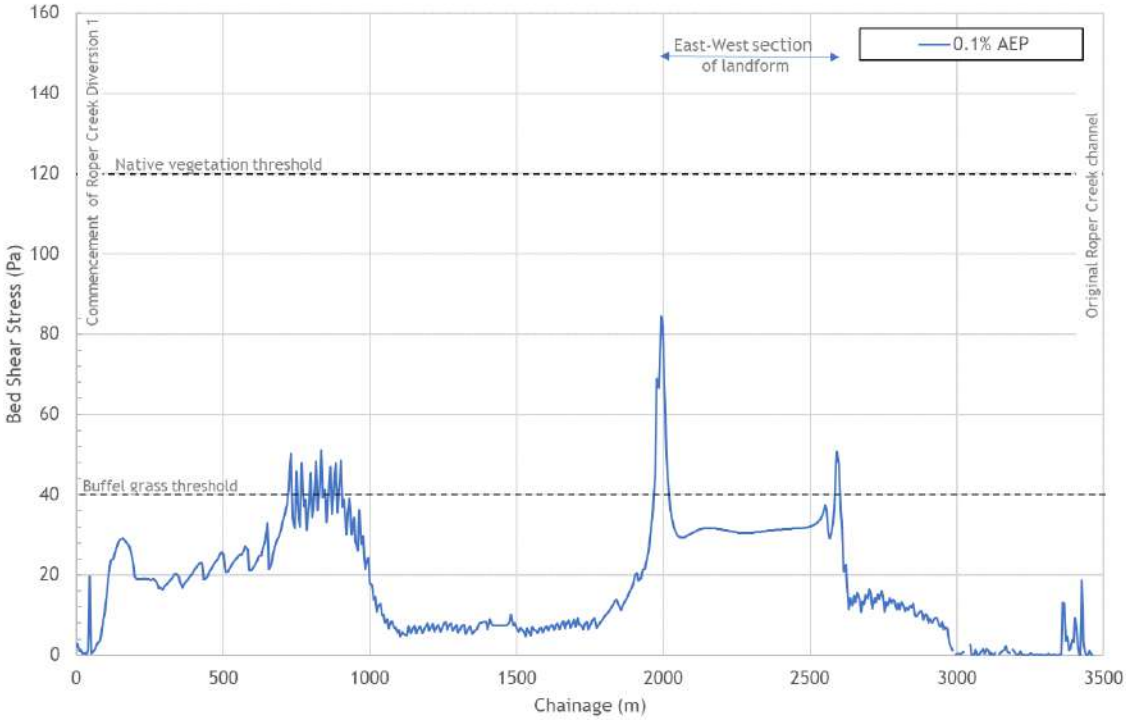

Figure 9.14 – Flood depths and extent, Final landform conditions, PMF

10 Mitigation and management measures

10.1 POTENTIAL IMPACTS

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

- impacts on the geomorphology 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, 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.

10.2 FLOODING AND GEOMORPHIC IMPACTS

Potential impacts of the Project on flood levels and flood velocities in Roper Creek are addressed in Section 9 of this report. In summary, the proposed conditions levees would increase the depth and frequency of flooding downstream of the mine for events up to and including the 5% AEP event. There would be no change for the more frequent events or impact upstream of the mine from approved conditions.

It is proposed to increase the width of the floodplain post mining to improve the flood conveyance, which in turn would mitigate the increased flooding downstream of the mine.

The proposed Roper Creek Diversion 2 realignment has been designed to replicate the channel that it replaces as much as practicable. The operational phase Diversion 2 would generally satisfy the guideline alluvial channel hydraulic criteria but the results are higher than for pre-mining conditions. The proposed post mining final landform floodplain changes would reduce all of the key hydraulic criteria to be close to the pre-mining conditions and therefore be more sustainable.

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 Roper Creek 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).

10.3 REGIONAL WATER AVAILABILITY IMPACTS

The water balance modelling results indicates that between 460 ML/year and 1,330 ML/year will be required from the external supply (Anglo pipeline), under median climatic conditions (refer Section 6.3.4). This is slightly higher than previous modelling results undertaken as part of the Western Extension Surface Water Assessment (WRM, 2018), which predicted that between 420 ML/year and 990 ML/year would be required under median climatic conditions.

This change is primarily due to the increase in predicted net CHPP usage (113 to 170 L/ROM t), which is based on recent observed usage. As the external water supply is sourced from surplus mine affected water reserves of a neighbouring mine, the external supply requirements will have no impact on regional water availability.

10.4 STREAM FLOW IMPACTS

10.4.1 During active mining operations

10.4.1.1 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 10.1. Note that areas managed under the ESCP have been included in the total captured catchment area.

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 6.3% and 7.8% of the Roper Creek catchment to the downstream boundary of the mine, depending on the Stage. This is generally consistent with the catchment that would be excised as part of the approved mine.
- Of the total Stage 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 10.1 – Catchment area captured within the whole mine water management system

Catchment	Total catchment area (km^2)	Captured catchment area (km^2)			
		Stage 1	Stage 2	Stage 3	Stage 4
Roper Creek (to d/s of site)	389	25.9	30.3	26.0	24.5

Given that areas managed under the ESCP will drain from the site following treatment, and the sediment dam catchments typically have higher runoff coefficients than under natural conditions, the loss of stream flows will likely be less than the total 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 or water licences for the take of water are located on Roper Creek downstream of the mine.

10.4.1.2 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 south and subsequent capture and re-use of drainage from operational catchment areas.

The additional surface disturbance area associated with the Project would excise an additional 110 ha (maximum during operations) from the catchment area of the former Thirteen Mile Gully and other associated drainage features. This represents approximately 2% 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.

The loss also represents less than 0.3% 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.

10.4.2 Post-mining landform

At the completion of mining, permanent drainage of waste rock emplacement areas will be installed to minimise capture of surface runoff into the residual voids in general accordance with the configuration shown in Figure 7.1. 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 6.8 km^2 will continue to drain to the residual voids.

The net change in catchment area draining from the site is summarised in Table 10.2. 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 6.8 km^2 (compared to pre-mining conditions), a decrease of less than 2%. This is a reduction compared to the approved final landform, which would excise 7.4 km^2 of catchment that would otherwise drain to Roper Creek.
- 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 10.2 - Post-mining landform - captured catchment areas

Catchment	Pre-mining catchment area (km^2)	Post-mining catchment area (km^2)	Captured catchment area (km^2)
Roper Creek (to d/s of site)	389	382.2	6.8

10.5 REGIONAL WATER QUALITY AND ENVIRONMENTAL VALUES

10.5.1 Overview

Section 5 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 catchment runoff water management system are provided in Section 5.8. Further details of the proposed waterway diversions and associated levee infrastructure are provided in Sections 8 and 9.
- 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 stormwater management system are provided in Section 5.7.
- 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 5.5 and Section 6.
- 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 5.4.
- 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 contaminated water management system and its expected performance are provided in Section 5.6.

10.5.2 Performance of the water management system

An assessment of the water management system is given in Section 6. The results of the water balance modelling indicate that, under the current model assumptions and configuration, there is less than a 1% chance of 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 5.7). As described in Section 4.4.3, 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 (233 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.

10.5.3 Controlled releases

There are no proposed changes to the current release conditions as prescribed in Condition C5 of the site's EA (EPML00716913, dated 26 February 2020).

Due to the salinity of water currently stored in MWD, and the high salinity of the groundwater inflows and external water supply, the water balance modelling indicates that no controlled releases from site would occur over the life of the Project. As such, there would be no impacts on downstream water quality or environmental values of the downstream waterway associated with controlled releases of mine affected water.

Discharges may continue to be undertaken in accordance with Condition C5 of EPML00716913 if the salinity of water held on site decreases (e.g. if the salinity of the external water supply decreases).

10.5.4 Monitoring and maintenance

It will be necessary to manage each of these systems so 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 will be used to validate the anticipated quality of water runoff reporting to sediment dams. 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.

10.6 CUMULATIVE IMPACTS – SURFACE WATER

10.6.1 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.

10.6.2 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 10.3.

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 within the Roper Creek catchment upstream of the Project.

10.6.3 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.

10.6.4 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.

Table 10.3 – 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

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 (DES, 2018). 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 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.

10.6.5 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 10.4. No other projects have been identified which would further increase these impacts.

10.7 PROPOSED EA AMENDMENTS

10.7.1 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.

10.7.2 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.

10.7.3 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.

10.7.4 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, 2019) does not change.

10.7.5 Location and basic specification of regulated dams

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

11 Conclusion

The key findings of this surface water impact assessment of the Project are as follows:

- During operations, the Project would result in increases to the depth and frequency of flooding downstream of the mine for events up to and including the 5% AEP event. There would be no change for the more frequent events or impact upstream of the mine from approved conditions.
- The proposed removal of the operational flood levee at the end of mining would improve flood conveyance, which in turn would mitigate the increased flooding downstream of the mine that is predicted to occur during operations.
- The proposed Roper Creek Diversion 2 realignment has been designed to replicate the channel that it replaces as much as practicable. The operational phase Diversion 2 would generally satisfy the guideline alluvial channel hydraulic criteria but the results are higher than for pre-mining conditions. The proposed post mining final landform floodplain changes would reduce all of the key hydraulic criteria to be close to the pre-mining conditions and therefore be more sustainable.
- Modelling 0.1% AEP flood event indicates that bed shear against the toe of the landform would be below acceptable thresholds for native vegetation.
- The water balance modelling results indicates that between 460 ML/year and 1,330 ML/year will be required from the external supply (Anglo pipeline), under median climatic conditions. This is slightly higher than previous modelling results undertaken as part of the Western Extension Surface Water Assessment (WRM, 2018), which predicted that between 420 ML/year and 990 ML/year would be required under median climatic conditions.
- A maximum of between 6.3% and 7.8% of the Roper Creek catchment would be excised during the Project (depending on the mining stage). This is generally consistent with the catchment that would be excised as part of the approved mine.
- Post-mining, the catchment draining to Roper Creek (to the downstream of site) will reduce by around 6.8 km^2 (compared to pre-mining conditions) due to the Project. This is a reduction compared to the approved final landform, which would excise 7.4 km^2 of catchment that would otherwise drain to Roper Creek.
- It is unlikely that overflows from sediment dams will have a measurable impact on receiving water quality.
- No impacts on downstream water quality or environmental values of the downstream waterway are predicted to occur due to controlled releases of mine affected water.

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Appendix A – Water quality sampling plots

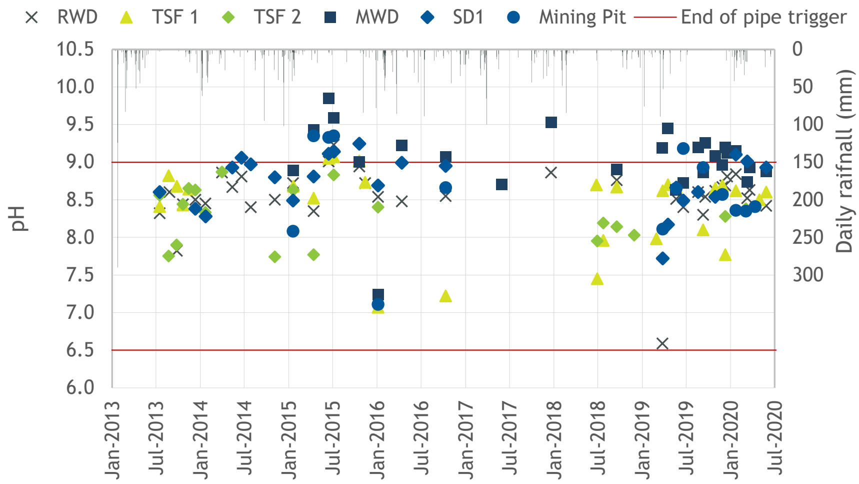


Figure A.1 - pH - Mine affected water dams

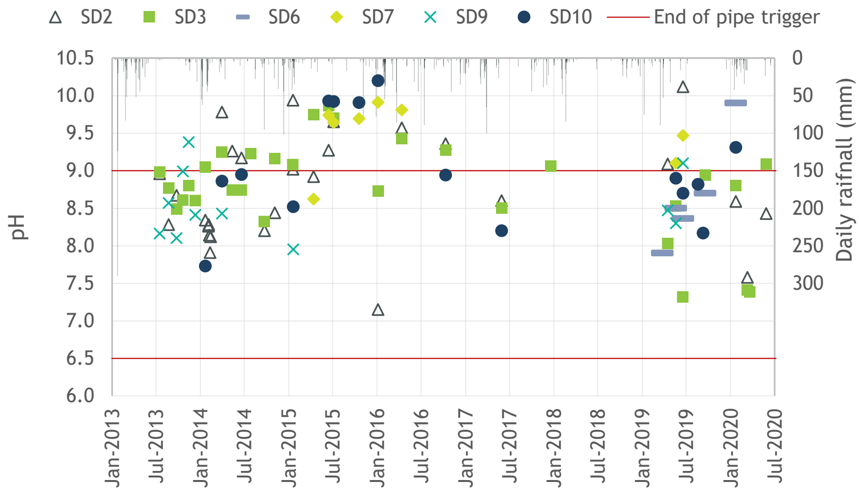
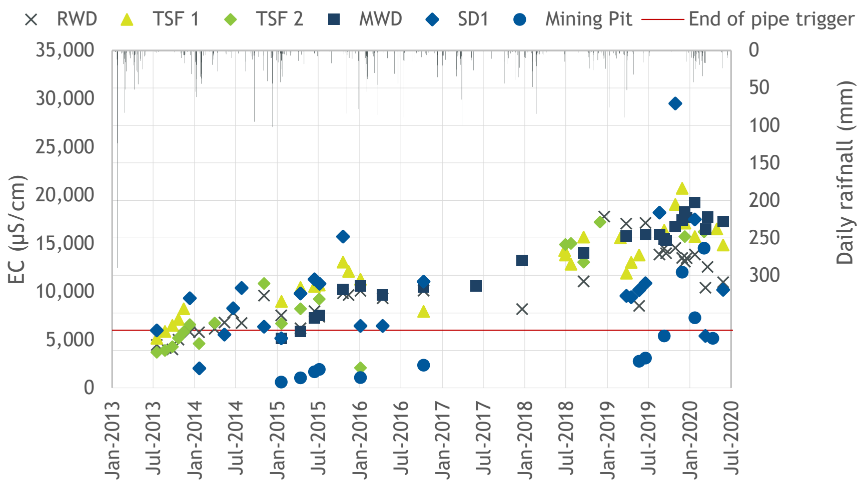
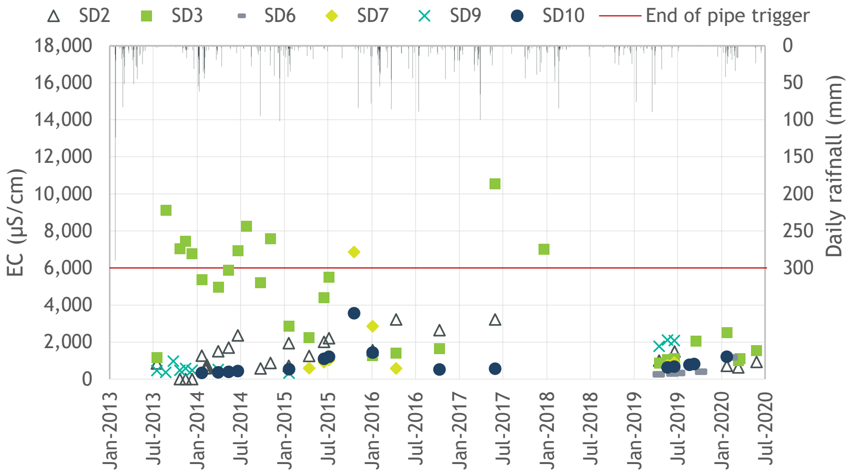


Figure A.2 - pH - On-site stormwater sediment dams



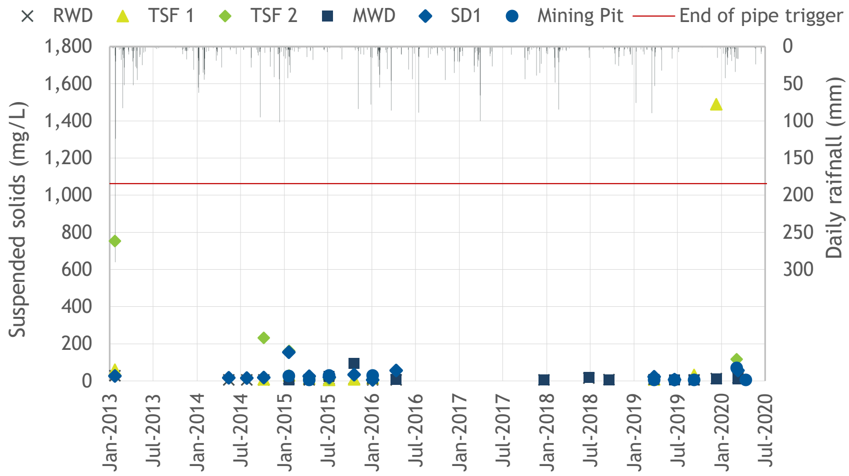
End of pipe trigger based on very high flow (see Table 4.4)

Figure A.3 - EC - Mine affected water dams



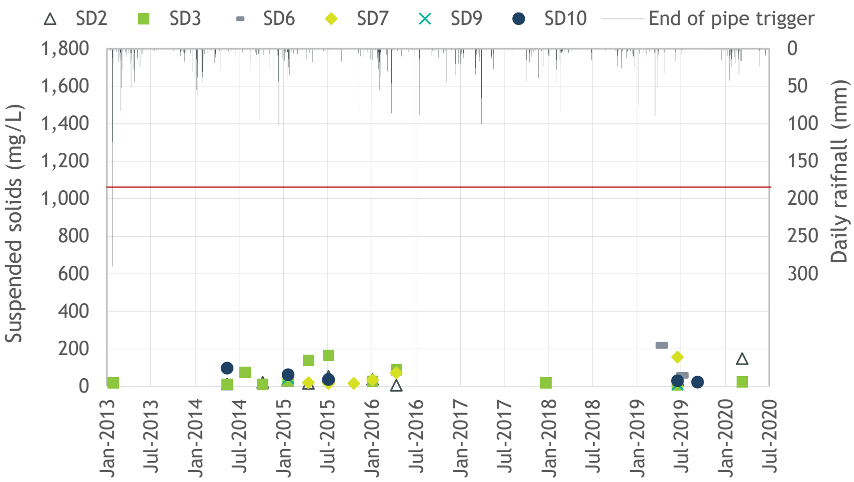
End of pipe trigger based on very high flow (see Table 4.4)

Figure A.4 - EC - On-site stormwater sediment dams



End of pipe trigger based on high flow (see Table 4.3)

Figure A.5 - Suspended solids - Mine affected water dams



End of pipe trigger based on high flow (see Table 4.3)

Figure A.6 - Suspended solids - On-site stormwater sediment dams

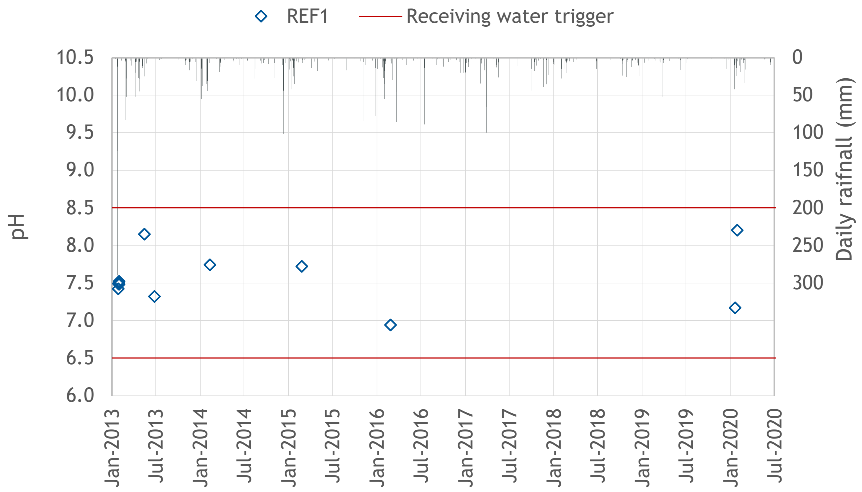


Figure A.7 - pH - Upstream surface water monitoring locations

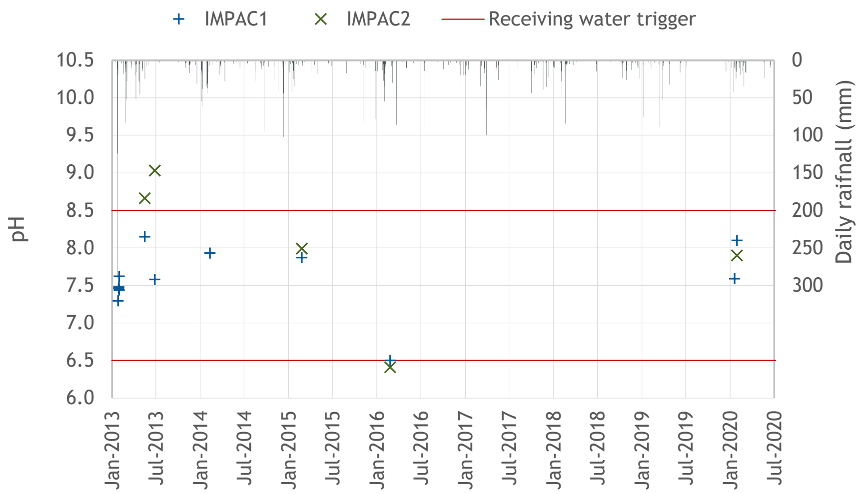
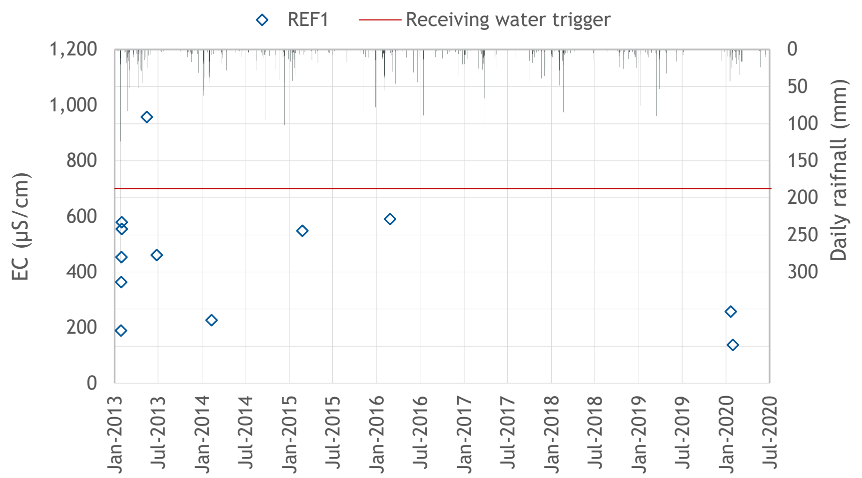
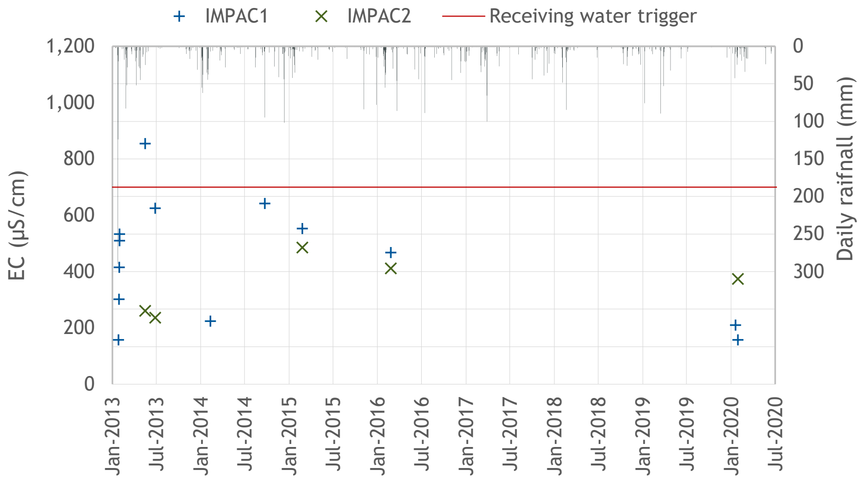


Figure A.8 - pH - Downstream surface water monitoring locations



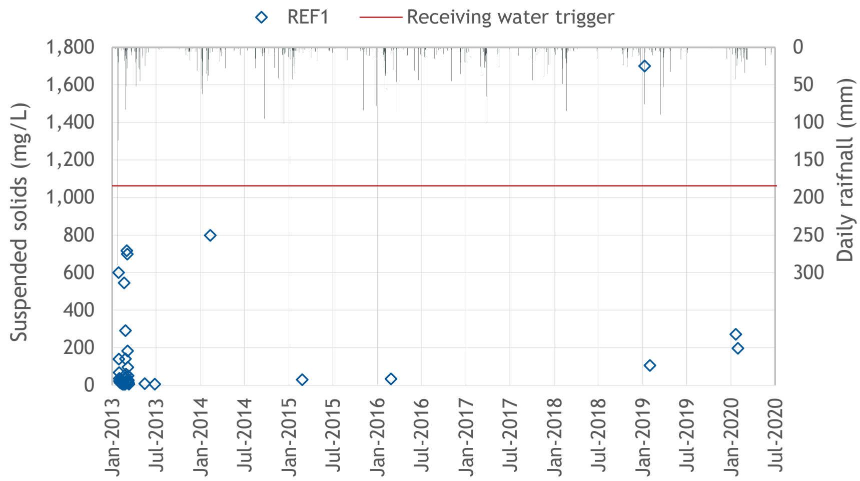
Receiving water trigger based on very high flow (see Table 4.4)

Figure A.9 - EC - Upstream surface water monitoring locations



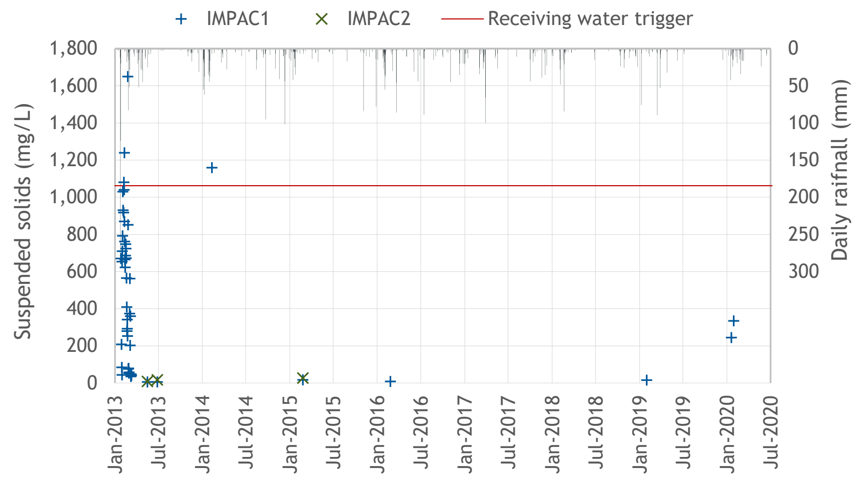
Receiving water trigger based on very high flow (see Table 4.4)

Figure A.10 - EC - Downstream surface water monitoring locations



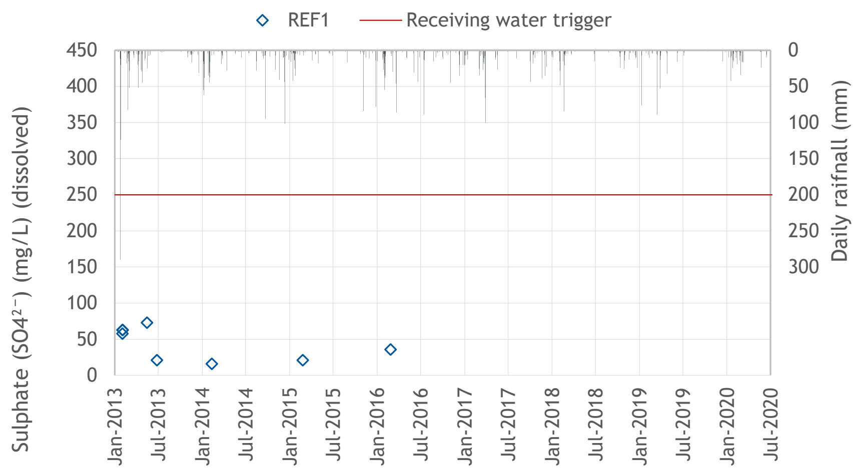
Receiving water trigger based on high flow (see Table 4.3)

Figure A.11 - Suspended solids - Upstream surface water monitoring locations



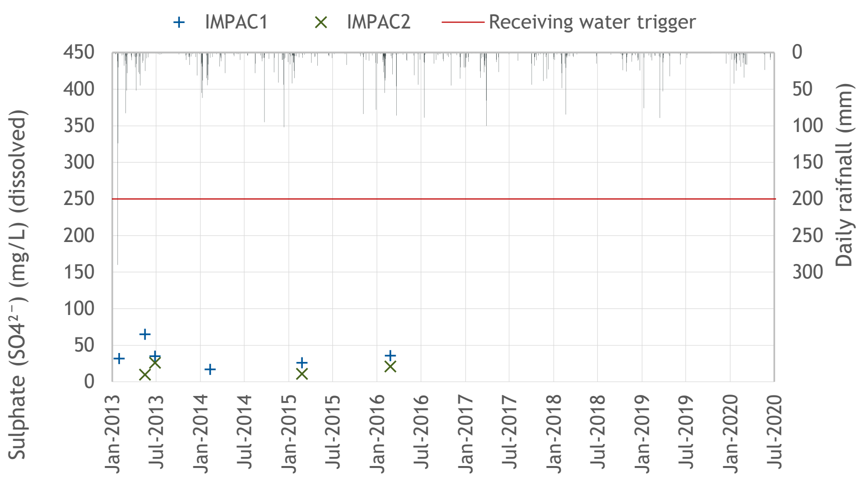
Receiving water trigger based on high flow (see Table 4.3)

Figure A.12 - Suspended solids - Downstream surface water monitoring locations



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

Figure A.13 - Sulphate - Upstream surface water monitoring locations



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

Figure A.14 - Sulphate - Downstream surface water monitoring locations

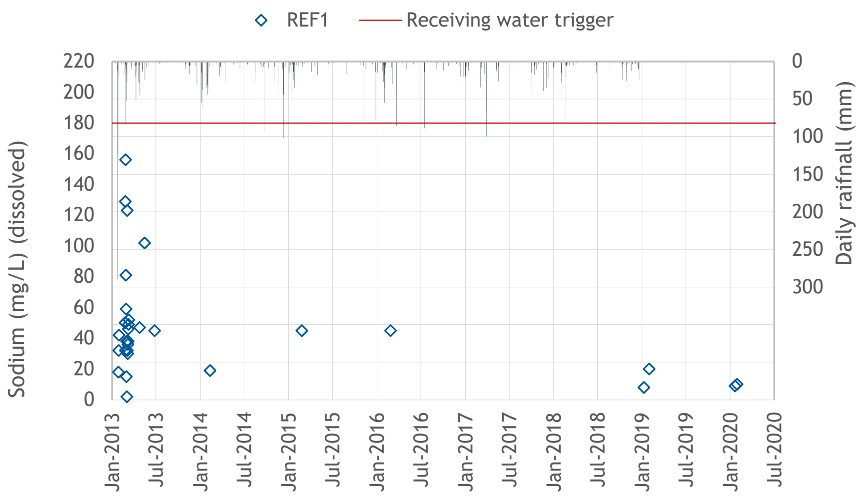


Figure A.15 - Sodium (dissolved) - Upstream surface water monitoring locations

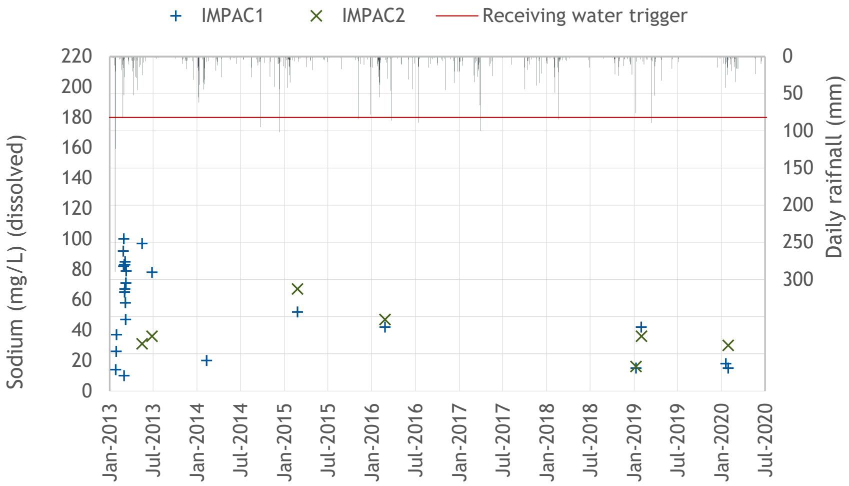


Figure A.16 - Sodium (dissolved) - Downstream surface water monitoring locations

Appendix B - Mine water balance model configuration

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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 Table B.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)	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 June 2020. This dataset is too short for water balance model forecasting. In addition, previous investigations of the site rainfall data undertaken by WRM have indicated that during certain periods it is inconsistent with data from surrounding rainfall stations (WRM, 2014). Therefore, regional data has been used to provide a long-term rainfall dataset.

A representative long-term rainfall dataset was obtained from the Queensland Government Department of Science (DES) SILO climate data service for the period January 1889 to January 2020 (131 years) (DES, 2020). Morton's Lake evaporation has been used to estimate evaporation losses from storages.

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

Figure B.1 shows the annual distribution of average monthly rainfall and evaporation from the SILO 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 - 2020)

Month	Monthly Rainfall (mm)	Monthly Evaporation (mm)
Jan	116.0	202.1
Feb	97.5	170.3
Mar	66.9	169.8
Apr	32.3	133.8
May	29.4	101.9
Jun	30.8	80.7
Jul	23.6	90.7
Aug	18.9	118.0
Sep	18.2	150.9
Oct	35.5	187.9
Nov	54.9	199.8
Dec	96.2	211.6
TOTAL	620.3	1,817.5

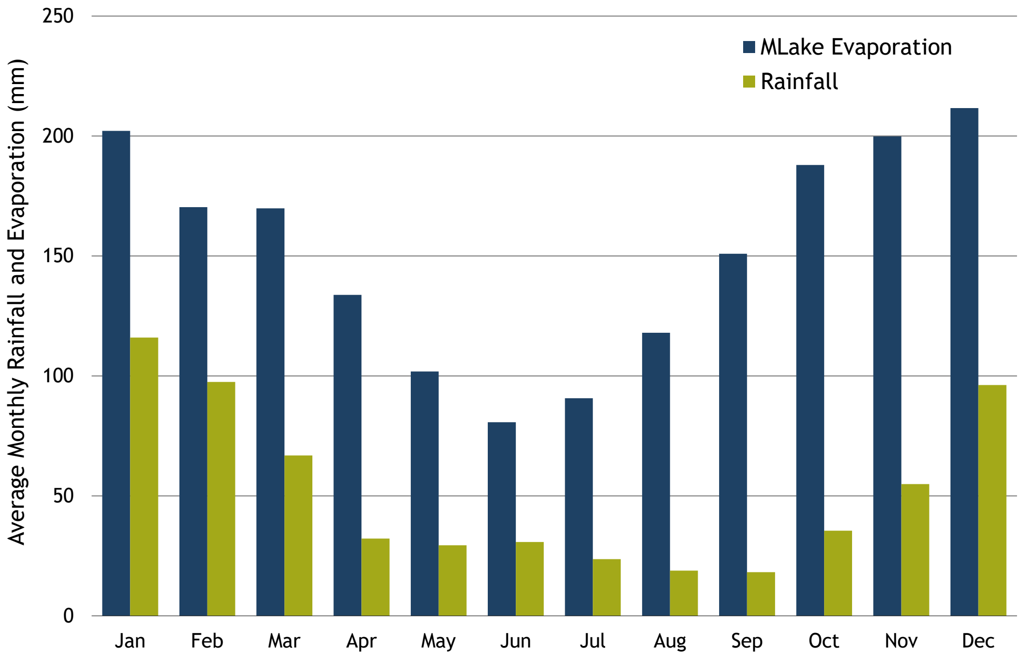


Figure B.1 - Distribution of monthly rainfall and evaporation (Data source: DES, 2020)

B3 Simulation methodology

The simulation used the 'forecast' simulation method in OPSIM. The model was run on a daily timestep for 24 years, to match the operational phase of the mine life, and incorporated five different representative stages of the mine life. The adopted model stages are summarised in Table B.3.

Table B.3 - Adopted model stages

Representative mine stage	Applied range of mine life	Stage duration
Stage 1 (2023)	Year 2021 - 2025	5 years
Stage 2 (2028)	Year 2026 - 2032	7 years
Stage 3 (2037)	Year 2033 - 2039	7 years
Stage 4 (2043)	Year 2040 - 2044	5 years

The forecast simulation type allows the model configuration to change over the modelled 24 years by linking the representative stages, reflecting variations in the water management system over time such as catchment area, production and groundwater inflows. Although the catchment areas will continuously change as the mine progresses, the adopted approach of modelling discrete stages will provide a reasonable representation of site conditions over the 24 year period.

The changes in the physical layout and site catchment areas are provided in Section B4. The adopted operating rules for the water balance model assessment are summarised in Table B.4.

To assess the effects of varying climatic conditions, the forecast model was run for 107 realisations (with each realisation corresponding to the 24-year mine life), using 131 years of climatic data available from January 1889 to December 2019. A different rainfall input sequence is applied to each realisation. The first realisation adopts climatic data from 1889 to 1912, the second from 1890 to 1913 etc. through the 131 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 131 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 February 2020), aerial photography (dated September 2019) and plans of operations disturbance areas for each mine stage.

Figure B.2 to Figure B.5 shows the locations of catchment areas and land use classifications for the water balance model, which have been summarised in Table B.4 to Table B.8.

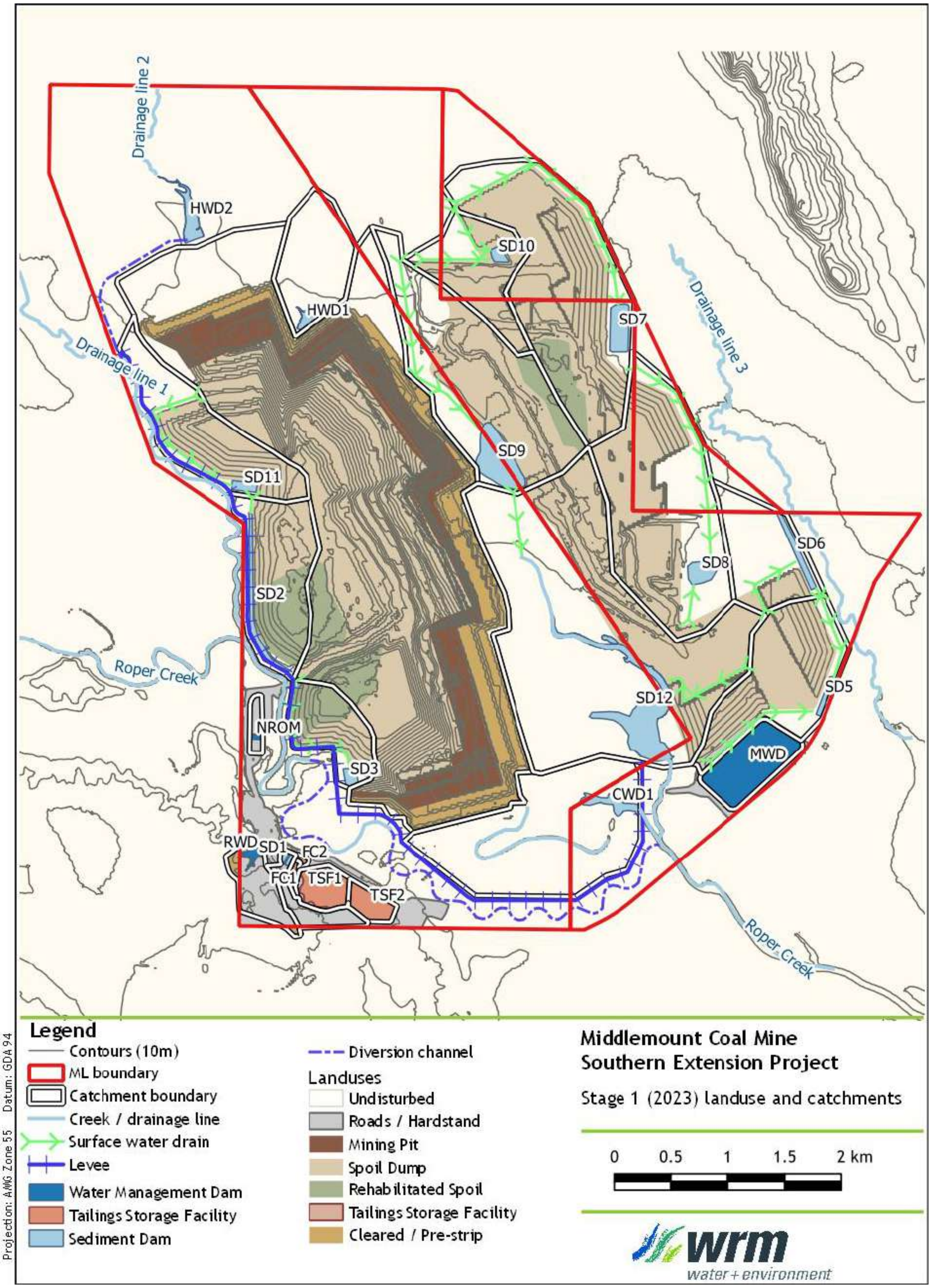


Figure B.2 – Catchment and land use breakdown – Stage 1 (2023)

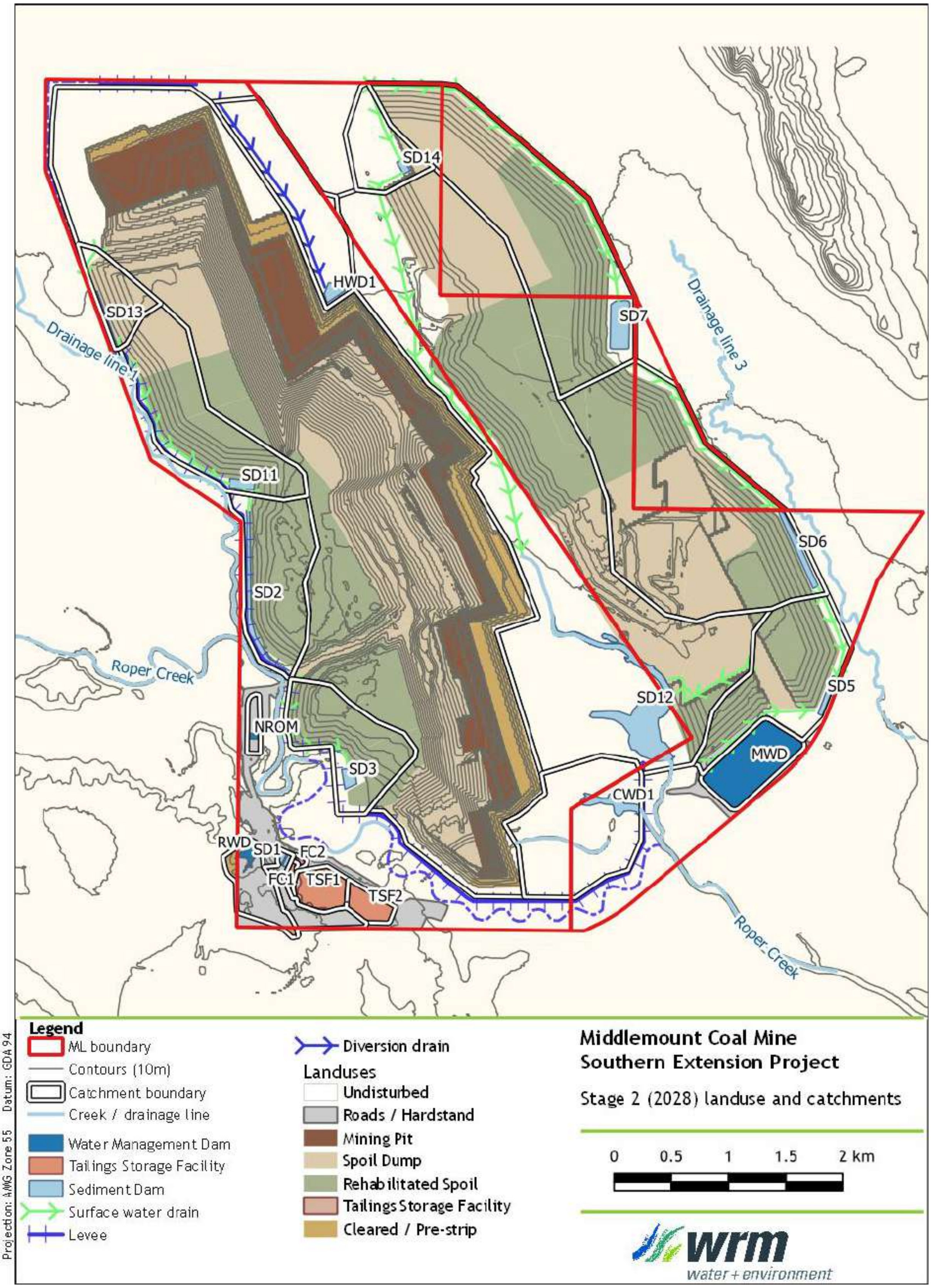


Figure B.3 – Catchment and land use breakdown – Stage 2 (2028)

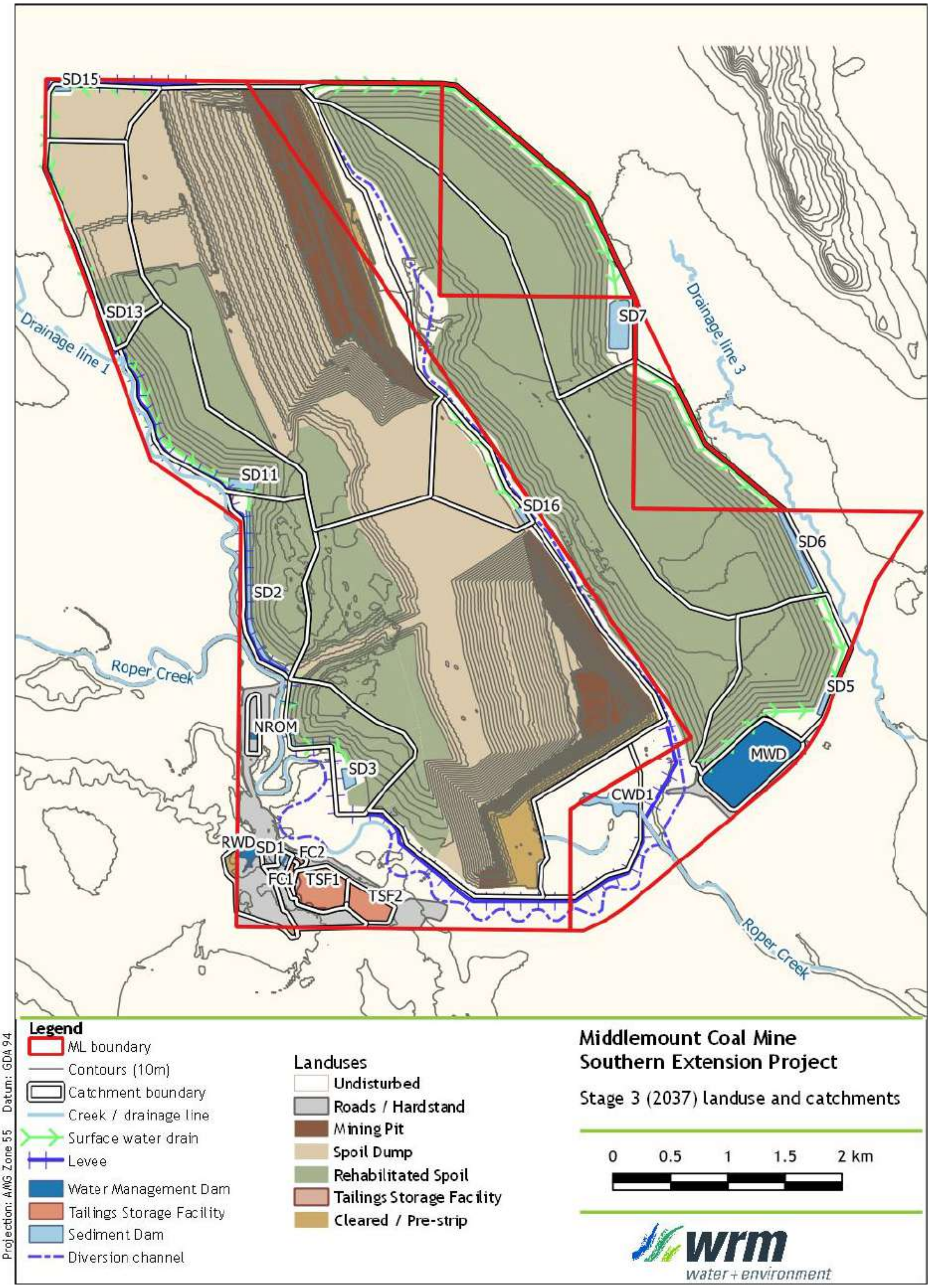


Figure B.4 – Catchment and land use breakdown – Stage 3 (2037)

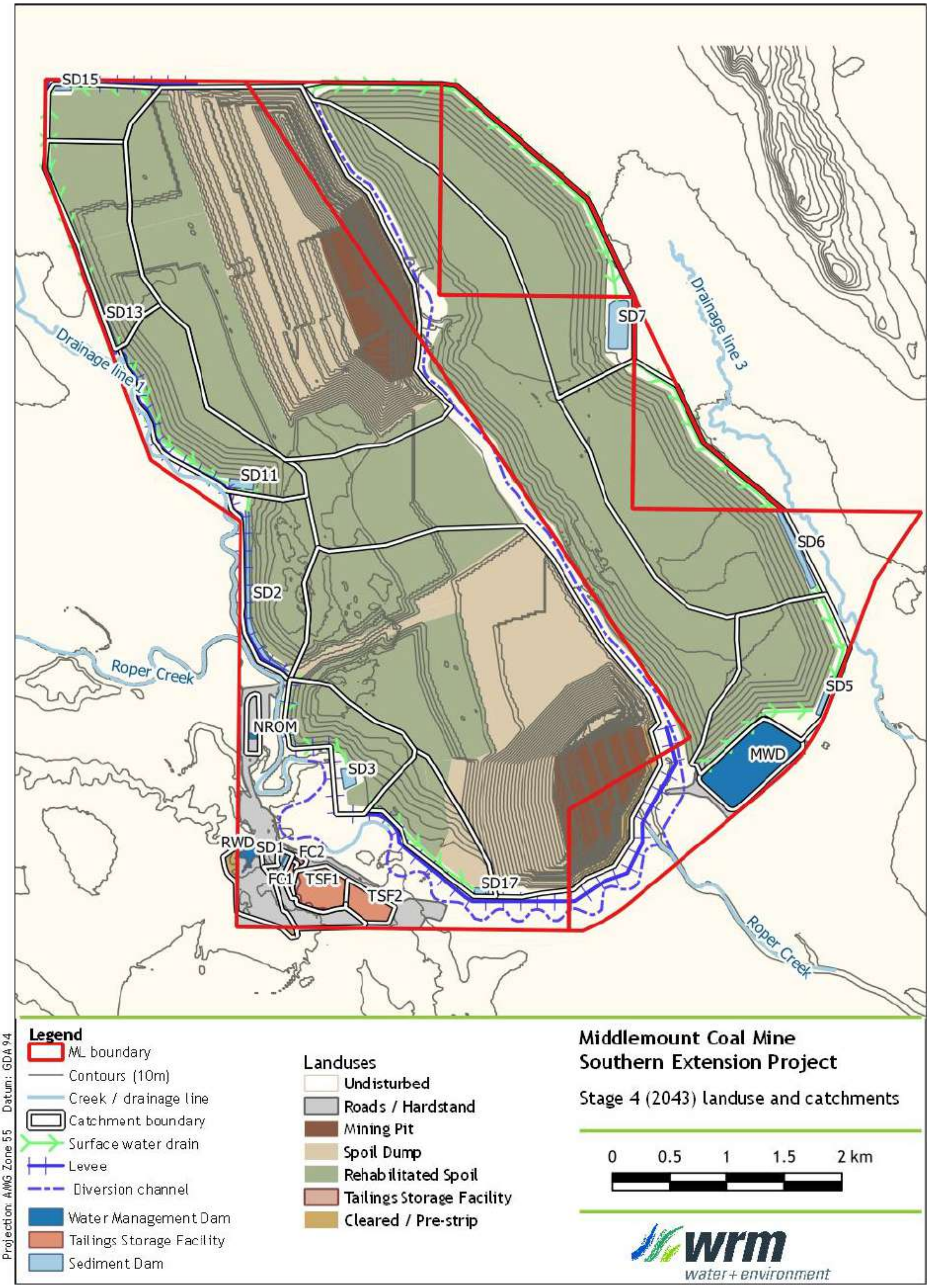


Figure B.5 – Catchment and land use breakdown – Stage 4 (2043)

Table B.4 - Middlemount Coal Mine catchment area and land use breakdown - Stage 1 (2023)

	Catchment area (ha)							
Dam name	Undisturbed	Roads / hardstand	Mining Pit	Spoil Dump	Rehab	Tailings	Cleared / Pre-strip	Total
Mine affected water dams								
Mining Pit	120.9	0.0	165.1	375.3	40.7	0.0	138.2	840.2
RWD	5.8	19.7	0.0	0.0	0.0	0.0	0.0	25.5
MWD	0.0	36.1	0.0	0.0	0.0	0.0	0.0	36.1
NROM	0.3	5.2	0.0	0.0	0.0	0.0	0.0	5.5
TSF1	0.0	2.6	0.0	0.0	0.0	12.8	0.0	15.5
TSF2	0.0	0.7	0.0	0.0	0.0	9.0	0.0	9.6
SD1	1.4	14.7	0.0	0.0	0.0	0.1	0.0	16.2
Sediment dams								
SD2	15.1	0.0	0.0	37.1	33.3	0.0	0.0	85.5
SD3	6.8	0.0	0.0	19.2	19.3	0.0	0.0	45.2
SD5	19.1	6.3	0.0	76.6	0.0	0.0	0.0	102.0
SD6	49.3	0.0	0.0	13.6	0.0	0.0	0.0	62.9
SD7	41.0	0.0	0.0	146.9	19.7	0.0	0.0	207.6
SD8	71.7	0.0	0.0	118.5	0.0	0.0	0.0	190.2
SD9	66.9	0.0	0.0	98.2	15.0	0.0	0.3	180.4
SD10	14.0	0.0	0.0	49.6	0.8	0.0	0.0	64.4
SD11	33.8	0.0	0.0	56.6	0.0	0.0	0.0	90.3
SD12	241.9	0.0	0.0	142.5	0.1	0.0	0.0	384.5

Table B.5 - Middlemount Coal Mine catchment area and land use breakdown - Stage 2 (2028)

	Catchment area (ha)							
Dam name	Undisturbed	Roads / hardstand	Mining Pit	Spoil Dump	Rehab	Tailings	Cleared / Pre-strip	Total
Mine affected water dams								
Mining Pit	121.6	0.0	232.9	481.1	144.0	0.0	140.0	1119.6
RWD	2.0	19.7	0.0	0.0	0.0	0.0	3.7	25.5
MWD	0.0	36.1	0.0	0.0	0.0	0.0	0.0	36.1
NROM	0.3	5.2	0.0	0.0	0.0	0.0	0.0	5.5
TSF1	0.0	2.6	0.0	0.0	0.0	12.8	0.0	15.5
TSF2	0.0	0.7	0.0	0.0	0.0	9.0	0.0	9.6
SD1	1.2	14.7	0.0	0.0	0.0	0.1	0.2	16.1
Sediment dams								
SD2	15.1	0.0	0.0	0.2	70.2	0.0	0.0	85.5
SD3	10.8	0.0	0.0	0.0	60.1	0.0	0.0	70.9
SD5	19.1	6.3	0.0	14.0	62.6	0.0	0.0	102.0
SD6	22.7	0.0	0.0	140.0	117.9	0.0	0.0	280.6
SD7	36.9	0.0	0.0	88.4	111.9	0.0	0.0	237.2
SD11	12.5	0.0	0.0	25.8	71.7	0.0	0.0	109.9
SD12	305.6	0.0	0.0	199.1	161.7	0.0	0.0	666.5
SD13	3.7	0.0	0.0	24.9	0.0	0.0	0.0	28.7
SD14	32.0	0.0	0.0	6.8	0.0	0.0	0.0	38.8

Table B.6 – Middlemount Coal Mine catchment area and land use breakdown – Stage 3 (2037)

	Catchment area (ha)							
Dam name	Undisturbed	Roads / hardstand	Mining Pit	Spoil Dump	Rehab	Tailings	Cleared / Pre-strip	Total
Mine affected water dams								
Mining Pit	54.0	0.0	206.6	751.8	254.2	0.0	63.1	1329.7
RWD	2.0	19.7	0.0	0.0	0.0	0.0	3.7	25.5
MWD	0.0	36.1	0.0	0.0	0.0	0.0	0.0	36.1
NROM	0.3	5.2	0.0	0.0	0.0	0.0	0.0	5.5
TSF1	0.0	2.6	0.0	0.0	0.0	12.8	0.0	15.5
TSF2	0.0	0.7	0.0	0.0	0.0	9.0	0.0	9.6
SD1	1.2	14.7	0.0	0.0	0.0	0.1	0.2	16.1
Sediment dams								
SD2	15.1	0.0	0.0	0.2	70.2	0.0	0.0	85.5
SD3	10.8	0.0	0.0	0.0	60.1	0.0	0.0	70.9
SD5	19.1	6.3	0.0	0.0	84.7	0.0	0.0	110.1
SD6	22.3	0.0	0.0	0.0	234.2	0.0	0.0	256.4
SD7	40.8	0.0	0.0	0.0	214.8	0.0	0.0	255.6
SD11	12.5	0.0	0.0	0.1	97.4	0.0	0.0	109.9
SD13	3.4	0.0	0.0	67.2	22.4	0.0	0.0	92.9
SD15	5.1	0.0	0.0	34.0	0.0	0.0	0.0	39.1
SD16	10.4	0.0	0.0	40.6	0.0	0.0	0.0	51.0

Table B.7 – Middlemount Coal Mine catchment area and land use breakdown – Stage 4 (2043)

Dam name	Catchment area (ha)							
	Undisturbed	Roads / hardstand	Mining Pit	Spoil Dump	Rehab	Tailings	Cleared / Pre-strip	Total
Mine affected water dams								
Mining Pit	8.8	0.0	151.1	635.6	439.9	0.0	19.8	1255.2
RWD	2.0	19.7	0.0	0.0	0.0	0.0	3.7	25.5
MWD	0.0	36.1	0.0	0.0	0.0	0.0	0.0	36.1
NROM	0.3	5.2	0.0	0.0	0.0	0.0	0.0	5.5
TSF1	0.0	2.6	0.0	0.0	0.0	12.8	0.0	15.4
TSF2	0.0	0.7	0.0	0.0	0.0	9.0	0.0	9.6
SD1	1.2	14.7	0.0	0.0	0.0	0.1	0.2	16.2
Sediment dams								
SD2	15.1	0.0	0.0	0.2	70.2	0.0	0.0	85.5
SD3	10.8	0.0	0.0	0.0	60.1	0.0	0.0	70.9
SD5	19.1	6.3	0.0	0.0	84.7	0.0	0.0	110.1
SD6	22.3	0.0	0.0	0.0	234.2	0.0	0.0	256.4
SD7	40.8	0.0	0.0	0.0	214.8	0.0	0.0	255.6
SD11	12.5	0.0	0.0	0.0	97.4	0.0	0.0	109.9
SD13	3.4	0.0	0.0	0.0	89.5	0.0	0.0	92.9
SD15	5.1	0.0	0.0	0.0	34.0	0.0	0.0	39.1
SD17	7.8	0.0	0.0	19.7	33.3	0.0	0.0	60.8

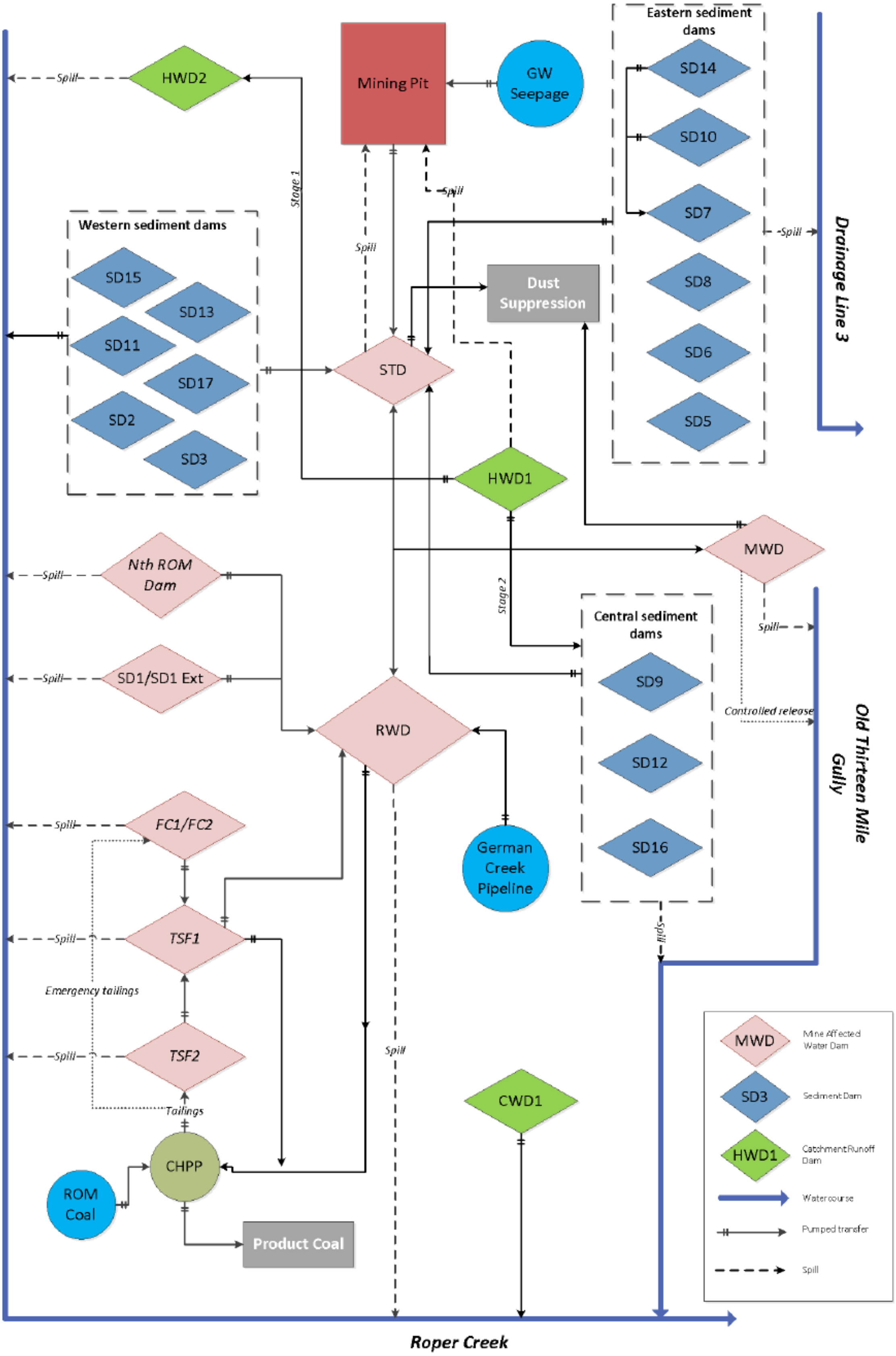


Figure B.6 – Water management system schematic – Stage 1 to Stage 4

Table B.8 – 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 as required, in accordance with the arrangement detailed in Section 5.8.3. • Water is imported if the inventory of MWD reduces below 750 ML.
2.0	***Water demands***	
2.1	CHPP	• Supplied from RWD and TSF1
2.2	Haul road dust suppression	• Supplied from STD and MWD • 100% loss assumed
3.0	***Open-cut operations***	
3.1	Mining pit	• Receives groundwater inflows. • 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 storage • Receives pumped transfers from NROM, TSF1, TSF2 and SD1 at up to 100 L/s if its inventory drops below 30 ML • Pumps to STD when it reaches an inventory of 120 ML at a maximum rate of 100 L/s • Can receive inflows from German Creek water supply • Overflows to Roper Creek
4.2	MWD	• Existing mine affected water storage • Receives pumped transfers from STD and the Mining Pit • Pumps to STD as required • Pumps to RWD (bypassing STD) • Supplies water to dust suppression demand • Can make controlled releases to Old Thirteen Mile Gully • Overflows to Thirteen Mile Gully
4.3	STD	• Existing mine affected water storage • Can receive pumped inflows from the Mining pit, RWD, MWD, and from the eastern, western and central sediment dams • Pumps to RWD and MWD 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 storage • Pumps to RWD at a maximum rate of 100 L/s • Overflows to Roper Creek
4.5	SD1/SD1 Extension	• Existing mine affected water storage • Pumps to RWD at a maximum rate of 50 L/s • Overflows to Roper Creek (via SD1 Extension)
4.6	Western sediment dams (SD2, SD3, SD11, SD13, SD15, SD17)	• On-site stormwater storages • SD2 is an existing storage. SD11, SD13, SD15 and SD17 are proposed storages for the Project. SD3 is existing but is proposed to be relocated and resized for the Project • Transfers to STD at up to a maximum rate of 100 L/s • Overflows to Roper Creek (SD2, SD3, SD11 and SD17 overflow via pumping, SD13 and SD15 overflow via spill)
4.7	Central sediment dams (SD9, SD12, SD16)	• On-site stormwater storages • SD9 is an existing storage. SD12 is a proposed storage which will sit within the Old Thirteen Mile Gully. SD16 is a proposed storage • Pumps to STD at up to a maximum rate of 100 L/s

Item	Node Name	Operating Rules
		• Overflows to the Old Thirteen Mile Gully
4.8	Eastern sediment dams (SD5, SD6, SD7, SD8, SD10, SD14)	• On-site stormwater storages • SD7 and SD8 are existing storages. SD5, SD6, SD10 and SD14 are proposed storages • SD10 and SD14 pump to SD7 when required to avoid spilling • SD5, SD6 and SD7 overflow to Drainage line 3
4.9	HWD1	• Proposed highwall catchment runoff water storage bordering the mining pit • Pumped to HWD2 during Stage 1 when it exceeds 2 ML inventory at up to 50 L/s • Pumped out to a location which is TBC from Middlemount during Stage 2 when it exceeds 2 ML inventory at up to 50 L/s • Overflows to the mining pit
4.10	HWD2	• Existing highwall catchment runoff water storage bordering the mining pit • Will receive pumped inflows from HWD1 once constructed • Overflows through a constructed diversion channel to Roper Creek
4.11	TSF1	• Receives decant water from TSF2 (active flocc cells) • Supplies water to RWD and the CHPP as required • Overflows to Roper Creek
4.12	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 • Supplies water to RWD • Overflows to Roper Creek
4.13	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, NROM, TSF1, TSF2, SD1, SD2, SD3, SD11, SD15, SD17 and HWD2
5.2	Thirteen Mile Gully	• Receives storage overflows from MWD, SD9, SD12 and SD16
5.3	Drainage Line 3	• Receives storage overflows from SD5, SD6, SD7 and SD8
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 B.7 shows a conceptual configuration of the AWBM model.

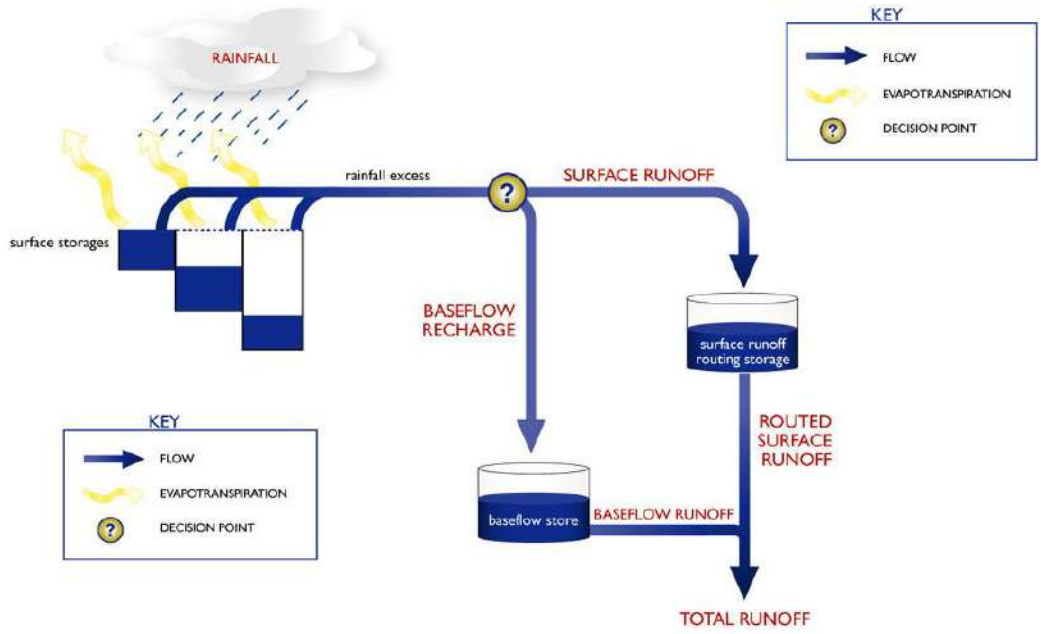


Figure B.7 – AWBM model configuration

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 Tables B.4 to B.7) on the mine site are shown in Table B.9.

The AWBM model parameters were based on the latest Middlemount Coal Mine water balance model used as part of the Middlemount water management documentation update (WRM, 2019). The adopted parameters were verified by confirming that the modelled inventories represented recorded MWD and mining pit inventory over 2014 – 2020 (see Section B8).

The AWBM model was originally 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 36.6%, 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. The simulated volumetric runoff percentage of 3.4% is slightly lower than undisturbed catchments.

Rehabilitated catchments have been assumed to have similar rainfall runoff characteristics as undisturbed catchments. We have therefore 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.9 – AWBM parameters

AWBM Parameter		Roper Creek	Undisturbed catchments	Hardstand	Mining Pit/Tailings	Spoil Dump	Rehab	Cleared
Surface Store Depth (mm)	C1	24	24	4	3	40	24	20
	C2	118	118	20	15	200	118	100
	C3	268	268	40	30	400	268	200
Partial Areas	A1	0.062	0.062	0.33	0.33	0.1	0.062	0.1
	A2	0.439	0.439	0.33	0.33	0.4	0.439	0.4
Base flow index	BFI	0.936	0	0	0	0.9	0	0
Base flow recession constant	Kb	0.53	0	0	0	0.8	0	0
Surface flow recession constant	Ks	0.73	0	0	0	0	0	0
Long-term runoff coefficient (%)	C_v	5.6%	5.6%	36.6%	40.6%	3.4%	5.6%	8.3%

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 B.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 170 L/ROM tonne (including return water from the TSF1). This rate is based on the historical net CHPP usage over 2017 and 2018 and has been confirmed as accurate from site personnel. The forecast net CHPP consumption over the Project life is provided in Table B.10.

Table B.10 - Forecast annual production data and water usage

Stage	Year	CHPP production and water usage		
		Feed tonnage (Mt)	Net CHPP Usage (ML)	Net CHPP Usage (ML/day)
1	2021	5.4	928	2.54
	2022	5.4	928	2.54
	2023	5.4	928	2.54
	2024	5.4	931	2.54
	2025	5.4	928	2.54
2	2026	5.4	928	2.54
	2027	5.4	928	2.54
	2028	5.4	931	2.54
	2029	5.4	928	2.54
	2030	5.4	928	2.54
	2031	5.4	928	2.54
	2032	5.4	925	2.53
3	2033	5.4	928	2.54
	2034	5.1	870	2.38
	2035	5.4	928	2.54
	2036	5.4	931	2.54
	2037	4.8	826	2.26
	2038	4.7	801	2.19
	2039	3.5	598	1.64
4	2040	3.8	651	1.78
	2041	3.5	596	1.63
	2042	1.9	332	0.91
	2043	3.2	549	1.51
	2044	1.3	225	0.61

B6.2 HAUL ROAD DUST SUPPRESSION

Mine site haul road dust suppression water and vehicle washdown is sourced from water cart fill points located at the MWD and STD. Dust suppression is preferentially sourced from the lowest quality water available onsite. This is controlled on a daily basis by site personnel.

MCPL has supplied historical monthly dust suppression demand volumes based on truck fill counts and truck capacity over the period January 2016 to September 2018. MCPL have previously advised that there is an approximate 25 ML/month of additional unmetered usage. The estimated average daily dust suppression demand over the period January 2016 to September 2018 was 3.25 ML/day, however the seasonal distribution of this demand varies.

The average monthly dust suppression rates are shown in Figure B.8.

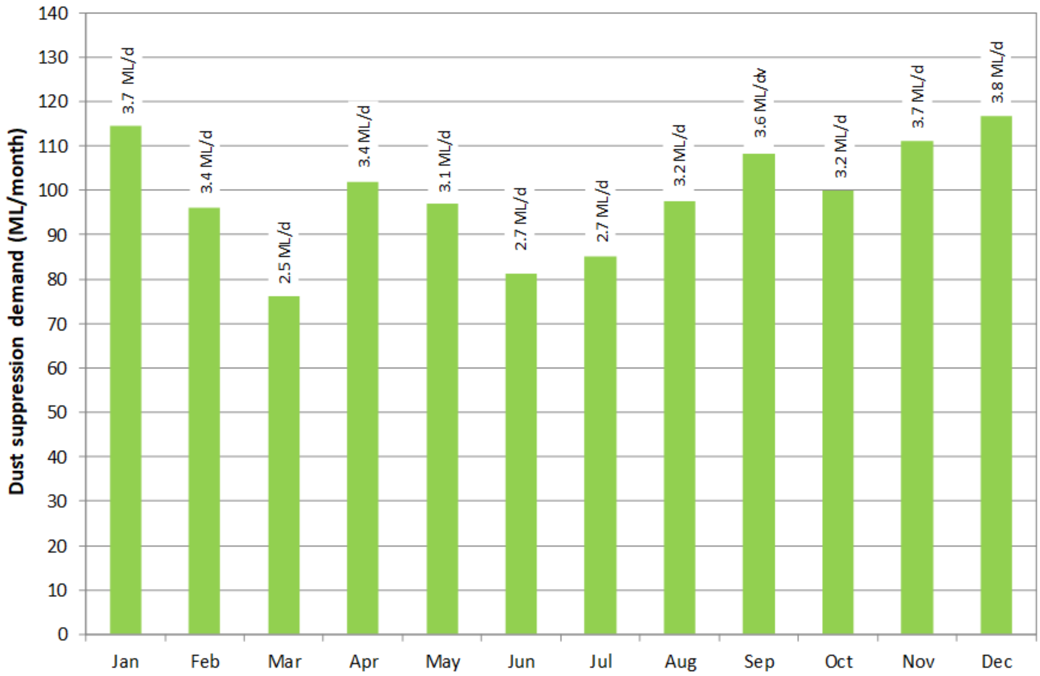


Figure B.8 - Adopted average monthly dust suppression demands

B7 Groundwater inflows

The adopted groundwater inflows to the open cut and underground mining areas are based on estimates provided by AGE (2020) and are summarised in Table B.11.

Table B.11 - Forecast groundwater inflows

Stage	Year	GW Inflow	
		ML/year	ML/day
1	2021	429	1.2
	2022	605	1.7
	2023	1270	3.5
	2024	770	2.1
	2025	1063	2.9
2	2026	833	2.3
	2027	846	2.3
	2028	1029	2.8
	2029	698	1.9
	2030	752	2.1
	2031	772	2.1
	2032	676	1.8
3	2033	1023	2.8
	2034	992	2.7
	2035	987	2.7
	2036	861	2.4
	2037	772	2.1
	2038	986	2.7
	2039	699	1.9
4	2040	429	1.2
	2041	587	1.6
	2042	603	1.7
	2043	452	1.2
	2044	243	0.7

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 2014 to May 2020. The model was configured to reflect the site operations during this period, with appropriate transfer rates, system configuration and water inflows and outflows.

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 Project parameters was undertaken.

B8.2 CALIBRATION RESULTS

The model had been previously calibrated to site data between January 2016 – August 2017. Extending the calibration backwards to 2014 and forwards to 2020 created inaccurate calibration results during the 2018 – 2020 period. The calibration overestimated results. It was noted that the calibrated AWBM parameters produced accurate results for the 2014 – 2018 period. It was also noted that there were numerous inaccuracies of site data from 2018 – 2020, including estimated values for site demands.

This suggests that the AWBM parameters were suitable but that some inaccuracies relating to the site data were causing errors in the calibration.

The following changes were made to the site data to refine the calibration:

- The CHPP usage data from 2018 shows negligible return water recycle and therefore appears to overestimate CHPP usage. A flat CHPP usage rate of 170 L/ROM tonne which was observed from 2016 – 2018 was applied from 2018 – 2020.
- The haul road dust suppression numbers from late 2018 onward show a flat rate with no seasonal variance. This is inconsistent with data from previous years. The average monthly values from 2017 have therefore been applied from 2018 – present.
- The onsite rainfall collected since 2014 has been collected at a number of different weather stations. Previous WRM investigations have indicated that the site station may have been poorly calibrated and overrepresents actual rainfall for numerous years. QLD Government SILO data for the site had therefore been used for the calibration to provide consistent results across the period.
- Groundwater inflow rates are not measured onsite but rather are estimated. Groundwater inflow rates of 1 ML/d from 2014 – 2016 and 1.7 ML/d from 2016 – present have therefore been assumed.

The observed and modelled inventory for the combined MWD and mining pit inventory is presented in Figure B.9, along with the site rainfall for the calibration period. Review of Figure B.9 indicates the following:

- The simulated combined inventory generally reproduces the observed inventory fluctuations over the calibration period between January 2014 and May 2020.
- 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.

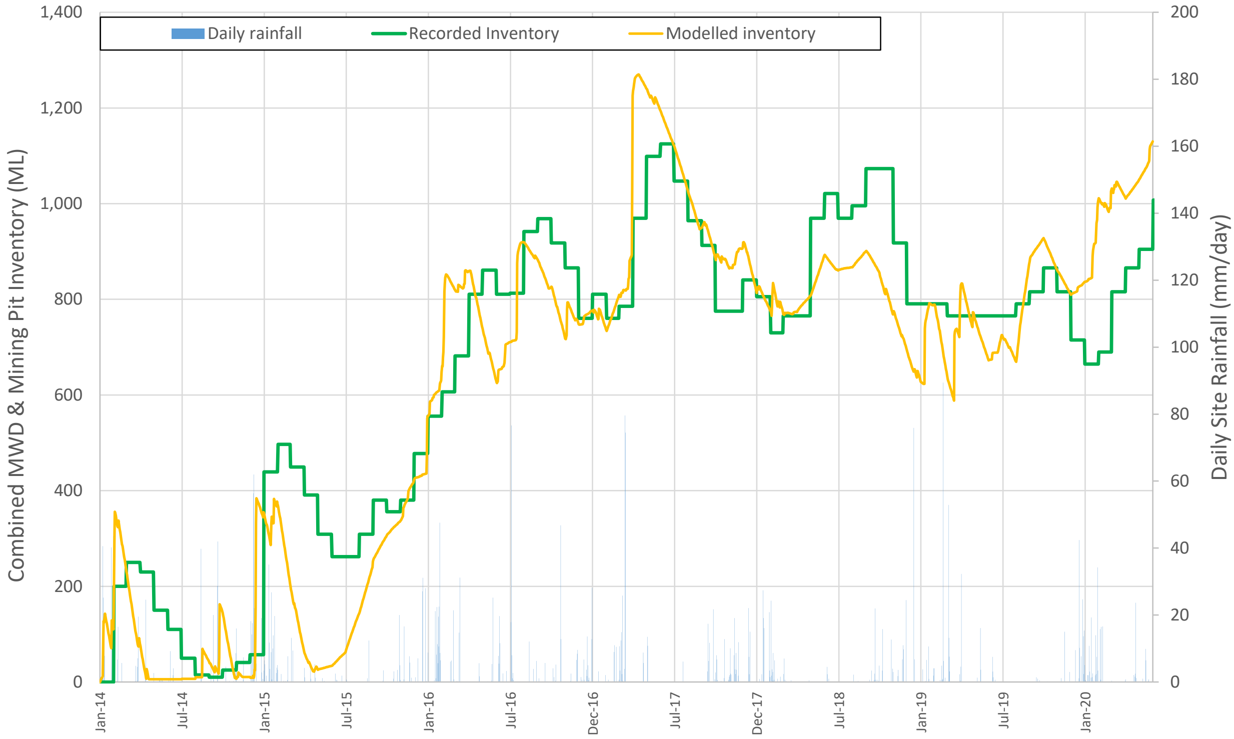
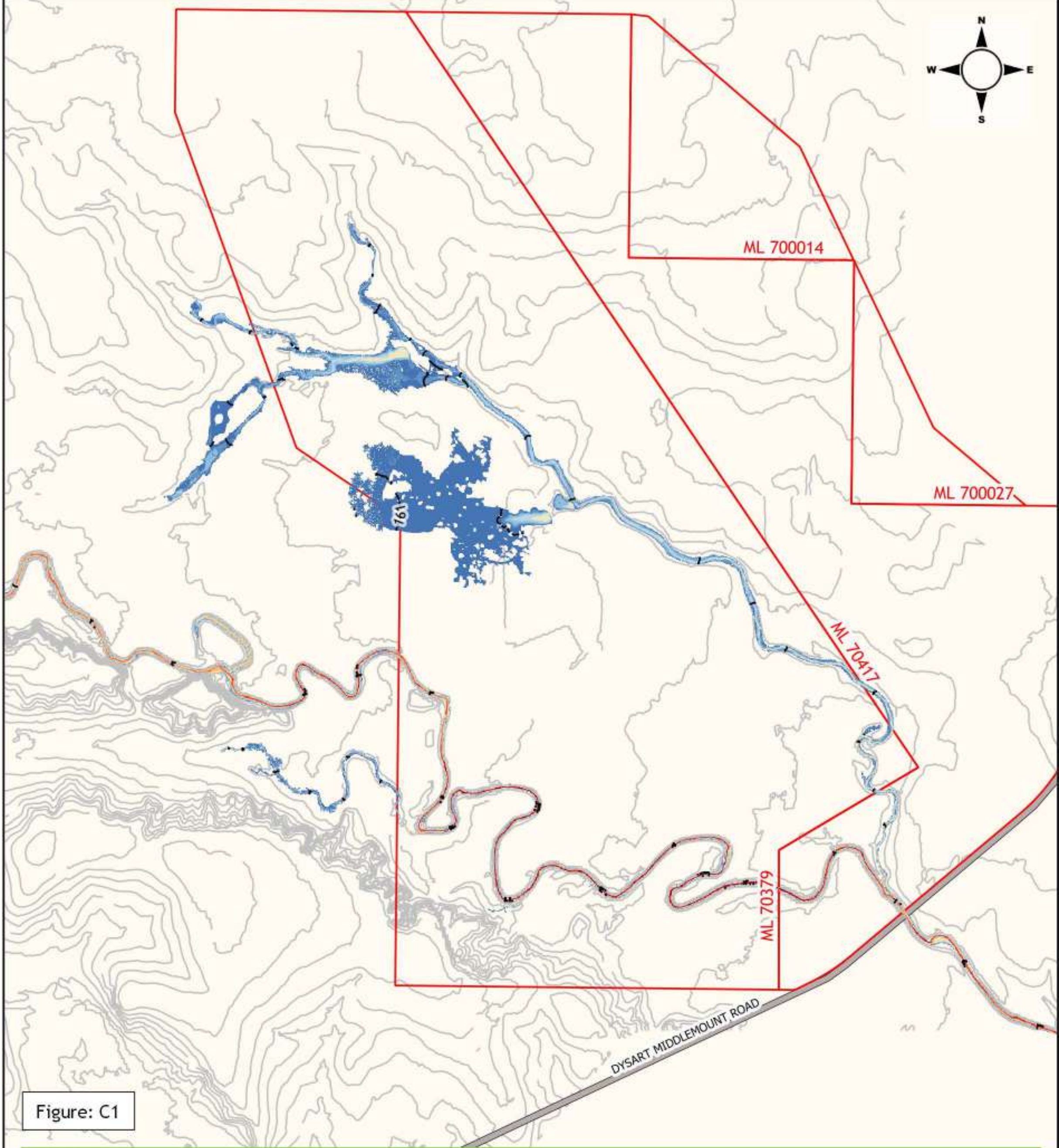


Figure B.9 – Model calibration – combined MWD and mining pit inventory

Appendix C – Flood depth and velocity maps



Legend

- ML Boundary
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

50% AEP Peak flood level, depth and extents : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

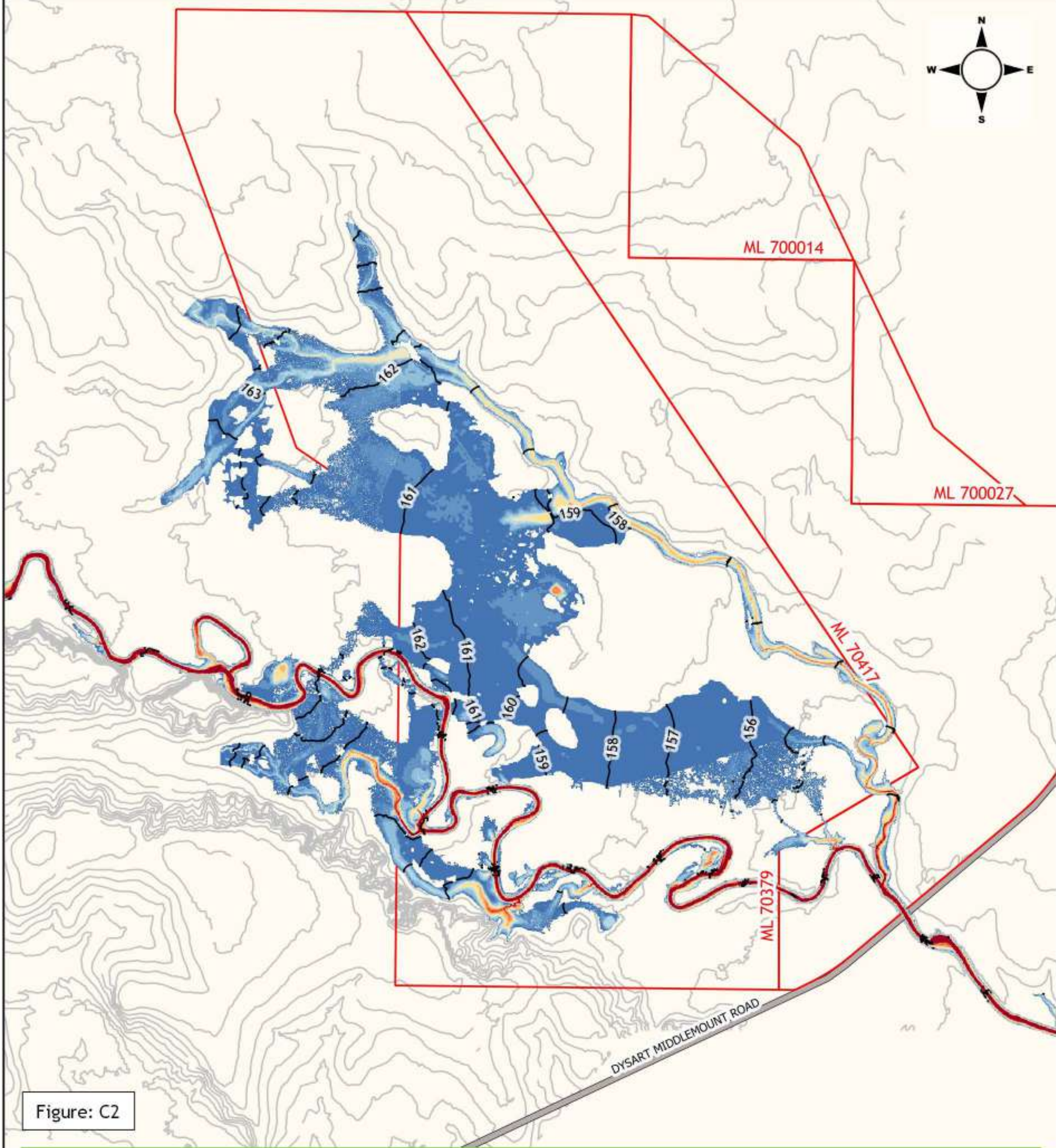


Figure: C2

Legend

- ML Boundary
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

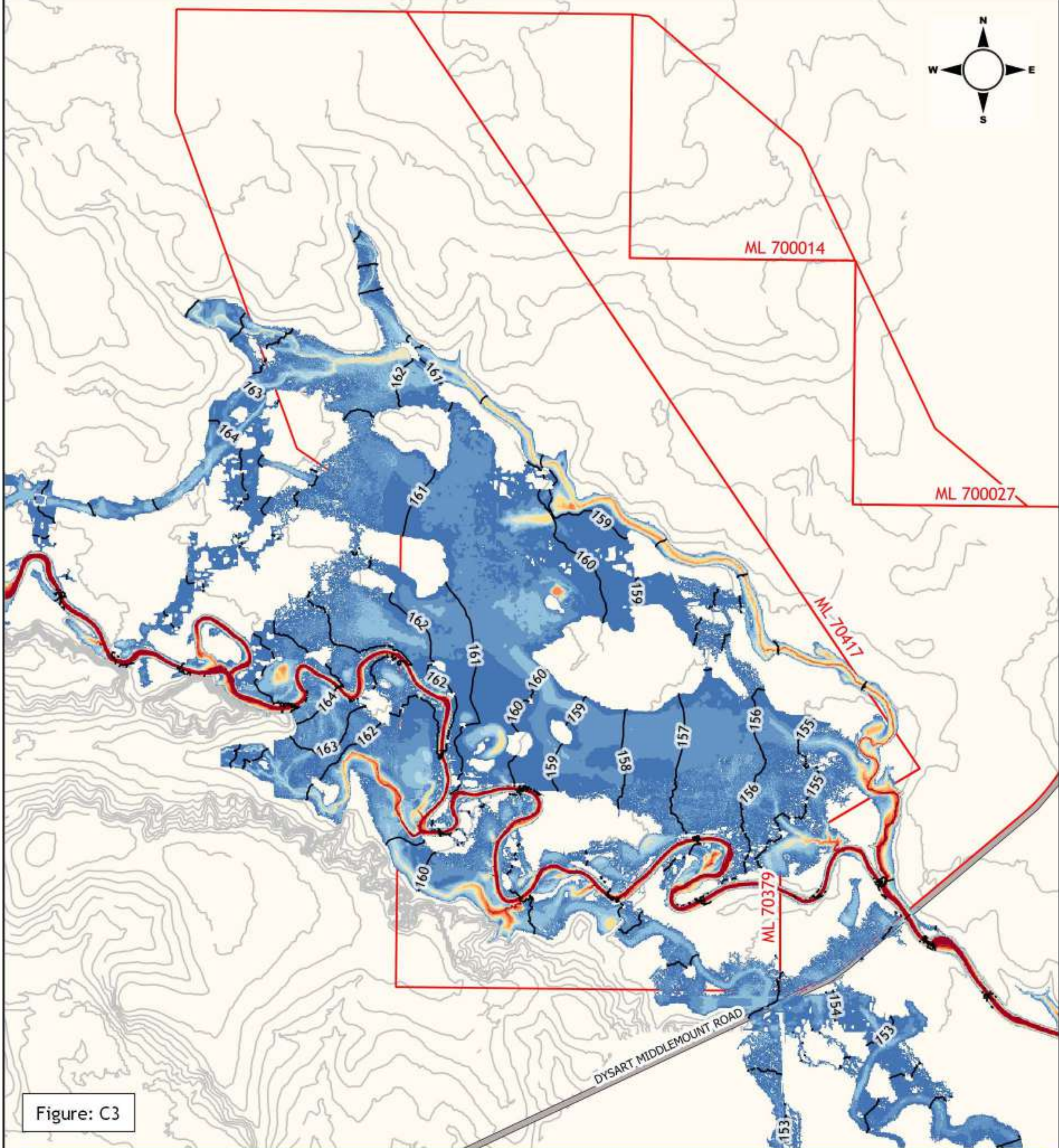
Middlemount Coal Mine Southern Extension Project

5% AEP Peak flood level, depth and extents : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

2% AEP Peak flood level, depth and extents : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

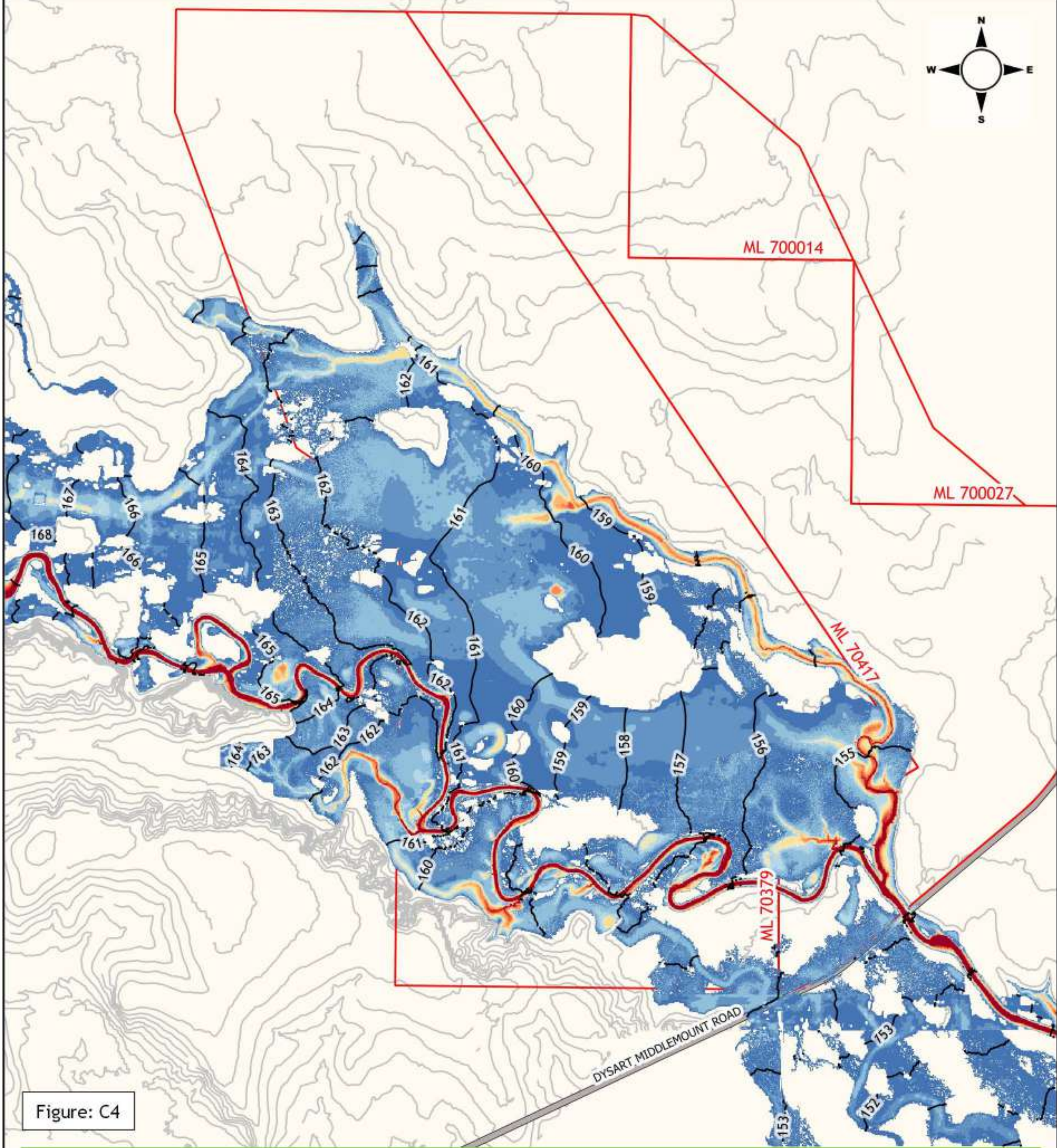


Figure: C4

Legend

- ML Boundary
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

1% AEP Peak flood level, depth and extents : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

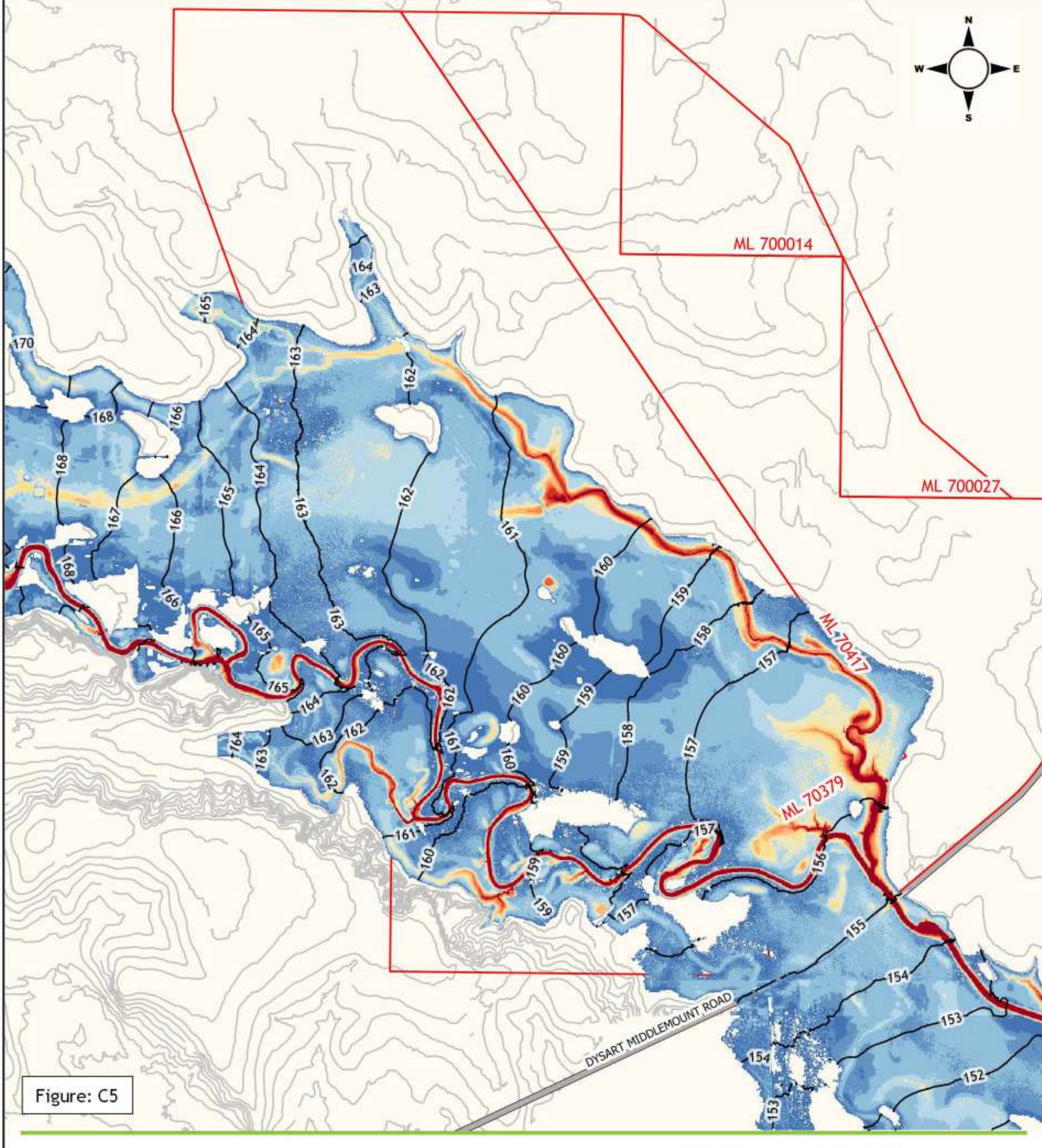


Figure: C5

Legend

ML Boundary

Road

Water surface elevation contour (mAHD)

Ground contour (2.5m interval)

Flood depth (m)

up to 0.25m	2.5 to 3.0m
0.25 to 0.5m	3.0 to 3.5m
0.5 to 1.0m	3.5 to 4.0m
1.0 to 1.5m	4.0 to 4.5m
1.5 to 2.0m	> 4.5m
2.0 to 2.5m	

Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood level, depth and extents : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

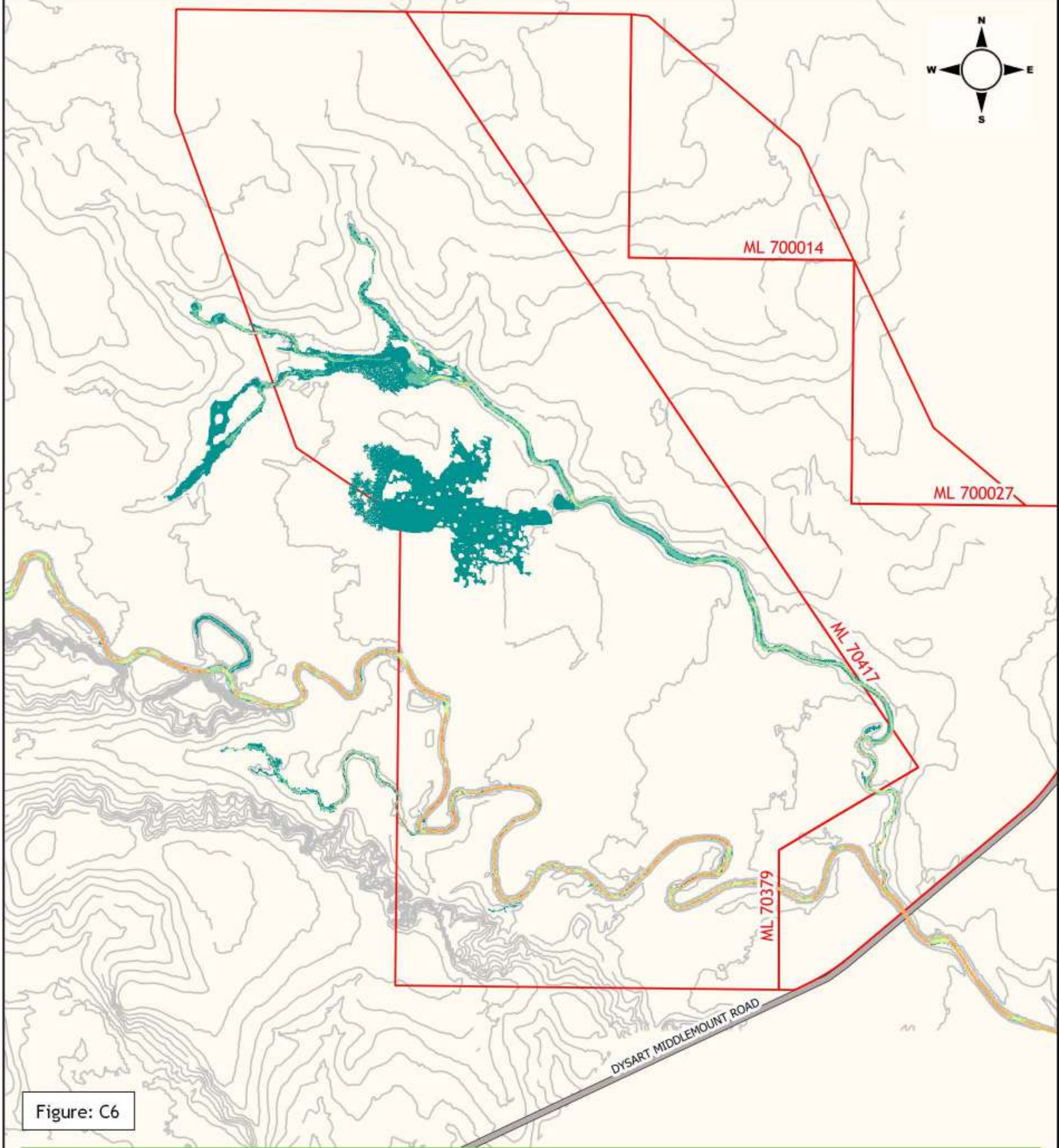


Figure: C6

Legend

- ML Boundary
- Road
- Ground contour (2.5m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

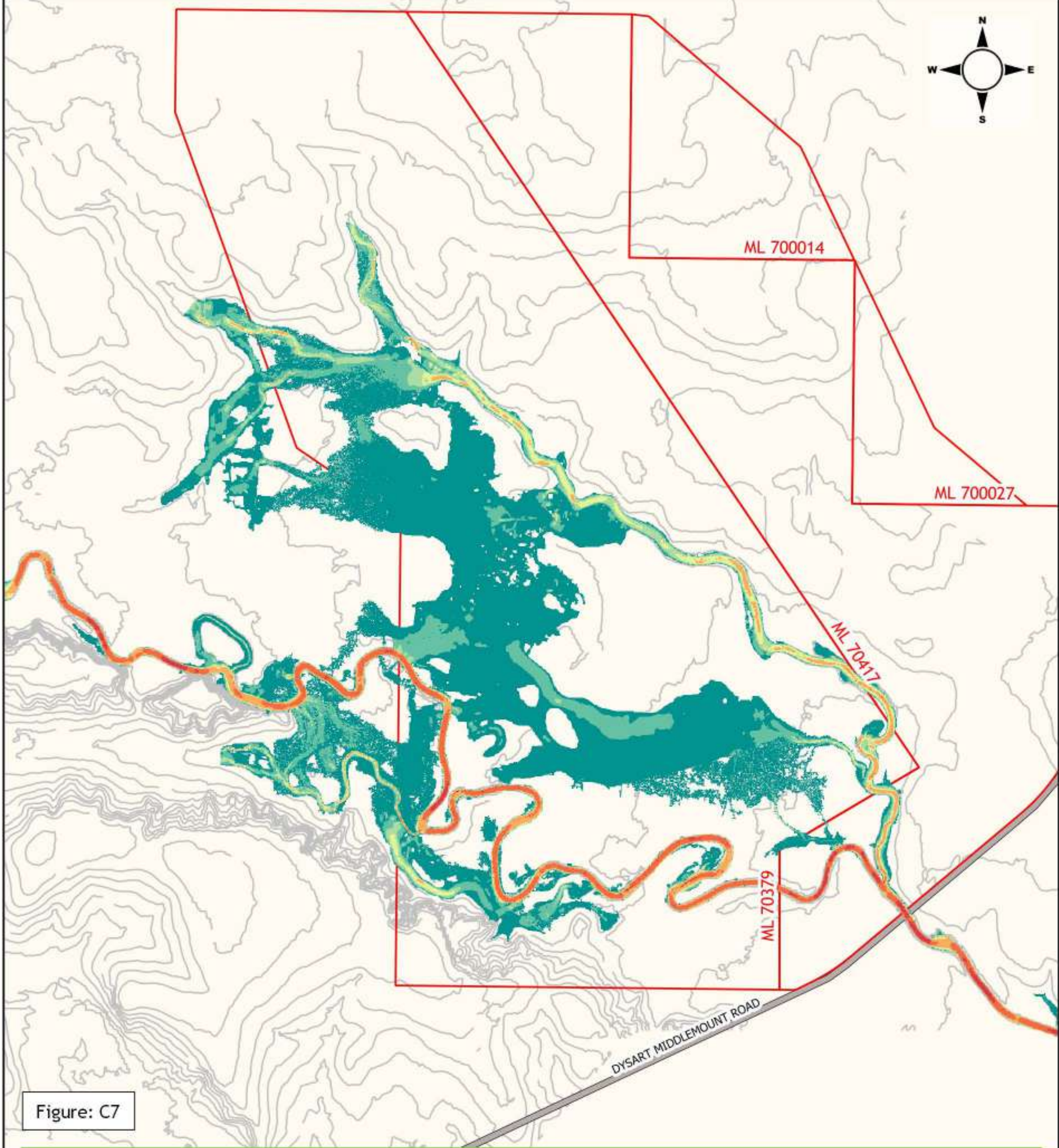
Middlemount Coal Mine Southern Extension Project

50% AEP Peak flood velocities : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water+environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Road
- Ground contour (2.5m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

5% AEP Peak flood velocities : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

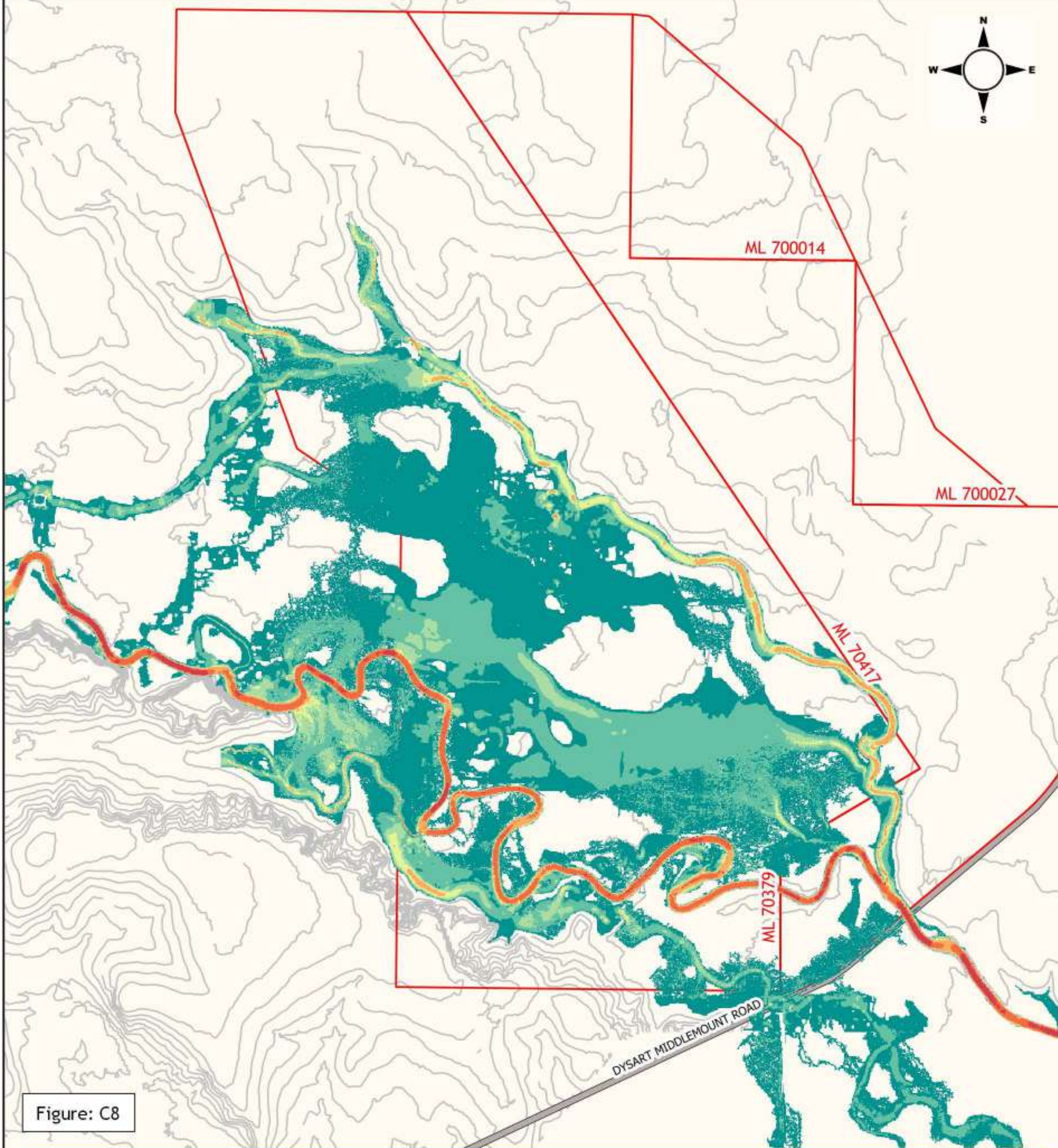


Figure: C8

Legend

- ML Boundary
- Road
- Ground contour (2.5m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

2% AEP Peak flood velocities : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

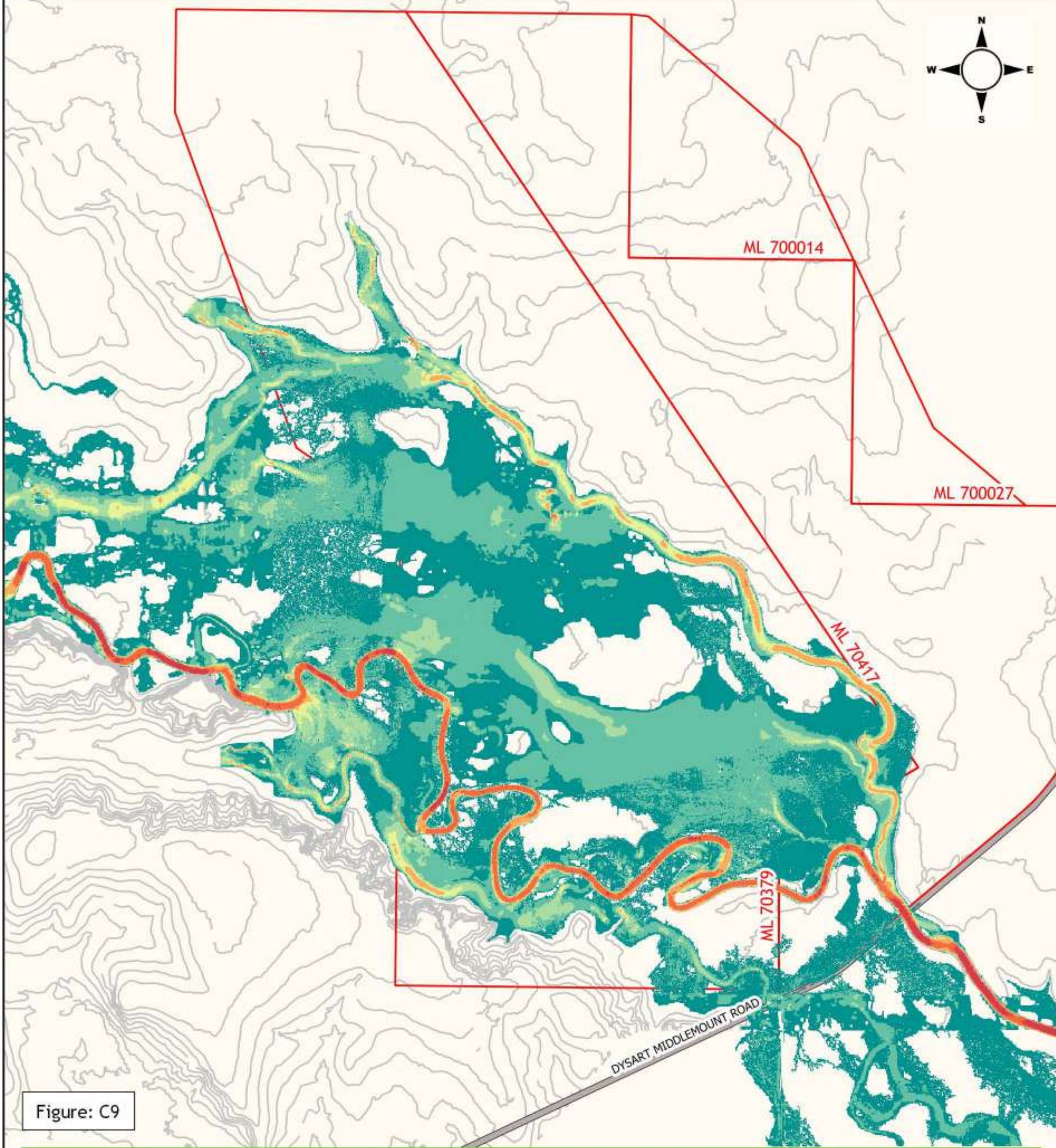


Figure: C9

Legend

- ML Boundary
- Road
- Ground contour (2.5m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

1% AEP Peak flood velocities : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

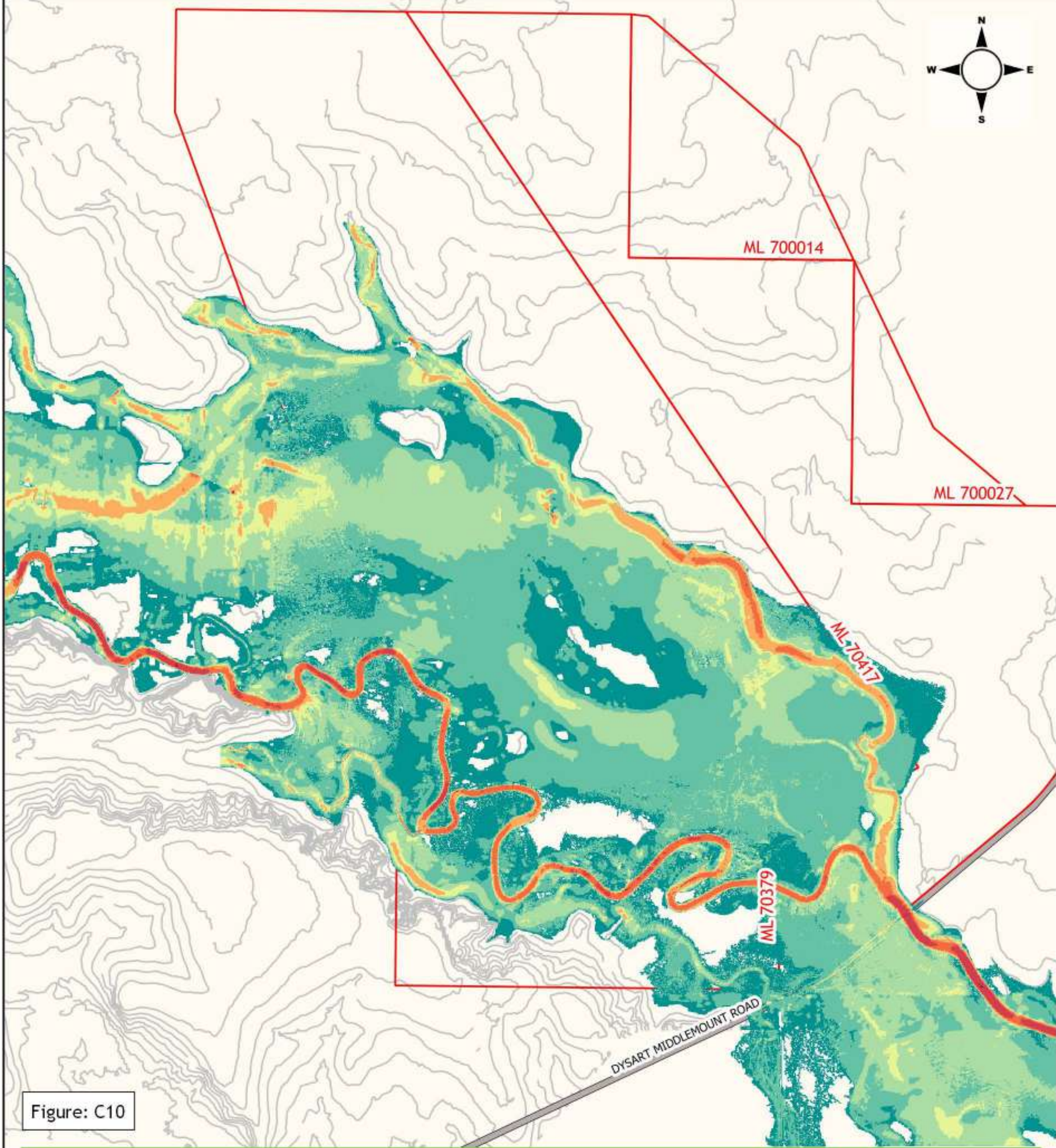


Figure: C10

Legend

- ML Boundary
- Road
- Ground contour (2.5m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

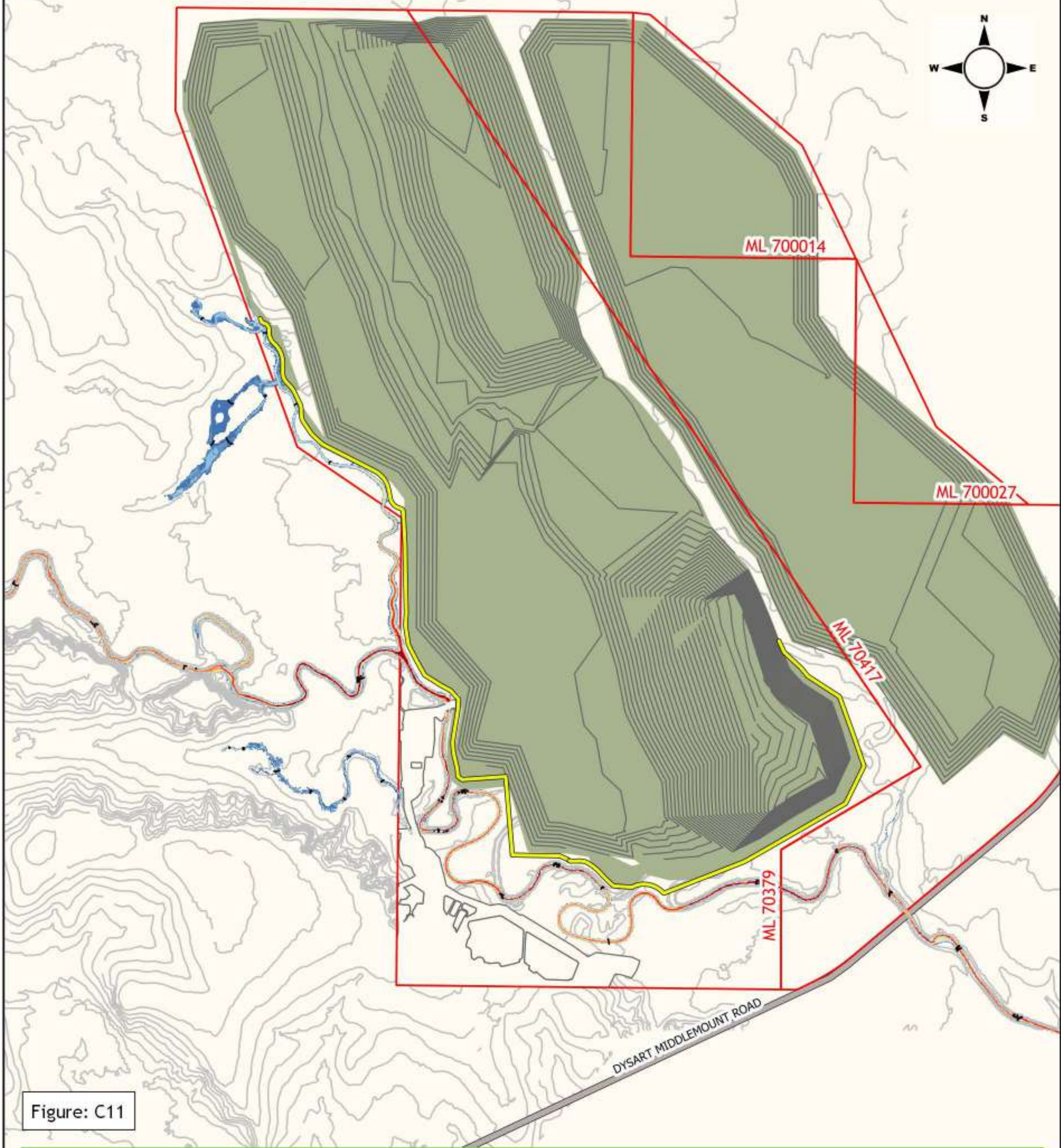
Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood velocities : pre-mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

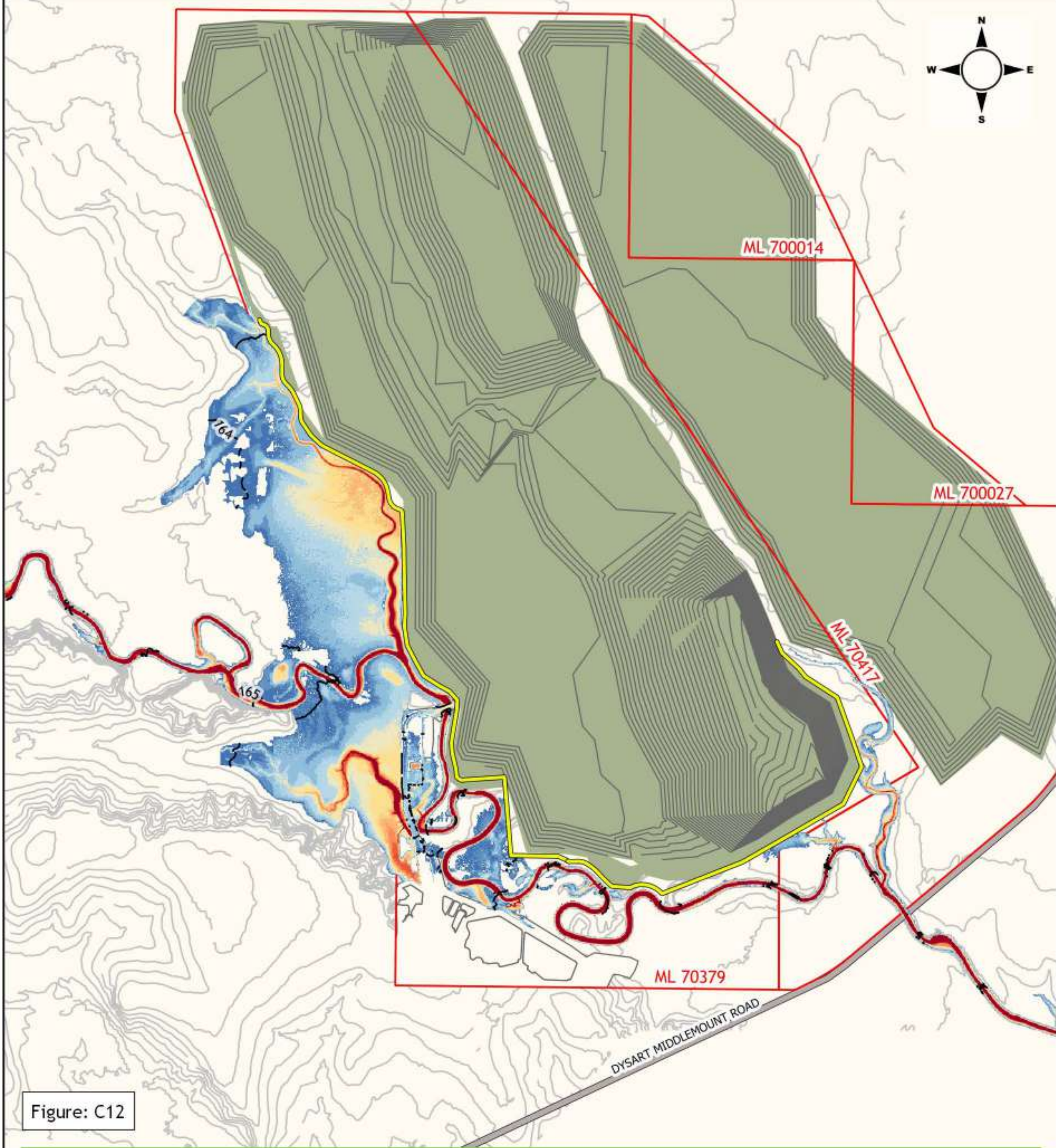
Middlemount Coal Mine Southern Extension Project

50% AEP Peak flood level, depth and extents : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

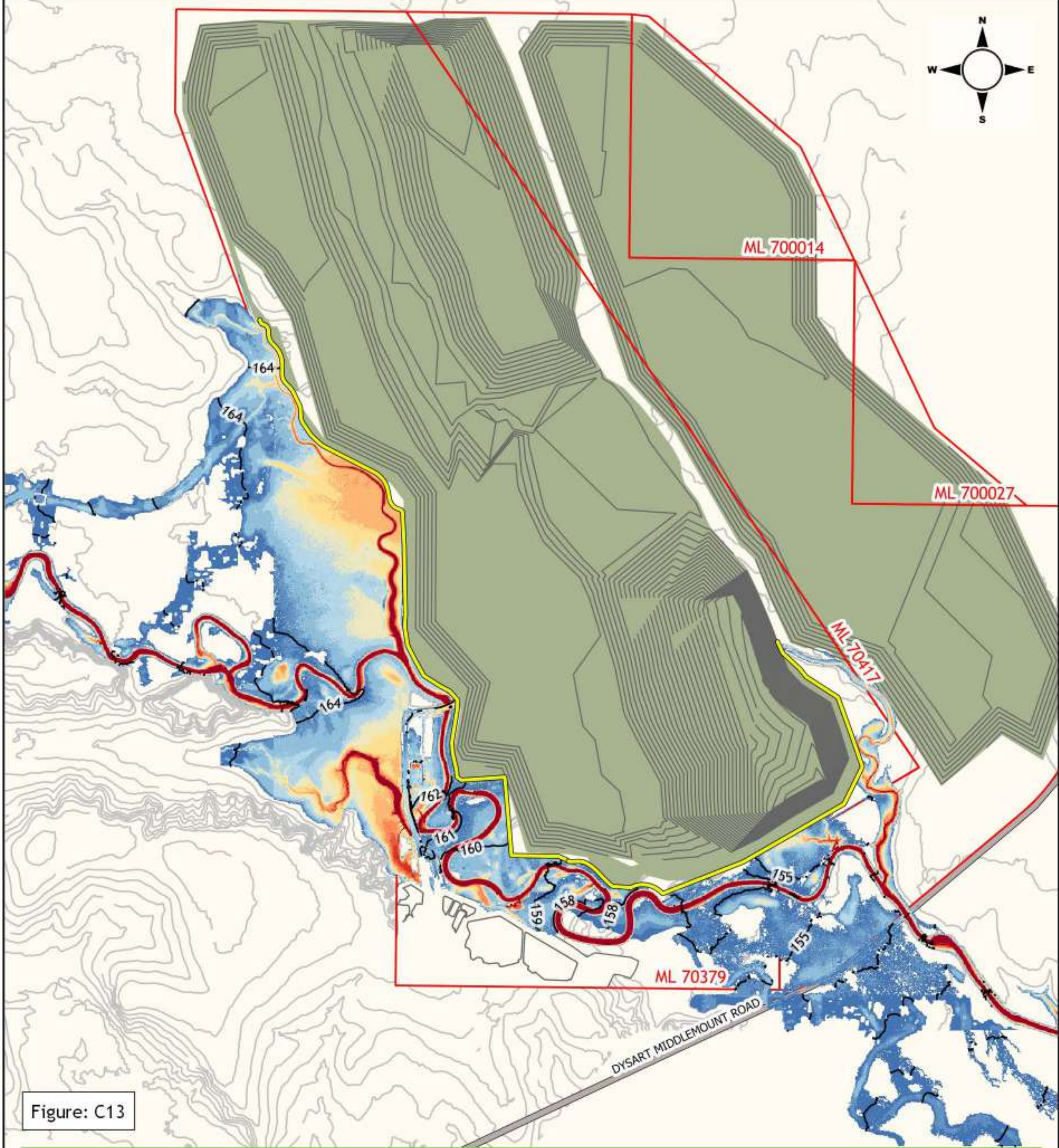
Middlemount Coal Mine Southern Extension Project

5% AEP Peak flood level, depth and extents : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

2% AEP Peak flood level, depth and extents : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

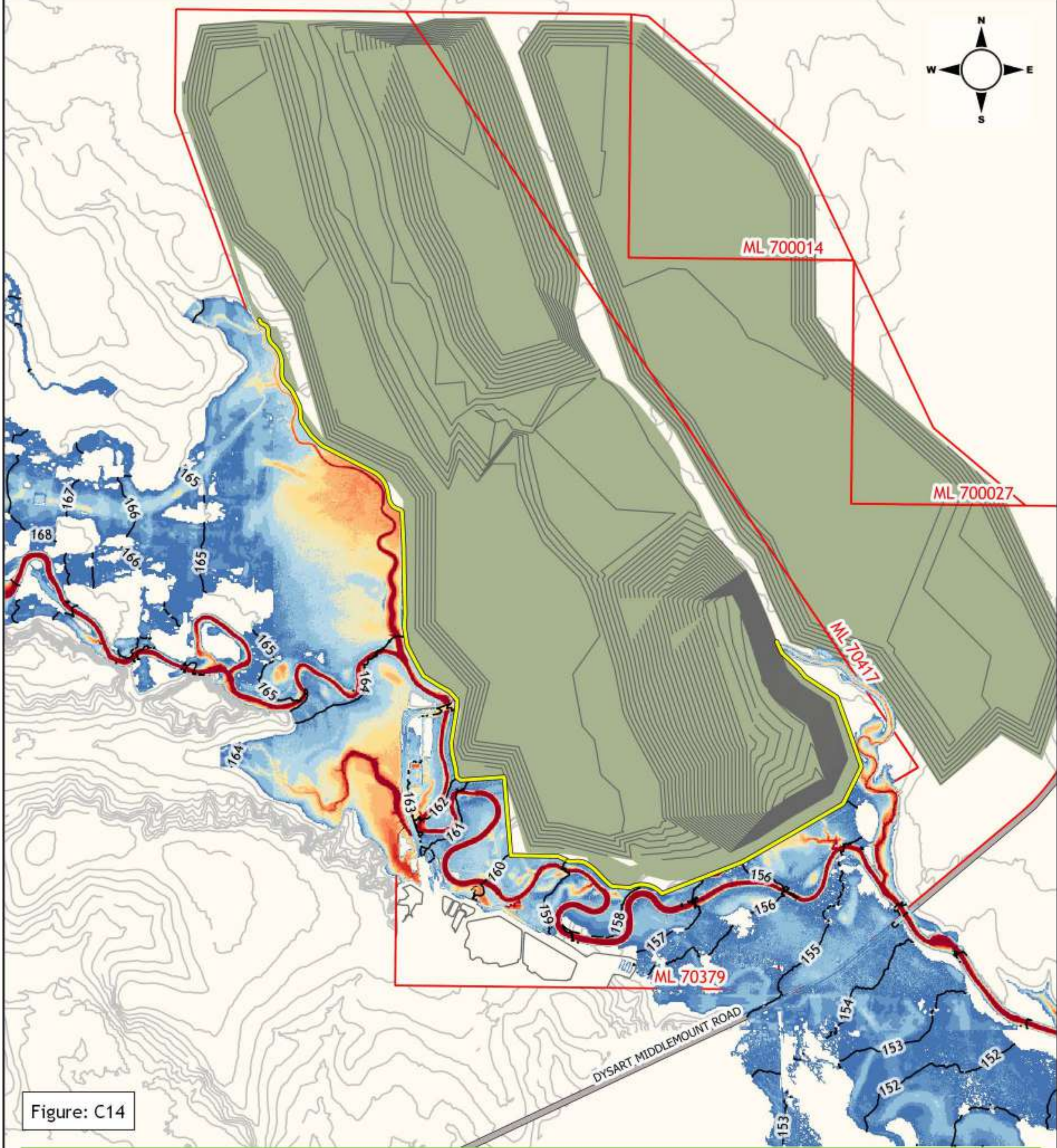


Figure: C14

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

1% AEP Peak flood level, depth and extents : approved mining conditions

0 0.5 1 1.5 2 km

Projection: MGA Zone 55 Datum: GDA 94

water + environment

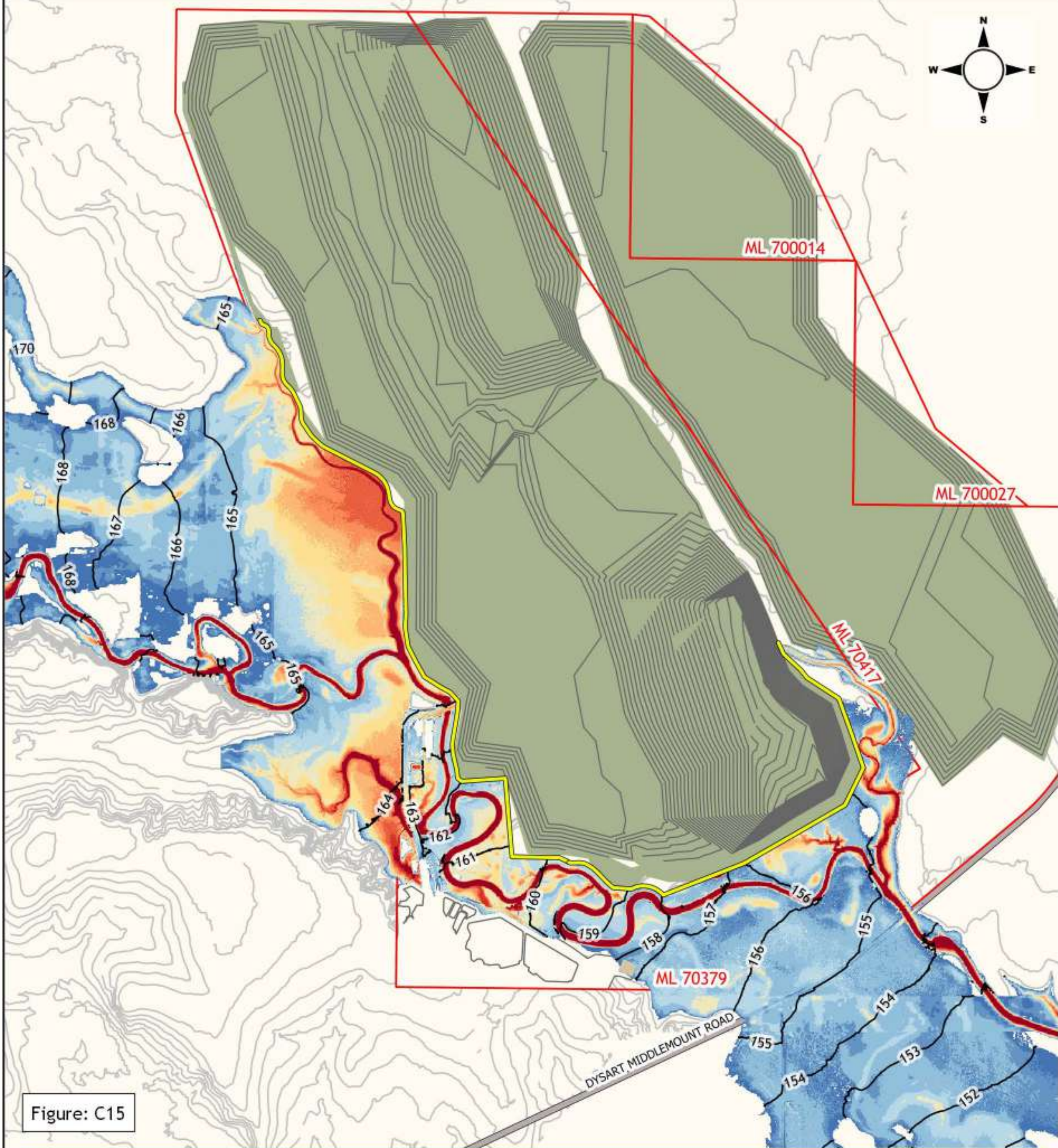


Figure: C15

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood level, depth and extents : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

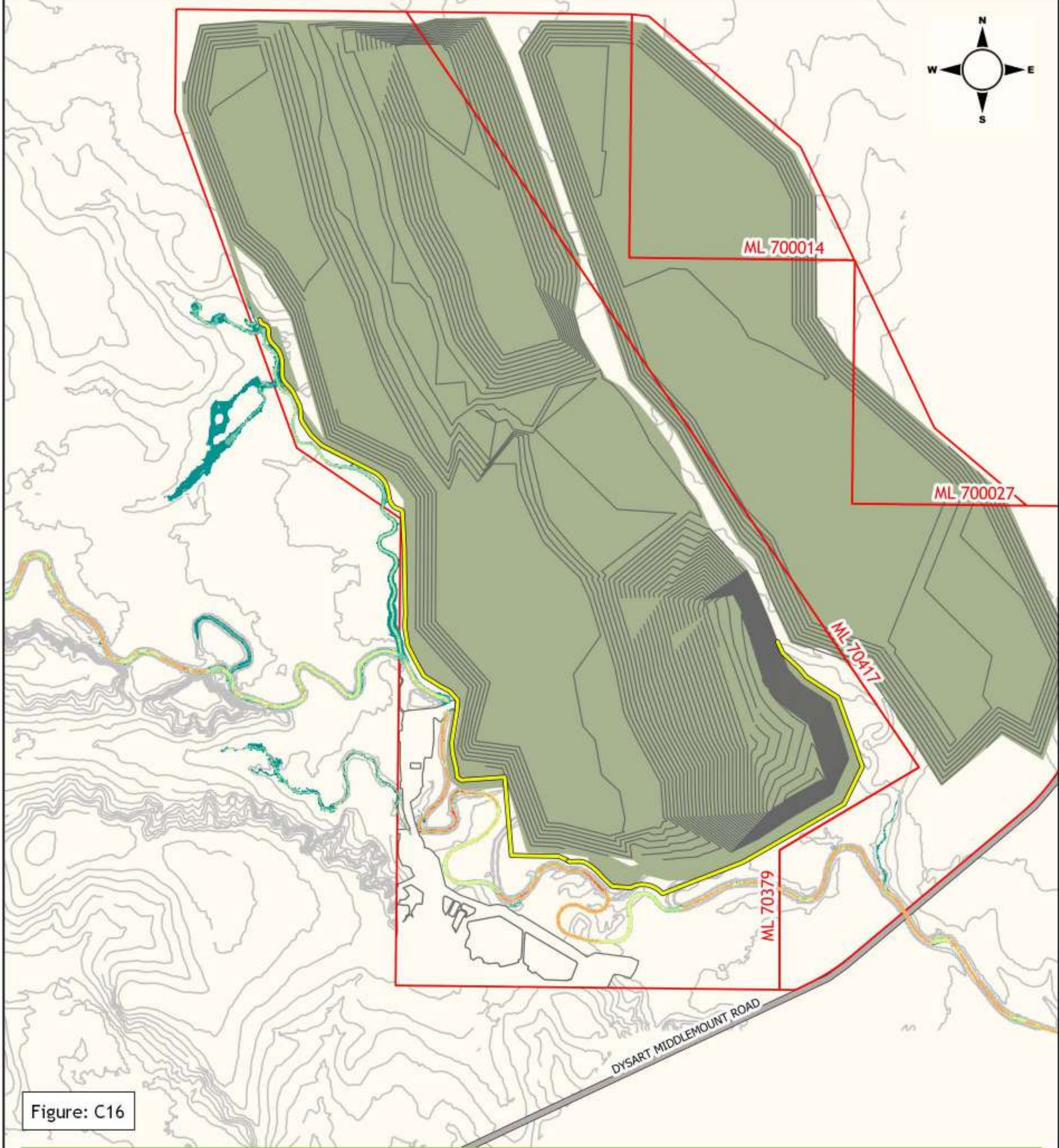


Figure: C16

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

50% AEP Peak flood velocities : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

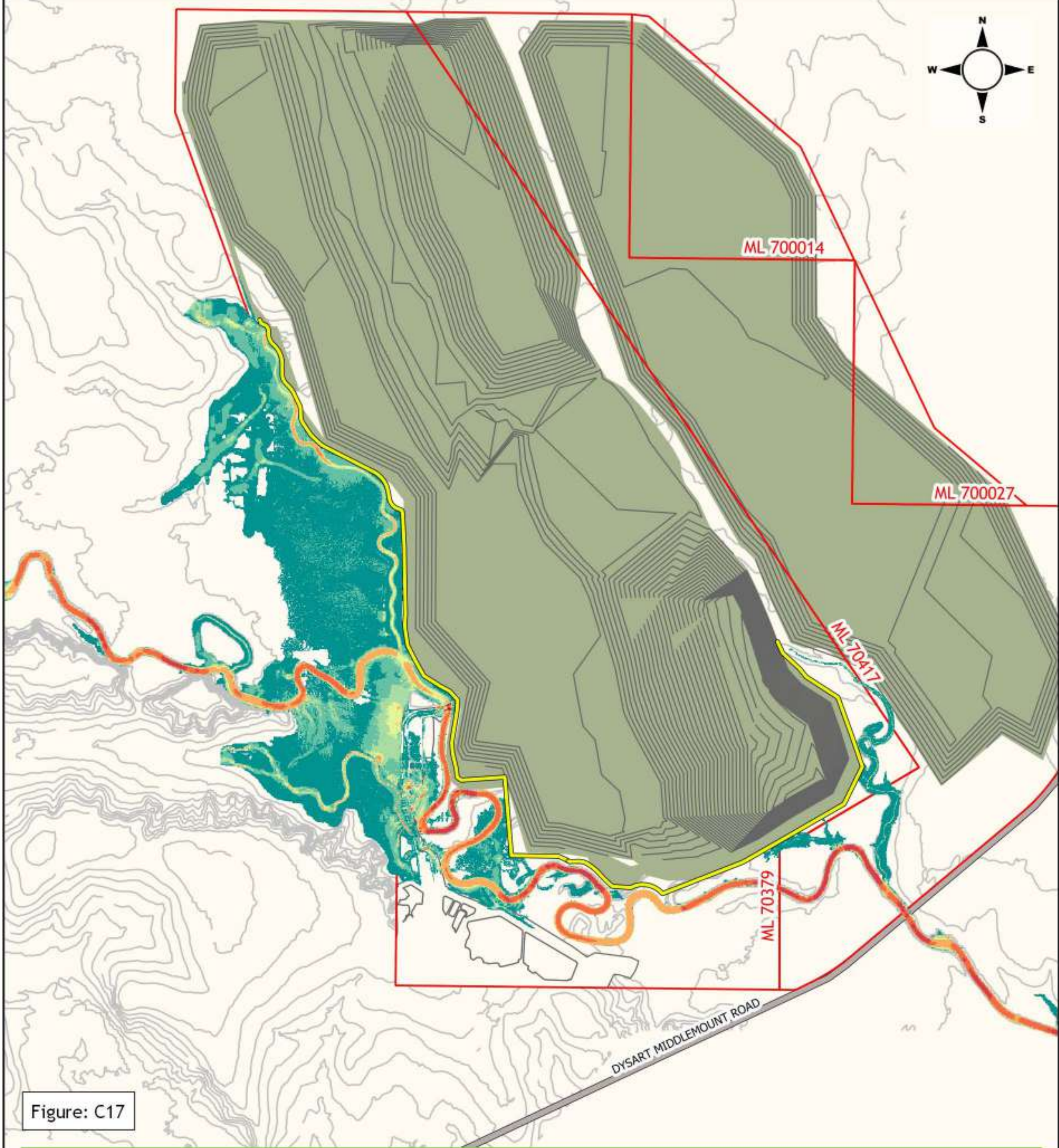


Figure: C17

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

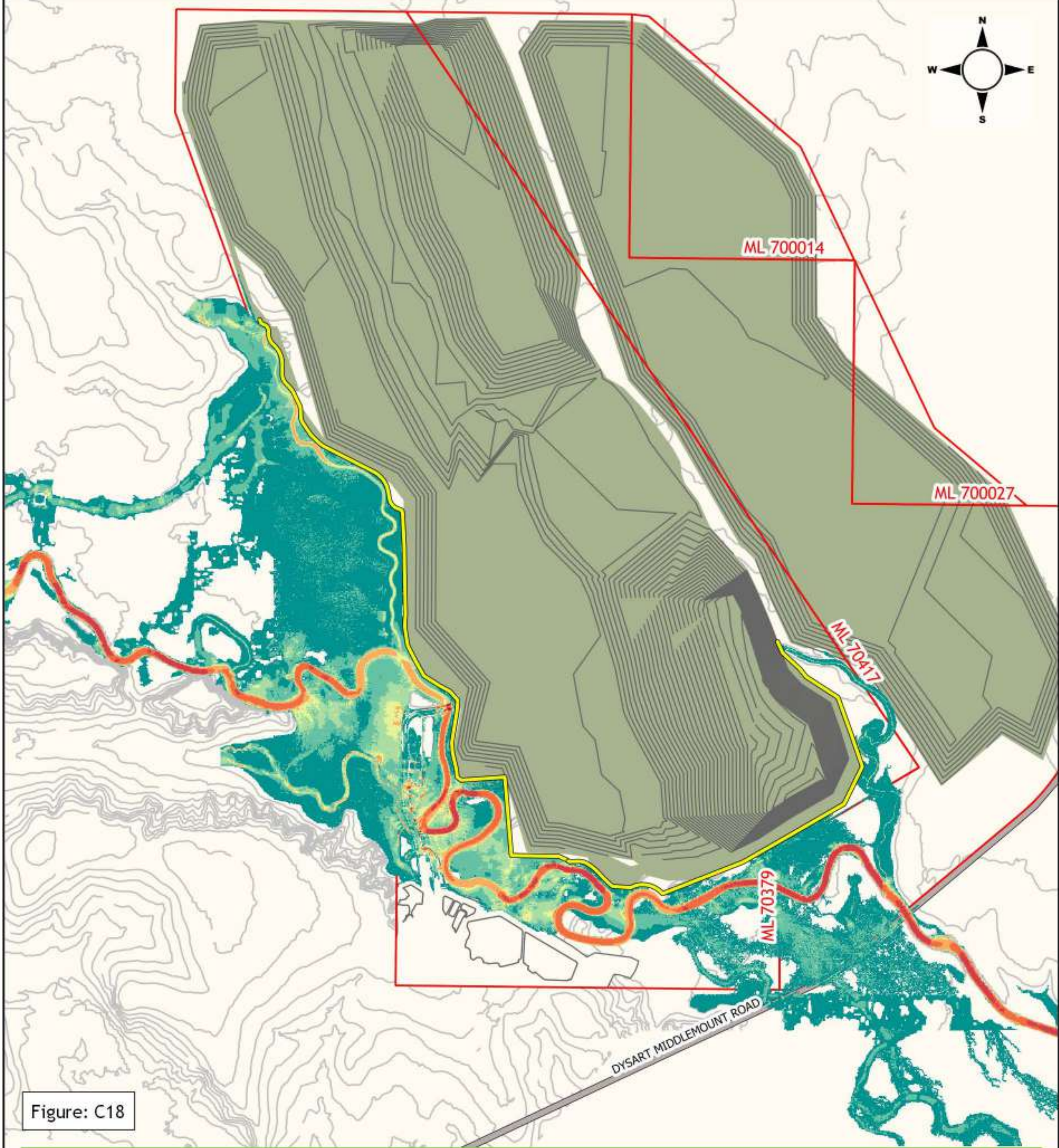
Middlemount Coal Mine Southern Extension Project

5% AEP Peak flood velocities : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

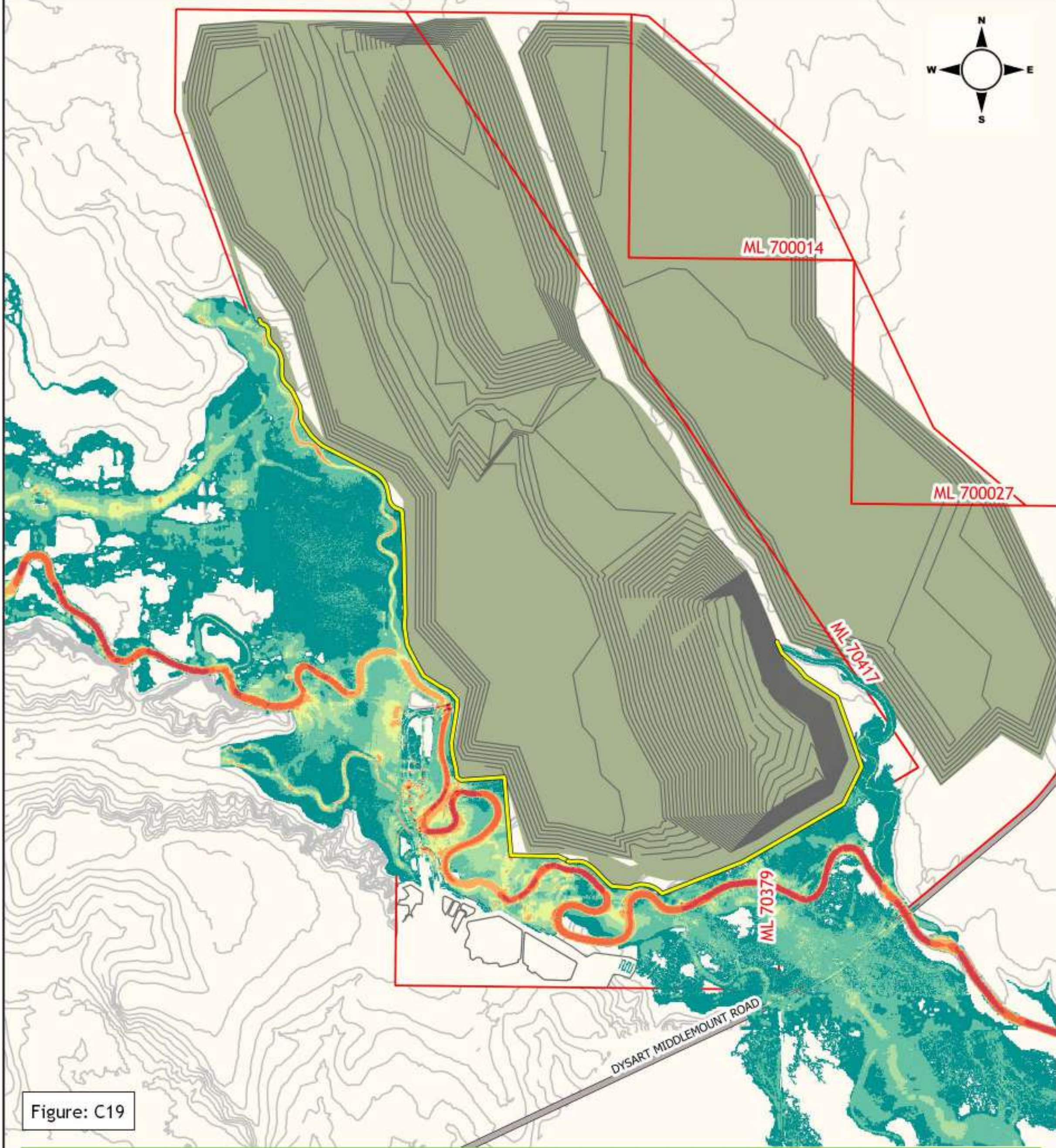
Middlemount Coal Mine Southern Extension Project

2% AEP Peak flood velocities : approved mining conditions

0 0.5 1 1.5 2 km

wrm water+environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

1% AEP Peak flood velocities : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

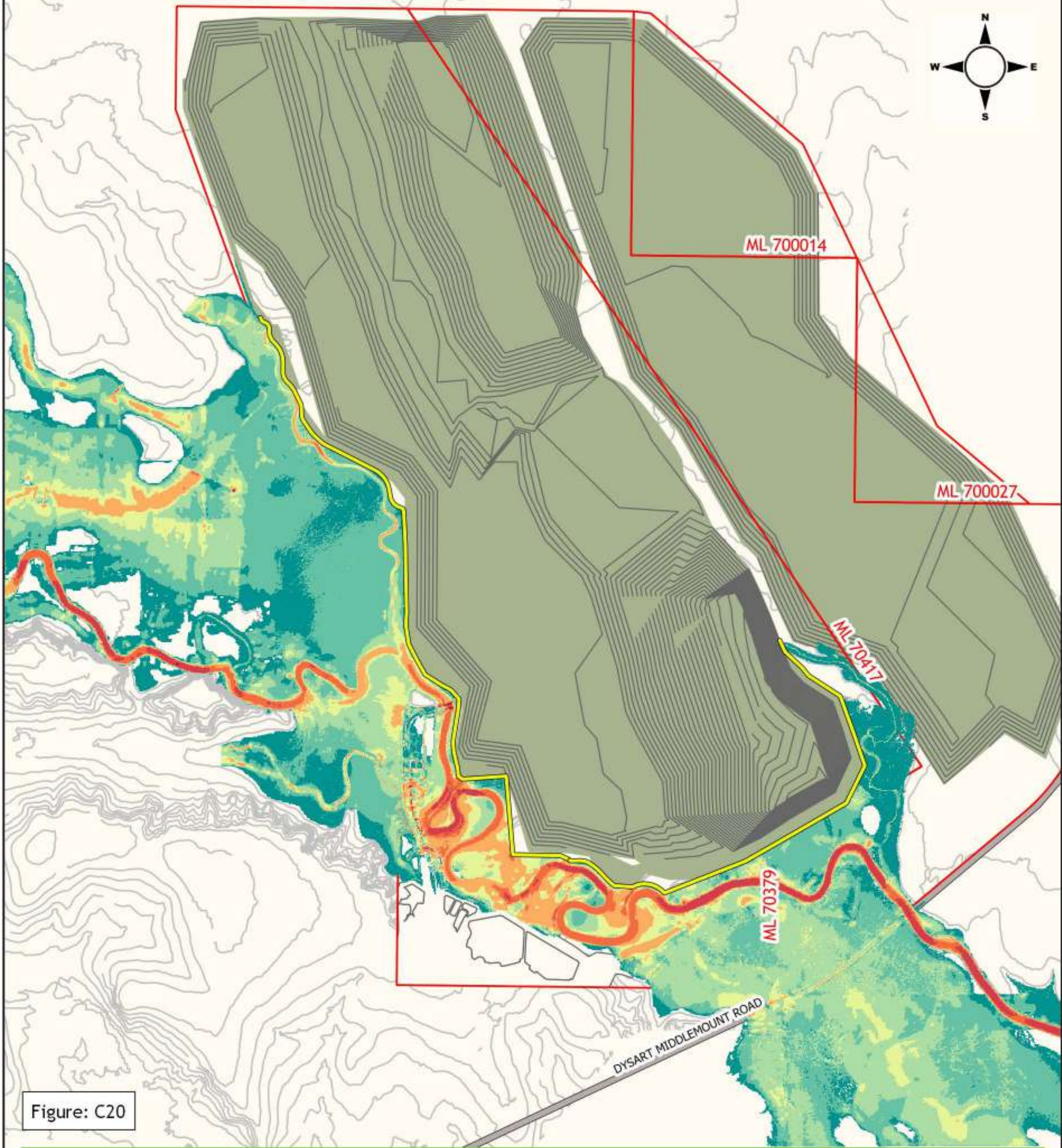


Figure: C20

Projection: MGA Zone 55 Datum: GDA 94

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood velocities : approved mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

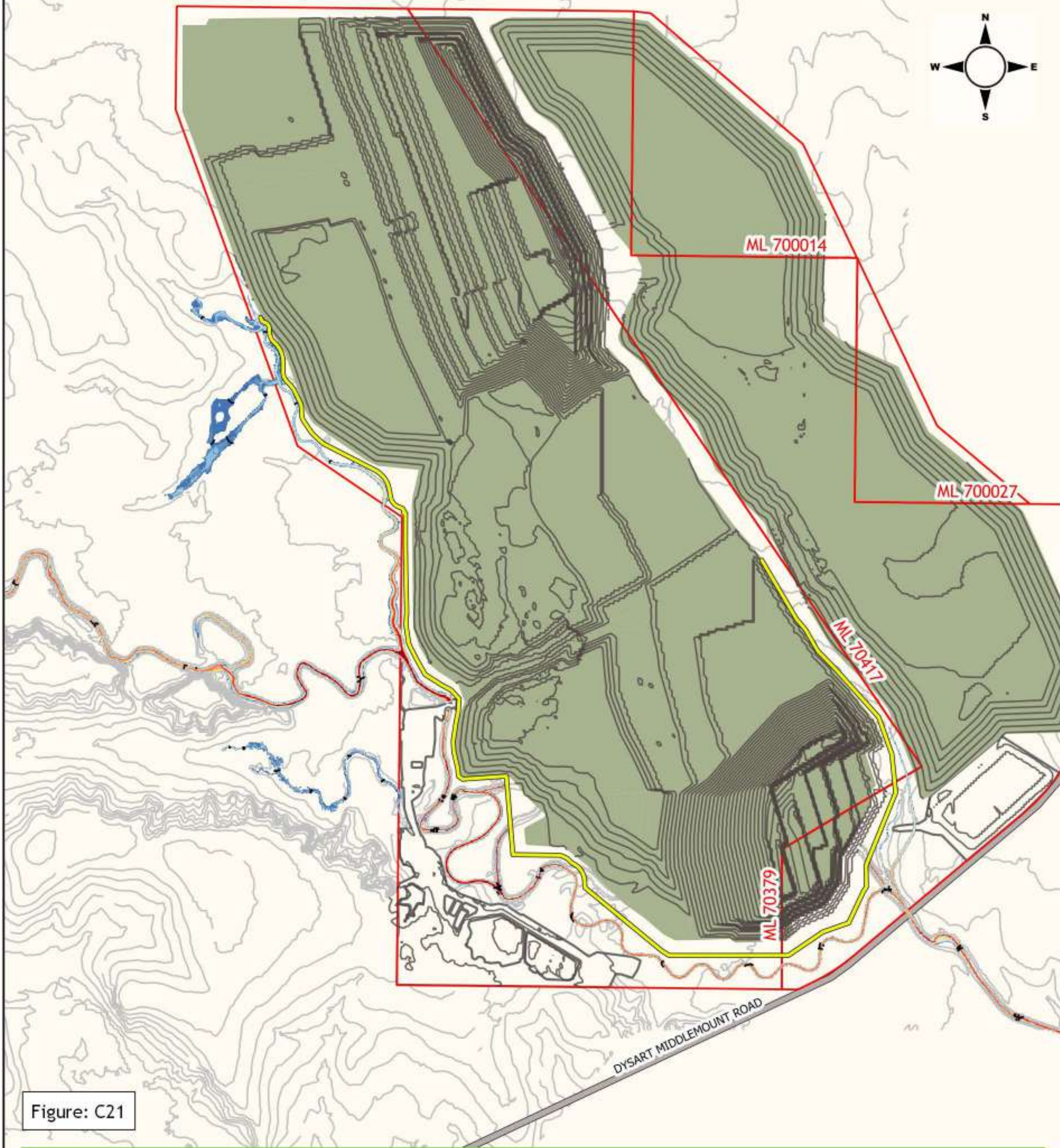


Figure: C21

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

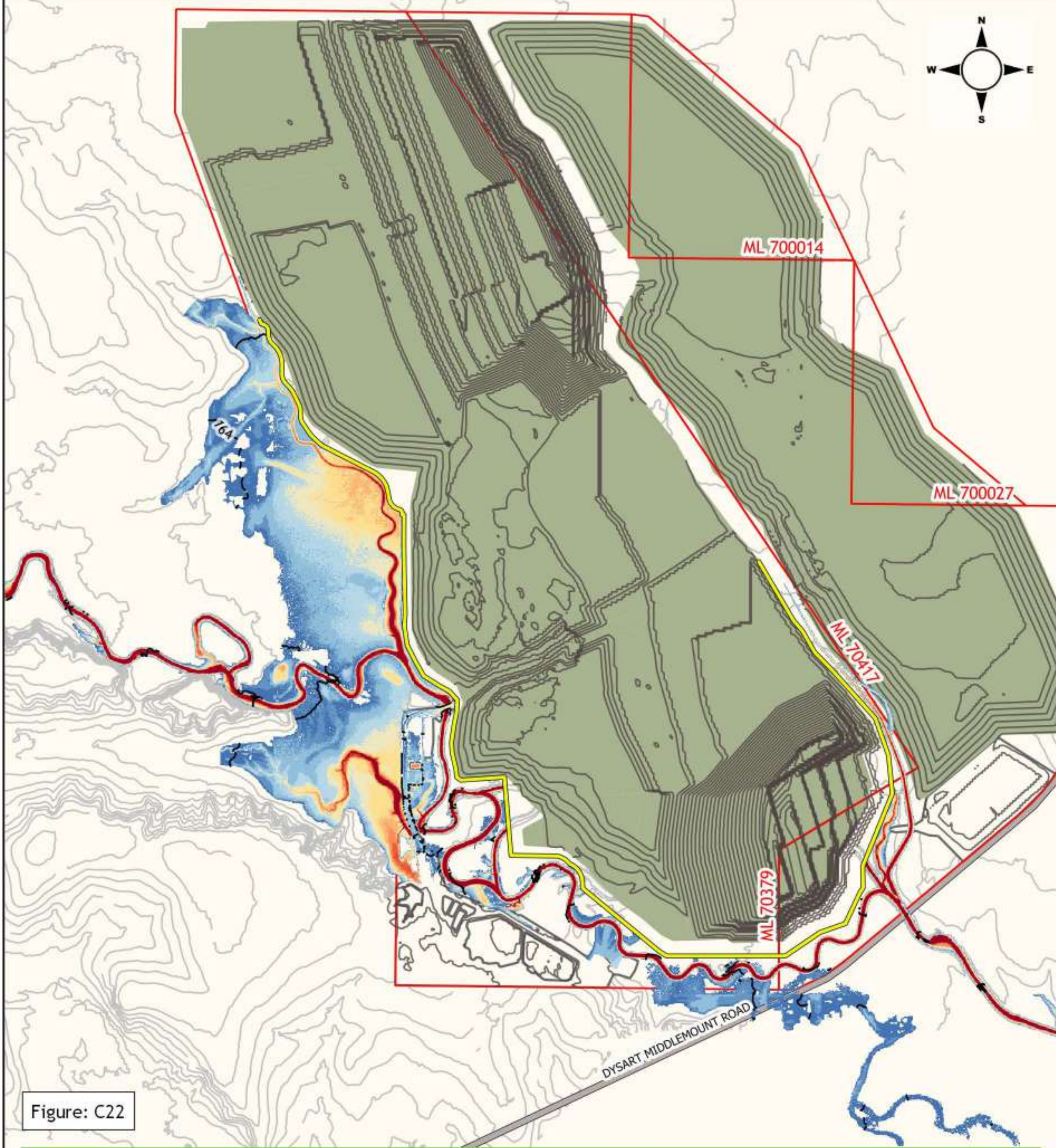
Middlemount Coal Mine Southern Extension Project

50% AEP Peak flood level, depth and extents : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

5% AEP Peak flood level, depth and extents : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

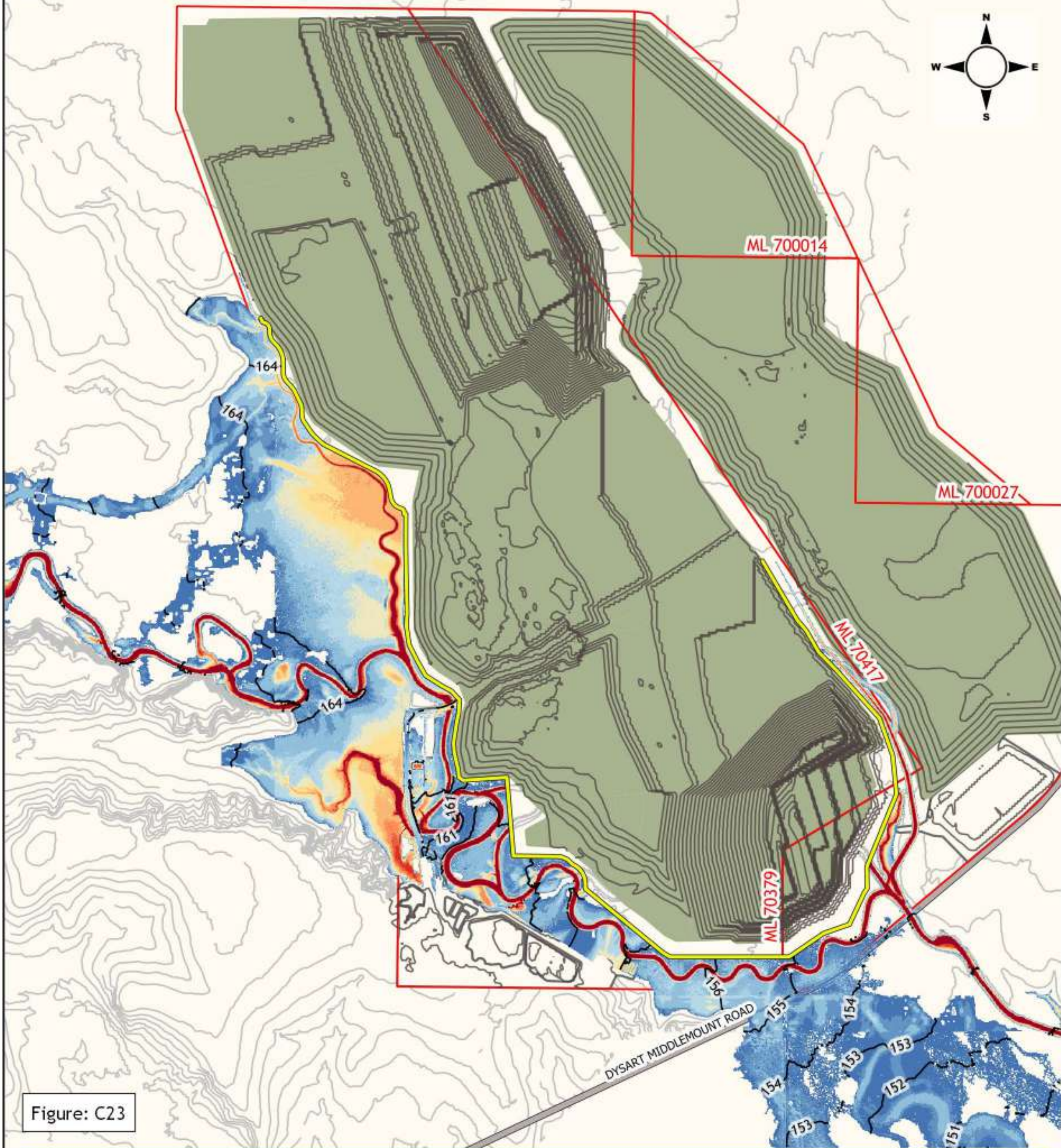


Figure: C23

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

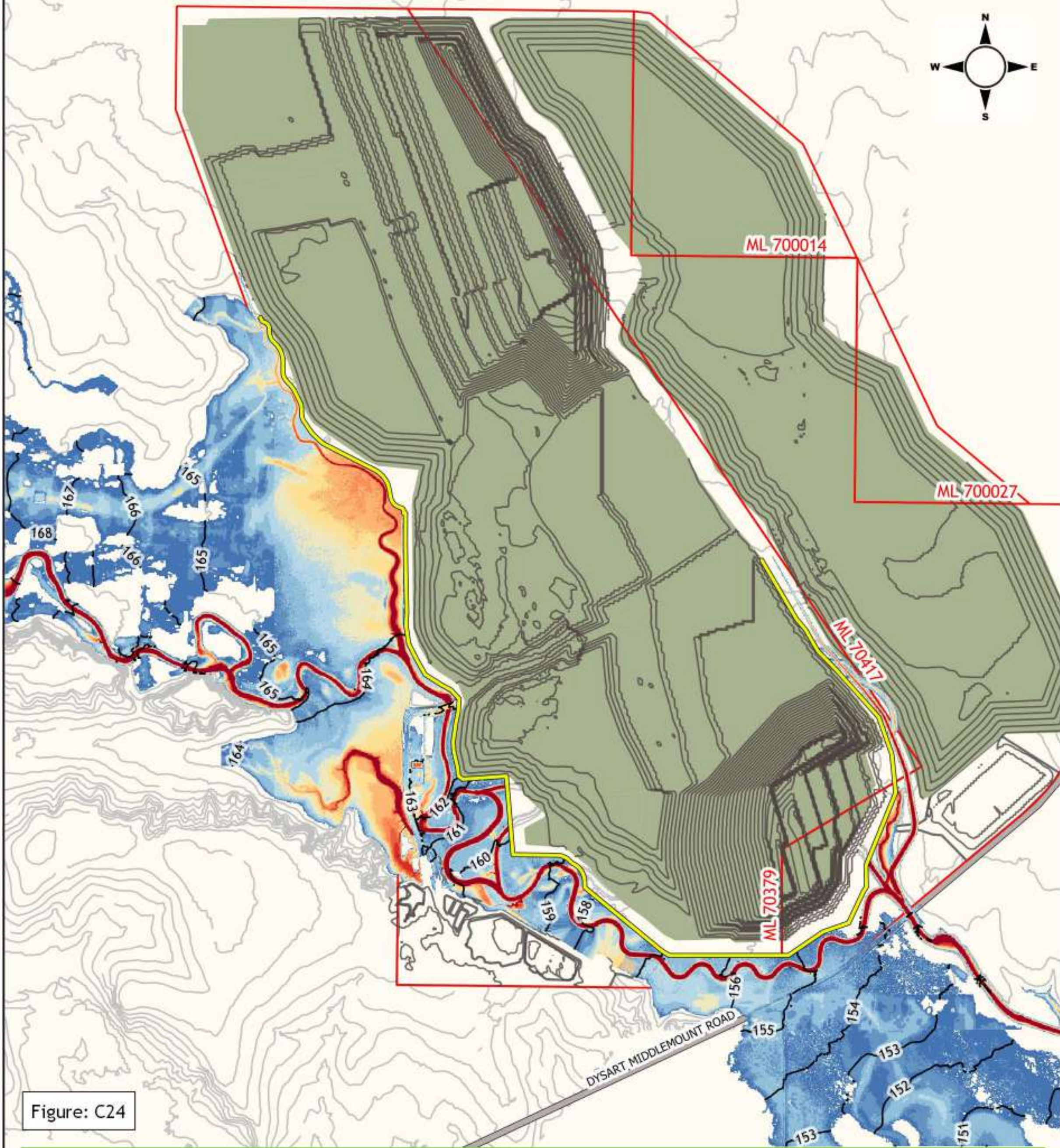
Middlemount Coal Mine Southern Extension Project

2% AEP Peak flood level, depth and extents : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

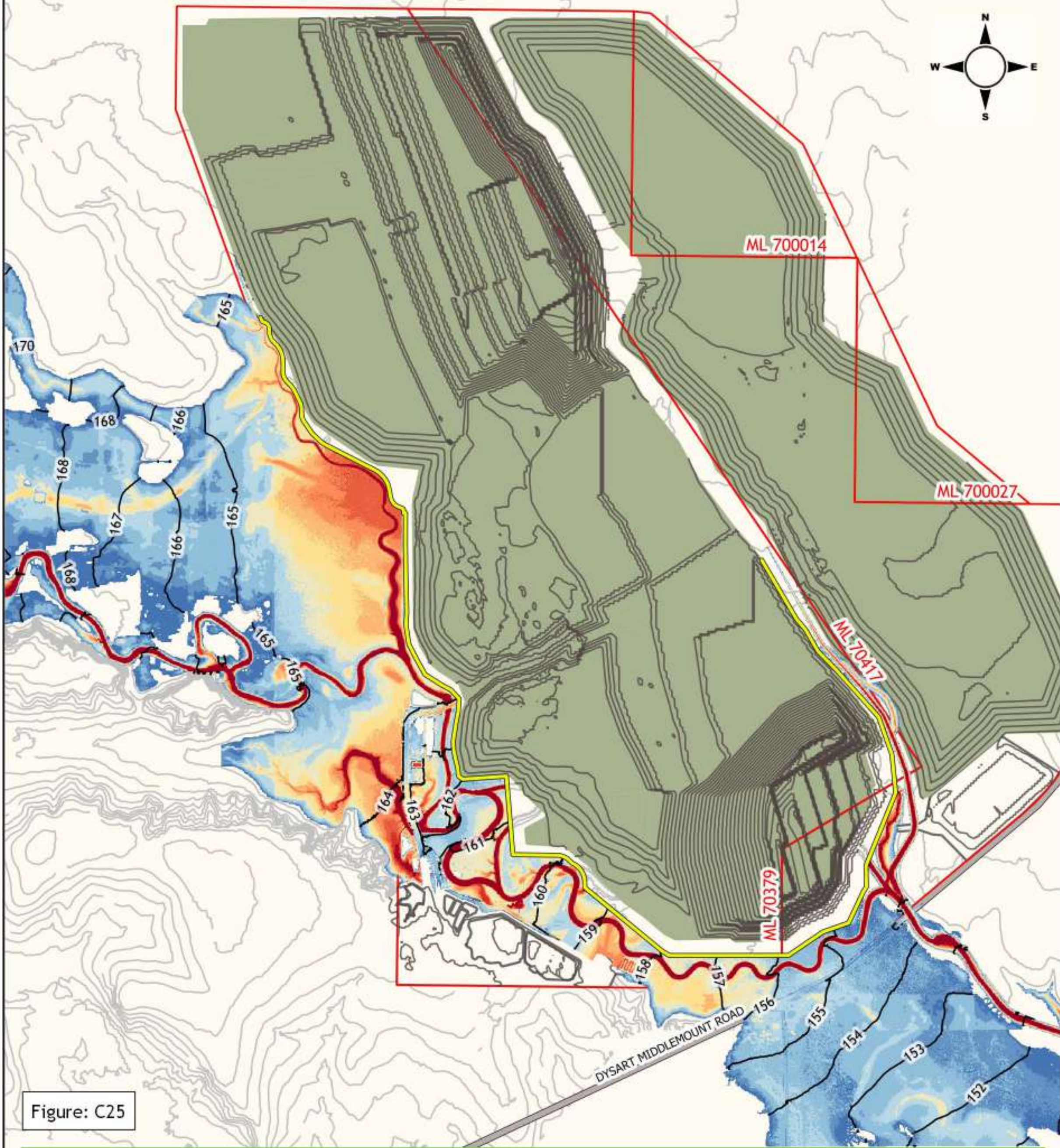
Middlemount Coal Mine Southern Extension Project

1% AEP Peak flood level, depth and extents : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

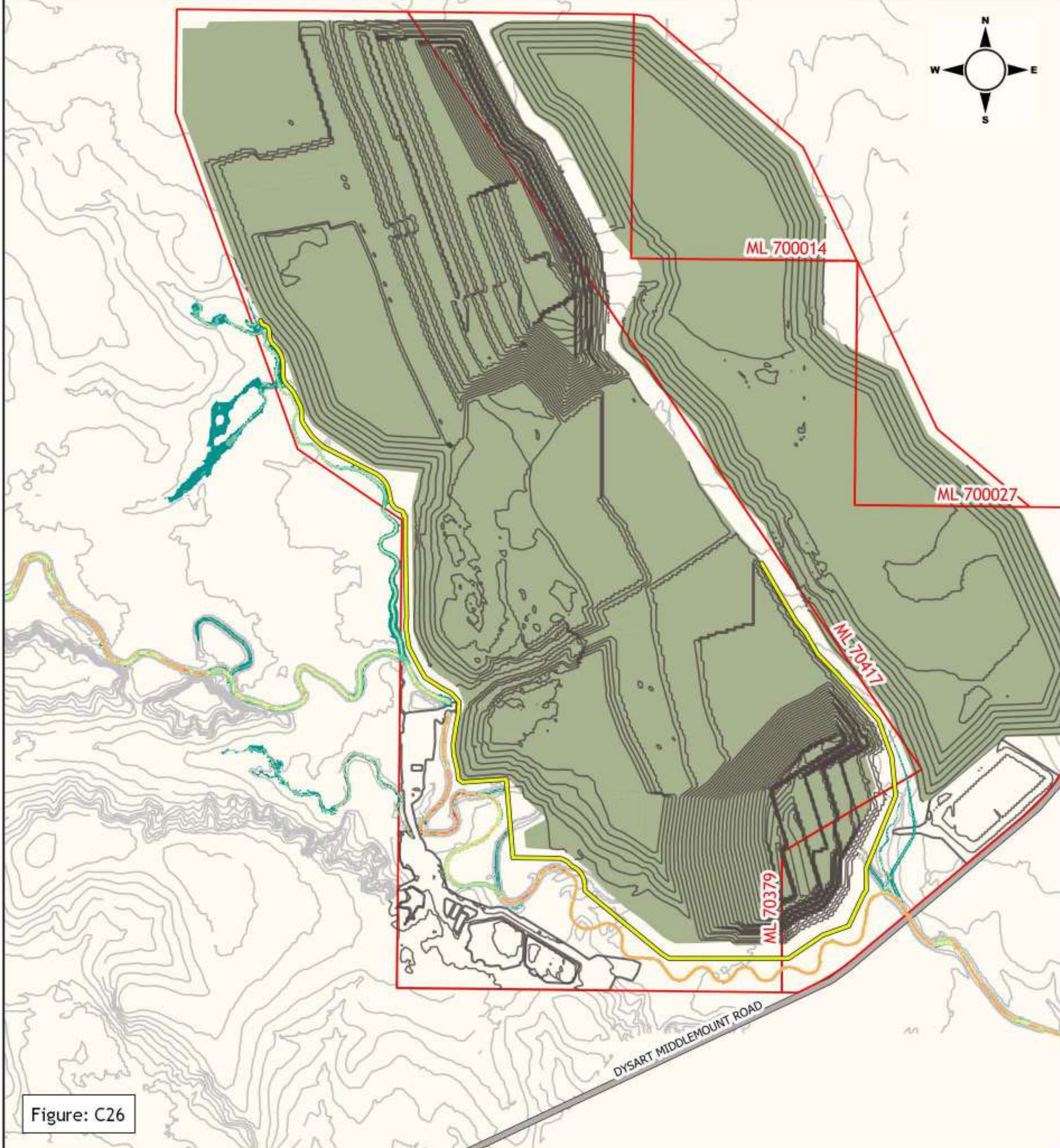
Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood level, depth and extents : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

50% AEP Peak flood velocities : proposed mining conditions

0 0.5 1 1.5 2 km

Projection: MGA Zone 55 Datum: GDA 94

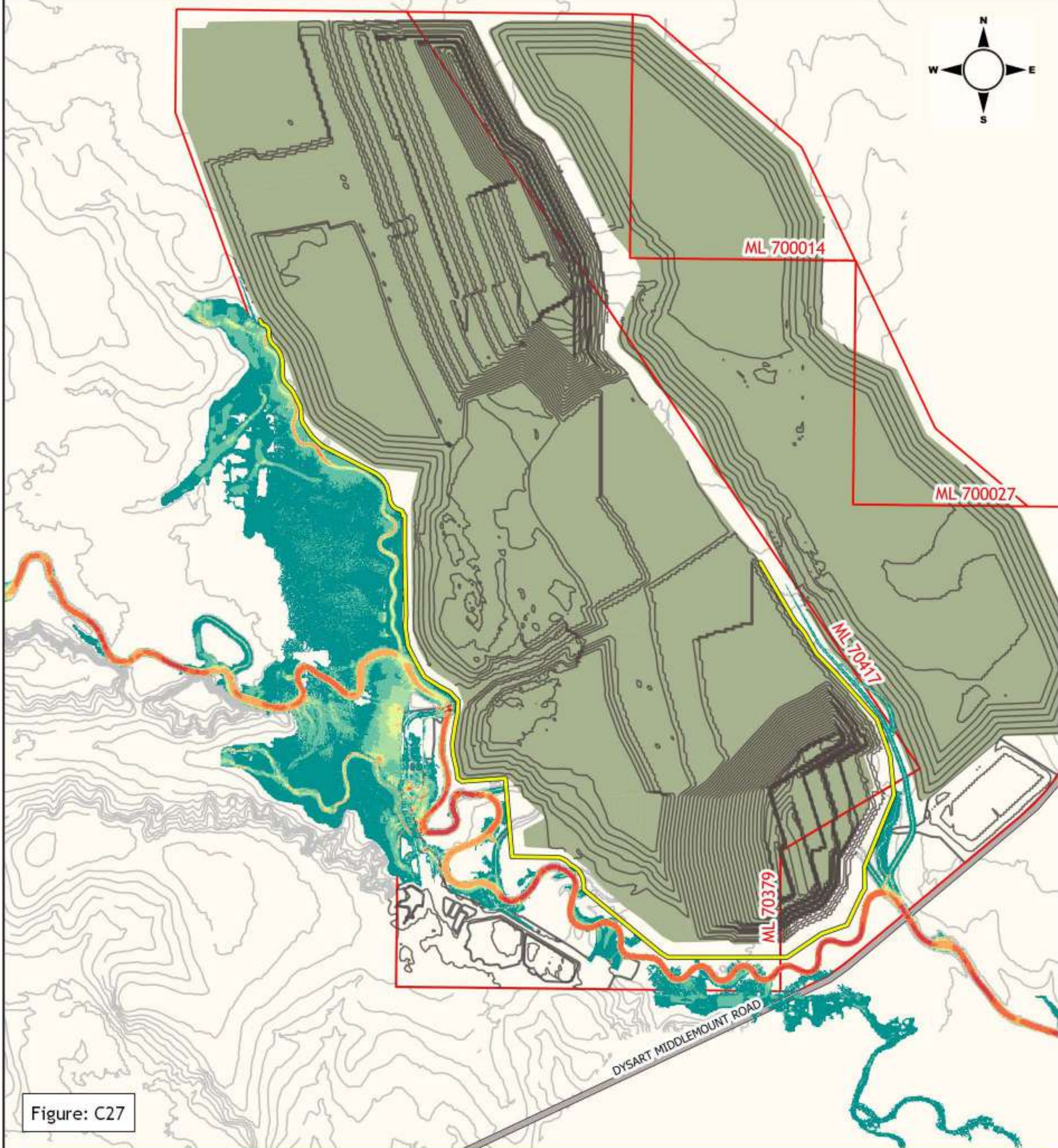


Figure: C27

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

5% AEP Peak flood velocities : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

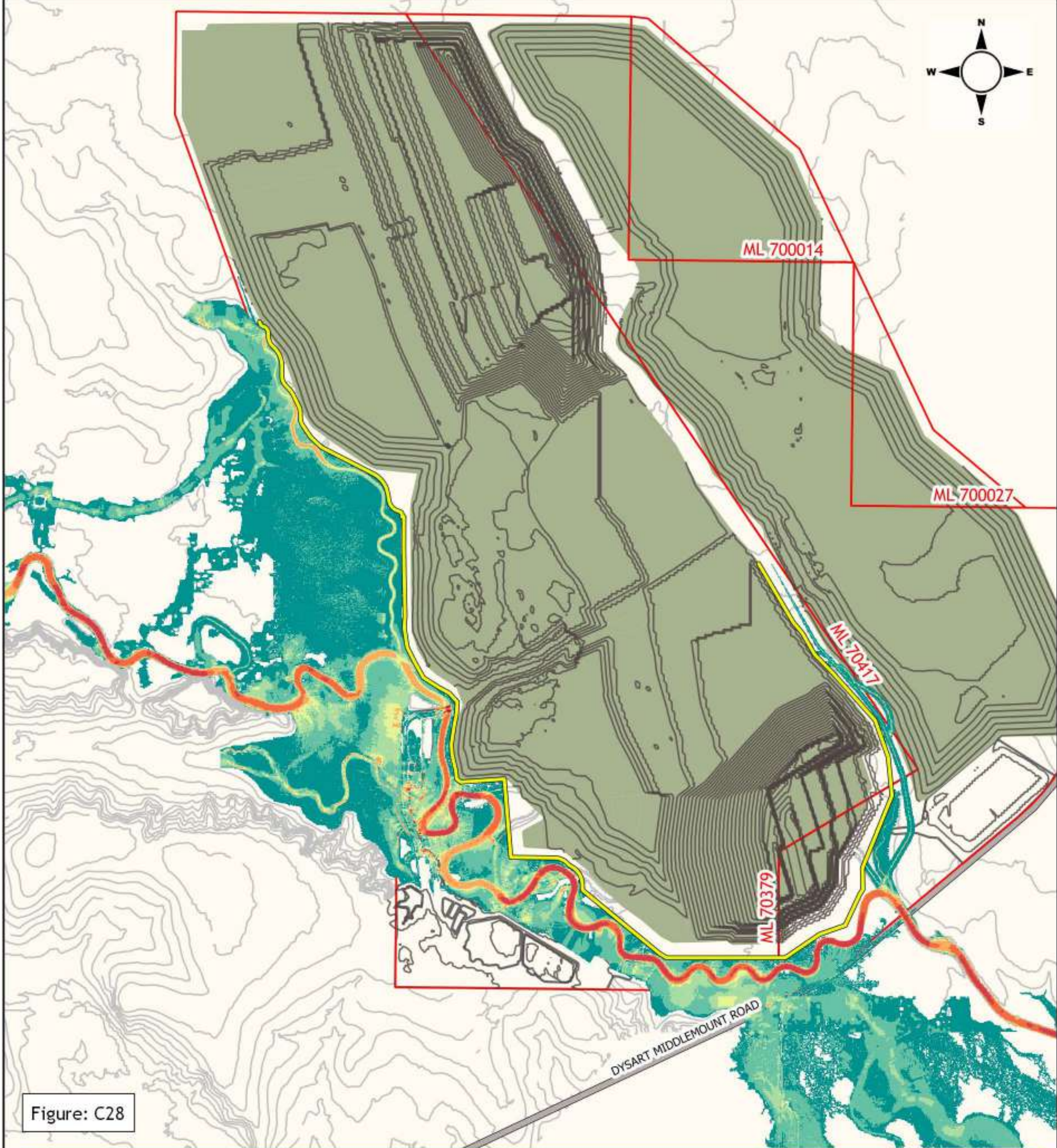


Figure: C28

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

2% AEP Peak flood velocities : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

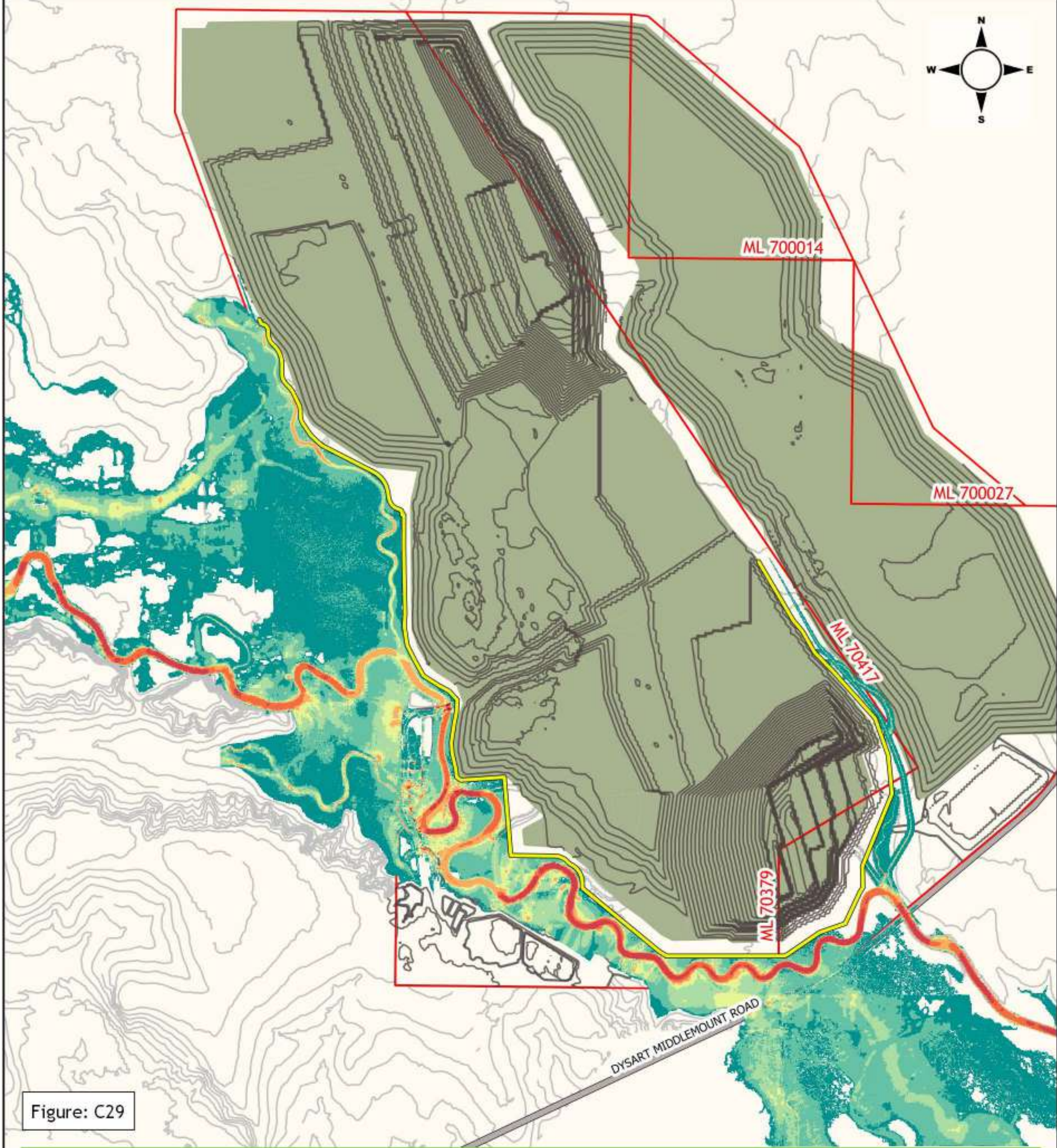


Figure: C29

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

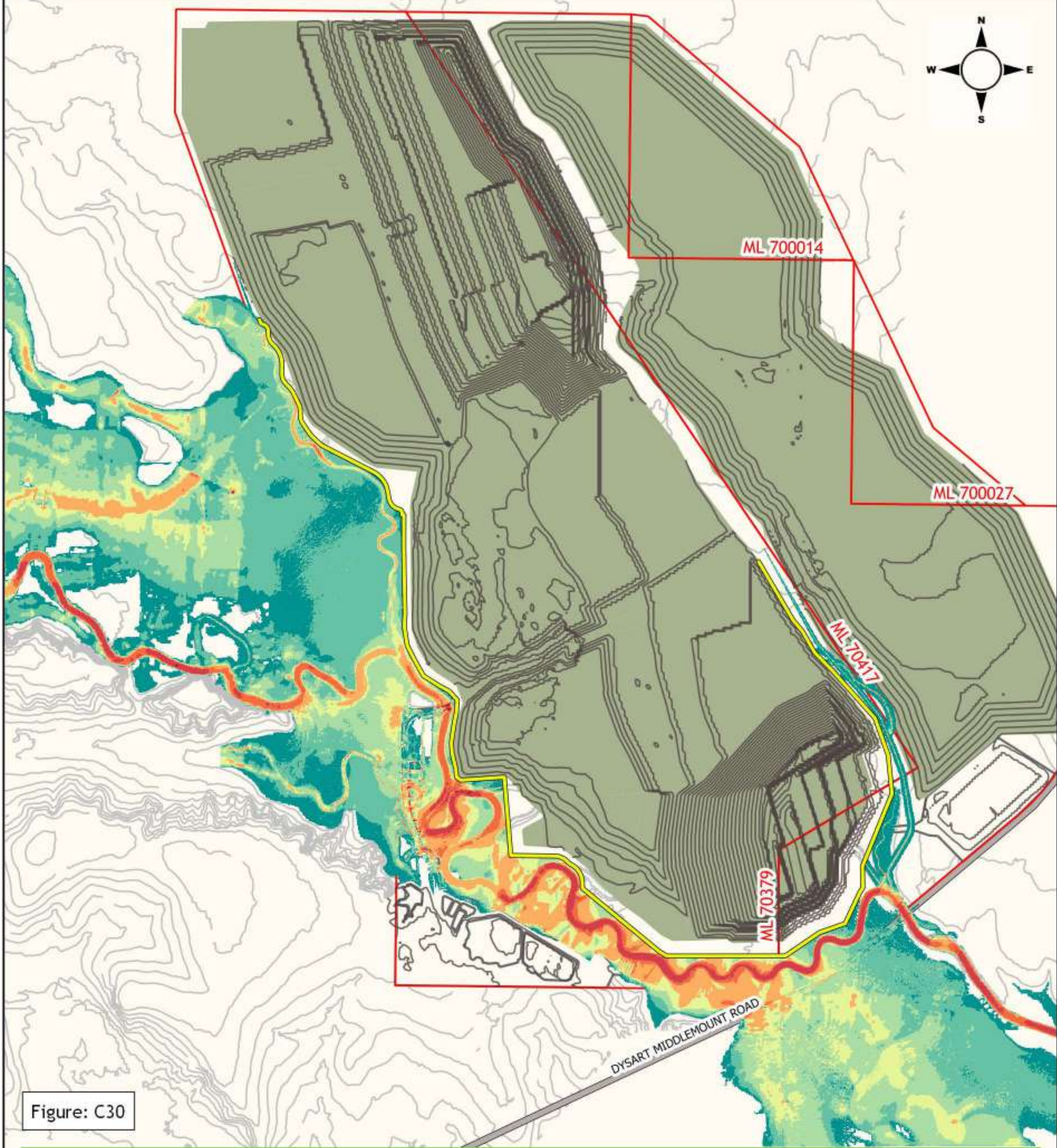
Middlemount Coal Mine Southern Extension Project

1% AEP Peak flood velocities : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

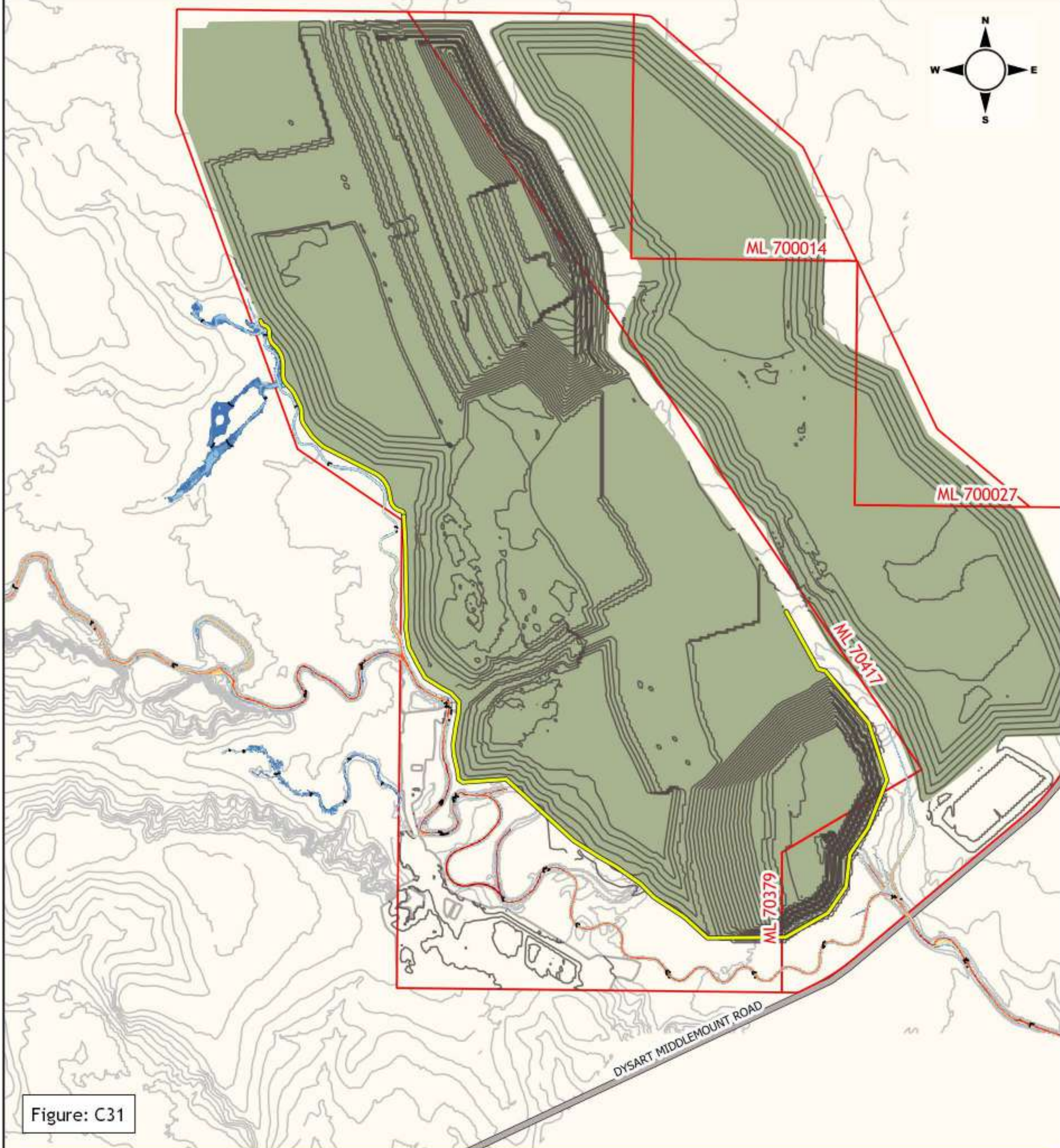
Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood velocities : proposed mining conditions

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

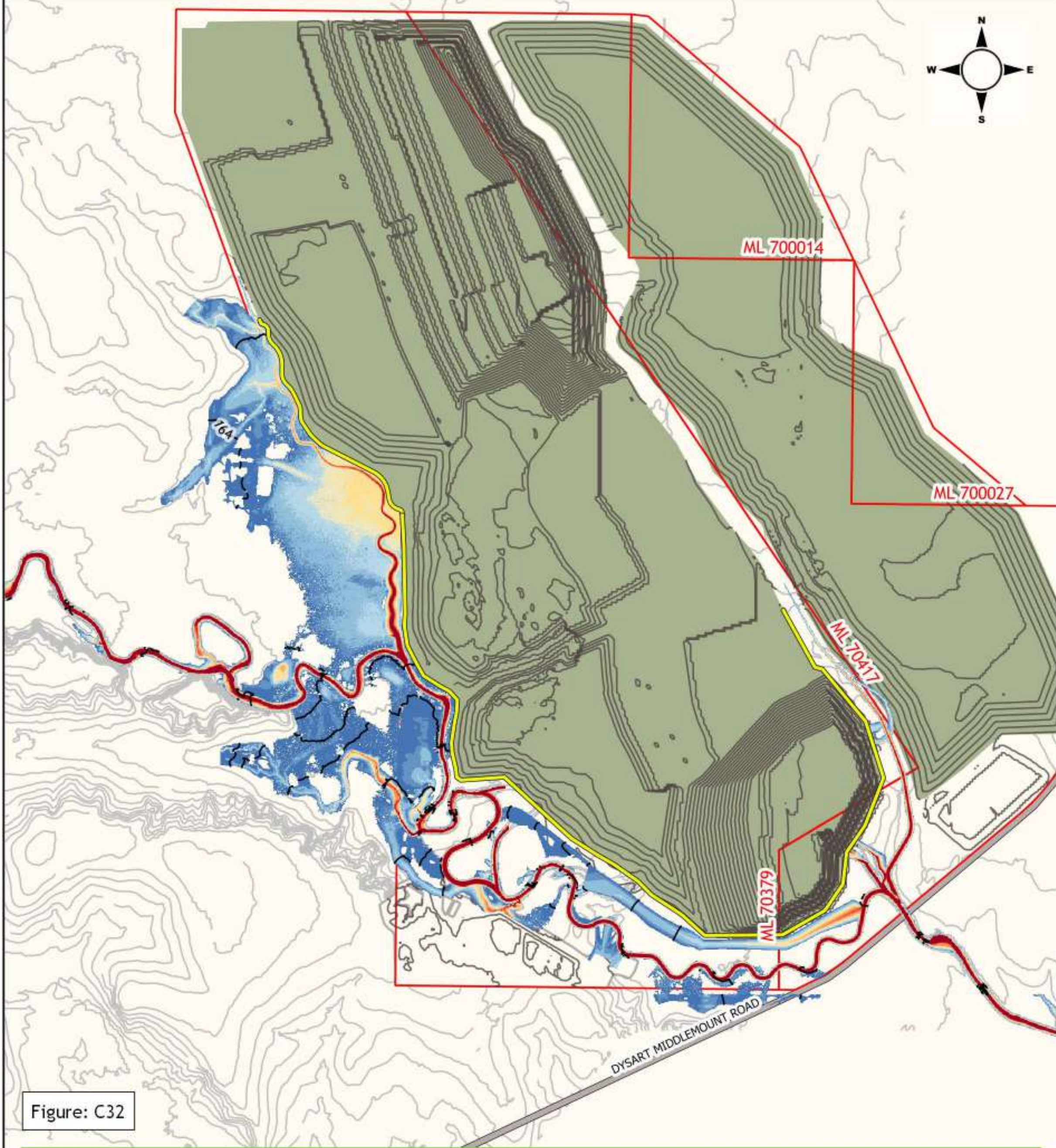
Middlemount Coal Mine Southern Extension Project

50% AEP Peak flood level, depth and extents : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

5% AEP Peak flood level, depth and extents : final landform

0 0.5 1 1.5 2 km

Projection: MGA Zone 55 Datum: GDA 94

wrm water + environment

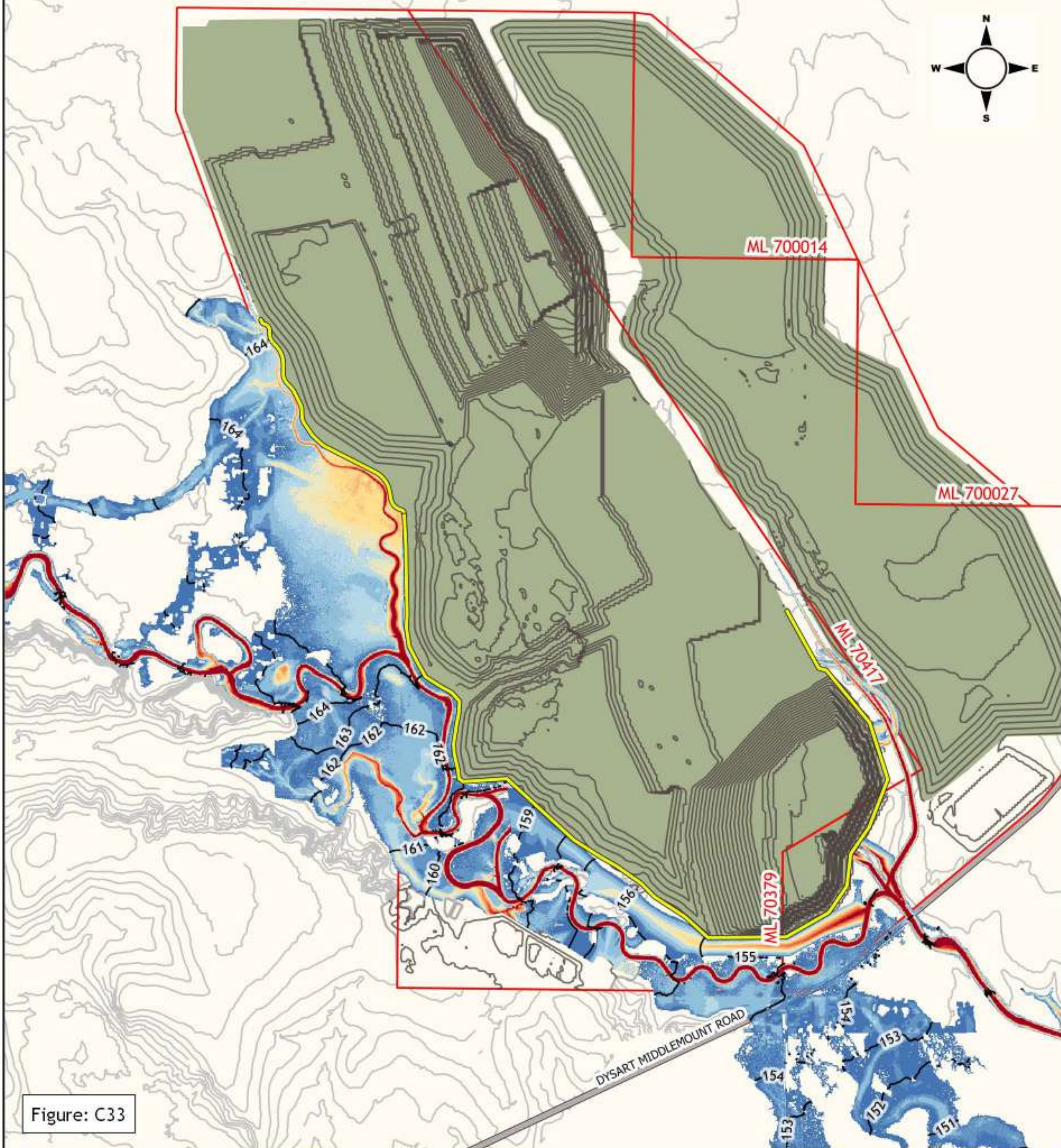


Figure: C33

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

2% AEP Peak flood level, depth and extents : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

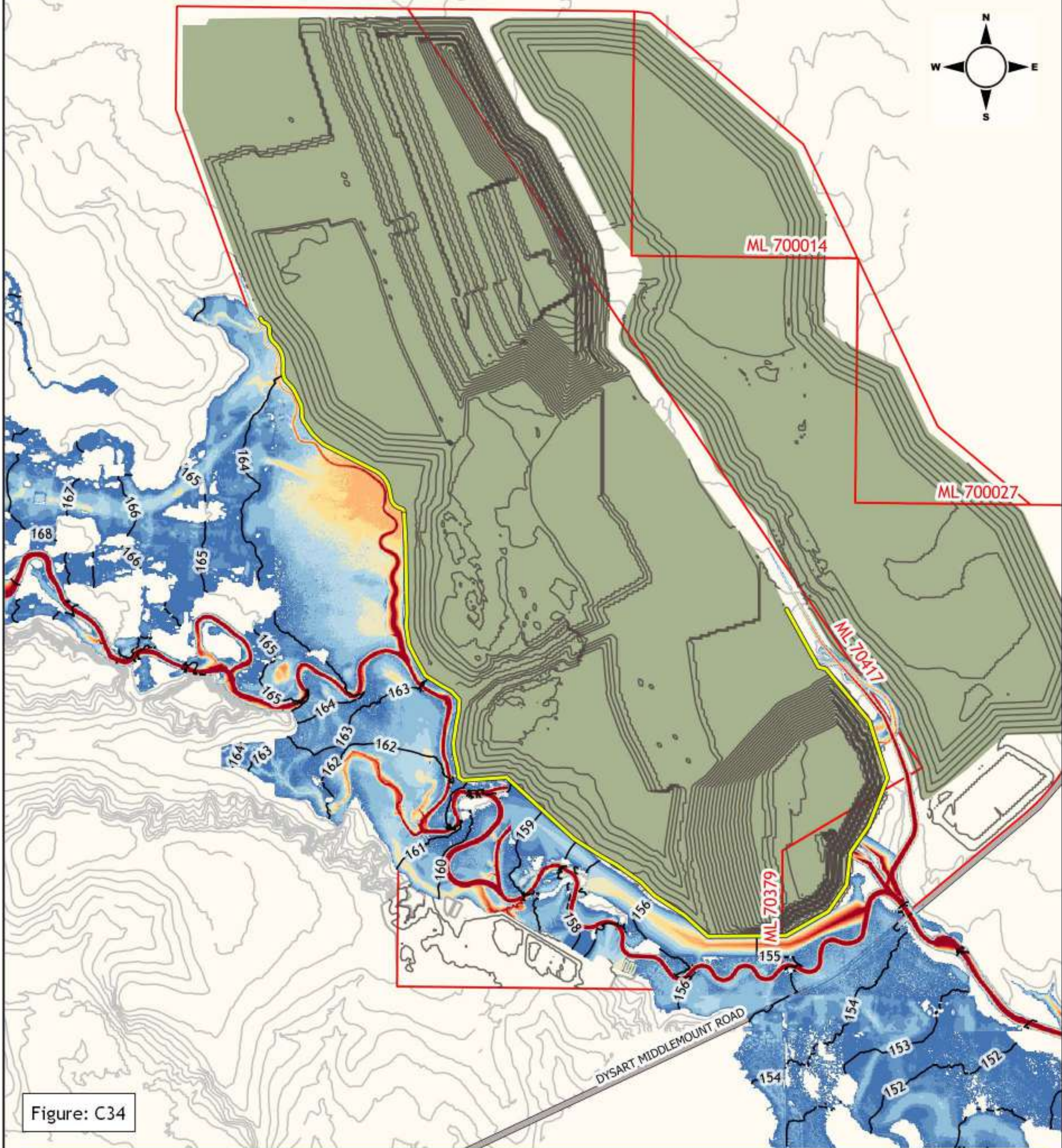


Figure: C34

Projection: MGA Zone 55 Datum: GDA 94

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

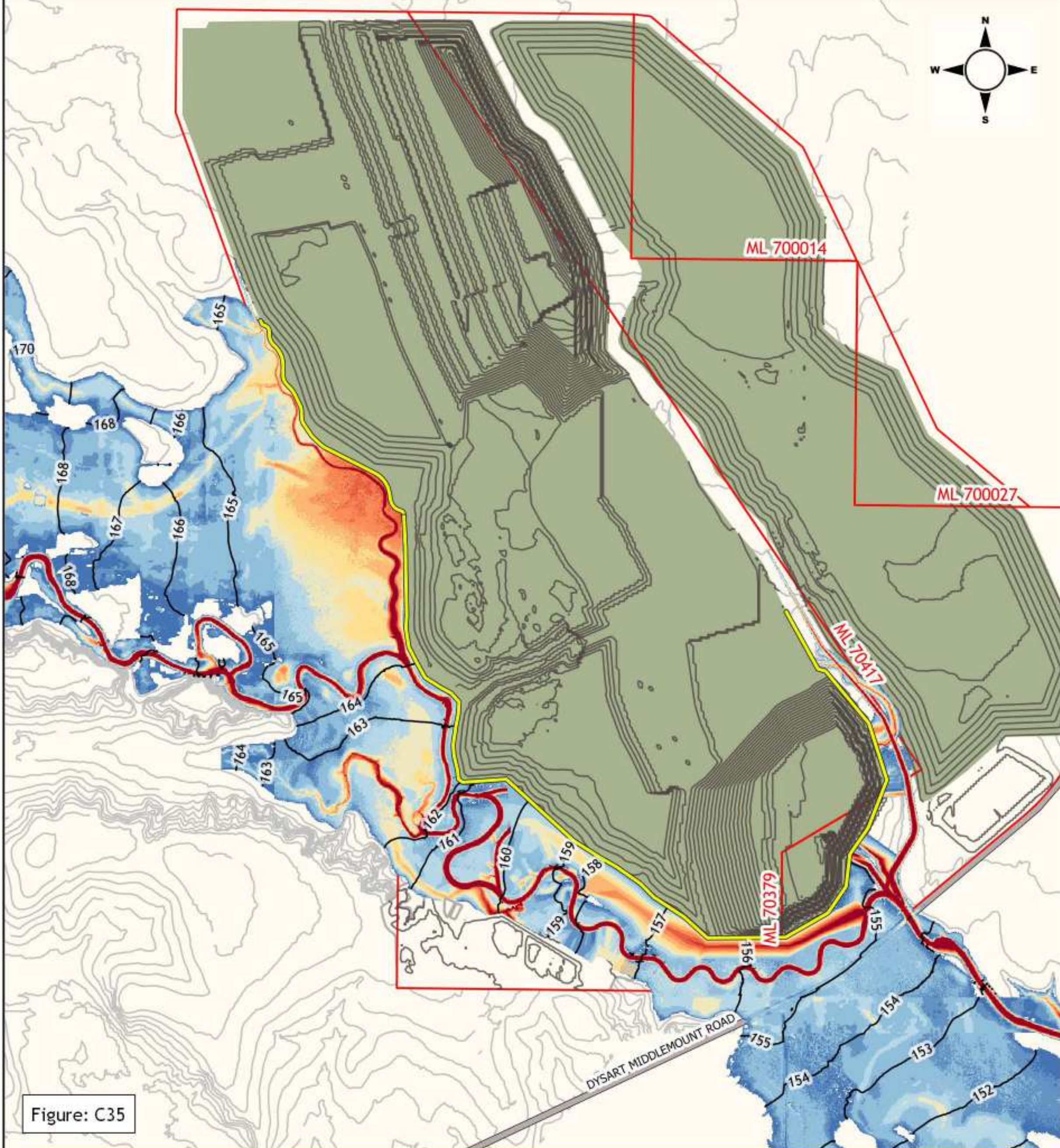
- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

1% AEP Peak flood level, depth and extents : final landform

0 0.5 1 1.5 2 km

wrm water + environment



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood level, depth and extents : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

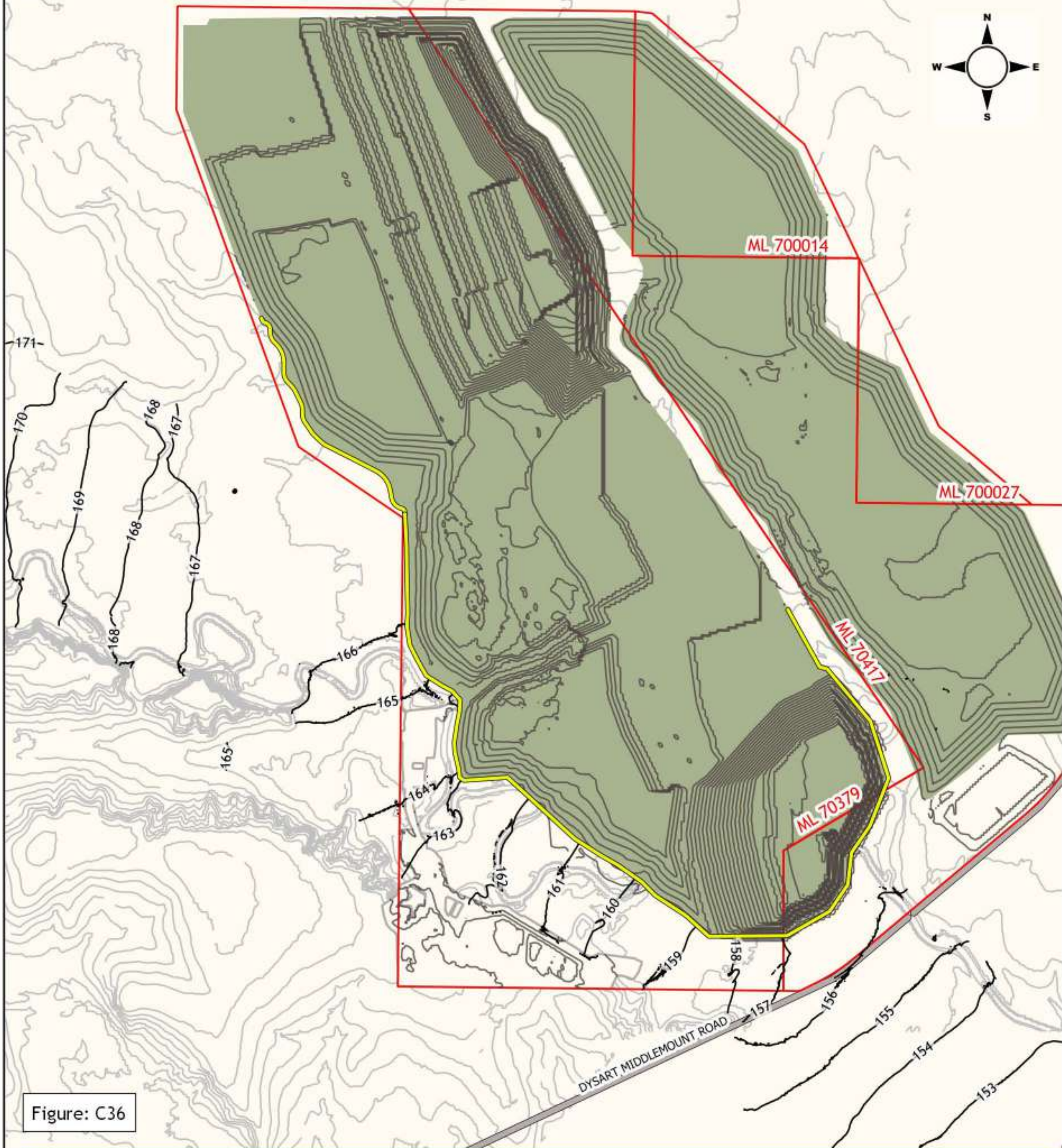


Figure: C36

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Water surface elevation contour (mAHD)
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood depth (m)

- up to 0.25m
- 0.25 to 0.5m
- 0.5 to 1.0m
- 1.0 to 1.5m
- 1.5 to 2.0m
- 2.0 to 2.5m
- 2.5 to 3.0m
- 3.0 to 3.5m
- 3.5 to 4.0m
- 4.0 to 4.5m
- > 4.5m

Middlemount Coal Mine Southern Extension Project

PMF Peak flood level, depth and extents : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

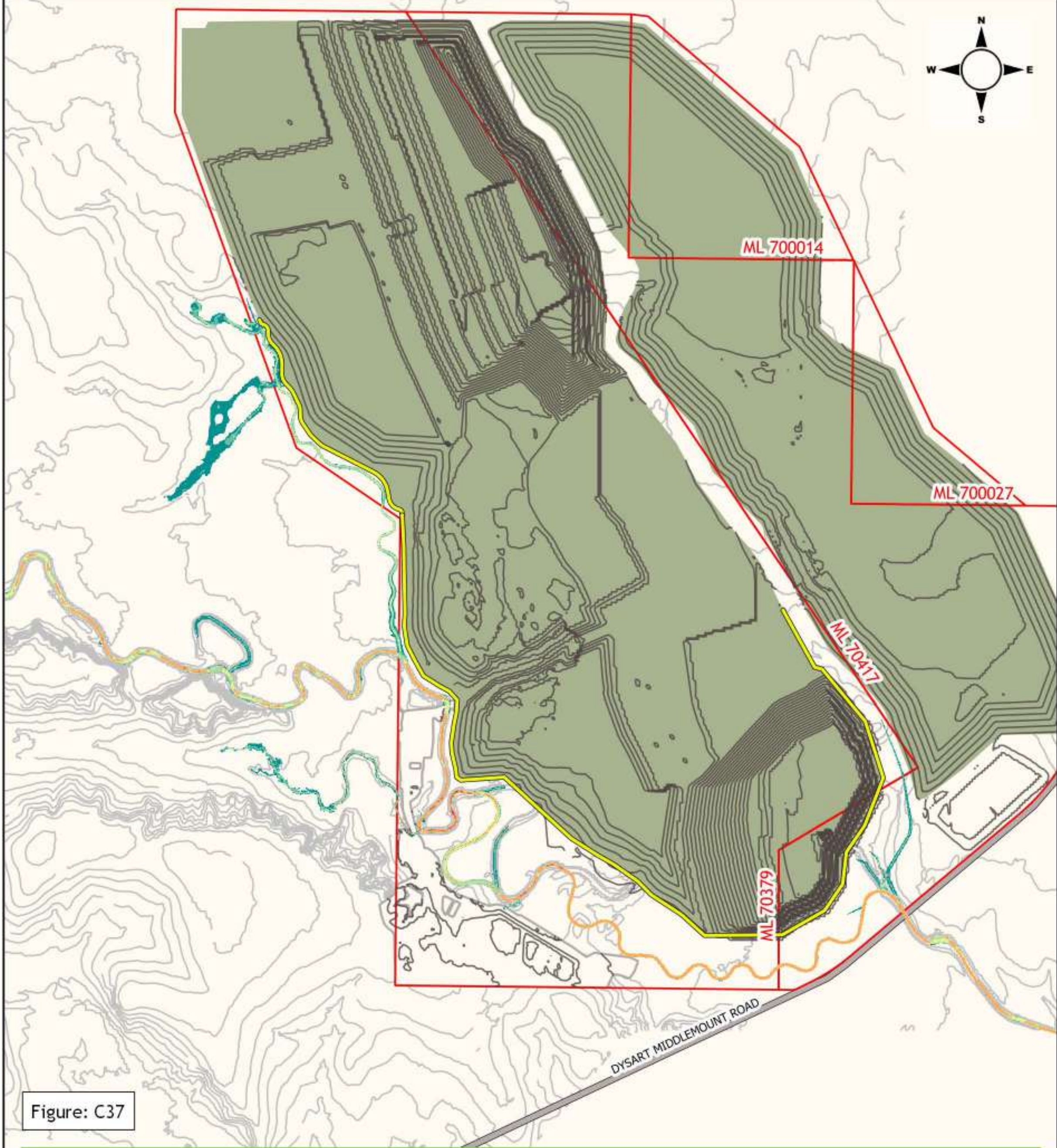


Figure: C37

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

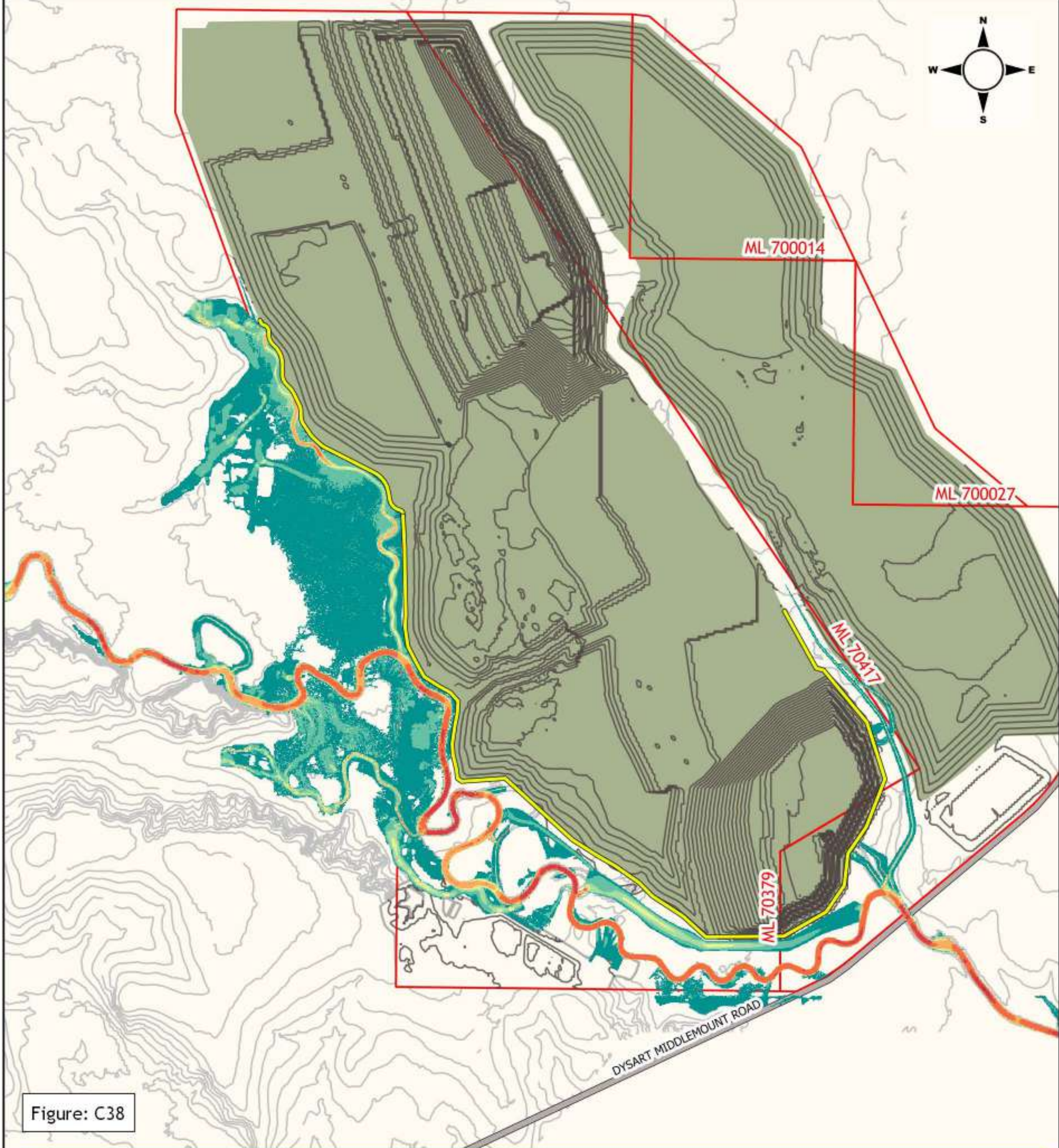
Middlemount Coal Mine Southern Extension Project

50% AEP Peak flood velocities : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

5% AEP Peak flood velocities : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

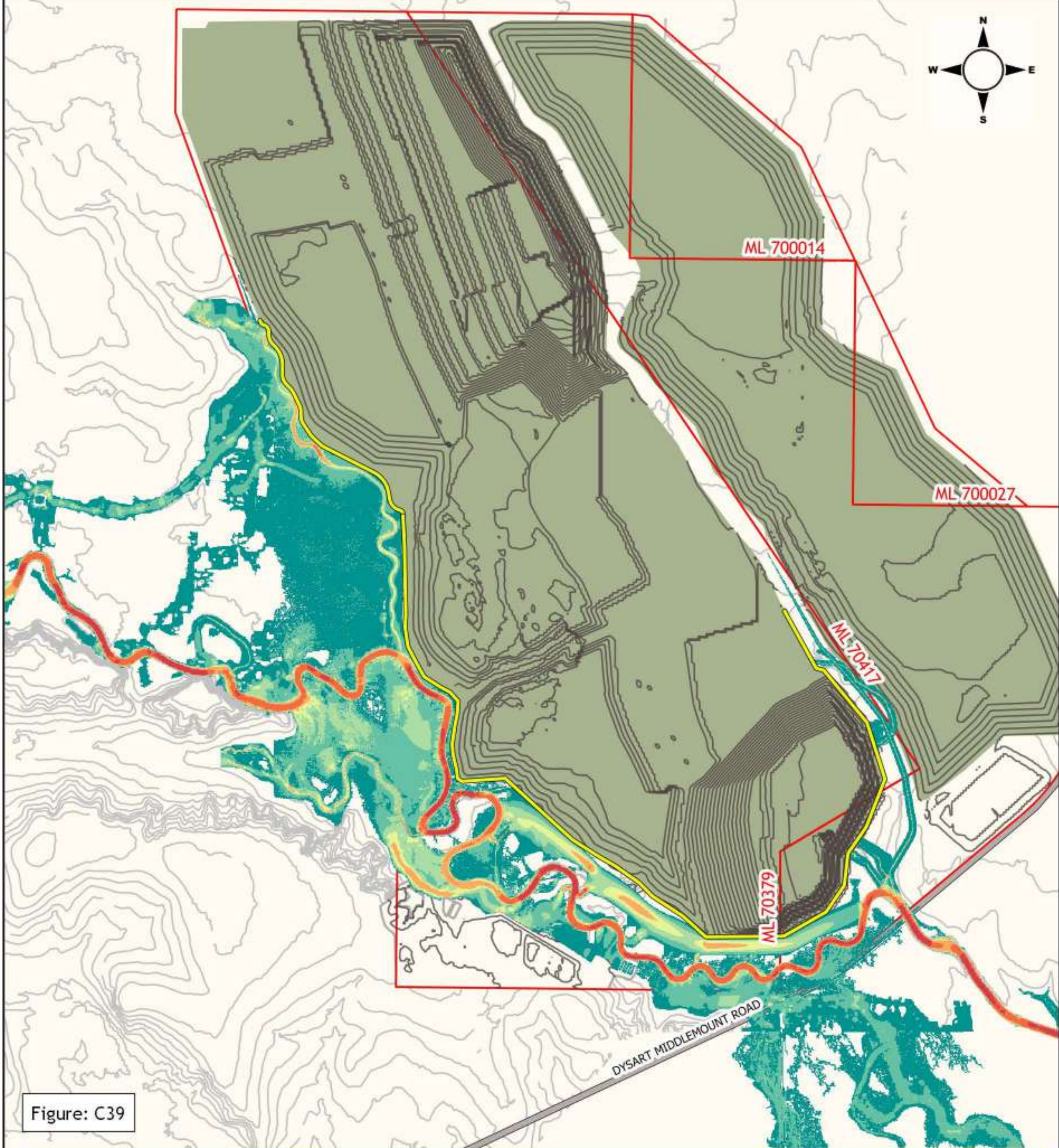


Figure: C39

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

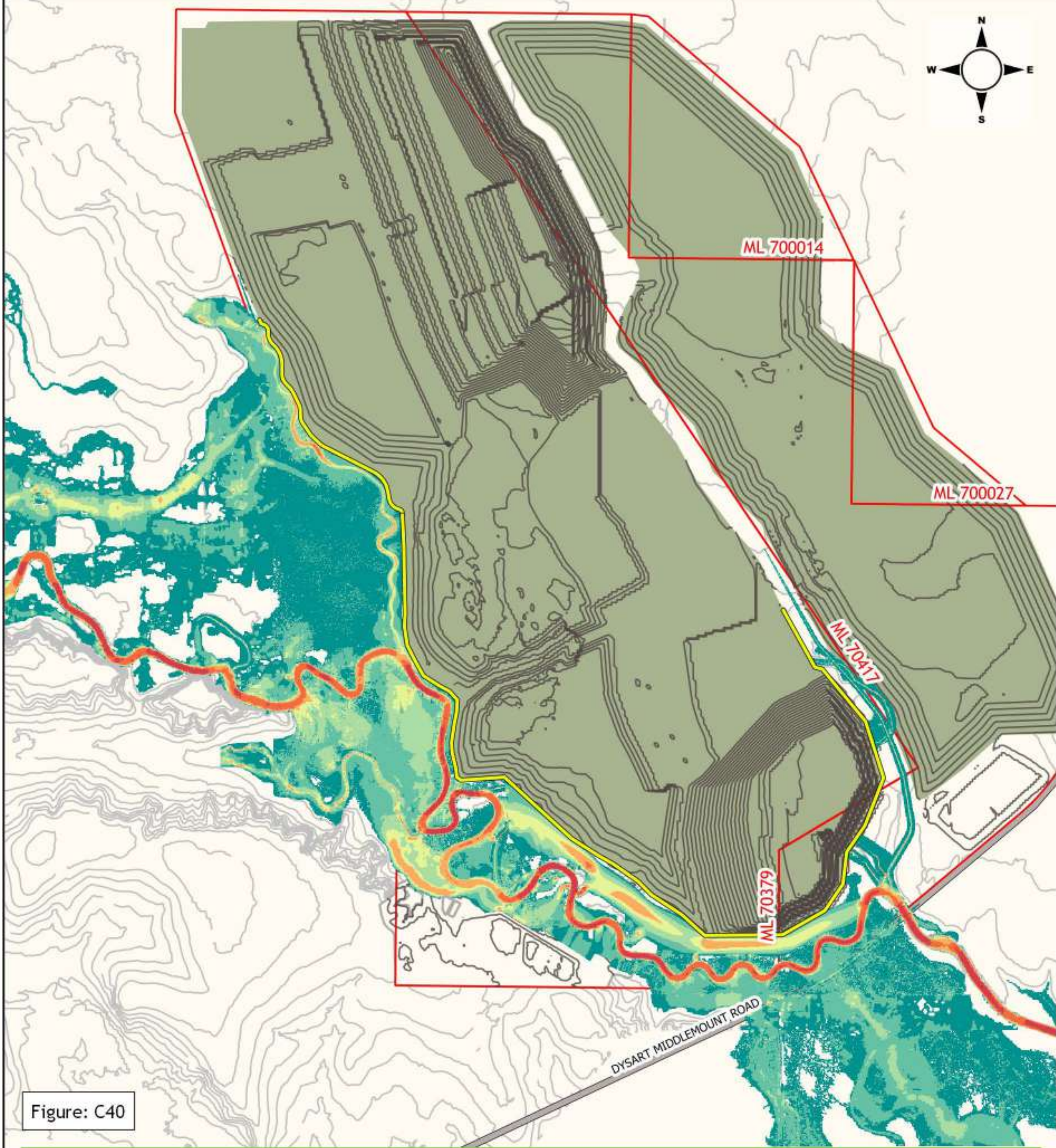
Middlemount Coal Mine Southern Extension Project

2% AEP Peak flood velocities : final landform

0 0.5 1 1.5 2 km

wrm water+environment

Projection: MGA Zone 55 Datum: GDA 94



Projection: MGA Zone 55 Datum: GDA 94

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

1% AEP Peak flood velocities : final landform

0 0.5 1 1.5 2 km

wrm water + environment

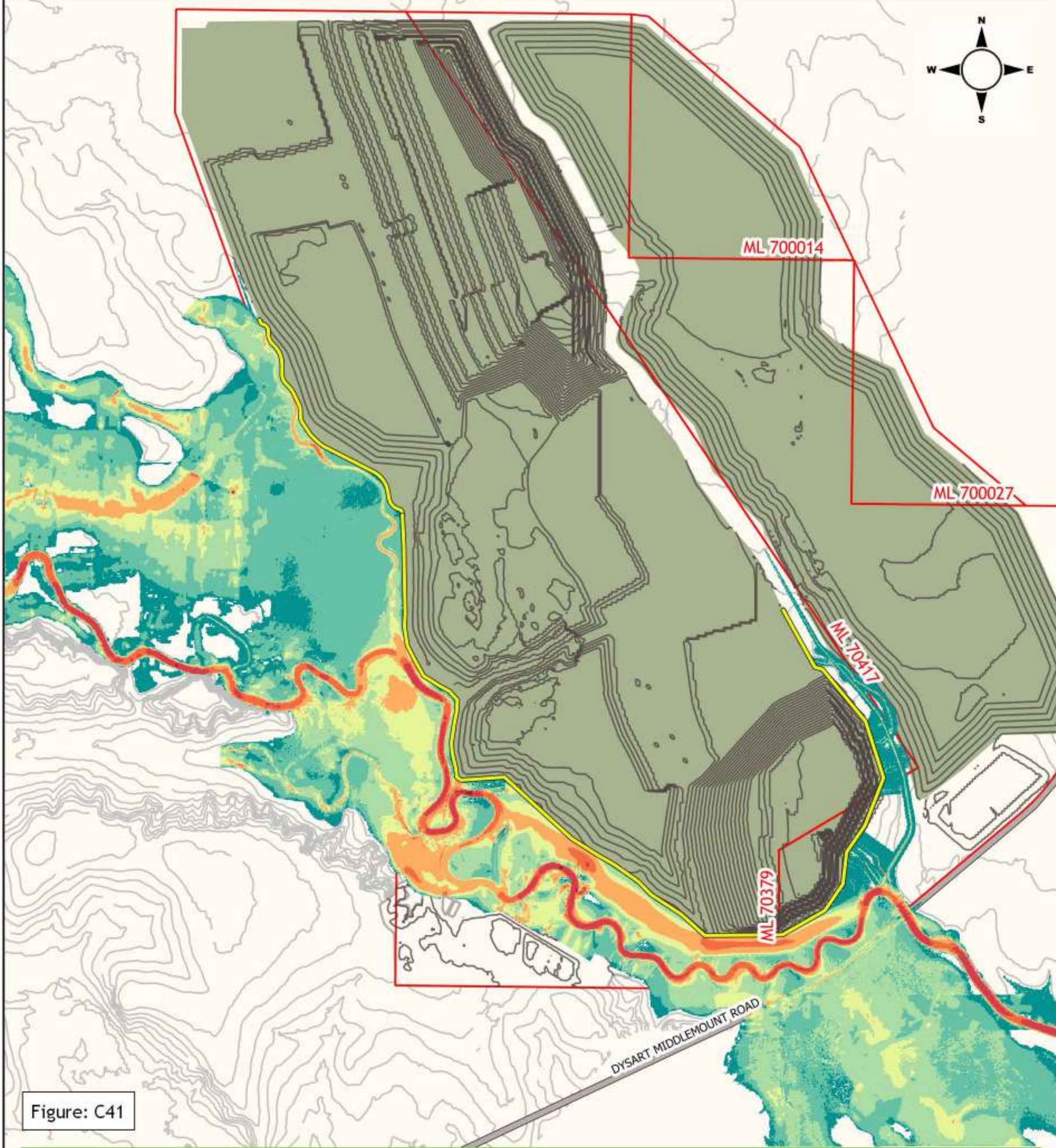


Figure: C41

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

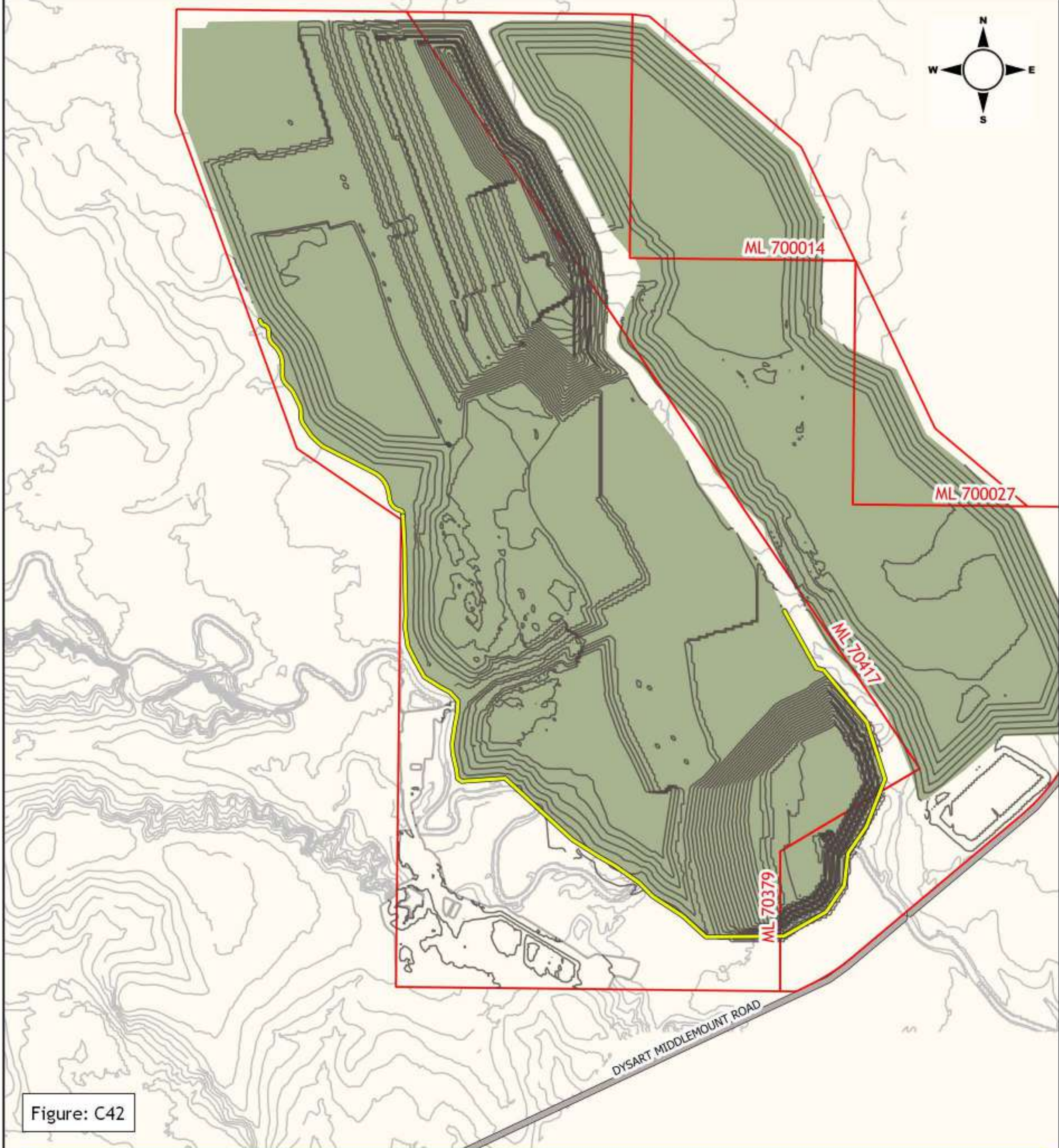
Middlemount Coal Mine Southern Extension Project

0.1% AEP Peak flood velocities : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity (m/s)

- up to 0.25m/s
- 0.25 to 0.5m/s
- 0.5 to 0.75m/s
- 0.75 to 1.0m/s
- 1.0 to 1.5m/s
- 1.5 to 2.0m/s
- 2.0 to 3.0m/s
- > 3 m/s

Middlemount Coal Mine Southern Extension Project

PMF Peak flood velocities : final landform

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

Appendix D – Flood Impact maps

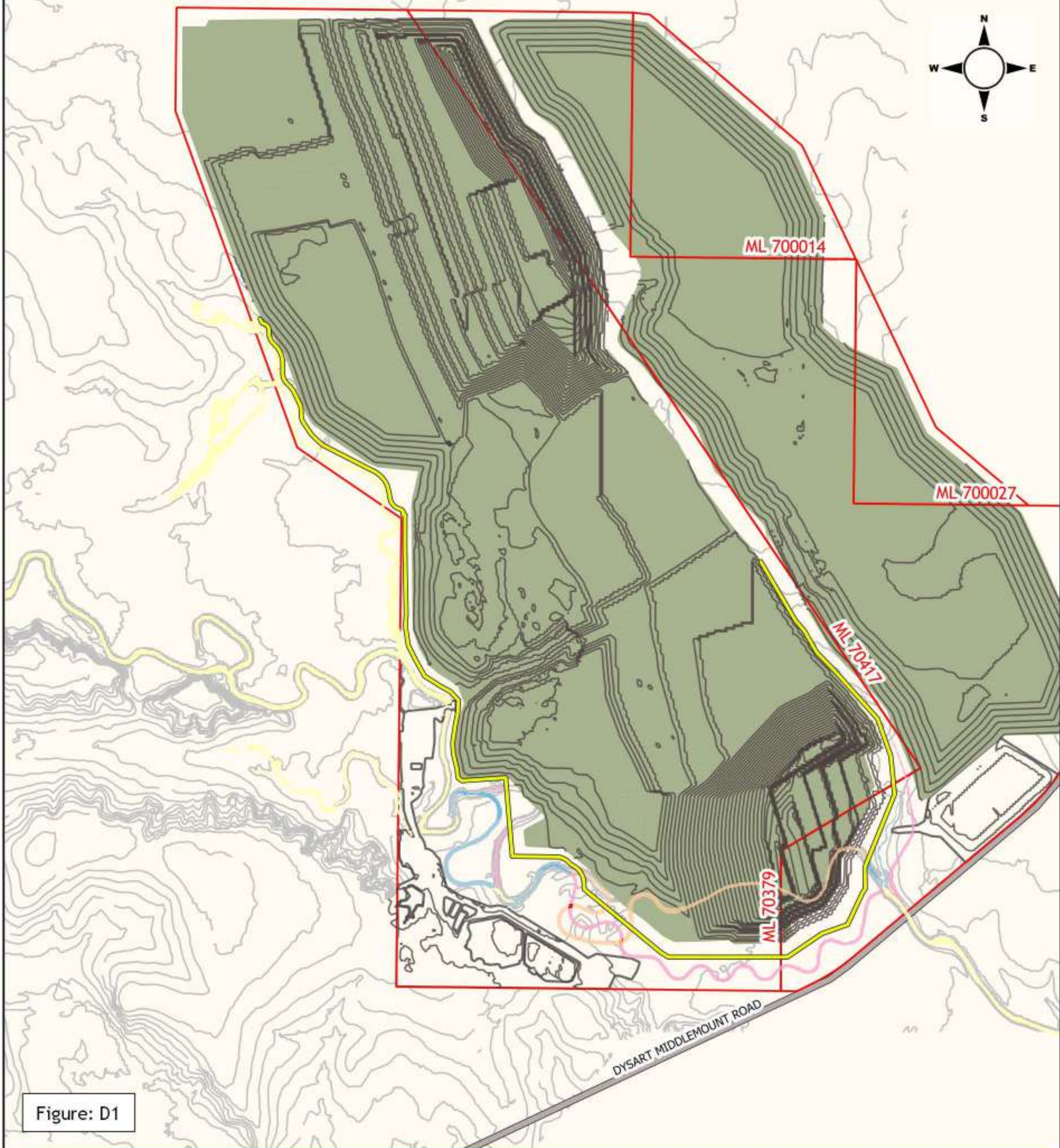


Figure: D1

Projection: MGA Zone 55 Datum: GDA 94

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

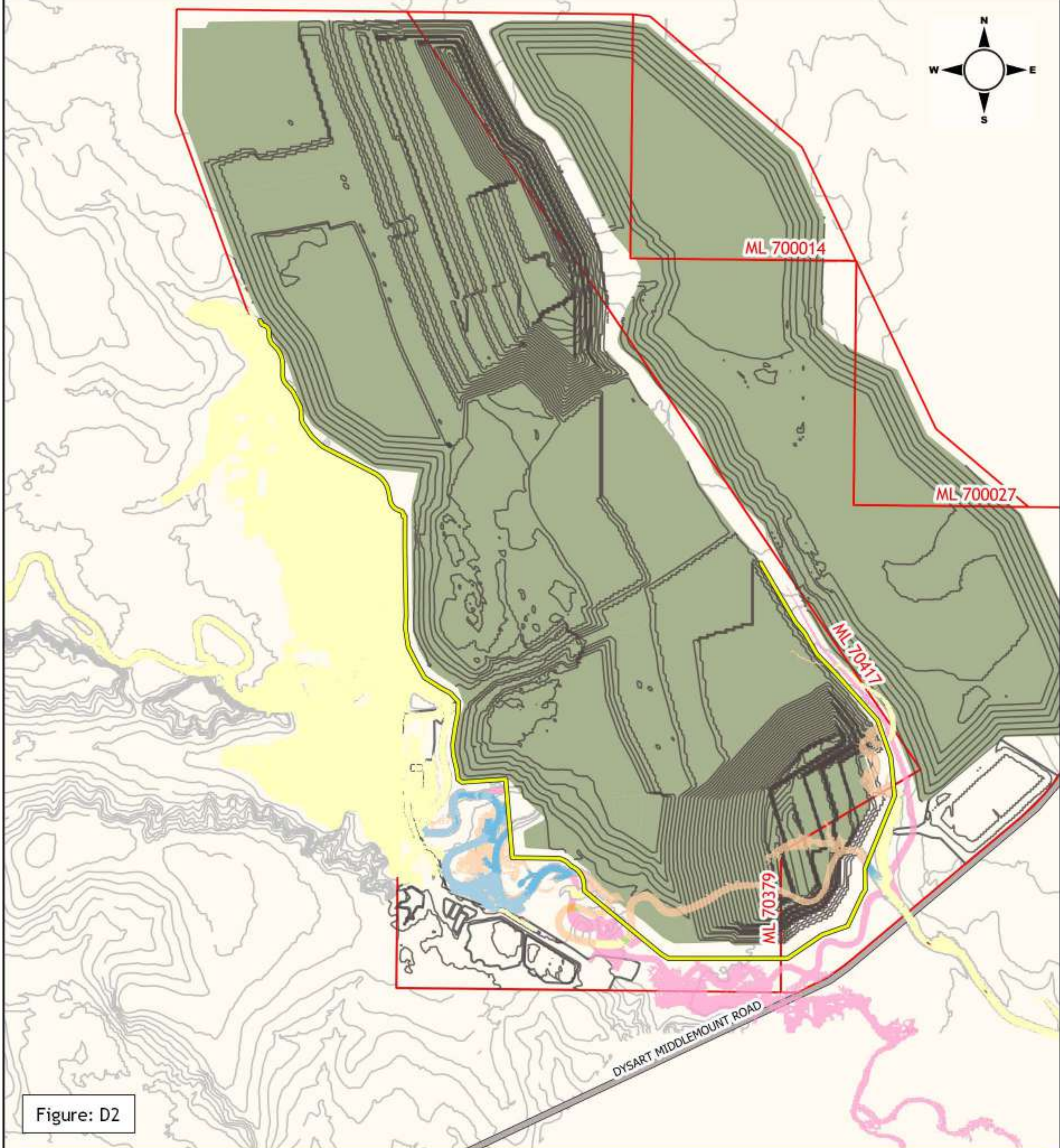
- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

50% AEP Proposed minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

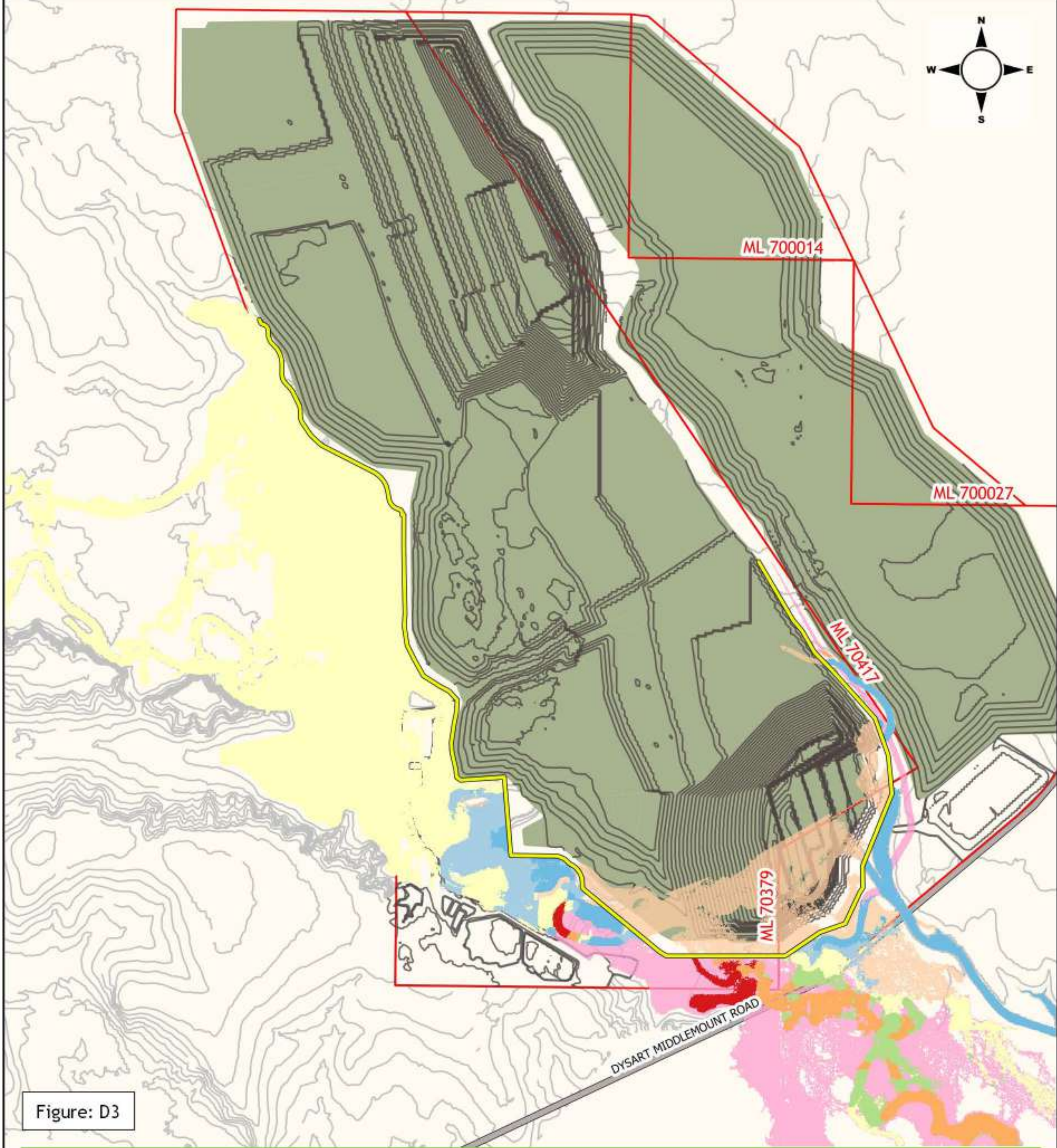
Middlemount Coal Mine Southern Extension Project

5% AEP Proposed minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

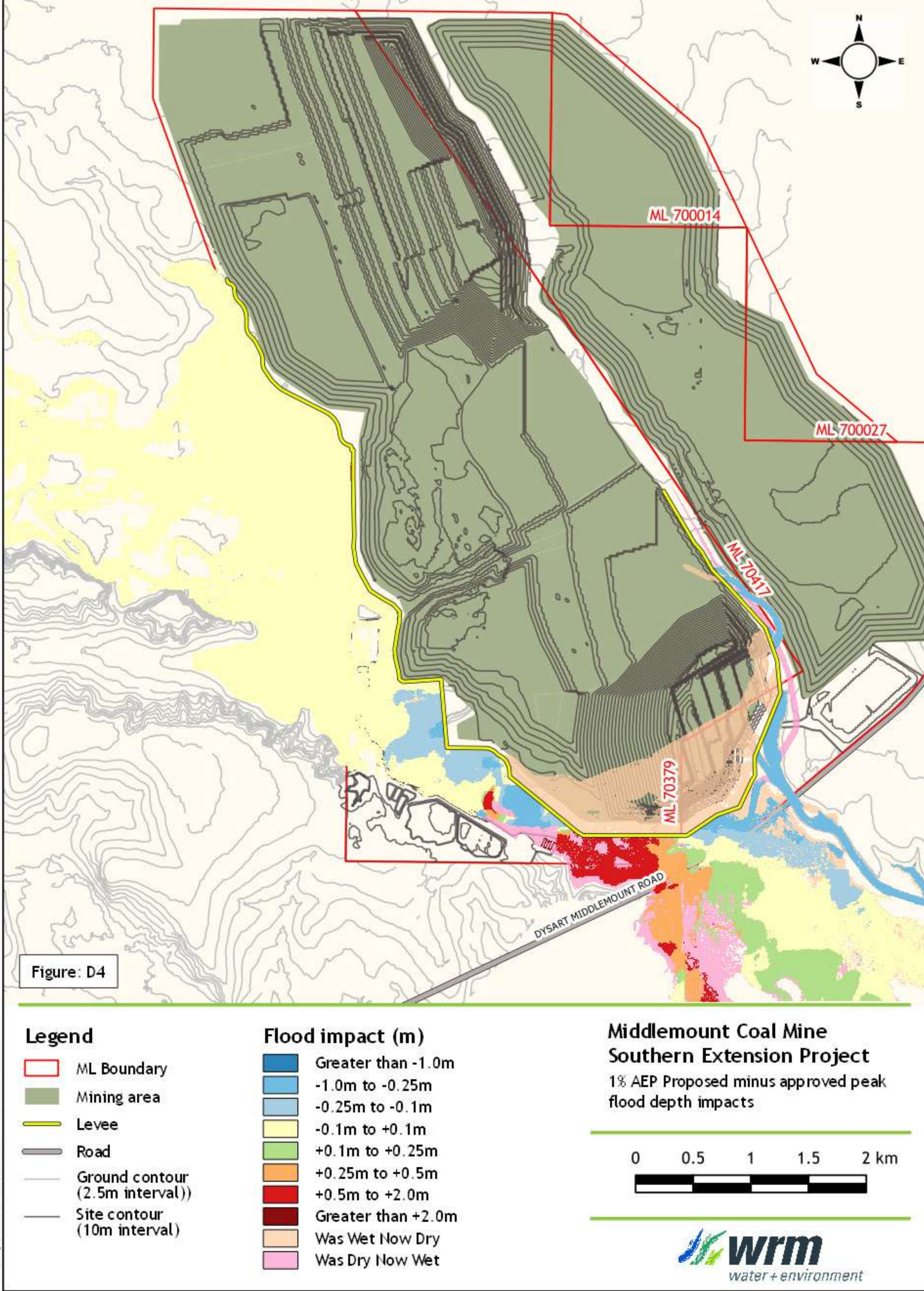
Middlemount Coal Mine Southern Extension Project

2% AEP Proposed minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm
water+environment

Projection: MGA Zone 55 Datum: GDA 94


ML 700014
ML 700027
ML 70417
ML 70379
DYSART MIDDLEMOUNT ROAD
Figure: D4
Legend
ML Boundary
Mining area
Levee
Road
Ground contour (2.5m interval))
Site contour (10m interval)
Flood impact (m)
Greater than -1.0m
-1.0m to -0.25m
-0.25m to -0.1m
-0.1m to +0.1m
+0.1m to +0.25m
+0.25m to +0.5m
+0.5m to +2.0m
Greater than +2.0m
Was Wet Now Dry
Was Dry Now Wet
Middlemount Coal Mine
Southern Extension Project
1% AEP Proposed minus approved peak flood depth impacts
0 0.5 1 1.5 2 km
wrm
water + environment
Projection: MGA Zone 55 Datum: GDA 94

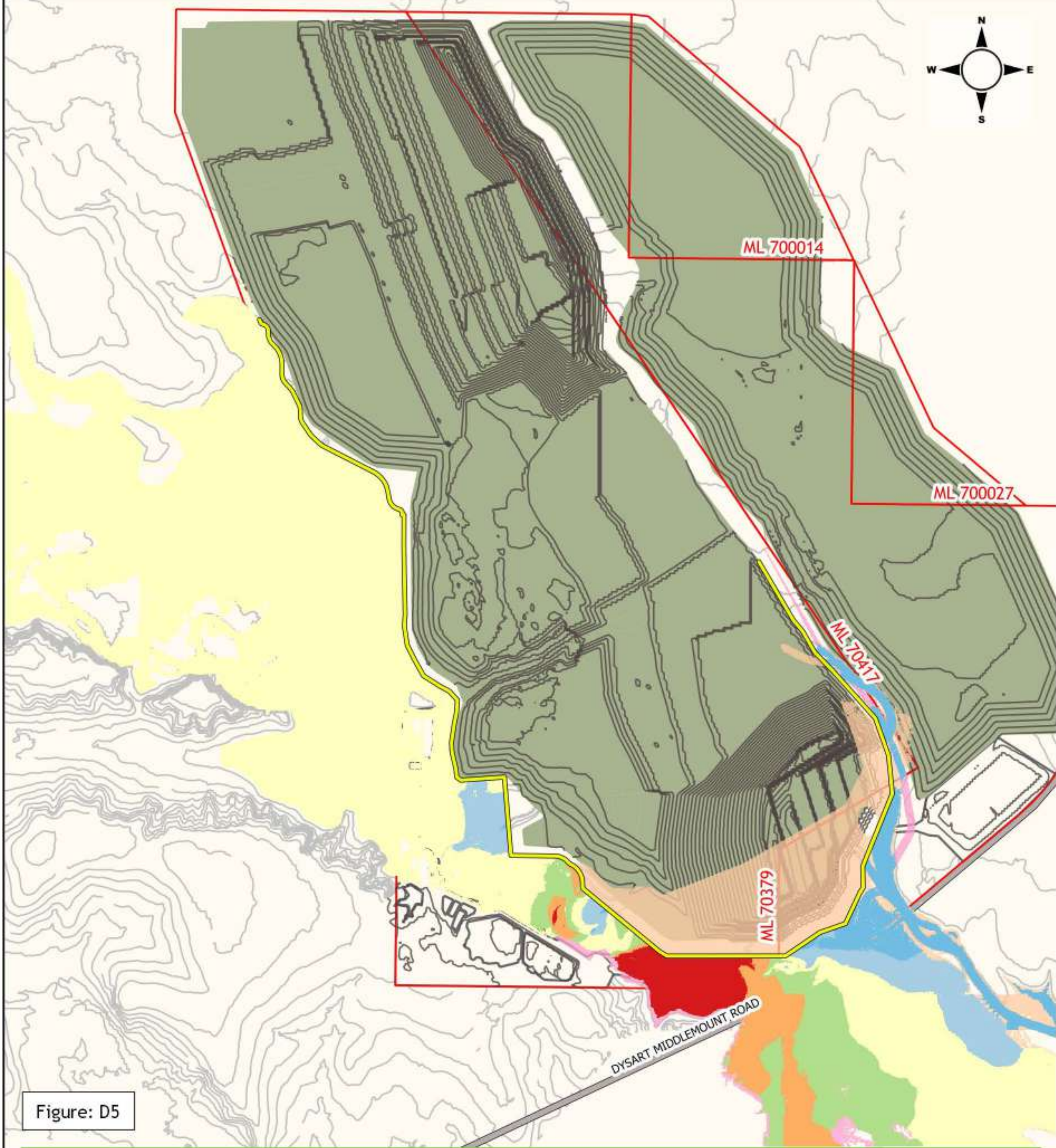


Figure: D5

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

0.1% AEP Proposed minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water+environment

Projection: MGA Zone 55 Datum: GDA 94

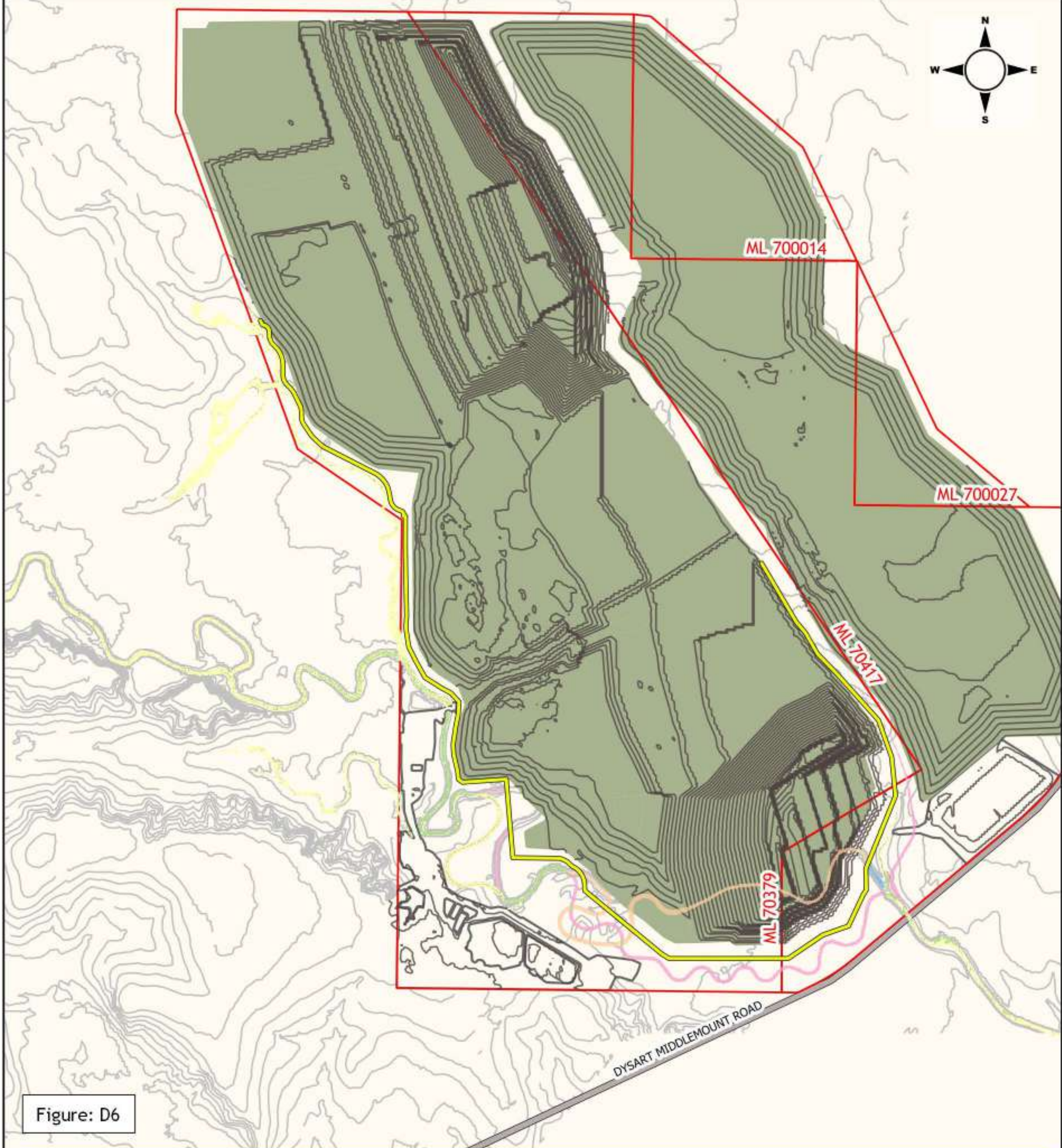


Figure: D6

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

50% AEP Proposed minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water+environment

Projection: MGA Zone 55 Datum: GDA 94

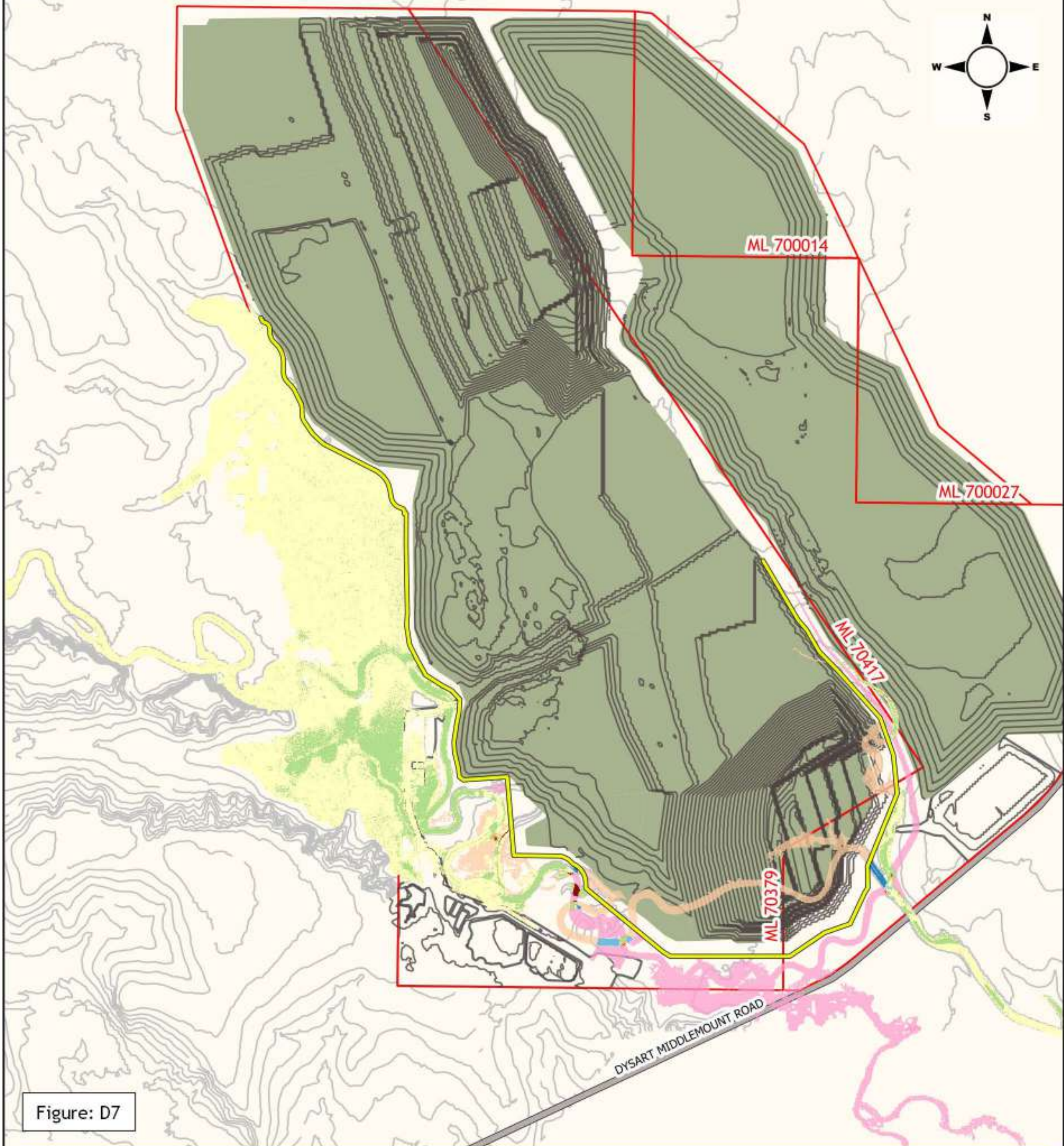


Figure: D7

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

5% AEP Proposed minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water+environment

Projection: MGA Zone 55 Datum: GDA 94

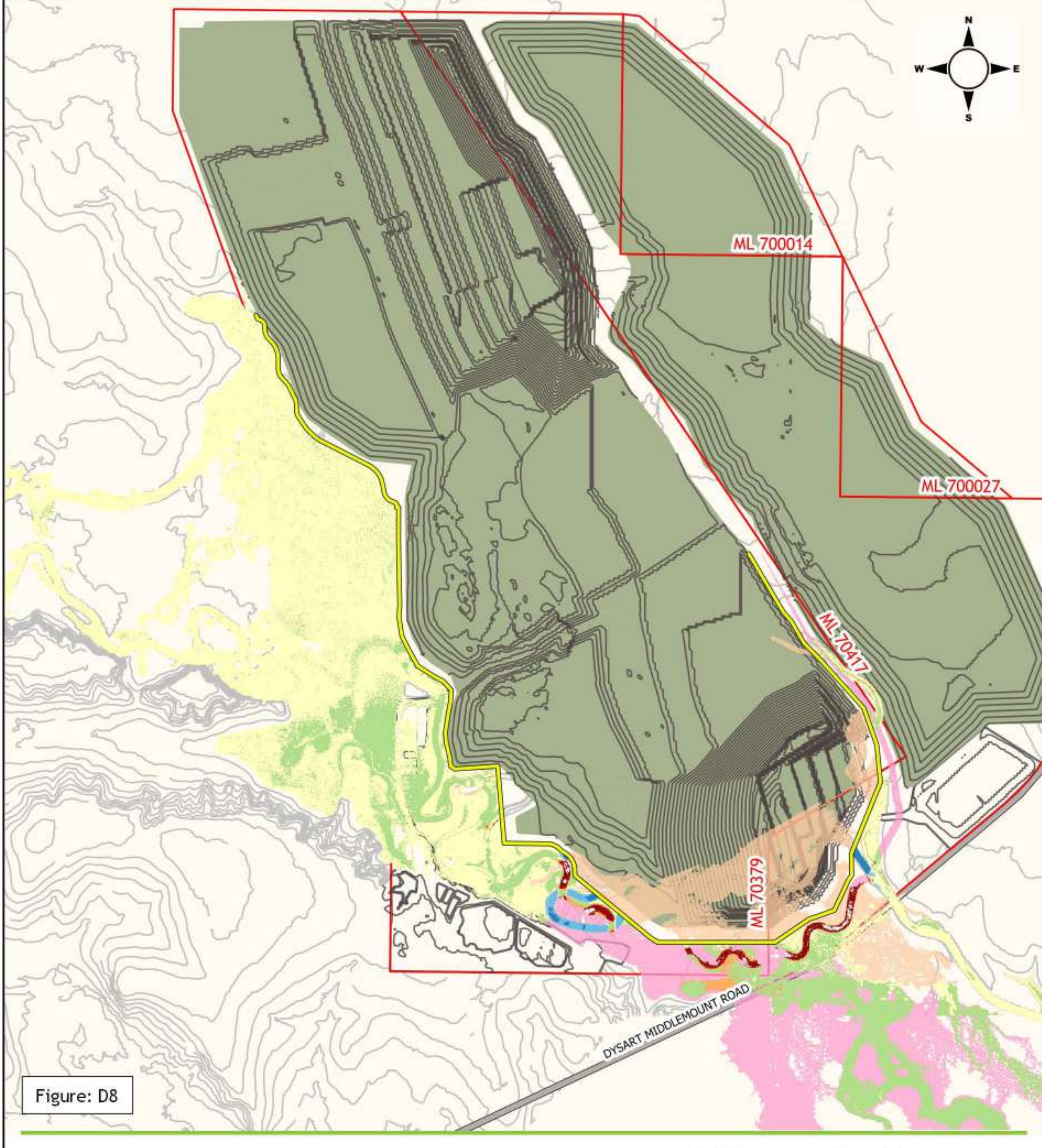


Figure: D8

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

2% AEP Proposed minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water+environment

Projection: MGA Zone 55 Datum: GDA 94

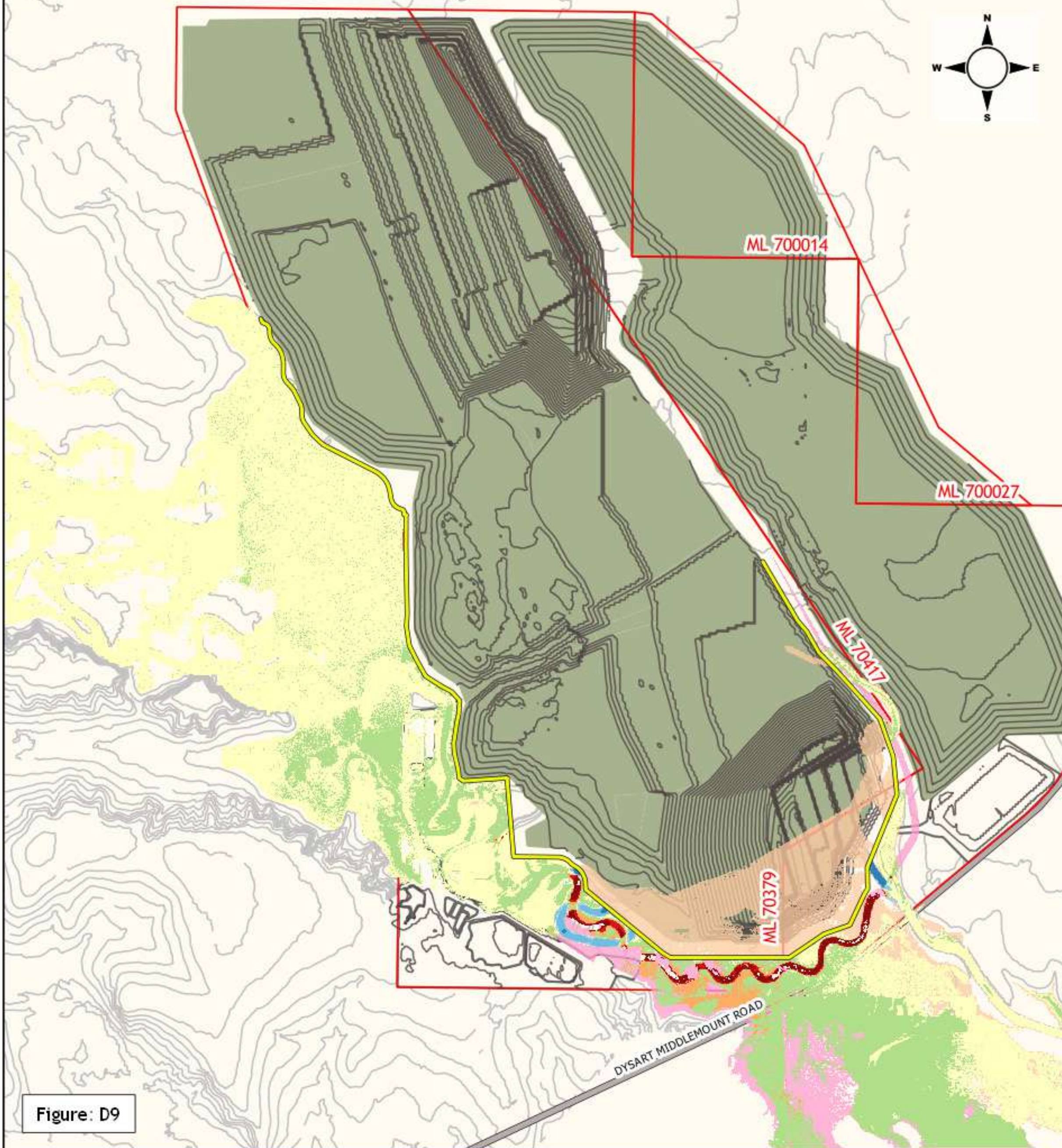


Figure: D9

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

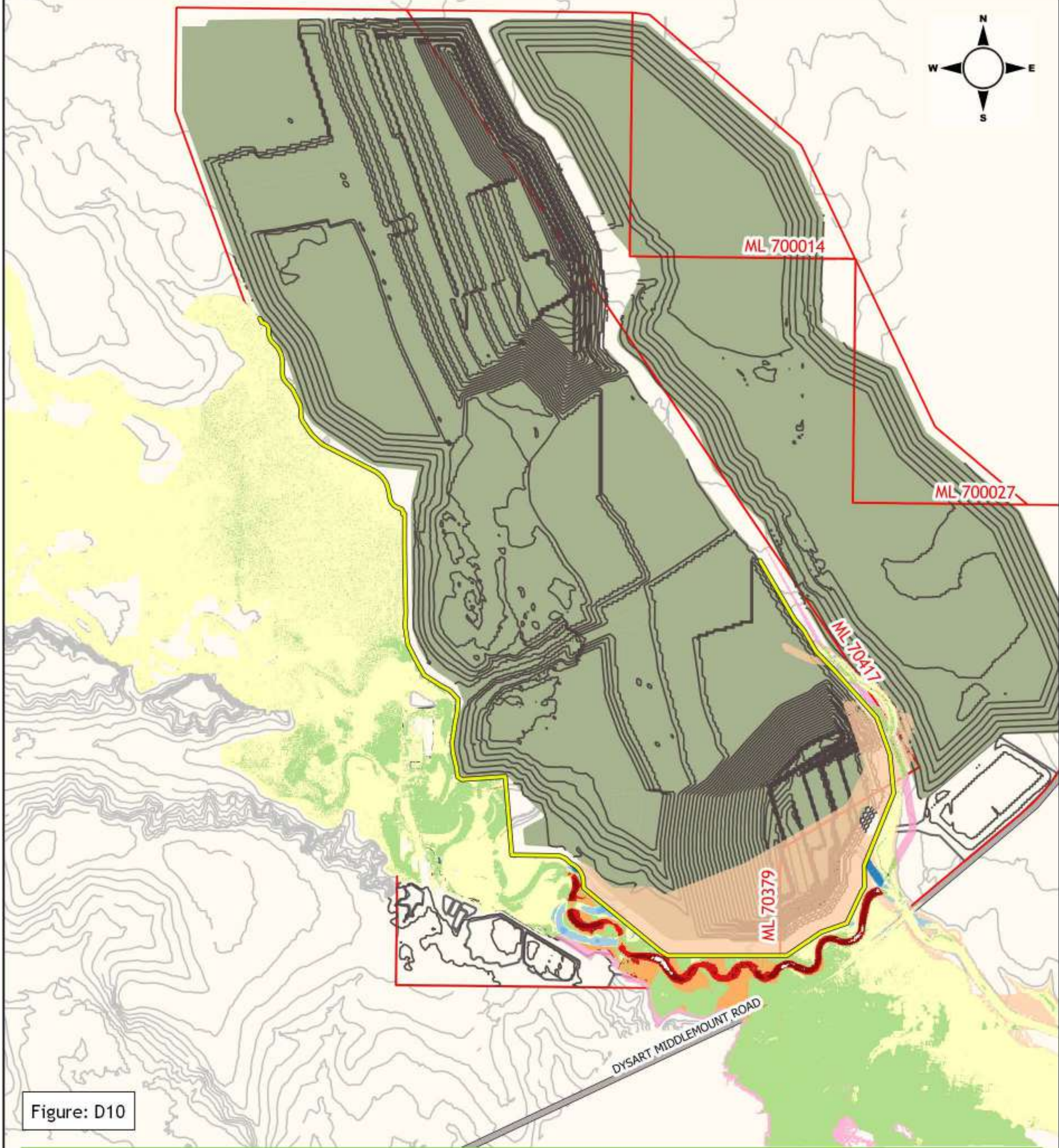
Middlemount Coal Mine Southern Extension Project

1% AEP Proposed minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water+environment

Projection: MGA Zone 55 Datum: GDA 94



Projection: MGA Zone 55 Datum: GDA 94

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

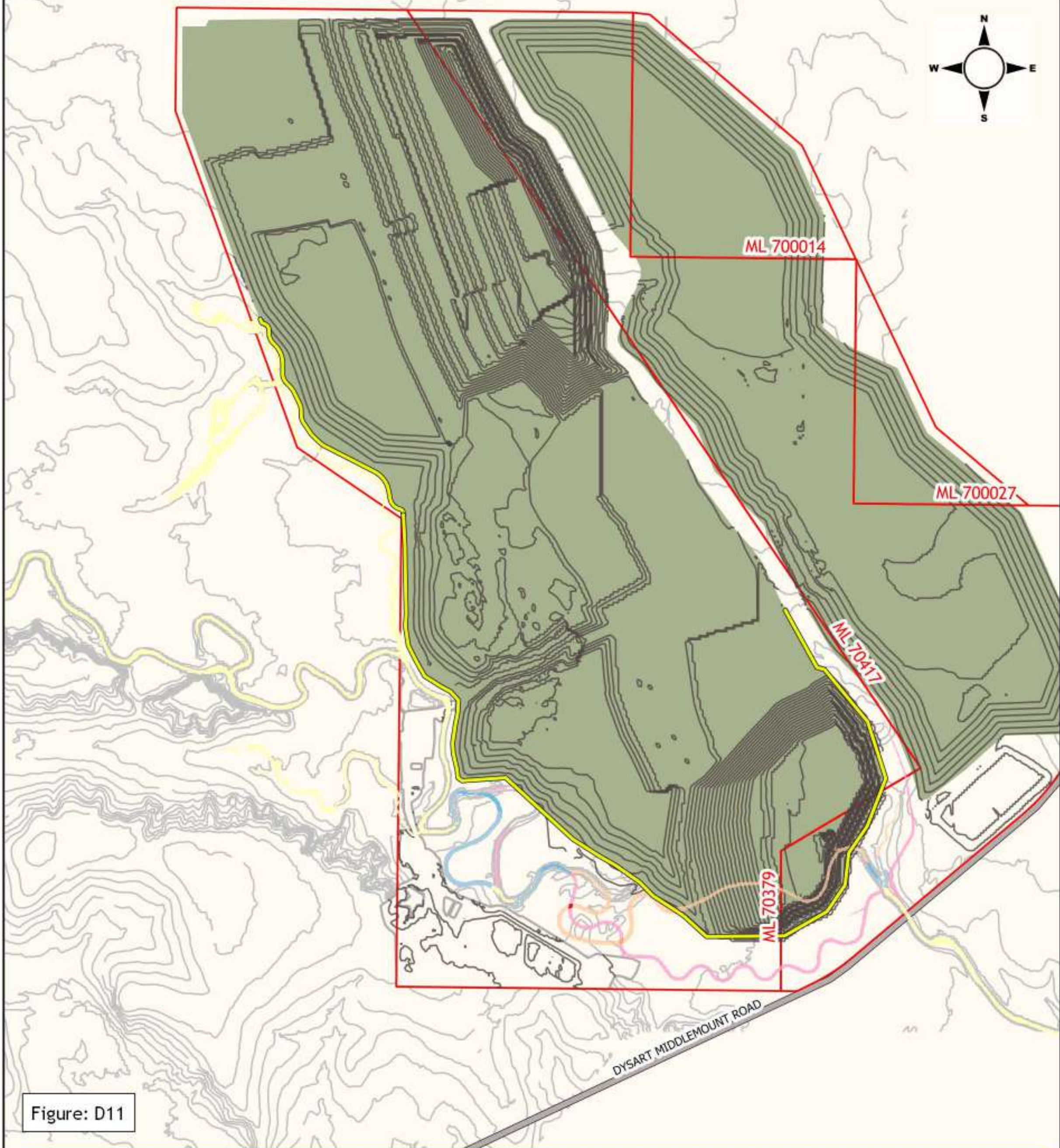
- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

0.1% AEP Proposed minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water+environment



Projection: MGA Zone 55 Datum: GDA 94

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

50% AEP Final landform minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

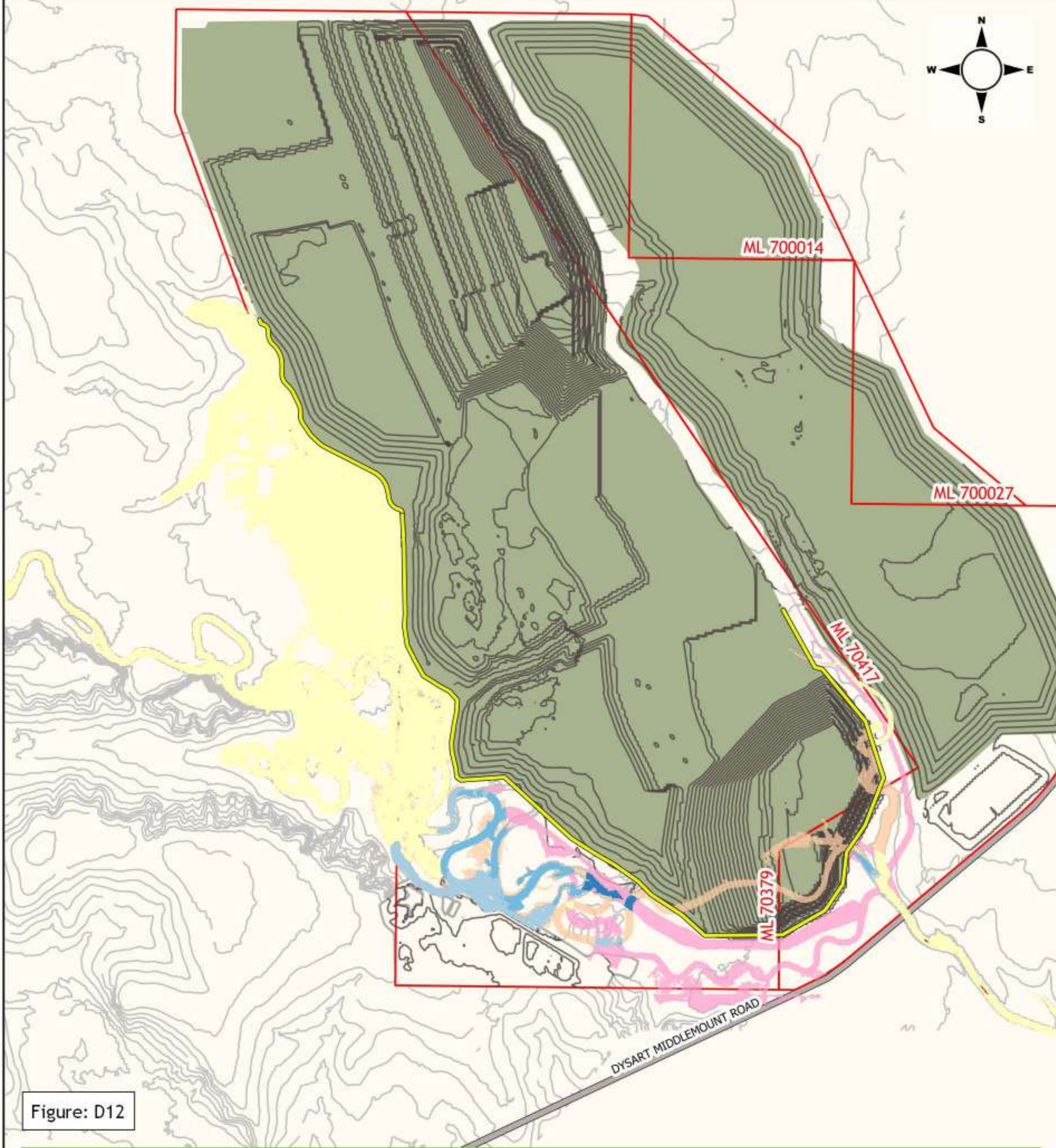


Figure: D12

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

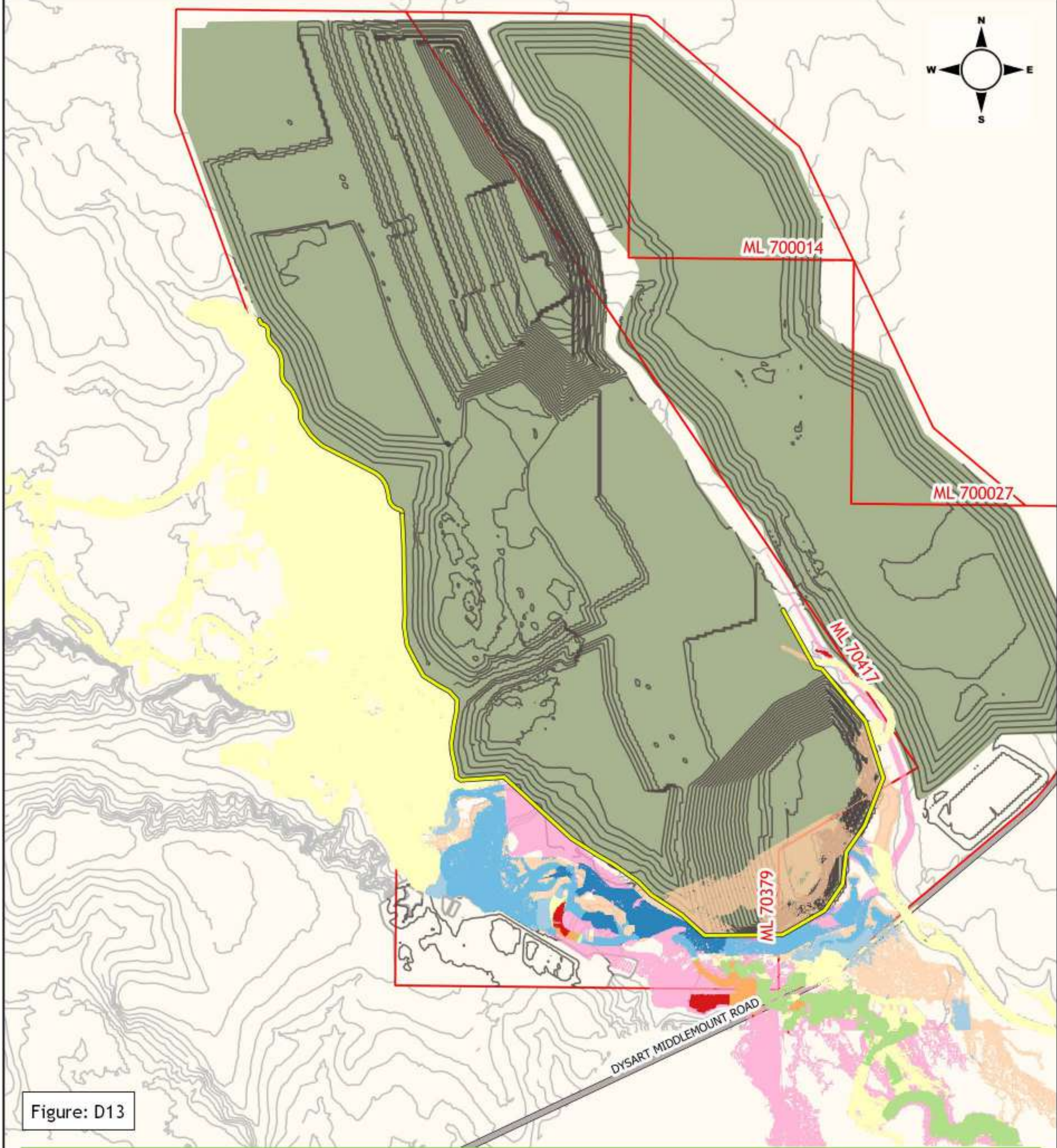
Middlemount Coal Mine Southern Extension Project

5% AEP Final landform minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

2% AEP Final landform minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water+environment

Projection: MGA Zone 55 Datum: GDA 94

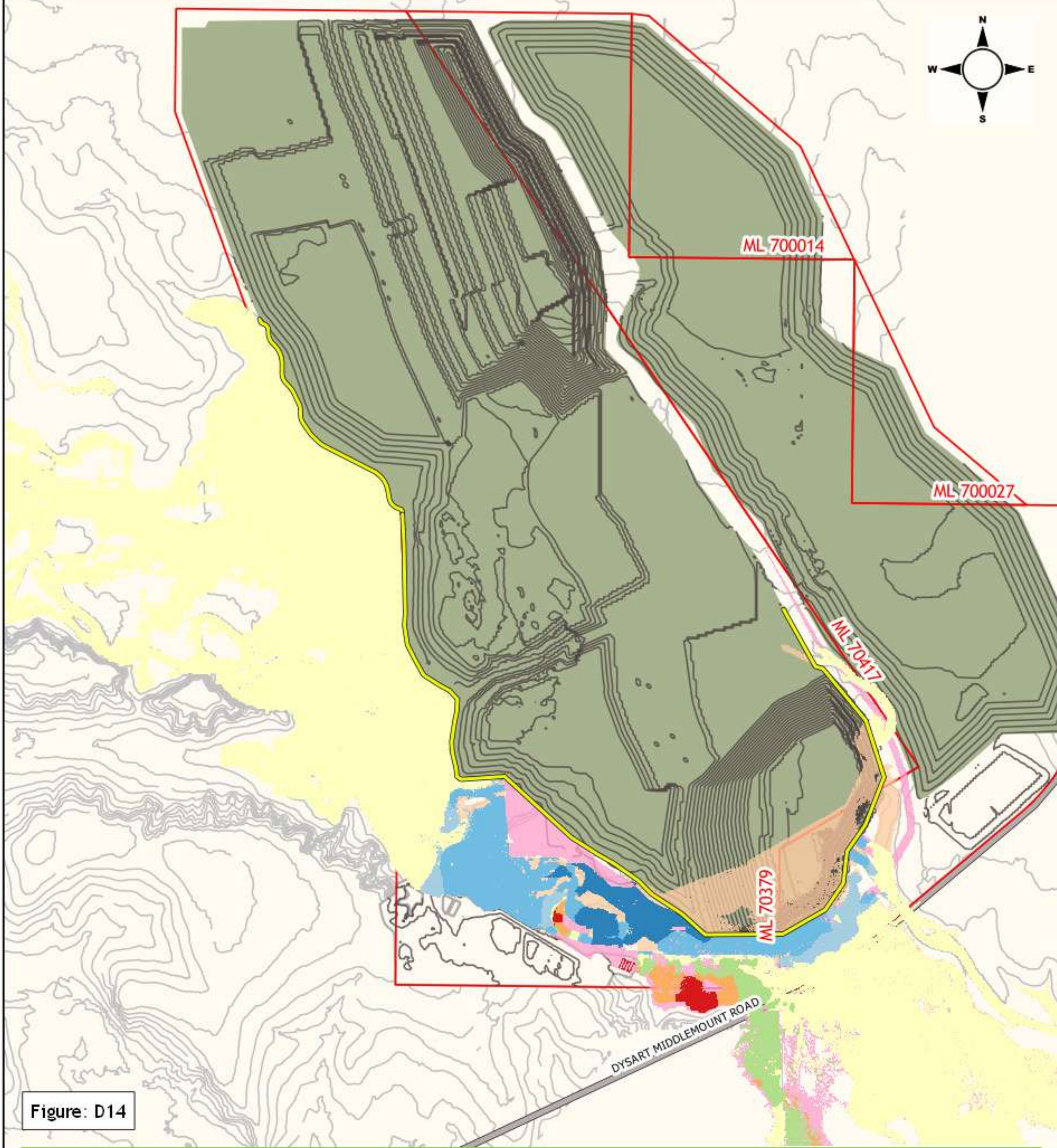


Figure: D14

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

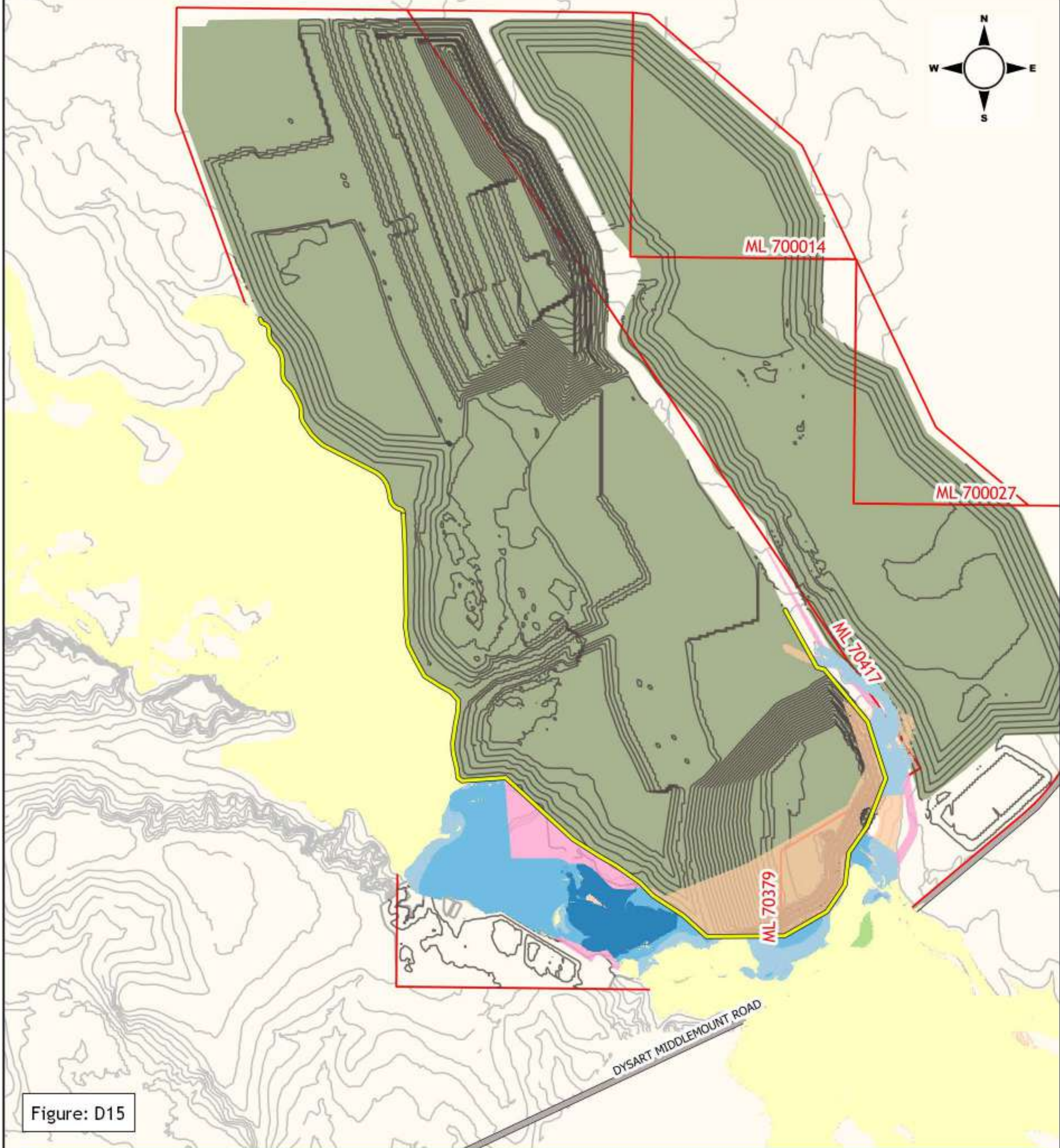
Middlemount Coal Mine Southern Extension Project

1% AEP Final landform minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water+environment

Projection: MGA Zone 55 Datum: GDA94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood impact (m)

- Greater than -1.0m
- -1.0m to -0.25m
- -0.25m to -0.1m
- -0.1m to +0.1m
- +0.1m to +0.25m
- +0.25m to +0.5m
- +0.5m to +2.0m
- Greater than +2.0m
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

0.1% AEP Final landform minus approved peak flood depth impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

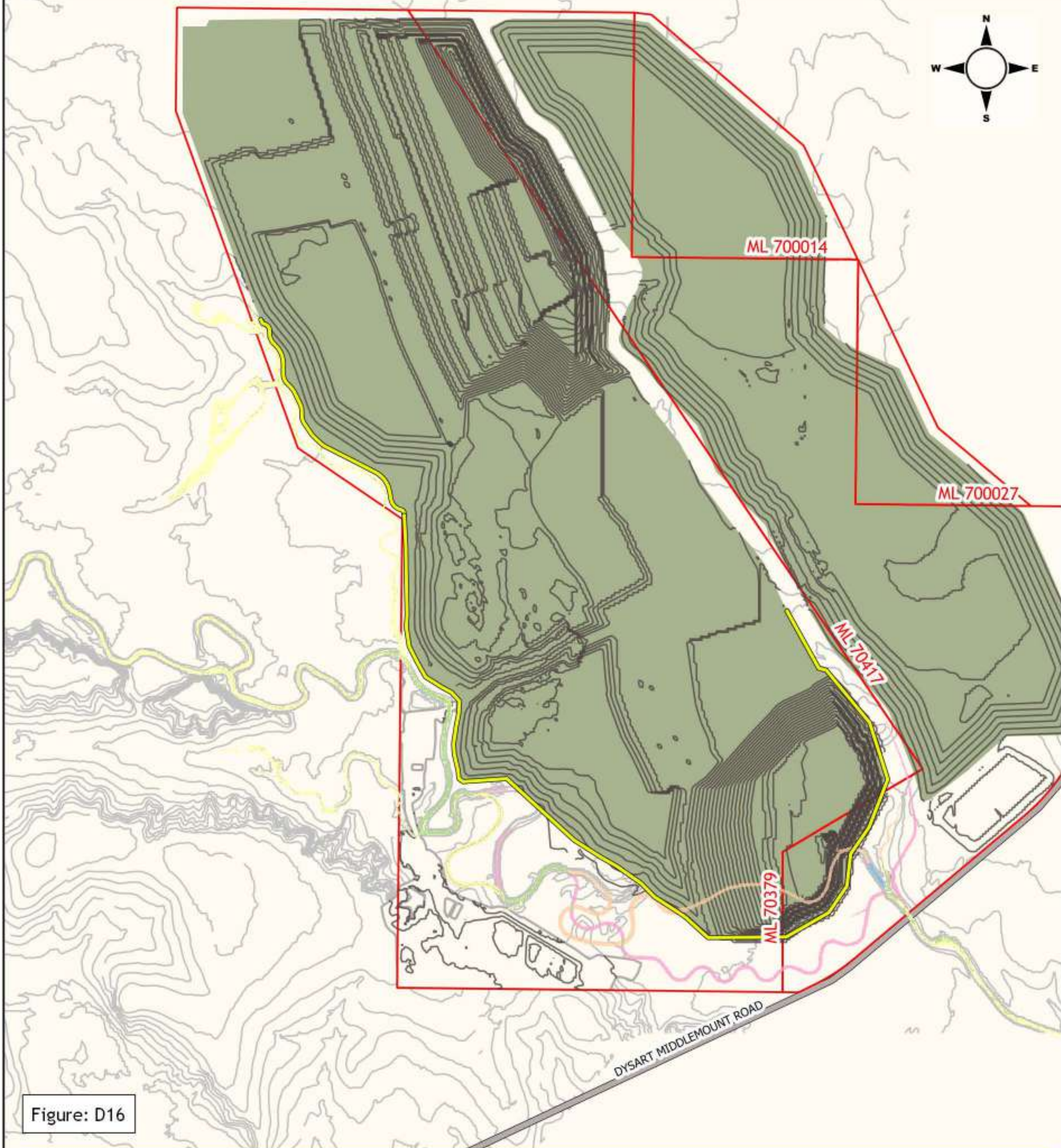


Figure: D16

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

50% AEP Final landform minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

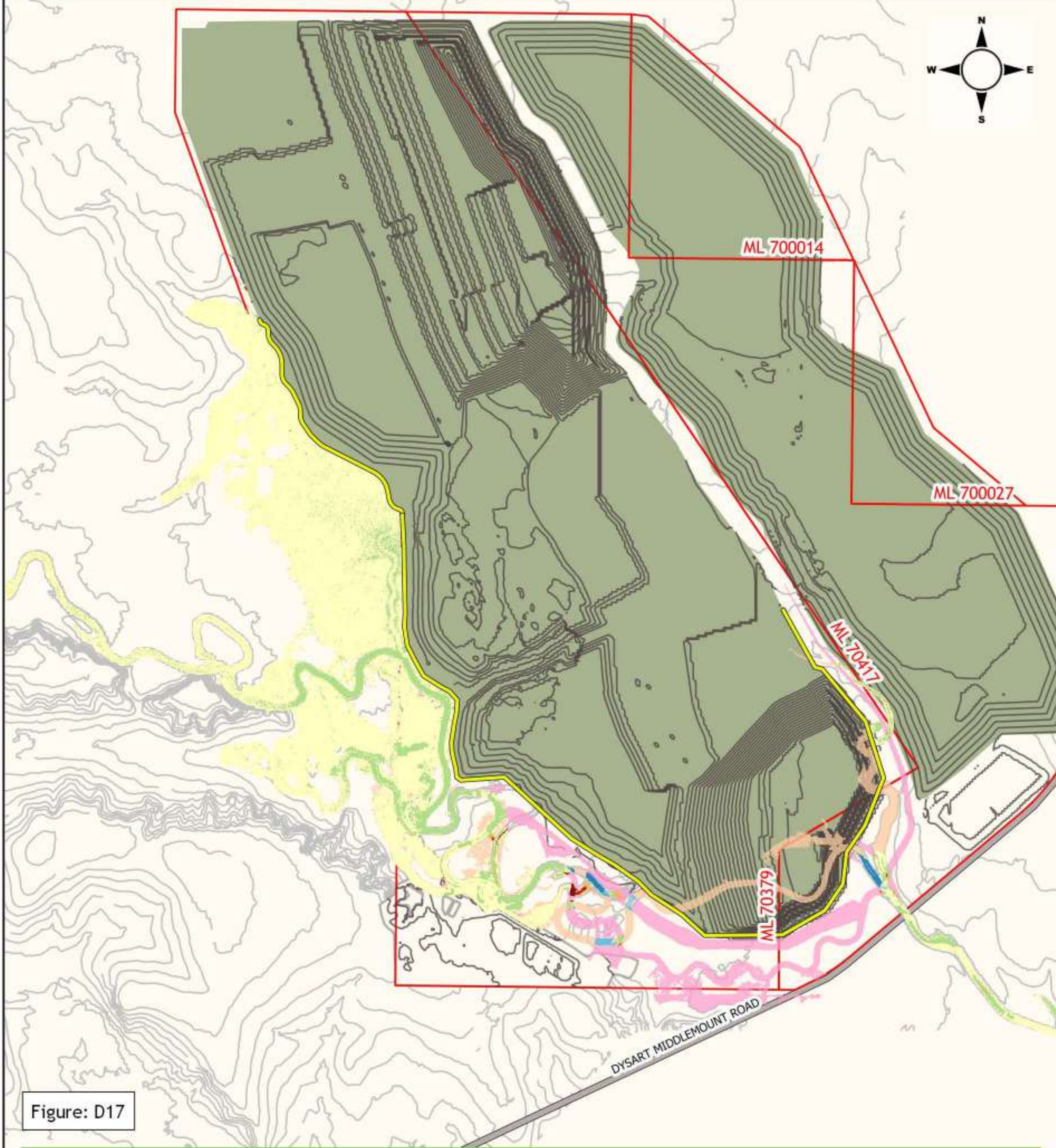


Figure: D17

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

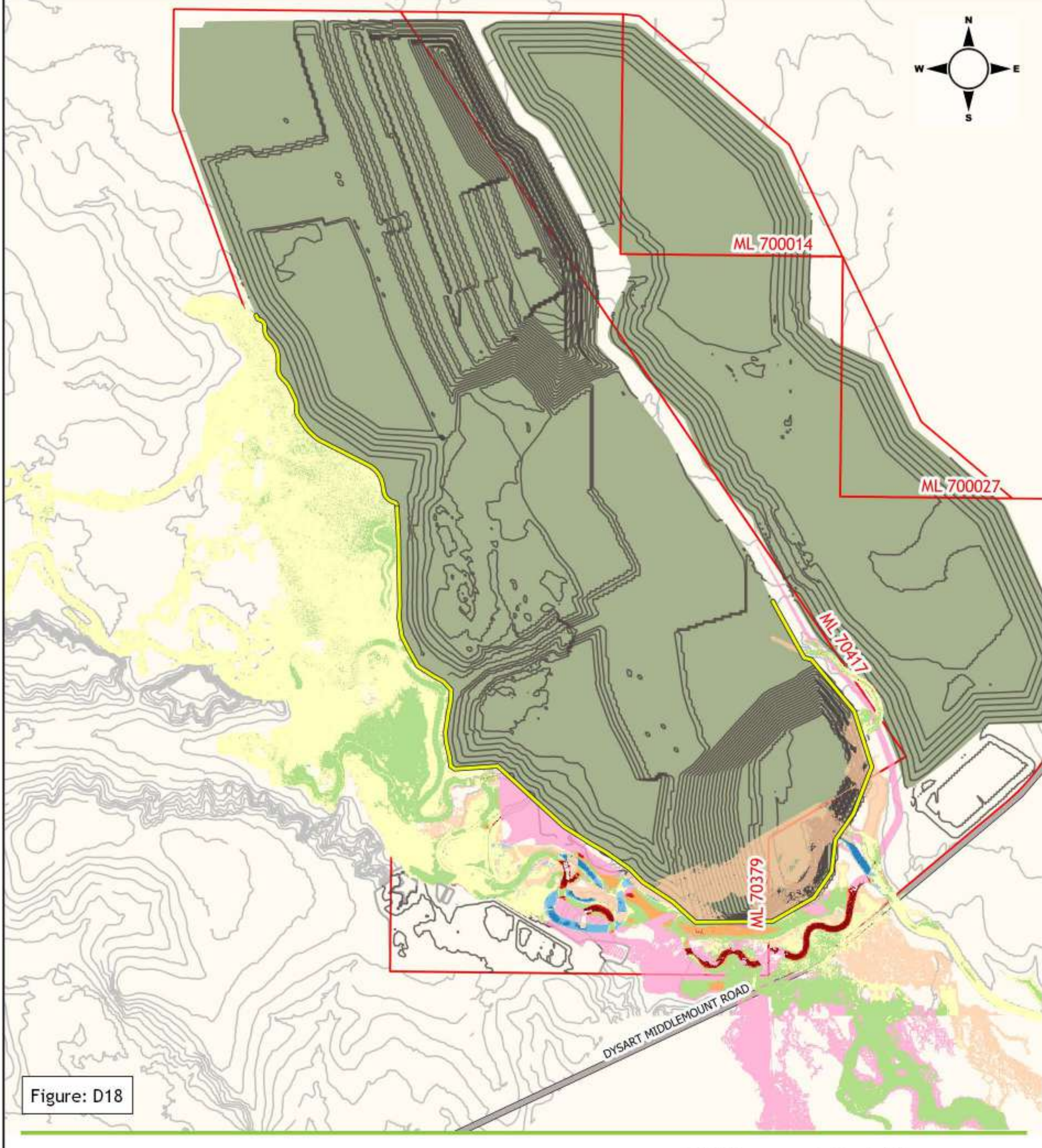
Middlemount Coal Mine Southern Extension Project

5% AEP Final landform minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water+environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

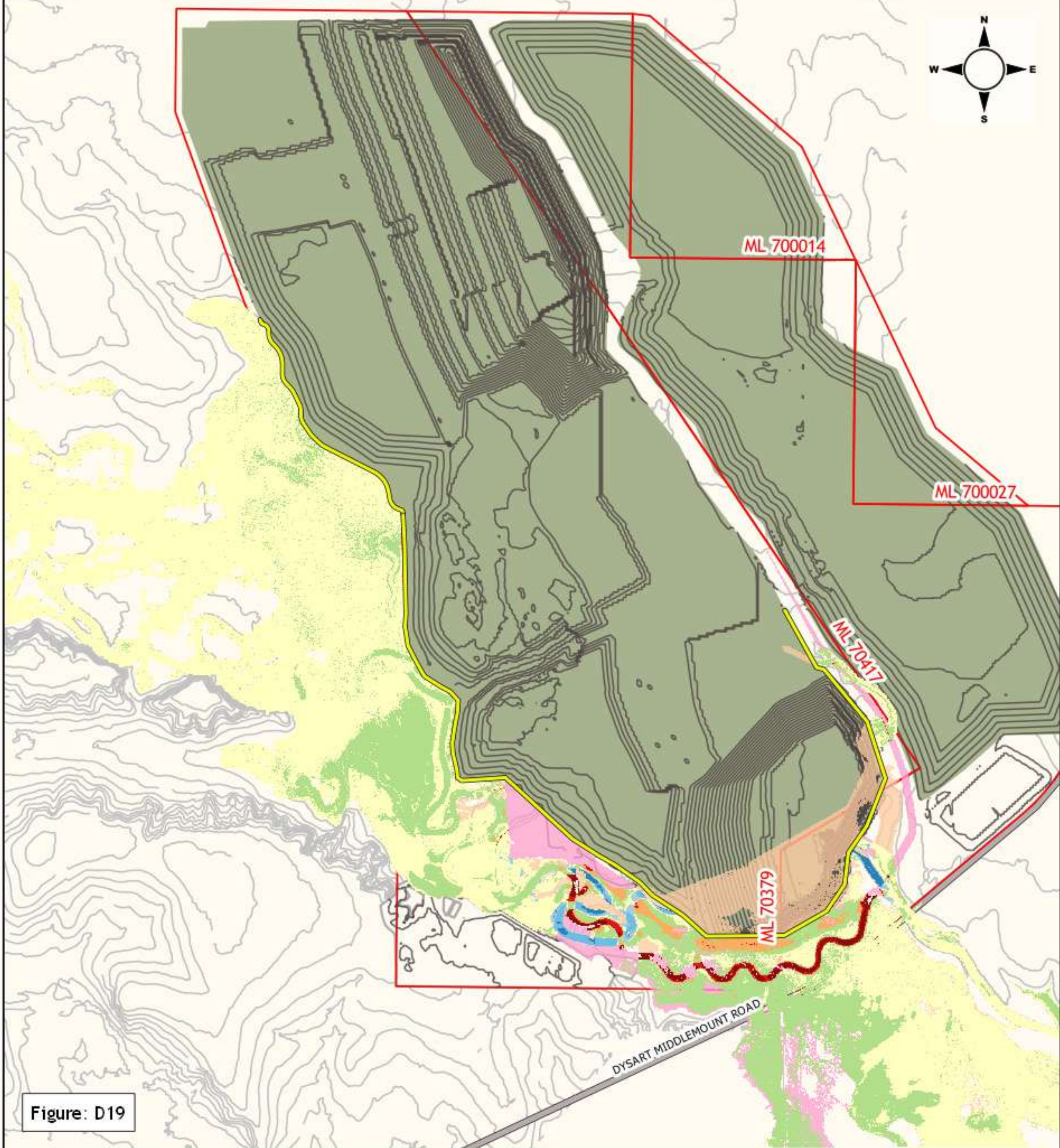
Middlemount Coal Mine Southern Extension Project

2% AEP Final landform minus approved peak velocity impacts

0 0.5 1 1.5 2 km

Projection: MGA Zone 55 Datum: GDA 94

wrm water + environment



Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

1% AEP Final landform minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA94

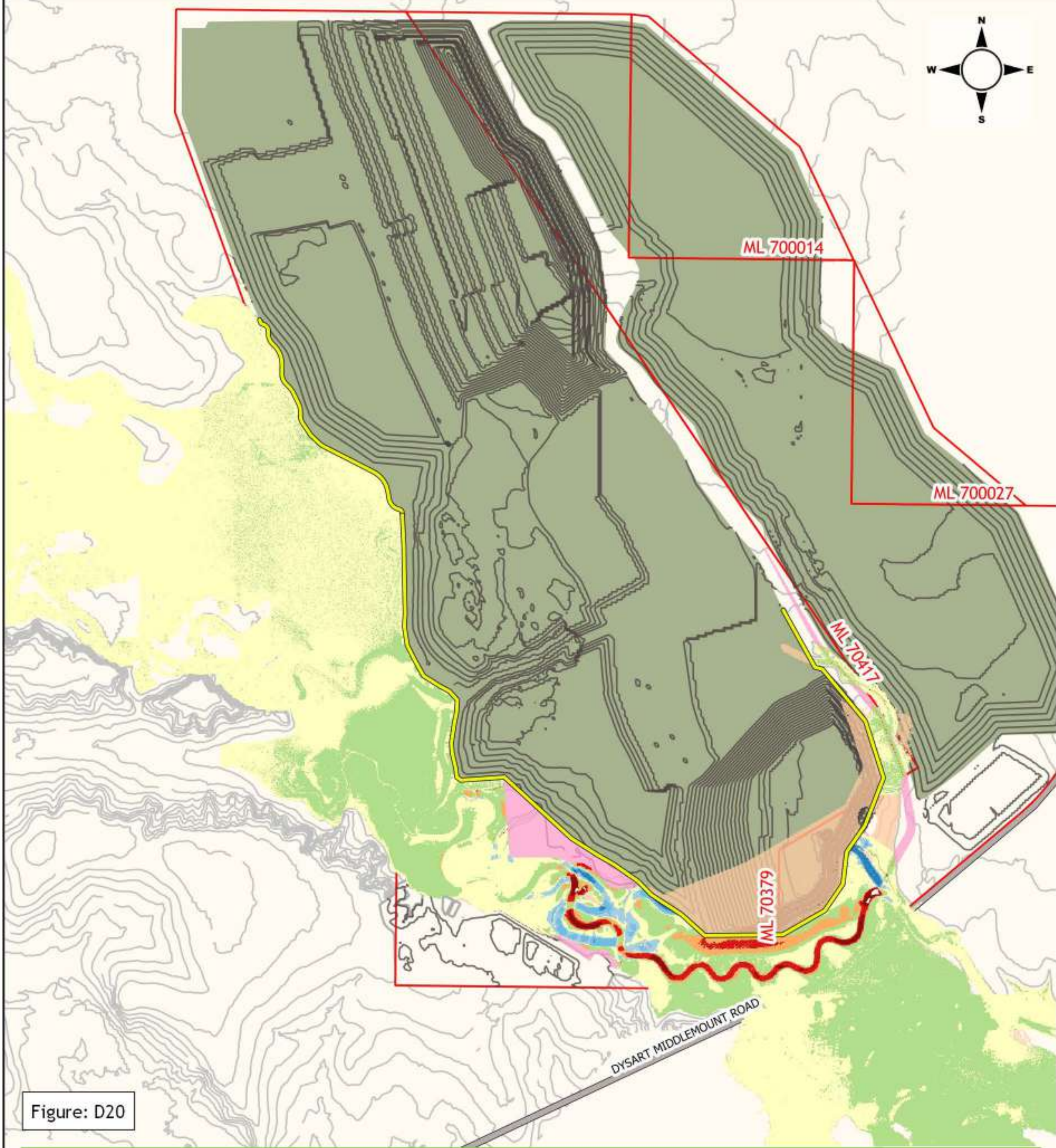


Figure: D20

Legend

- ML Boundary
- Mining area
- Levee
- Road
- Ground contour (2.5m interval))
- Site contour (10m interval)

Flood velocity impact (m/s)

- Less than -1.5m/s
- -1.5 to -1.0m/s
- -1.0 to -0.5m/s
- -0.5 to +0.0m/s
- +0.0 to +0.5m/s
- +0.5 to +1.0m/s
- +1.0 to +1.5m/s
- Greater than +2m/s
- Was Wet Now Dry
- Was Dry Now Wet

Middlemount Coal Mine Southern Extension Project

0.1% AEP Final landform minus approved peak velocity impacts

0 0.5 1 1.5 2 km

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94