Vulcan Complex Project

Surface water assessment

Vitrinite Pty Ltd

1571-06-B1, 17 September 2020

Report Title	Vulcan Complex Project Surface water assessment
Client	Vitrinite Pty Ltd
Report Number	1571-06-B1

Revision Number	Report Date	Report Author	Reviewer
0 [DRAFT]	11 March 2020	LZ/RN	JO
1	31 March 2020	LZ/RN	JO/DN
2	17 September 2020	LZ	JO

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



Julian Orth
Principal Engineer

NOTE: This report has been prepared on the assumption that all information, data and reports provided to us by our client, on behalf of our client, or by third parties (e.g. government agencies) is complete and accurate and on the basis that such other assumptions we have identified (whether or not those assumptions have been identified in this advice) are correct. You must inform us if any of the assumptions are not complete or accurate. We retain ownership of all copyright in this report. Except where you obtain our prior written consent, this report may only be used by our client for the purpose for which it has been provided by us.

Contents

1 Introduction 11
1.1 Background 11
1.2 Project description 11
2 Regulatory framework 17
2.1 Commonwealth 17
2.2 State 23
2.2.1 EP Act 1994 23
2.2.2 Water Act 2000 26
2.2.3 Water Supply (Safety & Reliability) Act 2008 27
3 Environmental Values 28
4 Existing surface water environment 31
4.1 Regional drainage characteristics 31
4.2 Local drainage network 31
4.2.1 Drainage Line 1 35
4.2.2 Existing drainage diversion 36
4.2.3 Drainage Line 2 37
4.3 Rainfall and evaporation 40
4.4 Streamflow 41
4.5 Water quality 43
4.5.1 Regional Isaac River water quality 43
4.5.2 Local water quality 46
4.6 Soil characteristics 50
4.6.1 Soil management units 50
4.6.2 Sodic and dispersive soils 50
5 Proposed surface water management strategy and infrastructure 51
5.1 Types of water generated onsite 51
5.2 Proposed water management infrastructure 51
5.3 Water management strategy overview 51
5.4 Diverted runoff water management 53
5.4.1 Flood protection levee 53
5.4.2 Diverted water drains and dams 53
5.5 Surface water management 53
5.5.1 Sediment dam locations and sizing 54
5.5.2 Haul road and access road sediment management 55
5.6 Mine affected water management 55
5.6.1 Mine affected water dams 55
5.6.2 Preliminary consequence assessment 56

5.6.3 Pit dewatering rates 56
5.7 Release of waters to the receiving environment 56
5.8 Sewage and effluent disposal 57
5.9 Post-closure conditions water management 57
6 Water balance model configuration 58
6.1 Overview 58
6.2 Simulation methodology 58
6.3 Catchment yield parameters 59
6.4 Conceptual water management system configuration and schematic 60
6.5 Site water demands 64
6.5.1 Haul road dust suppression 64
6.5.2 Potable water demand 64
6.6 Water sources 65
6.6.1 Groundwater 65
6.6.2 External water 65
6.7 Watercourse flow modelling 65
6.8 Water quality modelling 66
6.8.1 Adopted salinity parameters 67
7 Water management system assessment 68
7.1 Overview 68
7.2 Interpretation of model results 68
7.3 Water balance model results 69
7.3.1 Overall water balance 69
7.3.2 Mine affected water inventory 70
7.3.3 Jupiter pit water inventory 73
7.3.4 Dust suppression makeup requirements from external water sources 74
7.3.5 Spillway water discharges 75
7.3.6 Overall salt balance 78
7.3.7 Receiving waters water quality 79
7.3.8 Release scenarios 80
7.4 Sensitivity analysis 83
7.4.1 Haul road dust suppression 83
7.4.2 Climate change 86
7.5 Adaptive management of the water management system 88
8 Flood modelling and impact assessment 89
8.1 Overview 89
8.2 Adopted methodology 89
8.2.1 Hydrological model 89
8.2.2 Hydraulic model 89

8.3 Conditions assessed 89
8.3.1 General 89
8.4 Existing Conditions hydrologic model configuration 90
8.4.1 General 90
8.4.2 Design rainfall depths, intensities and temporal patterns 90
8.4.3 Design rainfall losses 90
8.4.4 Peak flow validation 92
8.4.5 Adopted design discharges 92
8.5 Hydraulic model development 93
8.5.1 Topographic data 93
8.5.2 Inflow and outflow boundaries 93
8.5.3 Manning's 'n' values 94
8.5.4 Hydraulic structures 94
8.6 Post-closure Conditions changes to the Existing COnditions 94
8.6.1 Proposed drainage corridor 94
8.6.2 Proposed Saraji Road culverts 97
8.6.3 Proposed flood protection levee 97
8.7 Existing Conditions design flood levels and extents 100
8.7.1 Existing Conditions modelling results 100
8.7.2 Scenario 1 – Existing Conditions (with levee) 100
8.7.3 Scenario 2 – Existing Conditions (no levee) 101
8.8 Post-closure conditions potential flood impacts 101
8.8.1 General 101
8.8.2 Scenario 1 – Post-closure Conditions impacts (with levee) 102
8.8.3 Scenario 2 – Post-closure Conditions impacts (no levee) 102
9 Surface water monitoring 105
9.1 Overview 105
9.2 Receiving water quality monitoring 106
9.2.1 Release contaminant trigger investigation levels 106
9.3 Mine affected water quality monitoring 109
9.4 Sediment dam monitoring 110
9.5 Receiving Environment Monitoring Program (REMP) 110
10 Cumulative impacts 111
10.1 Overview 111
10.2 Existing projects 111
10.3 New or developing projects 111
10.4 Cumulative impacts – surface water resources 112
10.4.1 Water quality 112
10.4.2 Loss of catchment and stream flows in the Isaac River 116
11 Summary of findings 118

11.1 Overview 118
11.2 Water management system performance 118
11.3 Flooding 118
11.4 Impacts on downstream water quality 119
11.5 Cumulative impacts 119
11.6 Final landform 119
12 References 120
Appendix A - **Existing Conditions flood maps and results 122**
Appendix B - **Post-closure Conditions flood impact maps 135**

List of Figures

Figure 1.1 – Locality plan 13
Figure 1.2 – Stage 1 (Year 2022) water management system plan 14
Figure 1.3 - Stage 2 (Year 2024) water management system plan 15
Figure 1.4 – Final landform (post-mining conditions) for the Project 16
Figure 3.1 - Isaac River Sub-Basin EVs 28
Figure 4.1 – Upper Isaac River drainage characteristics 32
Figure 4.2 – Regional catchments in the vicinity of the Project 33
Figure 4.3 – Local drainage features in the vicinity of the Project 34
Figure 4.4 – Photograph of Drainage Line 1 within the Project area 35
Figure 4.5 – Photograph of the existing railway culvert crossing of Drainage Line 1 at the eastern (downstream) Project boundary 36
Figure 4.6 – Photograph of the existing drainage diversion and levee within the Project area 37
Figure 4.7 – Photograph of Drainage Line 2 within the Project area 38
Figure 4.8 – Drainage line cross sections with 1% AEP flood levels 39
Figure 4.9 – Long term mean monthly rainfall and evaporation from SILO at the Project 40
Figure 4.10 – Flow volume and river height in the Isaac River at Deverill 41
Figure 4.11 – Sample flow sequence – Phillips Creek at Tayglen 1977 - 1979 42
Figure 4.12 – Measured mean monthly streamflow – Phillips Creek at Tayglen 1968-1988 42
Figure 4.13 – Recorded frequency curves at nearby DNRME gauges (no flow days included) 43
Figure 4.14 - Electrical Conductivity and Flow (Isaac River at Deverill Gauge) 45
Figure 4.15 - Flow vs Electrical Conductivity (Isaac River at Deverill Gauge) 45
Figure 4.16 - Water monitoring locations 49
Figure 6.1 – Water management system schematic for the Project 62
Figure 7.1 – Forecast MWD1 inventory 71
Figure 7.2 – Forecast annual maximum MWD1 inventory 72
Figure 7.3 – Forecast annual combined maximum water inventory in MWD2, MWD3, MWD4 and MWD5 72
Figure 7.4 – Jupiter forecast mine pit inventory 73
Figure 7.5 – Jupiter forecast annual maximum pit inventory 74
Figure 7.6 – Forecast external water requirement for dust suppression 75
Figure 7.7 – Forecast annual sediment dam overflows to the receiving waters 76
Figure 7.8 – Forecast total annual overflows from SD6 to DD1 76
Figure 7.9 – Forecast total annual pumped transfers from DD1 to the existing drainage diversion 77
Figure 7.10 – Forecast total annual overflow volumes from DD1 to the Jupiter pit 78

Figure 7.11 – Predicted Boomerang Creek annual maximum EC variation downstream of the Project 80
Figure 7.12 – Project release rate compared to flow rate in the receiving waters – Scenario 1 81
Figure 7.13 – Project release EC levels compared to EC levels in the receiving waters and corresponding water quality criteria – Scenario 1 81
Figure 7.14 – Project release rates compared to flow rates in the receiving waters– Scenario 2 82
Figure 7.15 – Project release EC levels compared to EC levels in the receiving waters as well as the corresponding water quality criteria – Scenario 2 83
Figure 7.16 – Forecast annual maximum MWD1 inventory – dust suppression sensitivity analysis 84
Figure 7.17 – Jupiter forecast annual maximum mine pit inventory – dust suppression sensitivity analysis 85
Figure 7.18 – Forecast annual total external water requirement - dust suppression sensitivity analysis 85
Figure 7.19 – Forecast annual total external water requirement – climate change 'best case' sensitivity analysis 87
Figure 7.20 – Forecast annual total external water requirement – climate change 'worst case' sensitivity analysis 88
Figure 8.1 – XP-RAFTS model configuration 91
Figure 8.2 – Jupiter Pit Existing Conditions hydraulic model configuration 95
Figure 8.3 – Jupiter Pit Final Landform (Post-closure Conditions) hydraulic model configuration 96
Figure 8.4 – Conceptual cross section of the proposed drainage corridor and the 10%, 1% and 0.1% AEP event water surface elevations for both levee scenarios 97
Figure 8.5 – Proposed flood protection levee alignment 99
Figure 9.1 – Proposed surface water monitoring locations 107
Figure 10.1 – Cumulative impact assessment 117
Figure A.1 – 10% AEP peak flood depths – Existing Conditions (with levee) 123
Figure A.2 – 1% AEP peak flood depths – Existing Conditions (with levee) 124
Figure A.3 – 0.1% AEP peak flood depths – Existing Conditions (with levee) 125
Figure A.4 – 10% AEP peak velocities – Existing Conditions (with levee) 126
Figure A.5 – 1% AEP peak velocities – Existing Conditions (with levee) 127
Figure A.6 – 0.1% AEP peak velocities – Existing Conditions (with levee) 128
Figure A.7 – 10% AEP peak flood depths – Existing Conditions (no levee) 129
Figure A.8 – 1% AEP peak flood depths – Existing Conditions (no levee) 130
Figure A.9 – 0.1% AEP peak flood depths – Existing Conditions (no levee) 131
Figure A.10 – 10% AEP peak velocities – Existing Conditions (no levee) 132
Figure A.11 – 1% AEP peak velocities – Existing Conditions (no levee) 133
Figure A.12 – 0.1% AEP peak velocities – Existing Conditions (no levee) 134
Figure B.1 – 10% AEP change in peak water levels – Post-closure Conditions (with levee) impacts 136

Figure B.2 - 1% AEP change in peak water levels - Post-closure Conditions (with levee) impacts _____137
Figure B.3 - 0.1% AEP change in peak water levels – Post-closure Conditions (with levee) impacts _____138
Figure B.4 - 10% AEP change in peak velocities – Post-closure Conditions (with levee) impacts _____139
Figure B.5 - 1% AEP change in peak velocities – Post-closure Conditions (with levee) impacts _____140
Figure B.6 - 0.1% AEP change in peak velocities – Post-closure Conditions (with levee) impacts _____141
Figure B.7 - 10% AEP change in peak water levels – Post-closure Conditions (no levee) impacts _____142
Figure B.8 - 1% AEP change in peak water levels – Post-closure Conditions (no levee) impacts _____143
Figure B.9 - 0.1% AEP change in peak water levels – Post-closure Conditions (no levee) impacts _____144
Figure B.10 - 10% AEP change in peak velocities - Post-closure Conditions (no levee) impacts _____145
Figure B.11 - 1% AEP change in peak velocities – Post-closure Conditions (no levee) impacts _____146
Figure B.12 - 0.1% AEP change in peak velocities – Post-closure Conditions (no levee) impacts _____147

List of Tables

Table 2.1 – IESC information requirements – surface water _____17
Table 2.2 – Application requirements for activities with impact to Water – Guideline ____25
Table 2.3 – Wastewater release to Queensland waters – technical guideline _____26
Table 3.1 – Water Quality Objectives default trigger values for the Project (from EPP WWB for Isaac Western Upland Tributaries) _____29
Table 4.1 – Evaporation (Morton's lake) statistics over the historical period (mm) _____40
Table 4.2 – Rainfall statistics over the historical period (mm) _____40
Table 4.3 – Water quality median data in the Isaac River at Deverill _____44
Table 4.4 – Baseline water quality monitoring _____46
Table 4.5 – Soil Management Units surveyed on site (AARC, 2019) _____50
Table 5.1 – Types of water managed within the Project _____52
Table 5.2 - Proposed sediment dams _____54
Table 5.3 - Proposed mine affected water dams _____55
Table 5.4 - 1% AEP 24 hour pit dewatering rates _____56
Table 6.1 - Simulated inflows and outflows to the water management system _____58
Table 6.2 - Application of representative mine stages to full mine life _____58
Table 6.3 - Adopted AWBM parameters _____59
Table 6.4 - Water management system operating rules for the Project _____60

Table 6.5 - Water storage catchment areas (Stage 1) 63
Table 6.6 - Water storage catchment areas (Stage 2) 63
Table 6.7 - Forecast Haul Road Dust Suppression usage 64
Table 6.8 - Estimated groundwater inflows 65
Table 6.9 - Phillips Creek AWBM parameters 66
Table 6.10 - Adopted salinity concentrations 67
Table 7.1 - Average annual water balance – all realisations 70
Table 7.2 - Average annual salt balance (based on TDS) 79
Table 7.3 – Projections of changes to climate 86
Table 8.1 – Peak design discharge comparison between XP-RAFTS and Rational Method 92
Table 8.2 - FFA at Tayglen gauge compared to XP-RAFTS peak discharge 92
Table 8.3 - Adopted design discharges, critical storm durations and temporal pattern 93
Table 8.4 – Indicative drainage corridor depths and velocities during Post-closure Conditions 97
Table 8.5 – 0.1% AEP flood levels adjacent to the proposed flood protection levee required for operations 98
Table 8.6 – Changes in peak water levels under Post-closure Conditions 103
Table 8.7 – Changes in peak velocities under Post-closure Conditions 104
Table 9.1 – Proposed surface water and mine water dam quality monitoring locations 105
Table 9.2 – Receiving waters water quality laboratory analysis parameters 108
Table 9.3 – Receiving water contaminant trigger levels 108
Table 9.4 – Dam laboratory analysis parameters 109
Table 9.5 – Mine affected water release limits 109
Table 10.1 – Existing projects considered in the cumulative impact assessment 113
Table 10.2 – Proposed projects considered in the cumulative impact assessment 115
Table 10.3 – Catchment area of existing projects considered in the cumulative impact assessment 116

1 Introduction

1.1 BACKGROUND

The Vulcan Complex Project (the Project or VCP), which is managed by Vitrinite Pty. Ltd., owner of Qld Coal Aust No.1 Pty. Ltd. and Queensland Coking Coal Pty. Ltd. (Vitrinite), is a proposed open pit operation located to the southeast of Moranbah, in Central Queensland. The Project is located on Exploration Permit (Coal) (EPC) 1234 and EPC 1732. The locations of the EPCs and the proposed Project mining lease application (MLA) area are shown in Figure 1.1. The proposed mine stage layouts for the Project, including all major surface water infrastructure elements required during operations and post-mining, are shown in Figure 1.2, Figure 1.3 and Figure 1.4.

WRM Water & Environment Pty Ltd (WRM) was engaged by Mining and Energy Technical Services Pty Ltd (METServe), on behalf of Vitrinite, to undertake a surface water impact assessment for the Project. The surface water impact assessment will form part of an Environmental Assessment application for the Project.

This report presents the following:

- An overview of the regulatory framework which applies to the Project (including aspects which do not directly relate to the surface water assessment) (Section 2);
- A description of the environmental values (EVs) of the receiving waters surrounding the Project (Section 3);
- A description of the existing surface water environment at the Project (Section 4);
- A description of the proposed water management strategy and details regarding water management infrastructure (Section 5);
- A detailed description of the configuration of the Project water balance model (Section 6);
- An assessment of the Project water management system performance (Section 7);
- An assessment of the potential flooding impacts of the Project (Section 8); and
- A description of the surface water monitoring strategy proposed for the Project (Section 9).

1.2 PROJECT DESCRIPTION

The Jupiter hard coking coal target has been defined and selected for open cut development via a single pit. The Project will operate for approximately 4 years and will extract approximately 6 million tonnes of run of mine (ROM) hard coking coal at a rate of up to 1.95 million tonnes per annum. The Project will target the Alex and multiple Dysart Lower coal seams. Truck and shovel mining operations will be utilised in the pit. ROM coal will be trucked off site to a coal handling and preparation plant (CHPP) at a nearby facility between Moranbah and Coppabella on the Peak Downs Highway.

A small out-of-pit waste rock dump will be established prior to commencing in-pit dumping activities that will continue for the life of the operation. Ancillary infrastructure, including a ROM pad, Mine Infrastructure Area (MIA), offices, roads and surface water management infrastructure will be established to the west and south of the open cut.

A realignment of the existing Saraji Road and services infrastructure to the eastern boundary of the proposed MLA area, adjacent to the existing rail easement, is also proposed. The re-alignment will occur on lease however the connection back to the

existing alignment of Saraji Road to the north will extend off lease and will be subject to a separate approvals process.
In-pit dumping will fill most of the pit during operations with the remaining final void to be backfilled upon cessation of mining, resulting in the establishment of a low waste rock dump landform over the former pit area. The initial out-of-pit waste rock dump will be rehabilitated in-situ.

Vitrinite has been granted an Environmental Authority (EA0002054) and a Mineral Development Licence (MDL3039) to permit extraction of a bulk sample of coal from the Jupiter target. Prior to commencement of the VCP, Vitrinite will extract up to 600 kilotonnes (kt) of high-quality ROM coking coal from the bulk sample pit for testing by a number of international coal consumers. To access the coking coal within the bulk sample area, up to an additional 150 kt of thermal coal lying above the coking coal, will also be extracted incidentally. The bulk sample does not form part of the VCP. However, its features are assumed to form part of baseline conditions for the purposes of environmental assessment of the VCP.

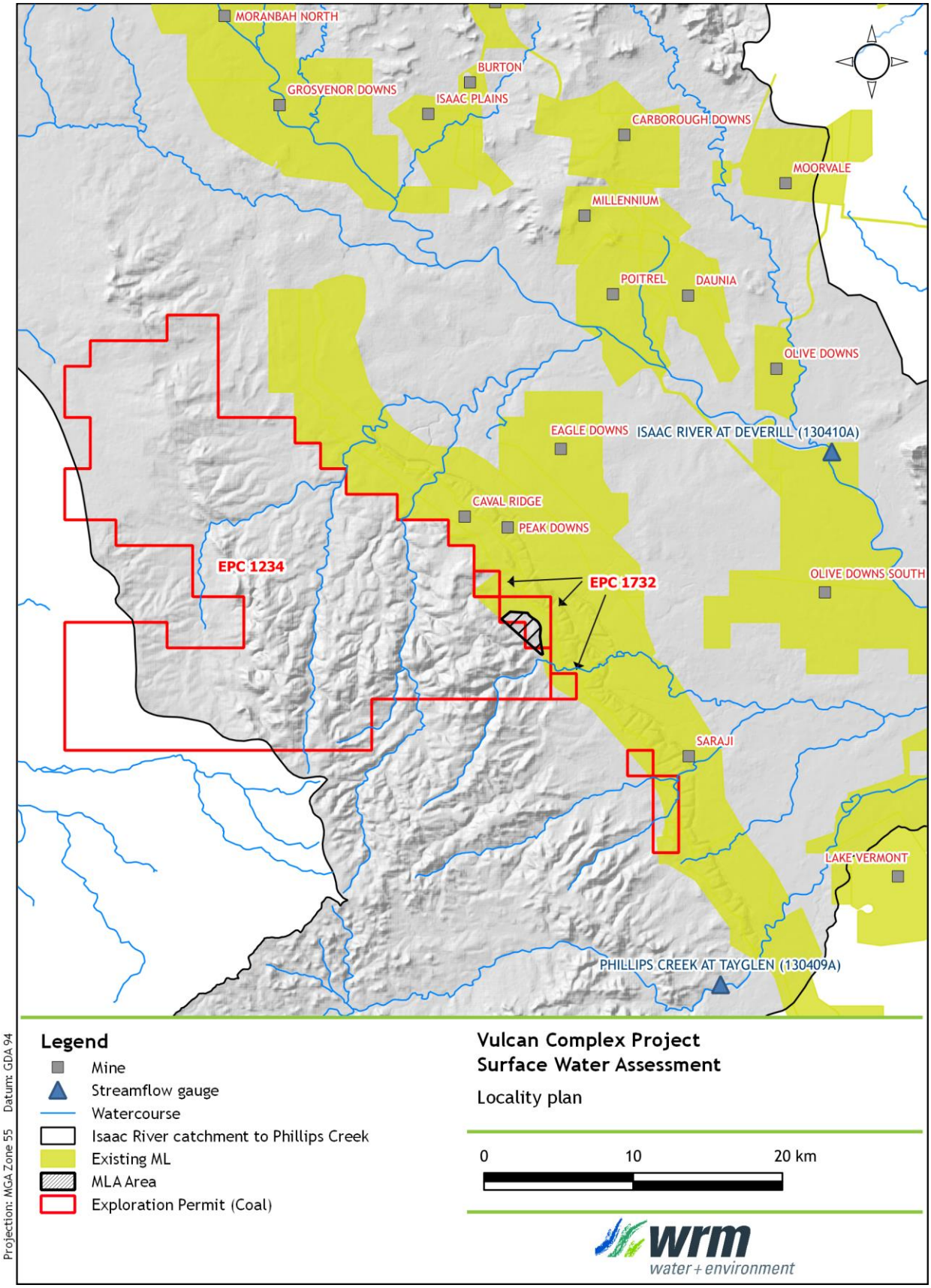


Figure 1.1 - Locality plan

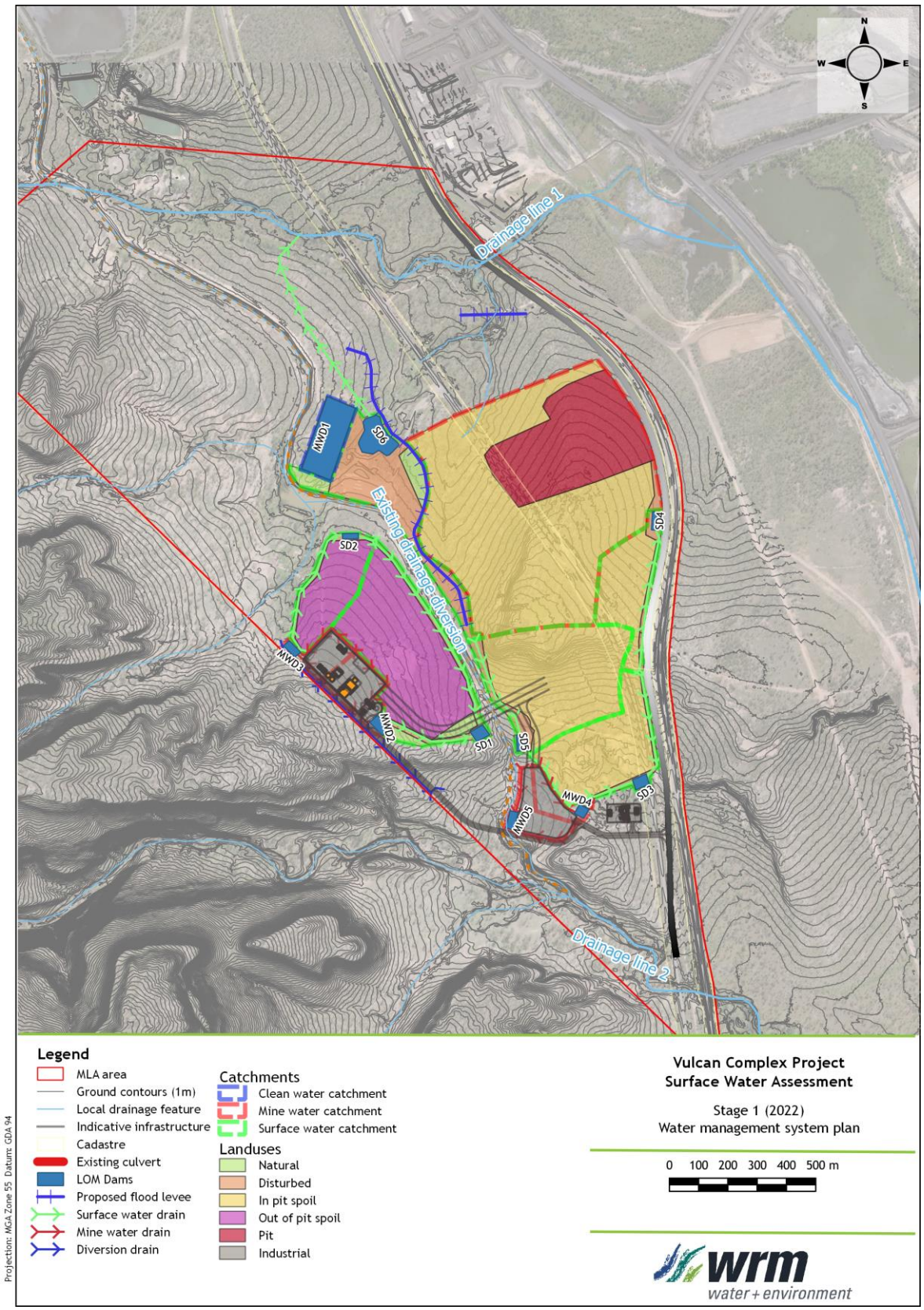


Figure 1.2 - Stage 1 (Year 2022) water management system plan

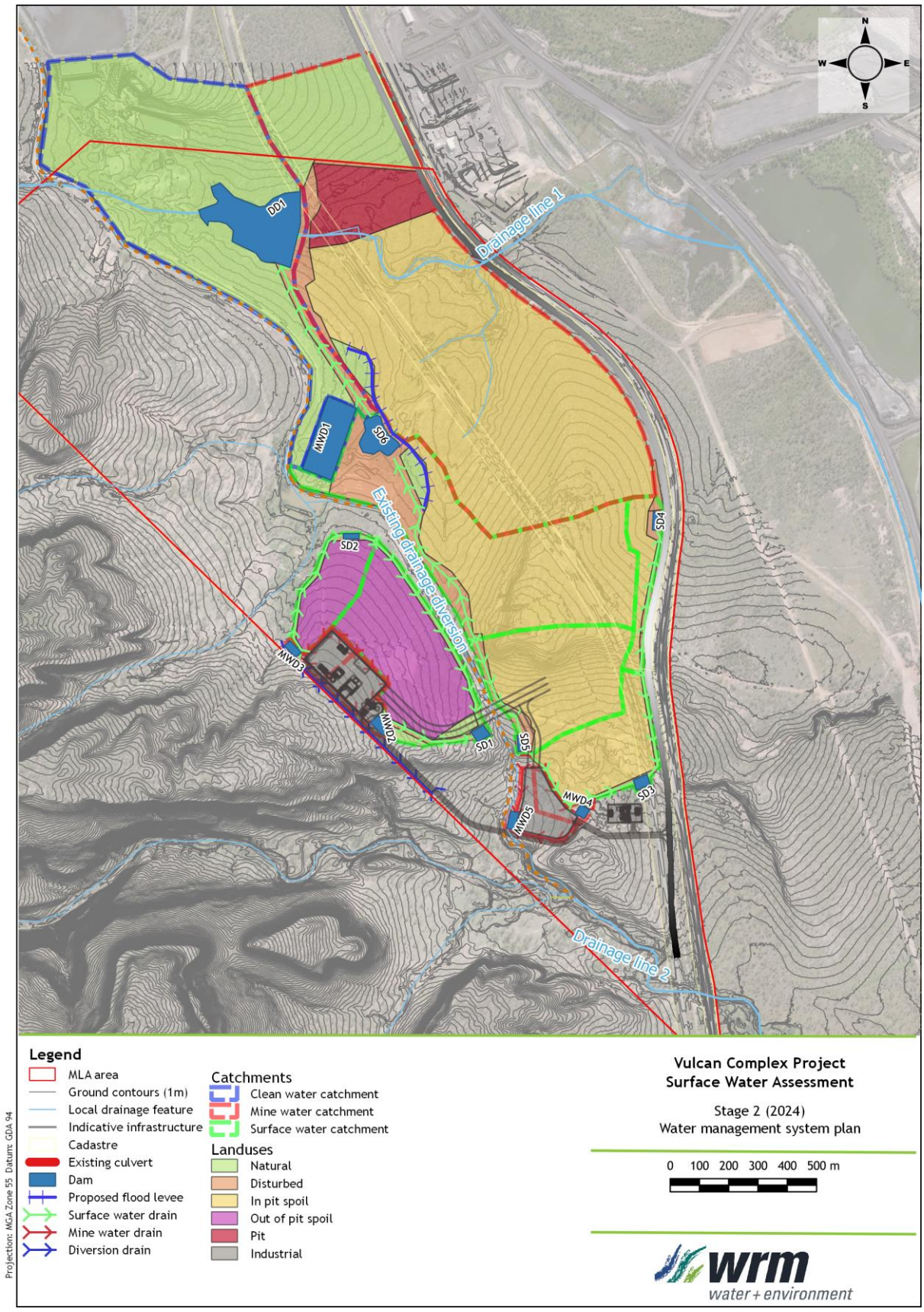


Figure 1.3 - Stage 2 (Year 2024) water management system plan

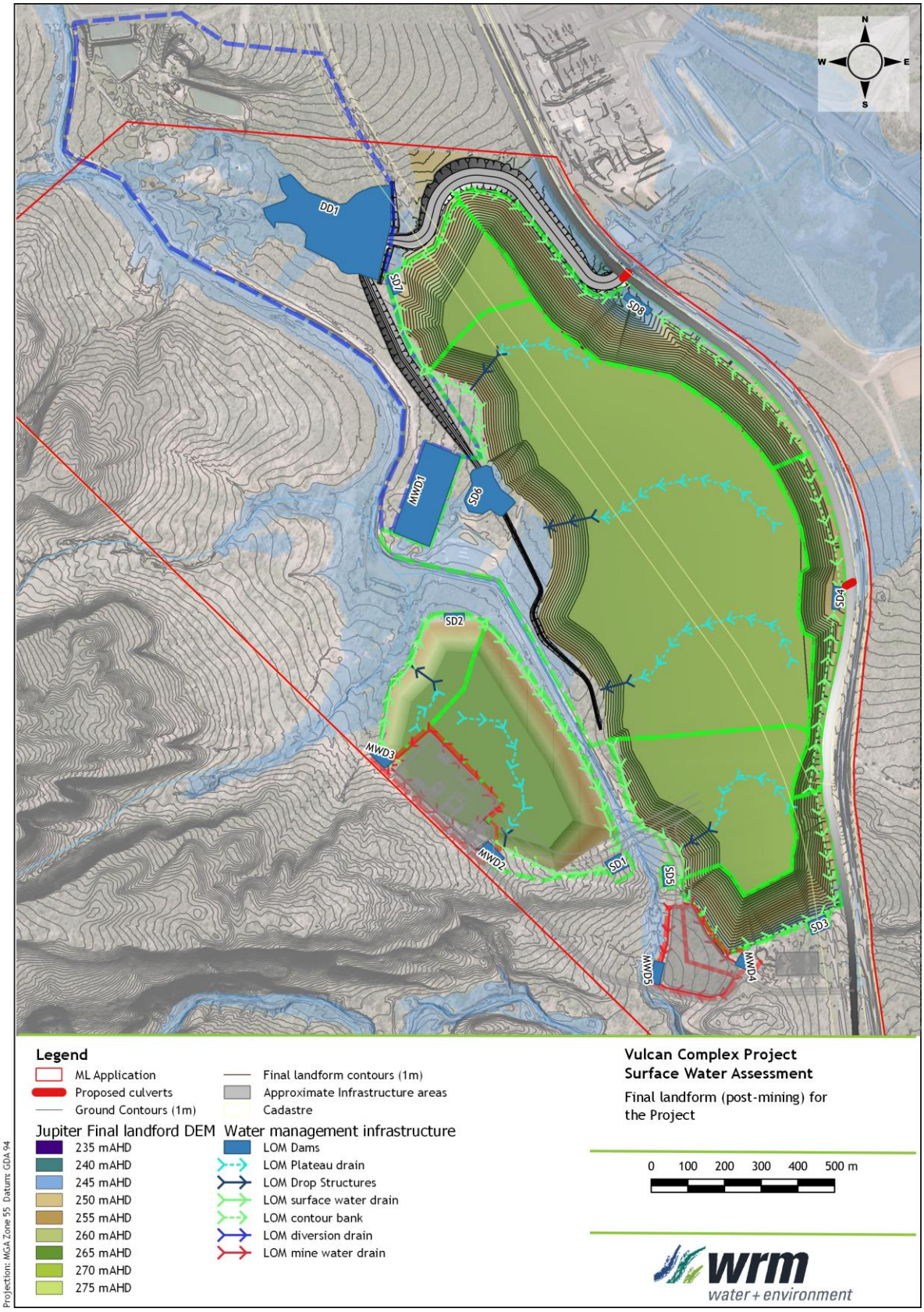


Figure 1.4 - Final landform (post-mining conditions) for the Project

2 Regulatory framework

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

2.1 COMMONWEALTH

The Project will be referred to the Department of the Environment and Energy for consideration under the *Environment Protection and Biodiversity Conservation Act 1999*.

The Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development has published information guidelines (IESC, 2018) for advice on coal seam gas and large coal mining development proposals. The report sections where the IESC information requirements have been addressed are outlined in Table 2.1.

Table 2.1 – IESC information requirements – surface water

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.	Section 1 and Main EA Report
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.	Section 1 and Main EA Report
Describe the statutory context, including information on the proposal's status within the regulatory assessment process and any applicable water management policies.	Section 2 and Main EIS Report
Describe how impacted water resources are currently being regulated under state or Commonwealth law, including whether there are any applicable standard conditions.	Section 2
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 4
• spatial, temporal and seasonal trends in streamflow and/or standing water levels;	Section 4.4
• spatial, temporal and seasonal trends in water quality data (such as turbidity, acidity, salinity, relevant organic chemicals, metals, metalloids and radionuclides); and	Section 4.5
• current stressors on watercourses, including impacts from any currently approved projects.	Section 4 & 10
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

Project information	Report section
Provide an assessment of the frequency, volume, seasonal variability and direction of interactions between water resources, including surface water/groundwater connectivity and connectivity with sea water.	Refer to Groundwater report
Surface water – analytical and numerical modelling	
Provide conceptual models at an appropriate scale, including water quality, stores, flows and use of water by ecosystems.	Section 5 & 6
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.	Section 6 & 8
Describe and justify model assumptions and limitations and calibrate with appropriate surface water monitoring data.	Section 6 & 8
Provide an assessment of the risks and uncertainty inherent in the data used in the modelling, particularly with respect to predicted scenarios.	Section 7.4
Provide a detailed description of any methods and evidence (e.g. expert opinion, analogue sites) employed in addition to modelling.	N/A
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 8.8 & 10
• Impacts associated with surface water diversions;	Section 8.8
• Impacts to water quality, including consideration of mixing zones;	Section 7.3.7
• 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; and	Section 7.3.7
• 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.	Sections 5, 8.6 & 8.8
Discuss existing water quality guidelines, environmental flow objectives and requirements for the surface water catchment(s) within which the development proposal is based.	Section 2 & 3
Identify processes to determine surface water guidelines and quantity thresholds which incorporate seasonal variation but provide early indication of potential impacts to assets.	Section 9
Propose mitigation actions for each identified significant impact.	Section 6 & 8
Describe the adequacy of proposed measures to prevent or minimise impacts on water resources and water-dependent assets.	Section 6 & 8
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

Project information	Report section
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 8
Surface water – data and monitoring	
Identify monitoring sites representative of the diversity of potentially affected water-dependent assets and the nature and scale of potential impacts, and match with suitable replicated control and reference sites (BACI design) to enable detection and monitoring of potential impacts.	Section 4.5
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 4.5
Identify data sources, including streamflow data, proximity to rainfall stations, data record duration and a description of data methods, including whether missing data has been patched.	Sections 4.3 & 4.4
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);	Section 4.5
• comparison of physico-chemical data to national/regional guidelines or to site- specific guidelines derived from reference condition monitoring if available; and	Section 4.5
• identify baseline contaminant concentrations and compare these to national guidelines, allowing for local background correction if required.	Section 4.5
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 9
Identify dedicated sites to monitor hydrology, water quality, and channel and floodplain geomorphology throughout the life of the proposed project and beyond.	Section 9
Water-dependent assets – context and conceptualisation	
Identify water-dependent assets, including:	
• water-dependent fauna and flora and provide surveys of habitat, flora and fauna (including stygofauna) (see Doody et al. [in press]); and	Refer to Main EA Report
• public health, recreation, amenity, Indigenous, tourism or agricultural values for each water resource.	
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 the identification of GDEs (see Doody et al. [in press]).	Refer to Groundwater Report
Describe the conceptualisation and rationale for likely water-dependence, impact pathways, tolerance and resilience of water-dependent assets. Examples of ecological conceptual models can be found in Commonwealth of Australia (2015).	Refer to Groundwater Report
Estimate the ecological water requirements of identified GDEs and other water-dependent assets (see Doody et al. [in press]).	Refer to Groundwater Report

Project information	Report section
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 & 4
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 9
Water dependent assets – impacts, risk assessment and management of risk	
Provide an assessment of direct and indirect impacts on water-dependent assets, including ecological assets such as flora and fauna dependent on surface water and groundwater, springs and other GDEs (see Doody et al. [in press]).	Refer to Groundwater Report
Describe the potential range of drawdown at each affected bore, and clearly articulate the scale of impacts to other water users.	Refer to Groundwater Report
Indicate the vulnerability to contamination (e.g. from salt production and salinity) and the likely impacts of contamination on the identified water-dependent assets and ecological processes.	Section 7.3.7
Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion and habitat fragmentation of water-dependent species and communities.	Section 5
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 7.3.7 & 7.3.8
Assess the overall level of risk to water-dependent assets through combining probability of occurrence with severity of impact.	Section 7 & 8
Identify the proposed acceptable level of impact for each water-dependent asset based on leading-practice science and site-specific data, and ideally developed in conjunction with stakeholders.	Section 0
Propose mitigation actions for each identified impact, including a description of the adequacy of the proposed measures and how these will be assessed.	Section 5 & 9
Water-dependent assets – data and monitoring	
Identify an appropriate sampling frequency and spatial coverage of monitoring sites to establish pre-development (baseline) conditions, and test potential responses to impacts of the proposal (see Doody et al. [in press]).	Section 9
Consider concurrent baseline monitoring from unimpacted control and reference sites to distinguish impacts from background variation in the region (e.g. BACI design, see Doody et al. [in press]).	
Develop and describe a monitoring program that identifies impacts, evaluates the effectiveness of impact prevention or mitigation strategies, measures trends in ecological responses and detects whether ecological responses are within identified thresholds of acceptable change (see Doody et al. [in press]).	
Describe the process for regular reporting, review and revisions to the monitoring program.	

Project information	Report section
Ensure ecological monitoring complies with relevant state or national monitoring guidelines (e.g. the DSITI guideline for sampling stygofauna (QLD Government 2015)).	
Water and salt balance, and water management quality	
Provide a quantitative site water balance model describing the total water supply and demand under a range of rainfall conditions and allocation of water for mining activities (e.g. dust suppression, coal washing etc.), including all sources and uses.	Section 7
Describe the water requirements and on-site water management infrastructure, including modelling to demonstrate adequacy under a range of potential climatic conditions.	Section 7
Provide estimates of the quality and quantity of operational discharges under dry, median and wet conditions, potential emergency discharges due to unusual events and the likely impacts on water-dependent assets.	Section 7.3.5 & 7.3.8
Provide salt balance modelling that includes stores and the movement of salt between stores and takes into account seasonal and long-term variation.	Section 7.3.6
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
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
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 4, 7, 9 & 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;	Section 10

Project information	Report section
• 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.	
Cumulative impacts – mitigation, monitoring and management	
Identify modifications or alternatives to avoid, minimise or mitigate potential cumulative impacts. Evidence of the likely success of these measures (e.g. case studies) should be provided.	
Identify measures to detect and monitor cumulative impacts, pre and post development, and assess the success of mitigation strategies.	Section 7.4, 7.5, 9 & 10
Identify cumulative impact environmental objectives.	
Describe appropriate reporting mechanisms.	
Propose adaptive management measures and management responses.	
Final landforms and voids – coal mines	
Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	
Assess the adequacy of modelling, including surface water and groundwater quantity and quality, lake behaviour, timeframes and calibration.	
Provide an assessment of the long-term impacts to water resources and water-dependent assets posed by various options for the final landform design, including complete or partial backfilling of mining voids. Assessment of the final landform for which approval is being sought should consider: • 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; and • measures to prevent migration of void water off-site. For other final landform options considered sufficient detail of potential impacts should be provided to clearly justify the proposed option.	Section 5 and Main EA report
Assess the probability of overtopping of final voids with variable climate extremes, and management mitigations.	N/A
Acid-forming materials and other contaminants of concern	
Identify the presence and potential exposure of acid-sulfate soils (including oxidation from groundwater drawdown).	Refer to Main EA Report, Geochemical Assessment Report and Section 6.8
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.	

Project information	Report section
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.	

2.2 STATE

2.2.1 EP Act 1994

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

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

2.2.1.1 Environmental Authority

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

- Management of contained water including release;
- Water management plan requirements;
- Regulation of water structures including dams and levees;
- Saline drainage management;
- Acid rock drainage management; and
- Storm water and sediment laden runoff management.

2.2.1.2 Model Mining Conditions

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

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

Schedule F – Water (Fitzroy model conditions) form the basis of the requirements for the Project water management system design.

2.2.1.3 Environmental Protection (Water and Wetland Biodiversity) Policy 2019

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

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

The EVs for the Project location are outlined in Section 3.

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

The relevant document, pursuant to the EPP WWB, for the Project is the *Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part)*, including all waters of the Isaac River Sub-basin (including Connors River, September 2011 [DEHP, 2011]). The document is made pursuant to the provisions of the EPP WWB. It contains EVs and WQOs for waters in the Isaac River Sub-basin, and they are listed under Schedule 1 of EPP WWB. Refer to Section 3 for further details.

2.2.1.5 Manual for Assessing Consequence Categories and Hydraulic Performance of Structures

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

2.2.1.6 Guideline – Application Requirements for Activities with Impacts to Water

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

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

- Discharges and releases;
- Unplanned and uncontrolled releases;
- Water infrastructure;
- Wetlands;
- Hydrology of receiving waters; and
- Mixing zones.

Table 2.2 lists the elements of the guideline relevant to this assessment and the sections of this report where those elements are addressed.

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

Table 2.2 – Application requirements for activities with impact to Water – Guideline

Item	Report section
Discharges and releases	
Identify activities that could lead to indirect impacts and unplanned/uncontrolled release of contaminants to water, such as, spills and leaks or stream bed and/or bank disturbance and describe the magnitude of the disturbance	Section 7.3.5 & 7.3.8
Identify the location, depth and configuration (if relevant) of the areas where the unplanned/uncontrolled release could be discharged to waters	Section 5 & 7.3.5
Identify infrastructure (including containment devices) with the potential to release unplanned/uncontrolled contaminants to waters	Section 6.4
Identify the potential contaminant type and quantities that could be released from infrastructure	Section 6.8 & 7.3.5
Water infrastructure	
Provide detail on the location and storage capacity of water infrastructure on the site which may include regulated structures, tailings dams, waste rock dams, water storage dams, levees, heap leach pads and any other water management infrastructure	Section 6.4
Wetlands	
Applicants must describe how the existing environmental values of any wetlands on, or adjacent to, the site will be maintained, or enhanced	Section 3
Ecology and hydrology of receiving waters	
Describe, preferably through the use of water quality monitoring or modelling, how the proposed ERA will impact on hydrology of receiving waters, preferably through modelling	Section 7.3

2.2.1.7 Technical Guideline – Wastewater release to Queensland Waters

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

The information requirements identified in this guideline are as follows:

- Describe the proposed activity;
- Describe the receiving environment;
- Predict outcomes or impacts of the proposed wastewater release; and
- Set circumstances, limits and monitoring conditions.

Table 2.3 lists the elements of the guideline relevant to this assessment and the sections of this report where those elements are addressed.

Table 2.3 – Wastewater release to Queensland waters – technical guideline

Item	Report section
Step 1 – Describe the proposed activity	
Define industry type and size (estimated production, current and ultimate)	Section 1.2
Identify the potential contaminants of concern in the proposed release	Section 6.8
Location and configuration of the proposed release	Section 6.4
Step 2 – Describe the receiving environment	
Identify water bodies potentially affected by the proposed release	Section 4
Provide all relevant information on the receiving environment based on desktop and field studies (e.g. current, background water quality condition)	
Include special consideration for ephemeral streams	
Identify all relevant EV and WQOs	Section 3
Ensure all government planning requirements applying to the water bodies have been considered	Section 2
Step 3 - Predict outcomes or impacts of the proposed wastewater release	
Assess whether contaminants are potentially toxic	Section 6.8 and 7.3
Predict the assimilative capacity and sustainable load	Section 7.3
Consider other potential impacts	Section 7.3
Step 4 – Set circumstances, limits and monitoring conditions	
Specify any circumstances related to the approved wastewater release	Section 6.4
Include a receiving environment monitoring program (REMP) requirement	Section 0
Include reporting requirements for the approved activity	Section 9

2.2.2 Water Act 2000

In Queensland, the Water Act 2000 (Water Act) is the primary statutory document that establishes a framework for the planning, allocation and use of non-tidal water. The Water Act is primarily administered by the Department of Natural Resources, Mines and Energy (DNRME).

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

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

A watercourse is defined by the Water Act as a river, creek or stream, including a stream in the form of an anabranch or a tributary, in which water flows permanently or intermittently. The DNRME have published a watercourse identification map of the state that shows: watercourses (other than their lateral limits); the downstream limit of watercourses; drainage features; lakes; and springs.

A watercourse determination for drainage features in the MLA area has been undertaken by the DNRME. DNRME determined that no watercourses intersect the MLA area and all

features are drainage features defined by the Water Act. These features are described in Section 4.

2.2.2.1 Water Plan (Fitzroy Basin) 2011

The Water Plan (Fitzroy Basin) 2011 is subordinate legislation to the Water Act. The plan is developed and administered by DNRME. The purpose of the plan is:

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

2.2.2.2 Water Regulation 2016

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

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

2.2.3 Water Supply (Safety & Reliability) Act 2008

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

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

3 Environmental Values

The Queensland Water Quality Guidelines and EPP WWB guidelines establish environmental values (EVs) and water quality objectives (WQOs) for natural waters in Queensland. The Project is located within the 'Isaac western upland tributaries' area of the Isaac River sub-basin, shown in Figure 3.1. Under the EPP WWB, the following EVs have been nominated for this area:

- Aquatic ecosystems;
- Irrigation;
- Farm supply/use;
- Stock Water;
- Aquaculture;
- Human consumption;
- Primary recreation;
- Secondary recreation;
- Visual recreation;
- Drinking water;
- Industrial use; and
- Cultural and spiritual values.

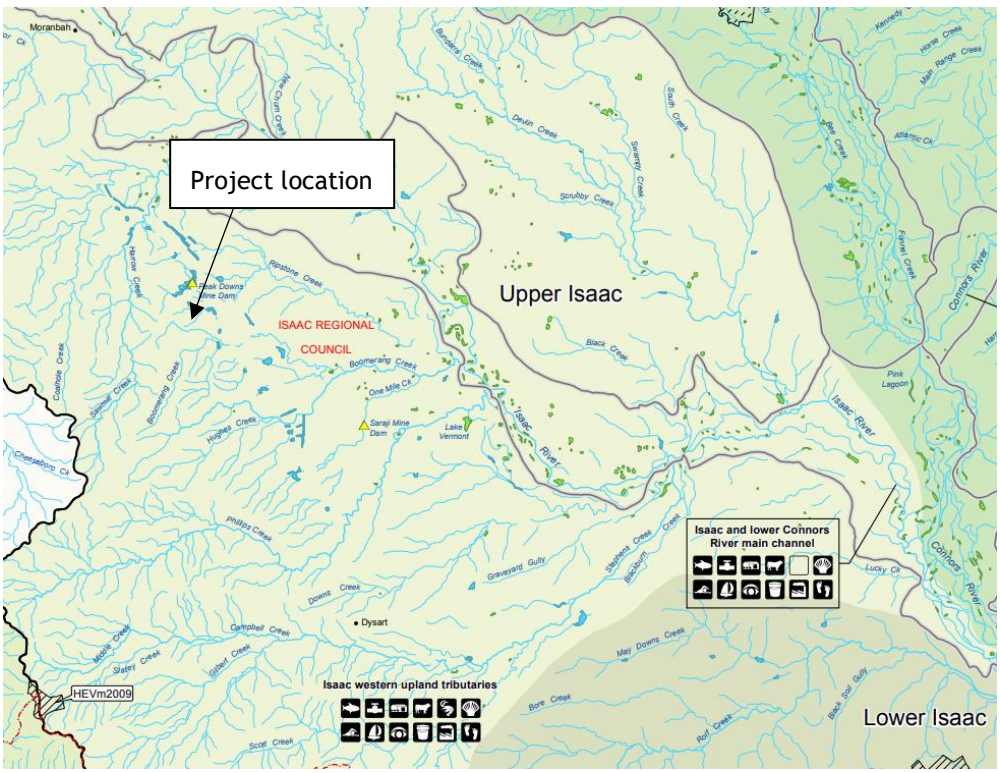


Figure 3.1 - Isaac River Sub-Basin EVs

The WQO default trigger values for the above EVs are provided in Table 3.1. The indicators and water quality guidelines relevant to the above surface water EVs are listed in Schedule 1 of EPP WWB and the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018).

Where different EVs have different WQOs, the Project has adopted the lowest concentration value for mine water and receiving waters trigger levels. WQO default trigger values are displayed for physio-chemical parameters only.

Table 3.1 – Water Quality Objectives default trigger values for the Project (from EPP WWB for Isaac Western Upland Tributaries)

Parameter	WQO	Relevant EV
Ammonia N	< 20 µg/L	Aquatic ecosystem[a]
Oxidised N	< 60 µg/L	Aquatic ecosystem[a]
Organic N	< 420 µg/L	Aquatic ecosystem[a]
Total nitrogen	< 500 µg/L	Aquatic ecosystem[a]
Filterable Reactive Phosphorus (FRP)	< 20 µg/L	Aquatic ecosystem[a]
Total Phosphorus	< 50 µg/L	Aquatic ecosystem[a]
Chlorophyll a	< 5 µg/L	Aquatic ecosystem[a]
Dissolved oxygen	85-110% saturation > 4 mg/L at surface	Aquatic ecosystem[a] Drinking water[b]
Turbidity	< 50 NTU	Aquatic ecosystem[a]
Suspended solids	< 55 mg/L	Aquatic ecosystem[a]
pH	pH 6.5-8.5	Aquatic ecosystem[a]
Conductivity (EC) baseflow	720 µS/cm	Aquatic ecosystem[a]
Conductivity (EC) high flow	250 µS/cm	Aquatic ecosystem[a]
Sulfate	25 mg/L	Aquatic ecosystem[a]
Total Dissolved Solids	< 2000 mg/L	Stock watering[c]
Colour	50 Hazen Units	Drinking water[b]
Total Hardness	150 mg/L as CaCO3	Drinking water[b]
Sodium	< 30 mg/L	Drinking water[b]
Aluminium	< 5 mg/L < 0.055 mg/L	Stock watering[c] Aquatic ecosystem[d]
Arsenic	2.0 mg/L 0.5 mg/L up to 5 mg/L < 0.024 mg/L	Irrigation[b, e] Stock watering[f] Aquatic ecosystem[d]
Beryllium	< 0.5 mg/L	Irrigation[g]
Boron	< 5 mg/L < 0.37 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Cadmium	< 0.01 mg/L < 0.0002 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Chromium	< 1 mg/L < 0.001 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Cobalt	< 0.1 mg/L	Irrigation[g]
Copper	< 1 mg/L < 0.0014 mg/L	Stock watering (cattle)[f,e] Aquatic ecosystem[d]
Fluoride	< 2 mg/L	Irrigation[g]

Parameter	WQO	Relevant EV
Iron	< 10 mg/L	Irrigation[g]
Lead	< 0.1 mg/L < 0.0034 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Lithium	< 2.5 mg/L	Irrigation[g]
Manganese	< 10 mg/L < 1.9 mg/L	Irrigation[g] Aquatic ecosystem[d]
Mercury	< 0.002 mg/L < 0.00006 mg/L	Irrigation[g] Aquatic ecosystem[d]
Molybdenum	< 0.05 mg/L	Irrigation[g]
Nickel	< 1 mg/L < 0.011 mg/L	Stock watering[f, e] Aquatic ecosystem[d]
Selenium	< 0.02 mg/L < 0.005 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Uranium	< 0.1 mg/L	Irrigation[g]
Vanadium	< 0.5 mg/L	Irrigation[g]
Zinc	< 5 mg/L < 0.008 mg/L	Irrigation[g] Aquatic ecosystem[d]

[a] Table 2 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem - moderately disturbed
[b] Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV
[c] Table 10 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Stock watering EV: salinity
[d] Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality: trigger values for slightly-moderately disturbed systems (95% level of protection)
[e] short-term trigger value
[f] Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Stock watering EV: heavy metals and metalloids
[g] Table 9 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Irrigation EV: heavy metals and metalloids

The Queensland Globe service (Queensland Government, 2019) was used to identify any wetlands in the vicinity of the Project. There were no matters of state environmental significance (MSES) wetlands, wetland values or wetland protection areas identified in the vicinity of the Project.

4 Existing surface water environment

4.1 REGIONAL DRAINAGE CHARACTERISTICS

The Project is located within the Isaac River sub-basin of the greater Fitzroy Basin. Figure 4.1 shows the Upper Isaac River catchment to its confluence with Phillips Creek.

The Isaac River commences approximately 100 km to the north of the Project site within the Denham Range. It drains in a south westerly direction through the Carborough and Kerlong Ranges before turning in a south easterly direction near the Goonyella Riverside Mine. It drains approximately 30 km to the east of the Project, and eventually flows to the Mackenzie River some 150 km to the southeast.

Three open water bodies are located in the Isaac upper catchment including Lake Elphinstone, Teviot Creek Dam and Burton Gorge Dam (Figure 4.1). Lake Elphinstone is a natural lake formed behind the Carborough Range whereas Teviot Creek Dam and Burton Gorge Dam are man-made structures that supply water to Burton and North Goonyella mines in the upper catchment.

Other than along the ranges, the majority of the Isaac River catchment has been cleared for agricultural use or for mining. There are several existing coal mines in the catchment, including Burton, North Goonyella, Goonyella Riverside, Broadmeadow, Broadlea North, Isaac Plains, Moranbah North, Millennium, Daunia, Poitrel, Grosvenor, Peak Downs, Saraji, Norwich Park and Lake Vermont.

Figure 4.2 shows the surrounding catchments of the Project area. The Project is located in the headwaters of the Boomerang Creek catchment. Boomerang Creek is a watercourse and tributary of the Isaac River. The catchment area of the Isaac River to Boomerang Creek is 5,226 square kilometres (km^2).

The Boomerang Creek catchment commences to the west of the Project area and drains in an easterly direction towards Saraji Road and the Norwich Park Branch Railway. The Ripstone Creek catchment lies to the north of the Project area and drains into Boomerang Creek approximately 30 km southeast of the Project. The headwater tributaries of Boomerang Creek are ephemeral streams which experience flow only after sustained or intense rainfall.

The predominant catchment land uses of Boomerang Creek include undeveloped areas with some stock grazing to the west of Saraji Road and stock grazing and coal mining to the east. Downstream of the Project, Boomerang Creek, as well as its tributaries to the south, flow into the existing BHP Billiton Mitsubishi Alliance (BMA) operations (Peak Downs and Saraji). The catchment area of Boomerang Creek is 788 km^2. The existing BMA operations have diverted and/or modified the original alignment of Boomerang Creek as shown in Figure 4.2 as well as Harrow Creek to the north. Additional diversions and/or modification of Boomerang Creek and its floodplain are also planned for approved operations further to the east.

4.2 LOCAL DRAINAGE NETWORK

Figure 4.3 shows the local drainage features within the vicinity of the Project. Drainage features that cross the Project area eventually drain to Boomerang Creek and subsequently to the Isaac River. The tributaries of Boomerang Creek which intersect the Project area include (Figure 4.3):

- Drainage Line 1;
- Drainage Line 2; and
- the existing drainage diversion.

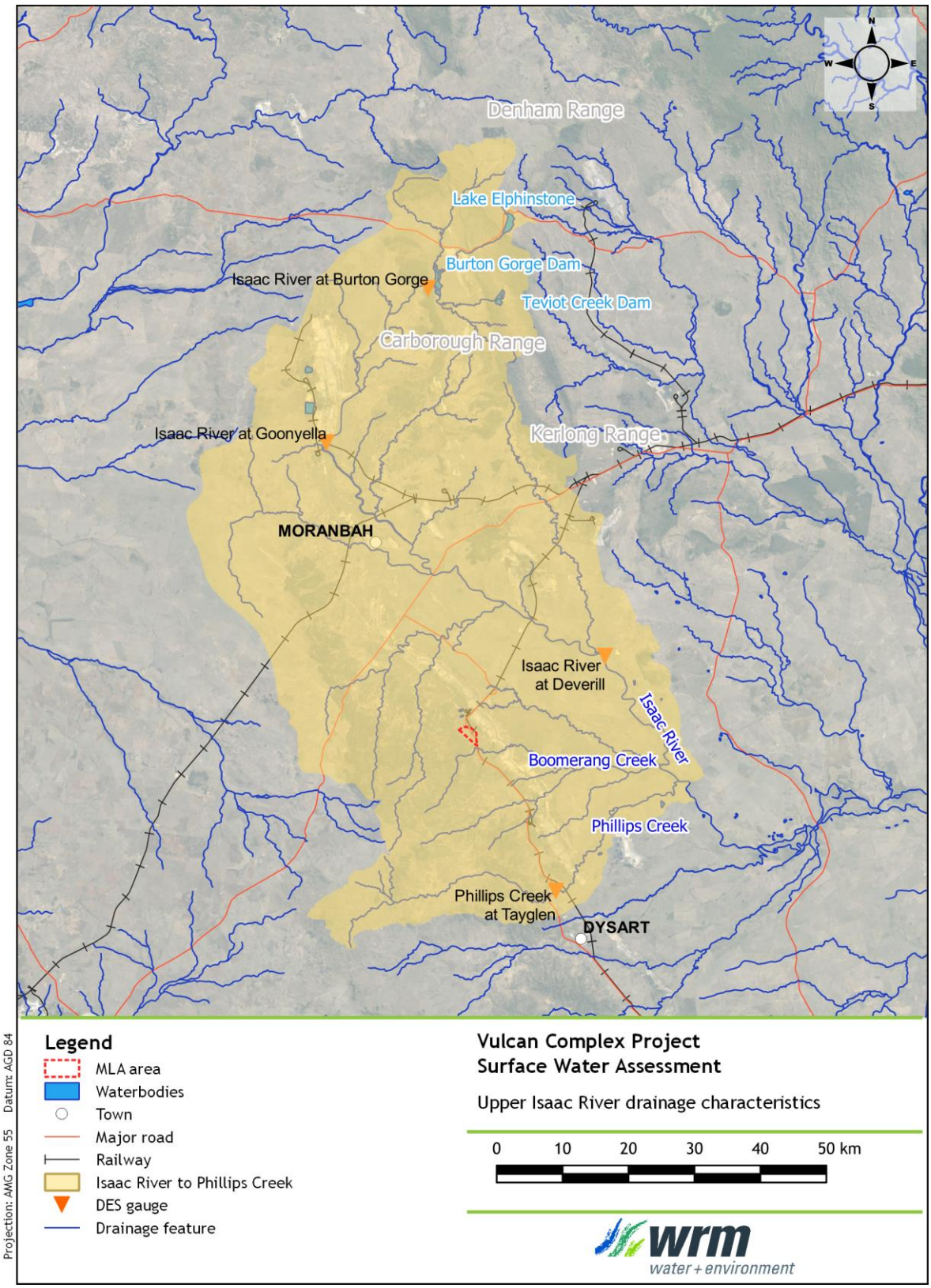


Figure 4.1 - Upper Isaac River drainage characteristics

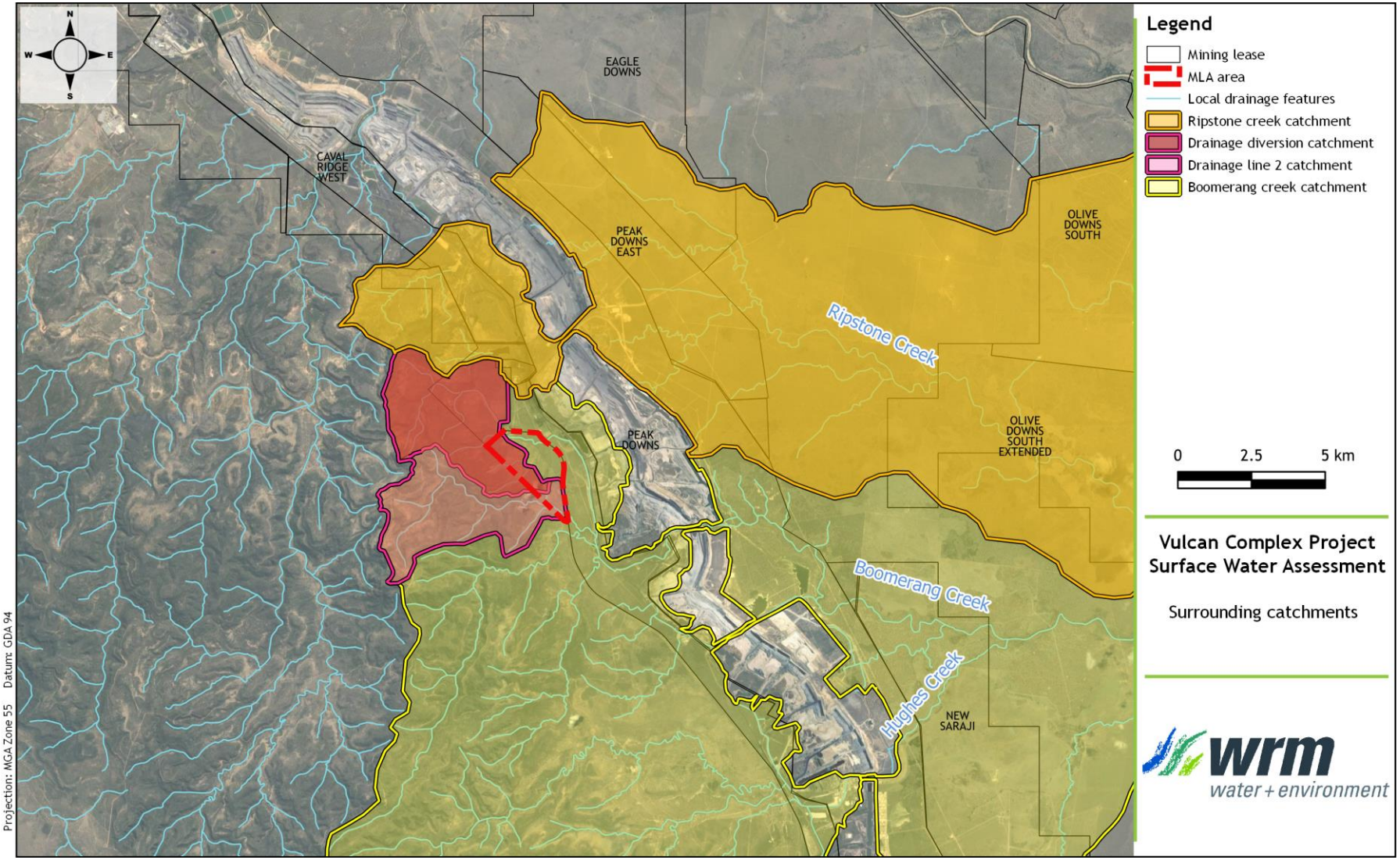


Figure 4.2 – Regional catchments in the vicinity of the Project

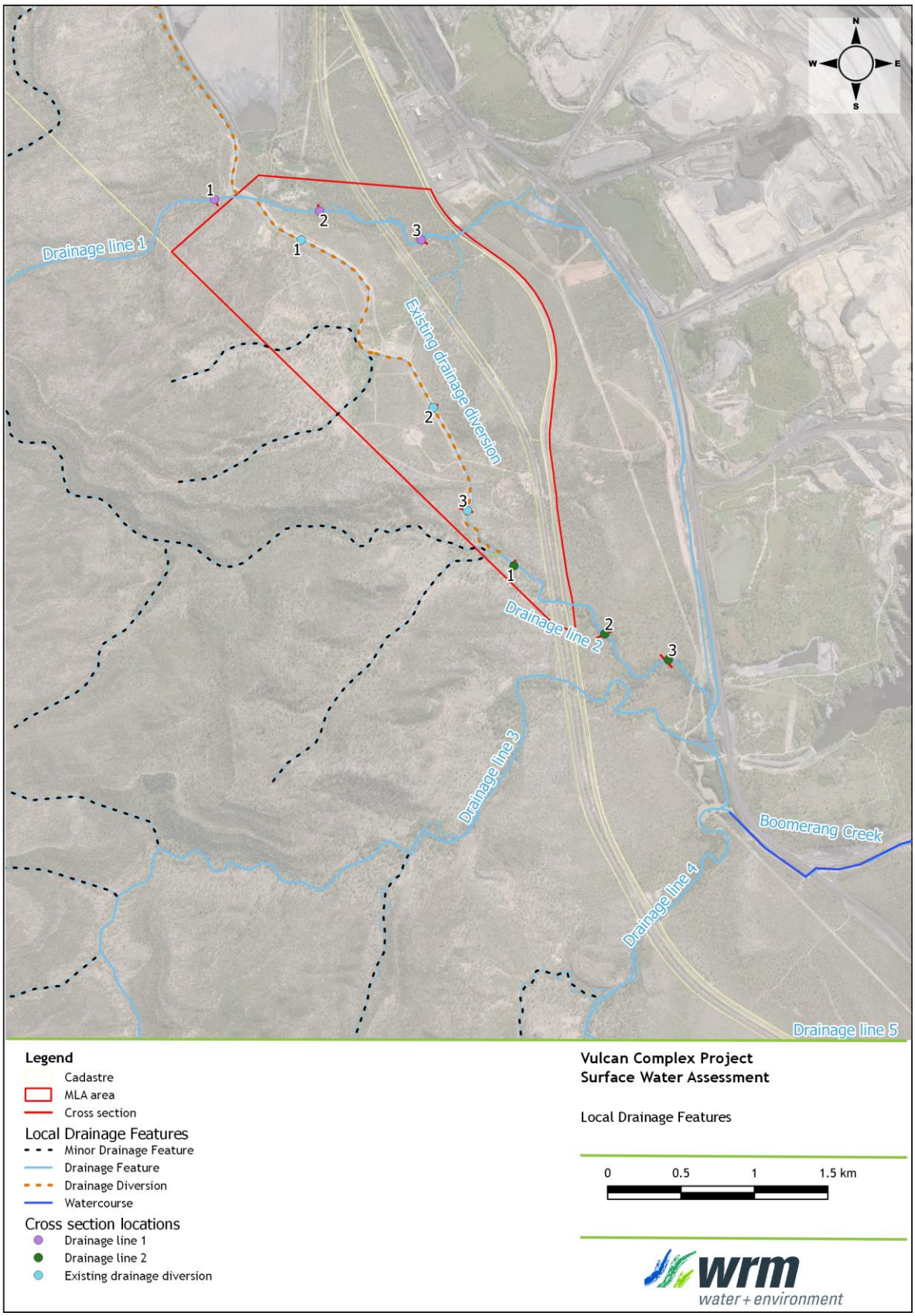


Figure 4.3 - Local drainage features in the vicinity of the Project

Figure 4.8 shows typical cross sections along the three local drainage features through the Project area at the locations shown in Figure 4.3.

4.2.1 Drainage Line 1

Drainage Line 1 drains the northern portion of the Project area to the east of the existing drainage diversion and includes the majority of the operational areas of the Project. Drainage Line 1 crosses the Saraji Road and the Norwich Park branch railway within the Project area before discharging into the Peak Downs Mine Lease (ML) downstream of the railway. Figure 4.4 and Figure 4.6 show photographs of Drainage Line 1 within the Project area and at the Railway culverts respectively.

Drainage Line 1 flows into an existing on-line water storage within the Peak Downs operations before eventually discharging into Drainage Line 2 approximately 1 km southeast of the Project boundary. Drainage Line 1 has been diverted and significantly modified within the Peak Downs ML.

The typical dimensions of the Drainage Line 1 channel through the Project area are (Figure 4.8):

- channel bed widths of 2 m to 5 m;
- channel top widths of 10 m to 25 m;
- channel depths 0.5 to 1 m; and
- overbank floodplain widths of 20 m to 50 m.

Drainage Line 1 will be diverted as part of the Project to allow access to the underlying coal. Drainage Line 1 will be reinstated by constructing a drainage corridor through backfilled spoil as shown in Figure 1.4. A new culvert crossing will be constructed under the realigned Saraji Road just upstream of the existing railway culverts.



Figure 4.4 – Photograph of Drainage Line 1 within the Project area



Figure 4.5 – Photograph of the existing railway culvert crossing of Drainage Line 1 at the eastern (downstream) Project boundary

4.2.2 Existing drainage diversion

An existing drainage diversion runs north-south along the length of the Project and flows into Drainage Line 2. Figure 4.6 shows a photograph of the existing drainage diversion and bund within the Project area. The existing drainage diversion appears to have been constructed in the 1970s to allow the construction of a Tailings Dam within the Peak Downs operations. The diversion flows in a south to southeast direction through the Project area and has a catchment area of approximately 16.0 km^2.

A levee is located along the majority of the existing drainage diversion and has an average height of 1 to 2 m and width of 5 to 10 m. The channel of the existing drainage diversion is located on the western side of the levee, with an average depth of 1 to 2 m and top width of 5 to 10 m (see cross section 1 and 2 in Figure 4.3). The channel width increases and deepens in the southern portion of the existing drainage diversion downstream of the levee (see cross section 3 in Figure 4.3).

The existing drainage diversion discharges into Drainage Line 2 within the Project area to the south of proposed operations. The Project will include upgrades to an existing crossing of the existing drainage diversion (which has been approved as part of the bulk sample). A second vehicle crossing will be included in this Project. The existing drainage diversion will not be modified as part of the Project.



Figure 4.6 – Photograph of the existing drainage diversion and levee within the Project area

4.2.3 Drainage Line 2

Drainage Line 2 drains through the southeastern corner of the Project area and has a catchment area of approximately 30 km^2. Drainage Line 2 crosses the Saraji Road and the Norwich Park branch railway within the Project area before discharging into the Peak Downs ML downstream of the railway. Figure 4.7 shows a photograph of Drainage Line 1 within the Project area and at the Railway culverts respectively.

Drainage Line 1 flows into an existing on-line water storage within the Peak Downs operations before eventually discharging into Drainage Line 2 approximately 1 km southeast of the Project boundary. Drainage Line 2 has been diverted and significantly modified within the Peak Downs ML.

The typical dimensions of the Drainage Line 2 channel are:

- channel bed widths of 3 m to 5 m;
- channel top widths of 10 m to 30 m;
- channel depths 1 to 2 m; and
- overbank floodplain widths of 50 m to 150 m.

Drainage Line 2 will not be modified as part of the Project.



Figure 4.7 - Photograph of Drainage Line 2 within the Project area

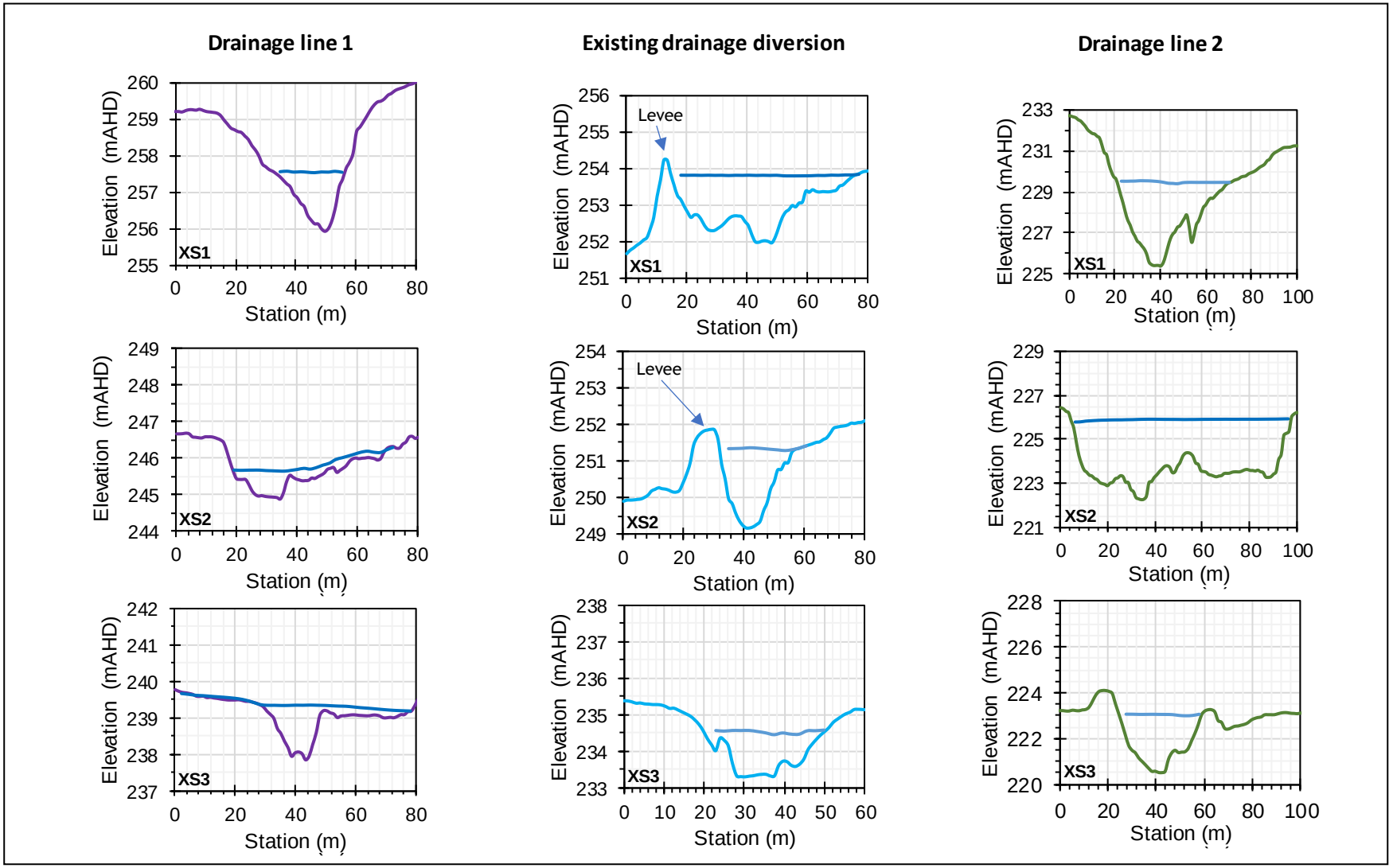


Figure 4.8 - Drainage line cross sections with 1% AEP flood levels

4.3 RAINFALL AND EVAPORATION

Long term rainfall and evaporation data at the Project is not available. Long term daily evaporation and rainfall data was sourced from the DES SILO climate data service at the approximate Project coordinates (Latitude: -22.35, Longitude: 148.2) from January 1889 to January 2019 (i.e. 130 years of data).

Table 4.1 shows statistics for Morton's lake evaporation and Table 4.2 shows statistics for rainfall (as mm/month and mm/year) over the historical dataset.

Figure 4.9 shows a comparison between the evaporation and rainfall. Evaporation rates are generally higher than rainfall throughout the year.

Table 4.1 - Evaporation (Morton's lake) statistics over the historical period (mm)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	240	204	201	152	118	94	103	142	171	215	222	239	1,967
90th %ile	224	190	186	144	109	88	97	125	160	199	214	229	1,891
Median	202	168	167	132	102	80	91	118	152	189	200	212	1,805
10th %ile	171	143	150	121	94	75	83	110	141	174	182	188	1,725
Min	120	122	127	94	76	59	77	97	121	160	121	145	1,506

Table 4.2 - Rainfall statistics over the historical period (mm)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	502	471	324	267	208	168	132	273	134	143	191	351	1254
90th %ile	209	221	160	70	66	74	61	61	48	88	100	150	882
Median	98	85	45	19	15	21	7	7	7	22	40	72	567
10th %ile	20	14	2	0	0	0	0	0	0	0	6	23	362
Min	0	0	0	0	0	0	0	0	0	0	0	2	221

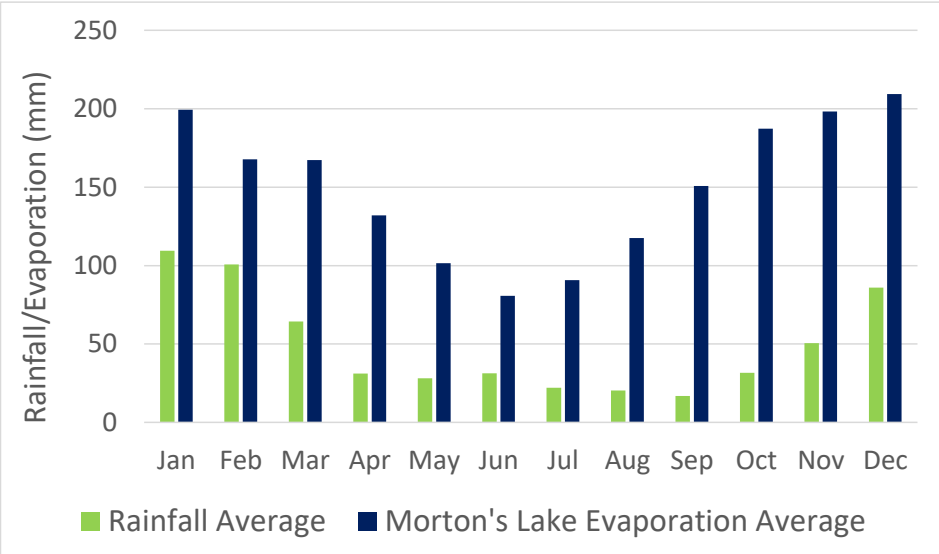


Figure 4.9 - Long term mean monthly rainfall and evaporation from SILO at the Project

4.4 STREAMFLOW

There is no stream flow data available for Boomerang Creek at the time of preparing this report. There are two streamflow gauges operated by the Department of Natural Resources, Mines and Energy (DNRME) in the vicinity of the Project including (see Figure 1.1):

- Isaac River at Deverill (approximately 25 km northeast of the Project); and
- Phillips Creek at Tayglen (approximately 30 km southeast of the Project).

The closest stream gauge is located on the Isaac River at Deverill (Station ID: 130410A). This gauge is located approximately 20 km upstream of where Boomerang Creek meets the Isaac River.

Historical flow and river height monitoring data (1968 to 2018) for the Isaac River at Deverill provides an indication of the flow regime (refer Figure 4.10). Surveyed cross section data for this gauging station collected in September 2014 (DNRME, 2017) indicates that sediment covers the bottom one metre of the gauge range. The mean river height data shown in Figure 4.10 suggests that surface flow above the sand is more likely to occur only in the wetter months from November to April, reducing to shallow subsurface flows from about May to October in an average year.

The Phillips Creek at Tayglen Creek streamflow gauge (Station ID: 130409A) is located on Phillips Creek. Phillips Creek is an easterly draining tributary of the Isaac River. DNRME maintains data for the gauge between 1968 and 1988. The catchment area to the gauge location is 344 km^2.

A typical sequence of recorded flows from this station is shown in Figure 4.11. The creek is characterised by brief periods of flow interspersed by long periods of no flow. This ephemeral behaviour is typical for streams in this part of the Fitzroy Basin.

The median annual flow over the period of record was approximately 12,730 ML/a (52 mm of runoff), most of which occurred in the summer months (as shown in Figure 4.12). Figure 4.13 compares flow frequency curves for a number of gauged catchments in the Isaac River catchment which are located in the vicinity of the Project. Figure 4.13 shows that for Phillips Creek at Tayglen, flow only occurred approximately 22% of the time, which would be similar to other creeks in the vicinity of the Project.

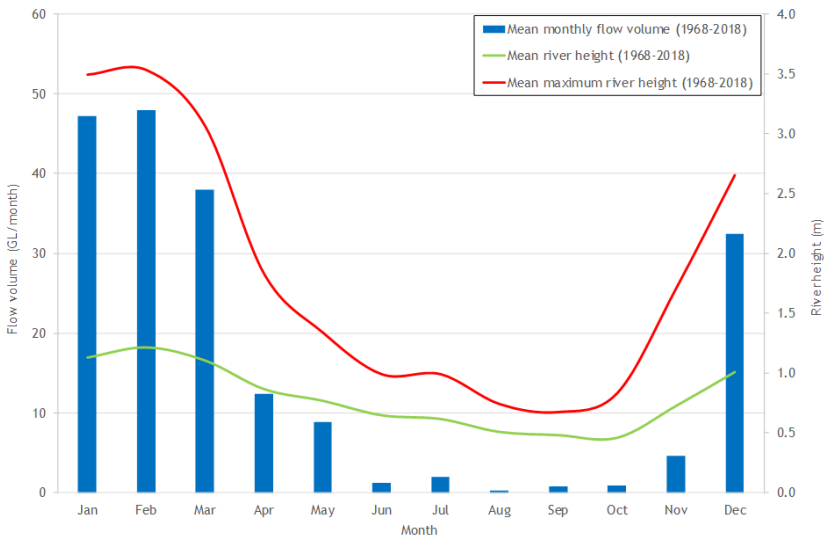


Figure 4.10 – Flow volume and river height in the Isaac River at Deverill

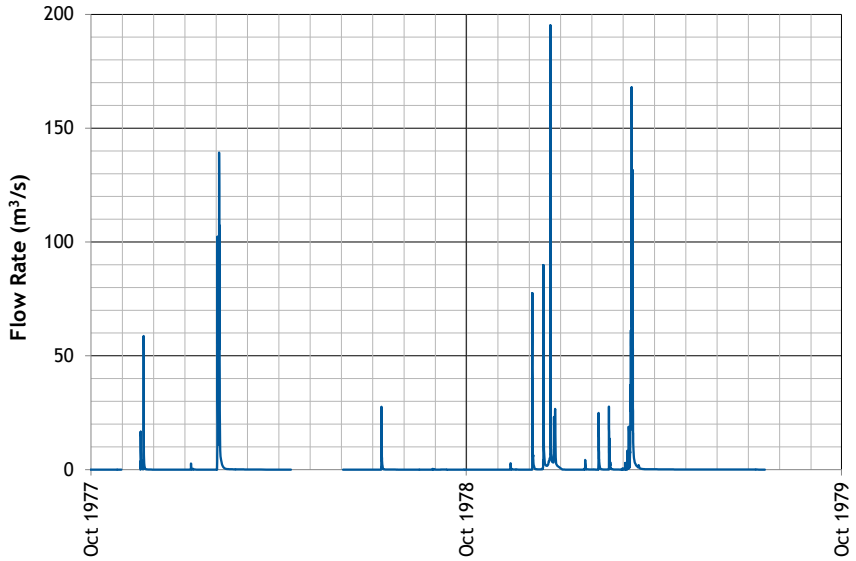


Figure 4.11 - Sample flow sequence - Phillips Creek at Tayglen 1977 - 1979

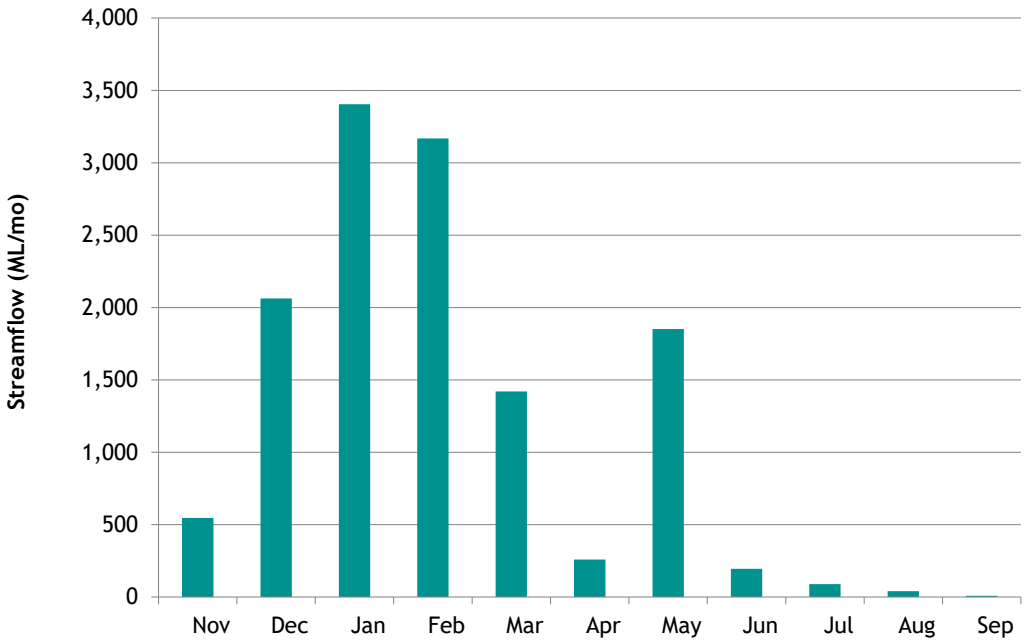


Figure 4.12 - Measured mean monthly streamflow - Phillips Creek at Tayglen 1968-1988

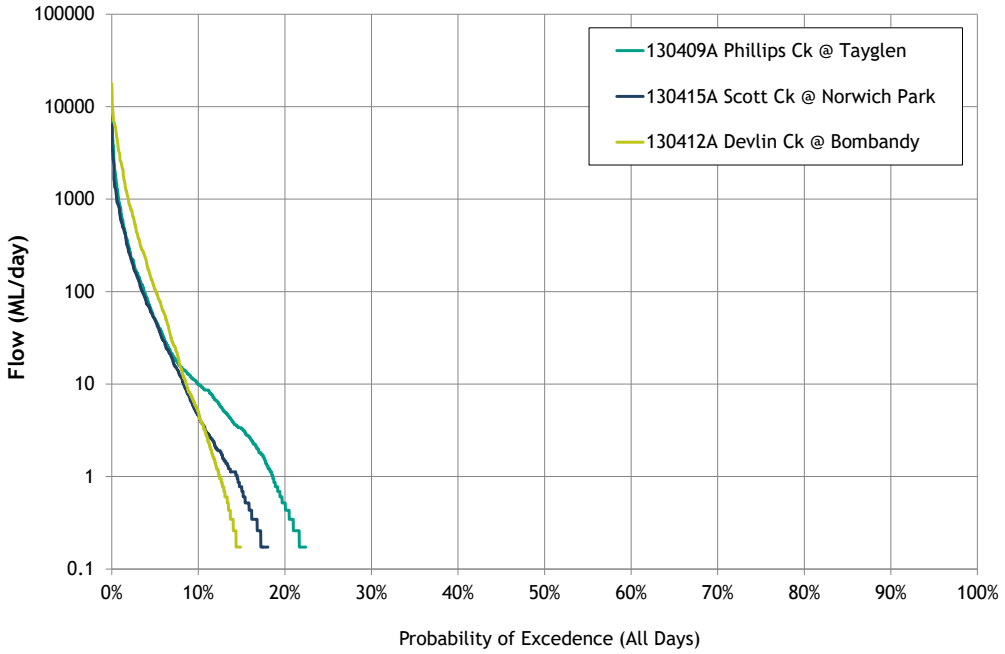


Figure 4.13 – Recorded frequency curves at nearby DNRME gauges (no flow days included)

4.5 WATER QUALITY

4.5.1 Regional Isaac River water quality

Publicly available regional water quality data for the Isaac River at the Deverill Gauging Station has been analysed for median results and are displayed in Table 4.3. This site was selected as complete datasets (i.e. individual sample analysis results) are publicly available, as opposed to summary data only.

DNRME has collected daily electrical conductivity (EC) data at the Isaac River at Deverill gauge. The Deverill gauge is located upstream of the point where Boomerang Creek drains into the Isaac River. The gauge would therefore be representative of water quality in the receiving waters of the Isaac River from the Project.

Figure 4.14 presents a time history of recorded instantaneous EC and stream flow for the Isaac River at Deverill gauging station. Figure 4.15 details the relationship between instantaneous flow and EC at the Isaac River at Deverill gauging station. The data collected by DNRME at the Deverill gauging station spans the period from 2011 to 2018 and indicates:

- The EC values for high flows greater than 200 m^3/s are generally below the high flow WQO EC of 250 µs/cm;
- The EC of instantaneous flows below 100 m^3/s vary significantly from 50 µS/cm to 1,870 µS/cm with many recorded values exceeding the low flow WQO EC of 720 µS/cm but are below the Peak Downs EA receiving waters trigger value of 2000 µS/cm;
- The mean daily EC has exceeded the low flow WQO on a total of 23 days over this period and all of these days experienced some flow (not stagnant flow); and
- The stream flows are highly ephemeral with baseflows ceasing within a few days or weeks of a runoff event, or at least flowing below the top of the sandy bed.

Table 4.3 – Water quality median data in the Isaac River at Deverill

Parameter	Unit	Isaac River at Deverill	WQO default guideline value (refer Table 3.1)
Aluminium - Total	mg/L	-	< 5 (stock)
Aluminium - Dissolved	mg/L	0.05	< 0.055 (aquatic)
Boron - Total	mg/L	0.06	< 5 (stock)
Calcium - Dissolved	mg/L	16	-
Chloride - Total	mg/L	32	-
Copper - Dissolved	mg/L	0.03	< 0.0014 (aquatic)
EC	µS/cm	261	< 720 (baseflow) < 250 (high flow)
Filterable Reactive Phosphorus	µg/L	0.35	< 20 (aquatic)
Fluoride - Total	mg/L	0.14	< 2 (irrigation)
Iron - Dissolved	mg/L	0.06	-
Manganese - Dissolved	mg/L	0.01	< 1.9 (aquatic)
Nitrate - Total	mg/L	1.4	-
Nitrogen – Total	µg/L	0.76	< 500 (aquatic)
pH	-	7.6	pH 6.5–8.5 (aquatic)
Phosphorus - Total	µg/L	0.35	< 50 (aquatic)
Potassium - Total	mg/L	4.55	-
Sodium - Total	mg/L	22	< 30 (drinking water)
Sulfate - Total	mg/L	10.9	< 25 (aquatic)
Total Alkalinity	mg/L	78	-
Total Dissolved Solids	mg/L	155	< 2,000 (stock)
Total Suspended Solids	mg/L	135	< 55 (aquatic)
Turbidity	NTU	247	< 50 (aquatic)
Zinc - Dissolved	mg/L	0.01	< 0.008 (aquatic)

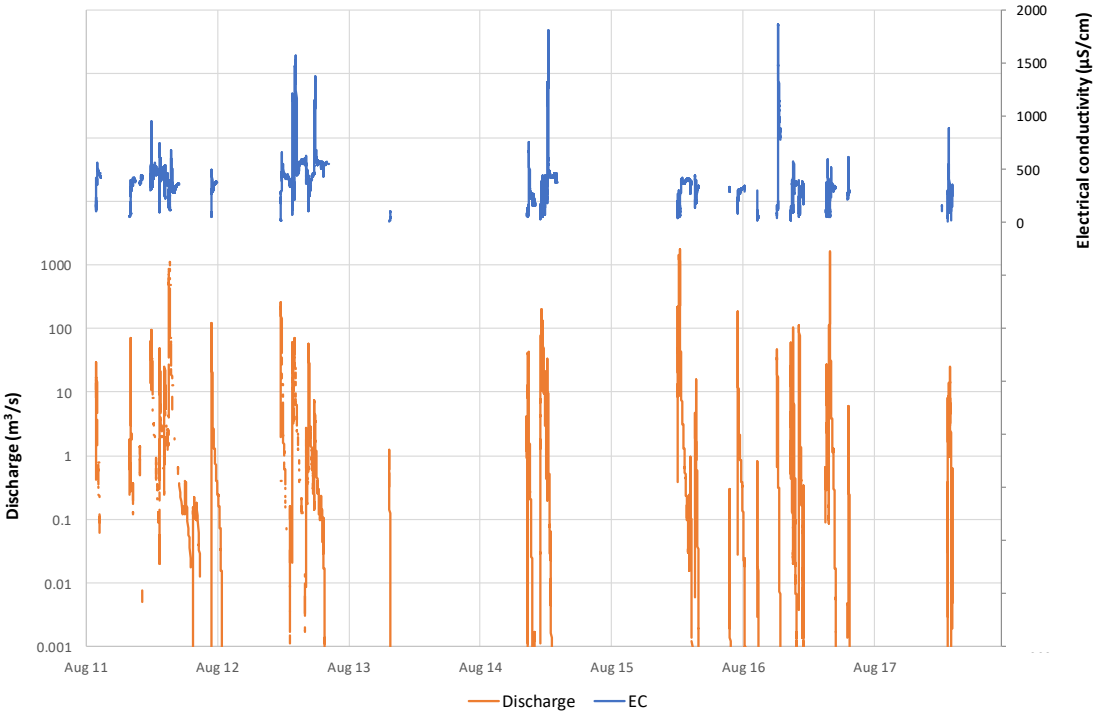


Figure 4.14 - Electrical Conductivity and Flow (Isaac River at Deverill Gauge)

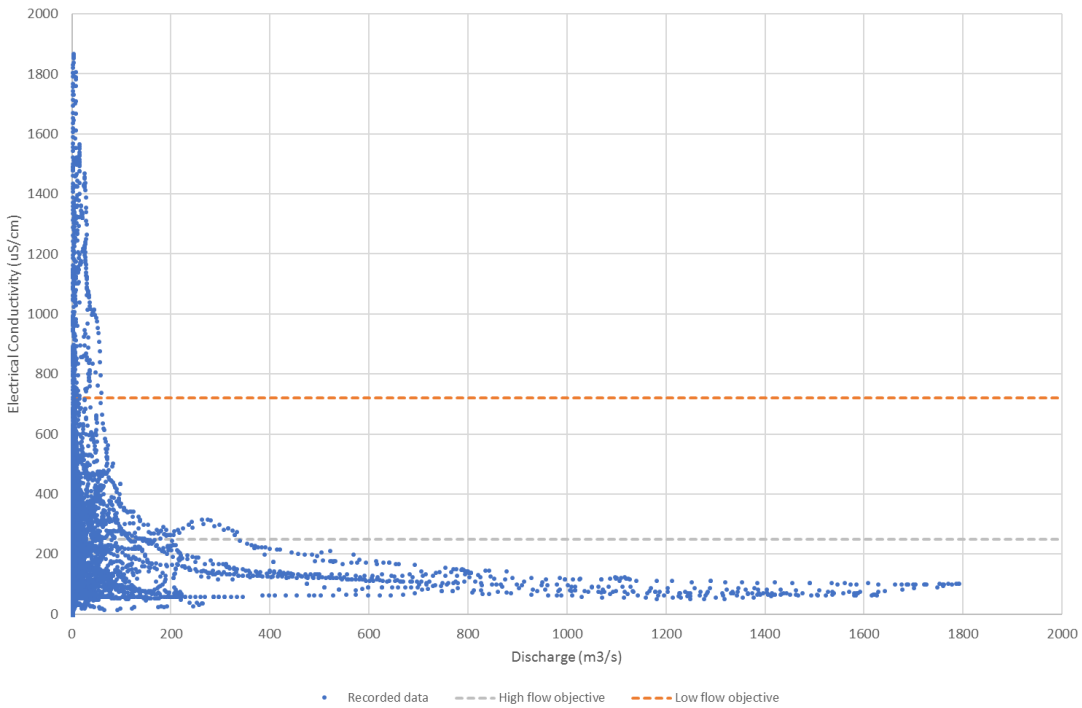


Figure 4.15 - Flow vs Electrical Conductivity (Isaac River at Deverill Gauge)

4.5.2 Local water quality

Water quality sampling was undertaken as a component of the baseline surface water quality sampling in February 2020. Analyses for a range of physico-chemical parameters were completed at sites VSW1, VSW2 and VSW3 (refer Table 4.4 for details and Figure 4.16 for monitoring locations).

Table 4.4 shows that certain baseline water quality values surrounding the Project do not meet the WQO for the region, these include:

- Electrical conductivity;
- Turbidity;
- Total hardness as CaCO3;
- Sulfate as SO4;
- Sodium;
- Ammonia as N;
- Nitrogen (total);
- Phosphorous (total);
- Dissolved Oxygen;
- Aluminium (filtered);
- Copper (filtered);
- Manganese (filtered); and
- Zinc (total).

Similar to the regional water quality data presented in Section 4.5.1, the local water quality data suggests that a number of parameters may exceed the WQOs. However, it is acknowledged that this is based on only one water quality sampling event.

To establish local water quality objectives, the QWQG require that with 3 or more reference sites, 12 samples are collected over at least 12, but preferably 24 months. Vitrinite has established more than 3 reference sites, which will continue to be either upstream reference sites or reference sites until mining commences. However, data collection is limited to periods of flow in an ephemeral system. Therefore, reliance is placed on regional water quality data to establish water quality objectives until there is sufficient data to develop local water quality objectives.

Table 4.4 – Baseline water quality monitoring

Parameter	Unit	VSW-1 Feb-20	VSW-2 Feb-20	VSW-3 Feb-20	WQO (see Table 3.1
pH Value	-	7.42	6.74	6.54	6.5 - 8.5 (Aquatic ecosystem)
Sodium Adsorption Ratio	-	6.64	2.92	1.69	-
Electrical Conductivity	µS/cm	1400	310	184	< 720 (baseflow) < 250 (high flow) (Aquatic ecosystem)
Total Dissolved Solids (Calc.)	mg/L	910	202	120	< 2,000 (Stock)
Suspended Solids (SS)	mg/L	10	55	20	< 55 (Aquatic ecosystem)
Turbidity	NTU	42.9	221	90.8	< 50 (Aquatic ecosystem)
Total Hardness as CaCO3	mg/L	191	37	26	< 150 (Drinking water)

Hydroxide Alkalinity as CaCO3	mg/L	<1	<1	<1	-
Carbonate Alkalinity as CaCO3	mg/L	<1	<1	<1	-
Bicarbonate Alkalinity as CaCO3	mg/L	63	12	4	-
Total Alkalinity as CaCO3	mg/L	63	12	4	-
Sulfate as SO4 - Turbidimetric	mg/L	212	40	19	< 25 (Aquatic ecosystem)
Chloride	mg/L	275	54	34	-
Calcium	mg/L	27	5	4	-
Magnesium	mg/L	30	6	4	-
Sodium	mg/L	211	41	20	< 30 (Drinking water)
Potassium	mg/L	8	7	7	-
Fluoride	mg/L	<1.0	0.1	<0.1	< 2 (Irrigation)
Ammonia as N	mg/L	0.05	0.1	<0.01	< 0.02 (Aquatic ecosystem)
Nitrite as N	mg/L	0.03	0.01	<0.01	-
Nitrate as N	mg/L	1.7	1.57	1.19	-
Nitrite + Nitrate as N	mg/L	1.73	1.58	1.19	-
Total Kjeldahl Nitrogen as N	mg/L	1.6	1.3	0.9	-
Total Nitrogen as N	mg/L	3.3	2.9	2.1	< 0.5 (Aquatic ecosystem)
Total Phosphorus as P	mg/L	0.04	0.09	0.05	< 0.05 (Aquatic ecosystem)
Reactive Phosphorus as P	mg/L	<0.01	<0.01	<0.01	< 0.02
Total Anions	meq/L	13.4	2.6	1.43	-
Total Cations	meq/L	13.2	2.7	1.58	-
Ionic Balance	%	0.87	----	----	-
Chlorophyll a	mg/m³	<4	<4	<4	-
Dissolved Oxygen	mg/L	6.7	7.3	7.3	> 4 (Drinking water)
		Dissolved Metals			
Aluminium	mg/L	0.11	0.45	0.39	< 0.055 (Aquatic ecosystem)
Arsenic	mg/L	0.001	<0.001	<0.001	< 0.024 (Aquatic ecosystem)
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	< 0.0002 (Aquatic ecosystem)
Chromium	mg/L	<0.001	<0.001	<0.001	< 0.001 (Aquatic ecosystem)
Cobalt	mg/L	<0.001	<0.001	<0.001	-
Copper	mg/L	0.003	0.001	0.002	< 0.0014 (Aquatic ecosystem)
Lead	mg/L	<0.001	<0.001	<0.001	< 0.0034 (Aquatic ecosystem)
Manganese	mg/L	0.039	0.019	0.015	< 1.9 (Aquatic ecosystem)
Molybdenum	mg/L	<0.001	<0.001	<0.001	-
Nickel	mg/L	0.002	0.002	0.002	< 0.011 (Aquatic ecosystem)
Selenium	mg/L	<0.01	<0.01	<0.01	< 0.005 (Aquatic ecosystem)

Silver	mg/L	<0.001	<0.001	<0.001	-
Uranium	mg/L	<0.001	<0.001	<0.001	< 0.1 (Irrigation)
Vanadium	mg/L	<0.01	<0.01	<0.01	< 0.5 (Irrigation)
Zinc	mg/L	0.024	<0.005	0.024	< 0.008 (Aquatic ecosystem)
Boron	mg/L	0.09	<0.05	<0.05	< 0.37 (Aquatic ecosystem)
Iron	mg/L	0.2	0.35	0.35	-
Mercury	mg/L	<0.0001	<0.0001	<0.0001	< 0.00006 (Aquatic ecosystem)
			Total Metals		
Aluminium	mg/L	0.89	3.38	1.56	< 5 (Stock)
Arsenic	mg/L	0.001	0.002	0.001	< 0.5 (Stock)
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	< 0.01 (Stock)
Chromium	mg/L	<0.001	0.002	0.001	< 1 (Stock)
Cobalt	mg/L	<0.001	0.001	<0.001	-
Copper	mg/L	0.004	0.004	0.002	< 1 (Stock)
Lead	mg/L	<0.001	0.004	0.002	< 0.1 (Stock)
Manganese	mg/L	0.042	0.034	0.024	< 10 (Irrigation)
Molybdenum	mg/L	0.001	<0.001	<0.001	< 0.05 (Irrigation)
Nickel	mg/L	0.002	0.004	0.003	< 1 (Stock)
Selenium	mg/L	<0.01	<0.01	<0.01	< 0.02 (Stock)
Silver	mg/L	<0.001	<0.001	<0.001	-
Uranium	mg/L	<0.001	<0.001	<0.001	-
Vanadium	mg/L	<0.01	<0.01	<0.01	-
Zinc	mg/L	0.031	0.017	0.029	< 5 (Irrigation)
Boron	mg/L	0.06	<0.05	<0.05	< 5 (Stock)
Iron	mg/L	0.79	3.26	1.62	< 10 (Irrigation)
Mercury	mg/L	<0.0001	<0.0001	<0.0001	< 0.002 (Irrigation)

Note: Recorded exceedances of the WQOs have been shaded in grey.

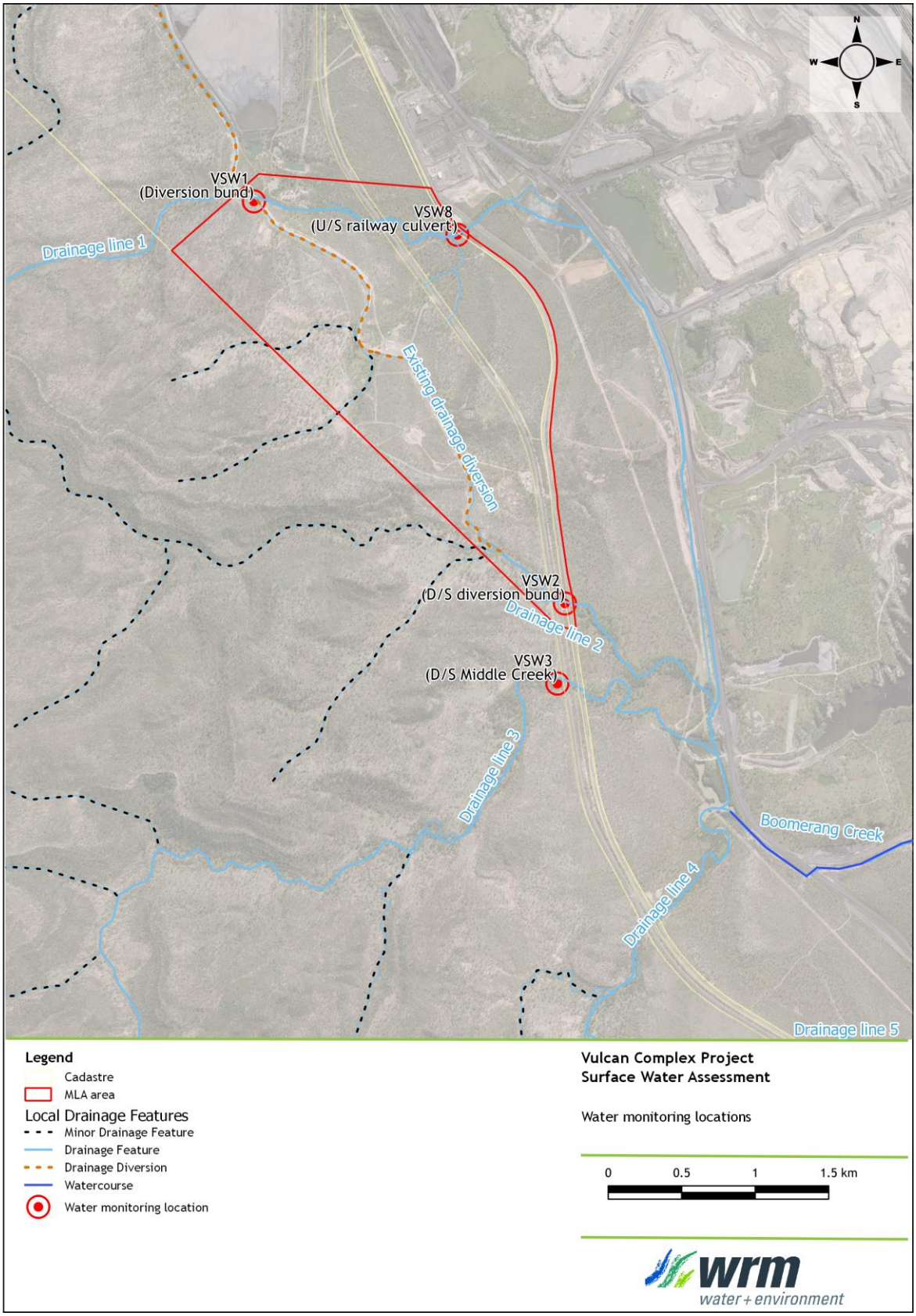


Figure 4.16 - Water monitoring locations

4.6 SOIL CHARACTERISTICS

AARC Environmental Solutions Pty Ltd (2019) completed a *Soil and Land Suitability Assessment* (SLSA) for the Project and surrounds. To characterise the soils at the site, AARC collected 42 detailed soil profiles and analysed 12 laboratory samples from the site and surrounds.

The area surrounding the Project is dominated by clastic sedimentary rocks of marine and lacustrine origin, including sandstones, mudstones, siltstones and coal. Surface geology at the site includes Quaternary clay, silt, sand, gravel and soil with colluvial and residual deposits, as well as late Tertiary to Quaternary poorly consolidated sand, silt, clay, minor gravel and high-level alluvial deposits (AARC, 2019).

4.6.1 Soil management units

AARC mapped the Soil Management Units (SMUs) across the site using the methodologies specified in the *Guidelines for Surveying Soil and Land Resources* (McKenzie et al, 2008) based on soil morphology, parent material and land attributes.

A description of each SMU found within the Project area is outlined in Table 4.5. The majority of the site consists of the Limpopo SMU, with a small southern portion of the Project site consisting of Crocodile and Zambezi SMUs.

Table 4.5 - Soil Management Units surveyed on site (AARC, 2019)

Soil Management Unit	Description
Crocodile	A shallow rocky soil unit associated with hill slopes and plateaus. Soil textures grade from loam at the surface, to loamy sands with depth; often containing rock material with little to no pedologic development throughout the solum.
Limpopo	The Limpopo unit is a brown texture-contrast soil. Soil textures predominantly grade from sands to clay sands in the surface soils to light clays in deeper horizons.
Zambezi	A predominantly grey coloured texture contrast soil with surface soils consisting of sands, increasing in clay content in deeper horizons. Lower horizons display diffuse orange to yellow mottles.

4.6.2 Sodic and dispersive soils

Sodic soils contain large concentrations of Sodium relative to other cations. These soils have a degree of dispersivity and can accelerate erosion.

AARC identified areas of high sodicity on site through the measurement of the Exchangeable sodium percentage and Emerson Class of surveyed soils. The Crocodile SMU was identified as having a low risk of dispersion and was not identified as being sodic.

For the remaining SMUs, AARC (2019) identified the depth horizons with sodic properties as follows:

- Limpopo SMU: Sodic below a depth of 0.5 m; and
- Zambezi SMU: Sodic below a depth of 0.5 m.

To control erosion from sodic dispersive soils, soils will be selectively handled and managed accordingly.

5 Proposed surface water management strategy and infrastructure

5.1 TYPES OF WATER GENERATED ONSITE

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. In addition, runoff from active mining areas (including coal stockpiles, etc.) may have increased concentrations of salts and other pollutants when compared to natural runoff. The proposed strategy for the management of surface water at the Project is based on the separation of water from different sources based on anticipated water quality.

Definitions of the types of water generated within the Project are shown in Table 5.1.

5.2 PROPOSED WATER MANAGEMENT INFRASTRUCTURE

The operational period of mining is expected to run for four years from 2021 to 2024.

Figure 1.2 and Figure 1.3 show indicative locations of the key features of the mine, including infrastructure related to the management of water on the Project site for two different stages of mining (Stages 1 and 2). The main components of water-related infrastructure include:

- diverted water drains to divert runoff from undisturbed catchments around areas disturbed by mining;
- a flood protection levee along the western side of the proposed Jupiter pit that may be formed by a haul road embankment;
- sediment dams and drains to collect and treat runoff from waste rock emplacement areas; and
- mine-affected water drains and dams to store water pumped out of the open cut mining areas and to collect runoff from the infrastructure areas.

The catchment areas of each of the mine water storages, as well as the assumed landuse contributing to each catchment are also shown in Figure 1.2 and Figure 1.3. Details of proposed water storages, including indicative storage sizes and pumping rules are provided in Section 6.4.

5.3 WATER MANAGEMENT STRATEGY OVERVIEW

The water management system for the Project aims to protect the identified downstream EVs and comprises the following key objectives:

- separate diverted water from mine affected water to ensure that up-catchment water and mine affected water do not mix wherever practicable;
- capture of mine affected runoff (e.g. mine industrial area, haul road/ROM pad runoff), storage and priority reuse as mine water supply;
- divert up-catchment water runoff from upstream catchments around the active mining area;
- limit external catchment runoff draining into pits;
- manage sediment from disturbed catchment areas (e.g. out-of-pit waste rock emplacements, cleared/pre-strip areas) by using erosion and sediment control (ESC) measures prior to release offsite;

- reuse onsite water (e.g. mine affected water) where possible to support mine operational water demands (and therefore limit mine affected water inventories under normal operating conditions); and
- manage any mine affected water releases to the receiving environment to meet environmental release conditions (not currently proposed).

The Project water management system will include mine water drainage, mine water storages, sediment dams, pit water storages and flood protection works (i.e. levees). Further details of the mine water management system are provided in Section 6.4.

Table 5.1 – Types of water managed within the Project

Water type	Definition
Mine affected water	In accordance with the DES *Guideline Model Mining Conditions* (2017), mine affected water means the following types of water: i) pit water, tailings dam water, processing plant water; ii) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the *Environmental Protection Regulation 2008* if it had not formed part of the mining activity; iii) rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with the standards and requirements of an Erosion and Sediment Control Plan to manage such runoff, provided that this water has not been mixed with pit water, tailings dam water, processing plant water or workshop water; iv) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated; v) groundwater from the mine dewatering activities; and vi) a mix of mine affected water (under any of paragraphs i to v) and other water.
Surface water	Surface water runoff from areas that are disturbed by mining operations (including out-of-pit waste rock emplacements). This runoff does not come into contact with coal or other carbonaceous material and may contain high sediment loads but does not contain elevated levels of other water quality parameters (e.g. electrical conductivity, pH, metals, metalloids, non-metals). This runoff must be managed to ensure adequate sediment removal prior to release to receiving waters.
Diverted water	Surface runoff from areas unaffected by mining operations. Diverted catchment water includes runoff from undisturbed areas and fully rehabilitated areas.
Raw water	Untreated water that has not been contaminated by mining activities.
Potable water	Treated water suitable for human consumption.
External water	Water supplied from a source that is external to Project area to make up water shortfalls for onsite water demands when site water sources cannot meet demand.

5.4 DIVERTED RUNOFF WATER MANAGEMENT

5.4.1 Flood protection levee

A flood levee is proposed along the western edge of the proposed mining operations to protect the site from potential floodwater that overflows from the existing drainage diversion. Part of the proposed flood levee may be formed by a haul road that will be located around the western side of the pit. The location of the proposed flood levee is shown in Figure 1.2 and Figure 1.3.

The levee will be a regulated structure under the EP Act and will therefore be required to have a crest above the 0.1% annual exceedance probability (AEP) event. An assessment of the levee against the requirements of the EP Act is given in 8.6.3.

There are no planned changes or modifications to BMA's existing drainage diversion and associated levee to the west of the Jupiter pit. The water managements system has been designed assuming it will remain unchanged during the operational period of the Project.

5.4.2 Diverted water drains and dams

The water management system has been designed to divert undisturbed catchments around mining operations wherever practicable.

Two diversion drains collect water from the undisturbed catchment to the west of the Project area and divert it around the out of pit emplacement to the existing drainage diversion (Figure 1.2 and Figure 1.3), which drains to the receiving waters.

During operations a free-flowing gravity drain will be constructed between the toe of the existing drainage diversion and the flood protection levee, draining north towards SD6 and Diverted Dam 1 (DD1). As the pit progresses to the north, the sections of the levee that are no longer required for pit flood protection will be replaced by the overburden dump and rehabilitated. This will allow the progressive staging of drainage from the in-pit dump to drain to Sediment Dam 6 (SD6).

The size and configuration of the drain will be confirmed during detailed design; however, it is expected that it will be designed to convey at least a 0.1% AEP (1 in 1,000-year ARI) flow event (assuming the existing drainage diversion is removed) as it will be a permanent landform structure. This will also limit the likelihood of flow interacting with the flood protection levee and ensure adequate capacity post-closure.

The drain alignment will be offset from the flood protection levee to limit the risk of impact on the integrity of the levee. The offset distance will be determined during the detailed design process and will be based on input from geotechnical specialists to confirm levee integrity.

DD1 will be constructed in Stage 2 to collect water from an undisturbed catchment (catchment area of approx. 56.8 ha) adjacent to the Jupiter pit. In addition, DD1 may potentially provide some level of flood protection for the Jupiter pit during the final year of operations.

Temporary drainage management measures including bunds, drains and re-contouring to the north of the pit progression may be constructed as required to prevent runoff and flood waters from flowing into the Jupiter pit. Note that these drainage management measures will be mined through as the Jupiter pit progresses to the north and may be implemented to delay the requirement for DD1. It is expected that temporary drainage measures will be designed to convey at least a 5% AEP (1 in 20-year ARI) flow event.

5.5 SURFACE WATER MANAGEMENT

Sediment water containment (runoff from spoil and incomplete rehabilitated areas) will be managed in accordance with the site Erosion and Sediment Control Plan (ESCP). The ESCP will adopt the three cornerstones of erosion and sediment control:

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

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

5.5.1 Sediment dam locations and sizing

Catchment runoff from both active and newly rehabilitated overburden dumps at the Project will be managed in accordance with an ESCP. The sediment dams have been sized in accordance with the IECA method (IECA, 2008), and have been based on the following design standards and methodology:

- 'Type D' sediment basins with a depth of 3m;
- 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 with an adopted volumetric event runoff coefficient for disturbed catchments of 0.45 (Group C soils – loamy clay); and
- solids storage volume = 50% of settling zone volume.

The adopted design standard does not provide 100% containment for runoff from disturbed areas. Hence, it is possible that overflows will occur from sediment dams several times during a wet season if rainfall exceeds the design standard.

A summary of the conceptual sediment dam capacities and surface areas (based on a depth of 3m) is provided in Table 5.2.

Table 5.2 - Proposed sediment dams

Storage name	Indicative commissioning year	Max. catchment area (ha)	Total volume required (ML)	Dam surface area (ha)	5-day dewatering rate (ML/d)	Overflows to
SD1	2020	18.7	4.1	0.18	0.54	Existing drainage diversion
SD2	2020	6.2	1.4	0.06	0.18	
SD3	2021	10.6	2.3	0.10	0.3	Drainage Line 2
SD4	2022	7.1	1.6	0.07	0.2	Drainage Line 1
SD5	2021	16.3	3.6	0.16	0.48	Existing drainage diversion
SD6	2022	91.4	20.0	0.89	2.7	Drainage Line 1 (Stage 1)/DD1 (Stage 2)
SD7	2024	9.0	2.0	0.09	0.26	Drainage Line 1
SD8	2024	16.0	3.5	0.16	0.46	

5.5.2 Haul road and access road sediment management

Runoff from haul roads and access roads will be managed through the site's Erosion and Sediment Control (ESC) Plan, which will be developed prior to the commencement of construction activities.

Management of runoff from these roads will be a combination of drainage control, erosion control and sediment control measures. The design of the measures will be undertaken during detailed design, but will likely include some of the following measures:

- Catch drains;
- Check dams;
- Grass swales;
- Rock lining/protection;
- Road surface gravelling;
- Sediment traps; and
- Sediment basins.

The sizing of haul/access road sediment basins will be undertaken in accordance with the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008). Any runoff captured within the sediment basins will be released to the downstream environment in accordance with the site ESCP or pumped back into the mine water system.

5.6 MINE AFFECTED WATER MANAGEMENT

5.6.1 Mine affected water dams

Table 5.3 shows the capacities of the proposed mine affected water dams at the Project. The dams sizes have been determined based on the water balance model (see Section 7) to ensure that the Jupiter pit can be adequately dewatered and limit the spill risk to the receiving waters.

The adopted full storage volumes (FSVs), surface areas and operating volumes (OVs) were refined using the water balance model and available space from site mapping. MWD1 has been designed to keep the pit dewatered for as long as practical. The remaining mine water dams have been sized to limit the risk of spills to the receiving waters.

To limit the risk of uncontrolled discharges from the mine water storages, OVs have been set for these water storages (as shown in Table 5.3) as follows:

- MWD1 has a maximum operating volume (MOV) of 140 ML. When the water inventory in MWD1 exceeds its MOV, all transfers to MWD1 (i.e. pit dewatering and mine water transfers) cease; and
- MWD2, MWD3, MWD4 and MWD5 have OVs. When the water inventory in these dams exceeds their respective OVs, these storages commence dewatering to MWD1.

Table 5.3 - Proposed mine affected water dams

Storage	FSV (ML)	OV (ML)	MOV (ML)	FSV surface area (ha)	FSV water depth (m)	Adopted dewatering rate (ML/d)
MWD1	152.5	-	140	2.6	9.0	-
MWD2	9.0	2.88	-	0.24	5.0	1.0
MWD3	5.5	1.76	-	0.15	5.0	1.0
MWD4	4.5	1.44	-	0.12	5.0	1.0
MWD5	6.5	2.08	-	0.17	5.0	1.0

5.6.2 Preliminary consequence assessment

A preliminary consequence assessment of the mine affected water dams using the *Manual for assessing consequence categories and hydraulic performance of structures* (DES, 2016) suggests that the consequence category of mine water dams will be low. This is based on the following:

- The expected harm to humans consequence category is low. The expected population at risk is zero given that most of the mine affected water dams will be small (except MWD1) and will not have a significant constructed wall (less than 3 m) that could fail. The proposed MWD1 location is not adjacent to any planned buildings, other places of occupation or public infrastructure (e.g., roads or rail) that would lie within the failure impact zone. The downstream receiving waters are unlikely to be used for water supply;
- The expected harm to general environment consequence category is low. The downstream receiving waters are heavily modified and have been diverted through the Peak Downs operations. Controlled releases of mine water are not proposed. Further, groundwater assessments predict there will negligible groundwater to manage in the mine water management system, a CHPP is not proposed for the Project and dump runoff quality is expected to be of a suitable quality to release to the receiving waters (following sediment removal). Hence any potential releases of contaminants to the receiving waters from mine water dams are unlikely to have an adverse effect; and
- The expected general economic loss or property damage consequence category is low. This is for similar reasons given for the expected harm to humans consequence category and remedial costs would likely be less than $1 million.

5.6.3 Pit dewatering rates

The timeframes required to dewater the Jupiter pit will be governed by the available pumping capacity. For this assessment, a pit dewatering rate of 100 L/s to MWD1 has been adopted. Alternative pumping capacities based upon the required duration to dewater the pit following a 1% AEP 24 hour storm event (assuming a volumetric rainfall/runoff coefficient of 1.0) are outlined in Table 5.4.

Table 5.4 - 1% AEP 24 hour pit dewatering rates

Stage	Dewatering duration (days)	Pit dewatering (L/s)
1	5	294
	10	147
	30	49
2	5	541
	10	270
	30	90

The alternative dewatering pump rates shown above may be adopted by site depending upon available pumping infrastructure.

5.7 RELEASE OF WATERS TO THE RECEIVING ENVIRONMENT

There are four key mechanisms through which water from the Project can enter the receiving environment:

- dewatering and overflows from sediment dams;
- overflows from mine affected water dams and the open cut pit;

- runoff from diverted water catchments; and
- runoff from rehabilitated catchments.

Sediment dam/mine affected overflows are a point source. Model predictions of volumes from sediment dam and mine affected dam overflows are provided in Section 7.3.5. Runoff from rehabilitated catchments is likely to be both a point and diffuse source of water to the receiving environment. When a sediment dam catchment is completely rehabilitated, and water quality monitoring of the runoff has established that it is consistent with natural background conditions, the sediment dam and associated drainage infrastructure will be decommissioned. Surface runoff and seepage from the rehabilitated catchment will be allowed to shed directly to the receiving environment.

5.8 SEWAGE AND EFFLUENT DISPOSAL

Sewage will be trucked offsite by registered waste transport contractors.

5.9 POST-CLOSURE CONDITIONS WATER MANAGEMENT

Figure 1.4 shows the conceptual final landform water management plan for the Project under post-closure conditions. The final landform plan has been developed with an aim to use water infrastructure constructed during operations. The post-closure layout shown in Figure 1.4 is conceptual only and may be updated should the mine plan and final landform plans change over the mine life.

The key features of the final landform include the following:

- No final voids are proposed as part of the final landform. The open cut pit will be backfilled with overburden material;
- Final landform batter slopes will be 17%;
- Contour banks will be constructed on batters to limit topsoil erosion until vegetation has been suitably established;
- Drainage structures will be constructed to direct runoff from disturbed areas to sediment dams;
- The plateau will be shaped to fall to the west with proposed drains and drop structures to drain the top of the landform to natural ground level;
- Mine water dams will be decommissioned following rehabilitation of infrastructure areas;
- A 10 m corridor between the pit shell crest and the toe of the final landform will be provided for drainage on the eastern side of the final landform;
- The constructed channel between SD6 and DD1 will be a permanent landform feature. A drainage corridor will be constructed through the northern side of the final landform; and
- Sediment dams SD7 and SD8 will be implemented on the northern side of the in-pit spoil dump, with specifications as outlined in Section 5.5.1.

When a sediment dam catchment is completely rehabilitated, and water quality monitoring of the runoff has established that it is consistent with natural background conditions, the sediment dam and associated drainage infrastructure will be decommissioned. Surface runoff and seepage from the rehabilitated catchment will be allowed to shed directly to the receiving environment.

When the drainage corridor is rehabilitated, DD1 will be decommissioned. DD1 will remain until this time to allow in-stream vegetation to establish before receiving upstream catchment flows.

6 Water balance model configuration

6.1 OVERVIEW

A computer-based operational simulation model (OPSIM) was used to assess the dynamics of the mine water balance under conditions of varying rainfall and catchment conditions throughout the development of the Project. The OPSIM model dynamically simulates the operation of the water management system and keeps account of all site water volumes and representative water quality on a daily time step.

The model has been configured to simulate the operations of all major components of the water management system. The simulated inflows and outflows included in the model are given in Table 6.1.

Table 6.1 - Simulated inflows and outflows to the water management system

Inflows	Outflows
Direct rainfall on water surface of storages	Evaporation from water surface of storages
Catchment runoff	Haul road dust suppression demand
Groundwater inflows to the open cut pit	Potable water demand
External water supply	Dam overflows
Trucked potable water	

6.2 SIMULATION METHODOLOGY

The Project water management system will change over the four-year mine life, including changes in catchment areas, production profile and site water demands. To represent the evolution of the mine layout over time, the Project was modelled in two discrete stages. Two representative years of the mine plan have been selected to reflect the average conditions over the mine stage.

The modelled mining stages are summarised in Table 6.2. Approved bulk sampling activities, which are proposed during Year 2020, have not been included in the water balance modelling assessment.

Table 6.2 - Application of representative mine stages to full mine life

Mine stage	Representative year	Applied range of mine life	Stage duration
Stage 1	2022	1/1/2021 to 31/12/2022	2 years
Stage 2	2024	1/1/2023 to 31/12/2024	2 years

6.3 CATCHMENT YIELD PARAMETERS

The OPSIM model uses the Australian Water Balance Model (AWBM) (Boughton, 2003) to estimate runoff from 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 evaporation (surface stores only). Simulated surface runoff occurs when the conceptual storages fill and overflow.

The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate values of runoff using a daily water 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 is converted into a runoff volume by multiplying the contributing catchment area.

The model parameters define the storage depths (C1, C2 and C3), the proportion of the catchment draining to each of the storages (A1, A2 and A3), and the rate of flux between them (K_{base}, K_{surf} and BFI). Catchments across the site have been characterised into the following land use types:

- Natural, representing areas in their undisturbed state;
- Open cut mining pit;
- In pit spoil, representing uncompacted dumped overburden material within the pit shell;
- Out of pit spoil, representing dumped overburden material outside of the pit shell; and
- Disturbed/industrial, representing roads, hardstands and stripped areas.

The adopted AWBM parameters are shown in Table 6.3. These parameters have been based on parameters typical for coal mines in this part of the Bowen Basin. The landuse configurations for the mining areas over the two modelled stages are shown in Figure 1.2 and Figure 1.3.

Table 6.3 - Adopted AWBM parameters

Parameter	Natural	Disturbed/Industrial	Pit	In pit spoil/Out of pit spoil
A1	0.134	0.1	0.134	0.07
A2	0.433	0.9	0.433	0.10
A3	0.433	-	0.433	0.83
C1	5.7	4	2.6	5
C2	57.8	16	26.7	10
C3	115.7	-	53.3	200
C_{avg}	75.9	14.8	35.0	167.4
BFI	0	0	0	0.5
k_{base}	0	0	0	0.9
k_{surf}	0.1	0	0	0.1
C_{v*}	18.7%	37.6%	28.3%	12.0%

* Long term volumetric runoff coefficient.

6.4 CONCEPTUAL WATER MANAGEMENT SYSTEM CONFIGURATION AND SCHEMATIC

Figure 1.2 and Figure 1.3 show the conceptual Project water management system layout as well as catchment areas and land uses for Stage 1 and Stage 2 respectively. Figure 6.1 shows the schematised plan of the proposed water management system configuration. The modelled water management system configuration is outlined in Table 6.4.

Table 5.2 and Table 5.3 shows the sediment dam and mine water dam sizes respectively that were adopted for the water balance assessment.

Table 6.4 - Water management system operating rules for the Project

Item	Node Name	Operating Rules
1	***External water supply***	
1.1	External water	• Mine affected water can be imported (assumed to be from Peak Downs) to supplement mine water demands; and • Supplies haul road dust suppression demands from MWD1 (3rd priority).
1.2	Trucked water	• Supplies the potable water demand.
2	***Supply to demands***	
2.1	Haul road dust suppression	• Sourced from the following: - 1st priority: MWD1; - 2nd priority: Sediment dams; and - 3rd priority: Pipeline from BMA. • 100% loss assumed; and • Demand values outlined in Section 6.5.1.
2.2	Potable water demand	• Sourced from trucked water delivered to site; • 100% loss assumed; and • Assumed constant rate of 50 ML/yr (as outlined in Section 6.5.2).
3	***Pit water***	
3.1	Jupiter pit	• Proposed mining pit active during all stages; • Dewaters to MWD1 at 100 L/s (8.64 ML/d), provided there is available storage in MWD1; and • Receives groundwater inflows as outlined in Section 6.6.1.
4	***Operation of mine affected dams***	
4.1	MWD1	• Proposed primary mine affected water storage; • Receives pump inflows from the Jupiter pit at 100 L/s (8.64 ML/d) until MWD1 reaches its max operating volume at 140 ML, at which point dewatering ceases. Pumped inflows recommence once the MWD1 inventory drops below its maximum operating volume; • Receives pumped inflows from MWD2, MWD3, MWD4 and MWD5 at 11 L/s (1 ML/d); • Supplies water to haul road dust suppression (1st priority); and

		• Overflows to SD6.
4.2	MWD2 & MWD3	• Collect (possibly) mine affected water from the mine infrastructure area; • Transfer water to MWD1 at 11 L/s (1 ML/d) per dam when the water depths exceed the operating volumes outlined in Table 5.3; and • Overflow to the existing drainage diversion.
	MWD4 & MWD5	• Mine affected water storages that capture runoff from the ROM pad; • Transfer water to MWD1 at 11 L/s (1 ML/d) per dam when the water depths exceed the operating volumes outlined in Table 5.3; and • Overflow to the existing drainage diversion.
5	***Operation of sediment dams***	
5.1	Primary sediment dams (SD1, SD2, SD3, SD4 & SD5)	• SD1 & SD2 collect water from the out of pit emplacement, SD3, SD4 & SD5 collect runoff from in pit spoil; • Supplies water to the haul road dust suppression as 2nd priority; and • Overflow to Drainage Line 1/existing drainage diversion.
5.2	SD6	• Proposed sediment dam that collects runoff from in pit spoil; • Pumps to the existing drainage diversion at 2.7 ML/d, once it exceeds its sediment storage volume; and • Overflows to Drainage Line 1 in Stage 1 and DD1 in Stage 2.
6	***Clean water storages***	
6.1	DD1 (Stage 2 only)	• Diverted water that receives inflows from the rural catchment to the northwest of Jupiter pit; • Receives potential overflows from SD6 and MWD1; • Transfers water to Boomerang Creek at 100 L/s (8.64 ML/d) from empty; and • Overflows to Jupiter pit.

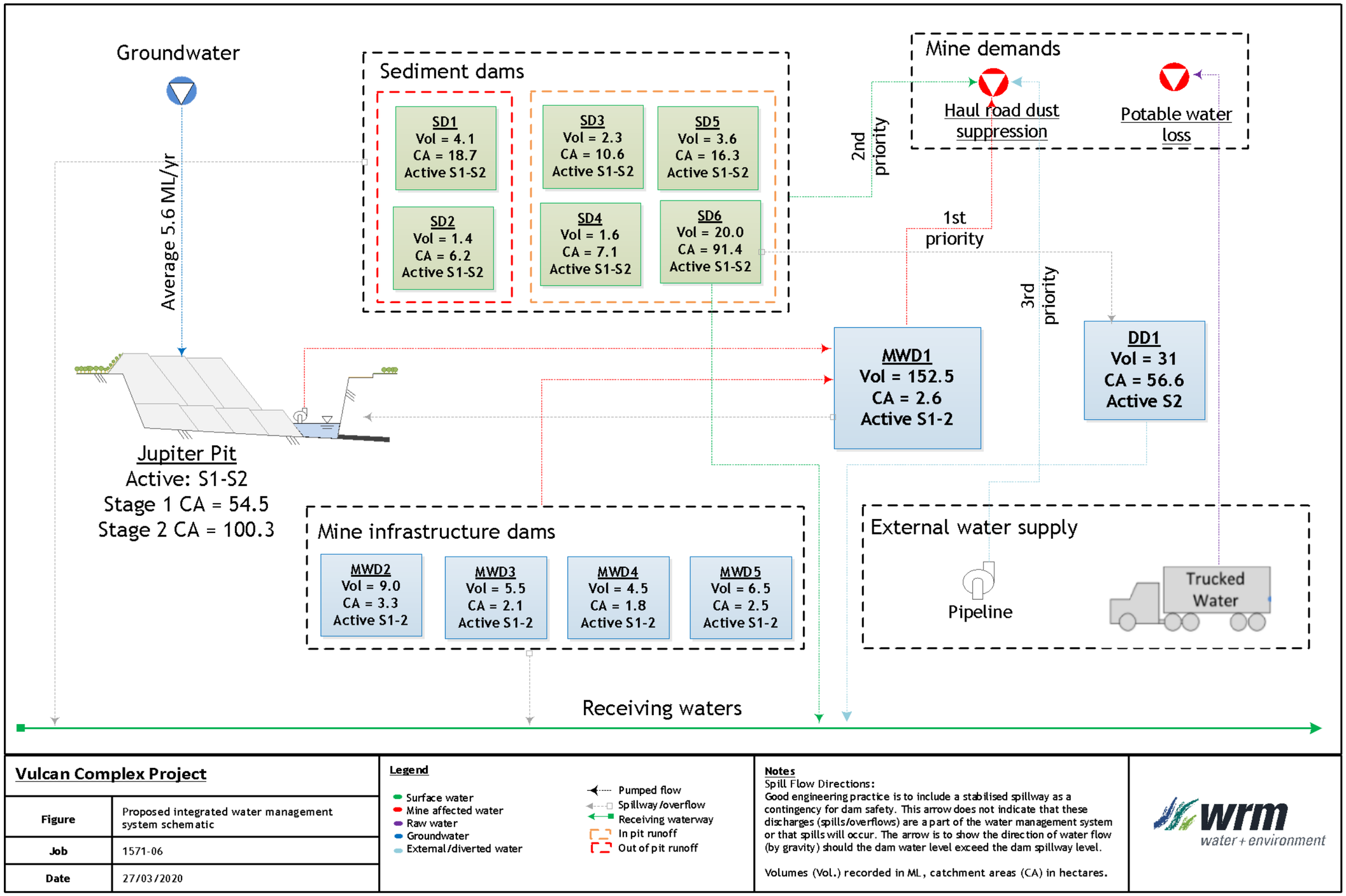


Figure 6.1 - Water management system schematic for the Project

Table 6.5 - Water storage catchment areas (Stage 1)

Dam	Landuse area (ha)					Total
	Natural	Disturbed/ Industrial	In Pit spoil	Out of pit spoil	Pit	
SD1	1.1	2.2	0.0	15.4	0.0	18.7
SD2	0.0	0.9	0.0	5.4	0.0	6.3
SD3	0.0	1.0	9.5	0.0	0.0	10.5
SD4	0.0	1.3	5.6	0.0	0.0	6.9
SD5	0.0	1.7	15.0	0.0	0.0	16.7
SD6	1.8	9.2	0.0	0.0	0.0	11
DD1	N/A	N/A	N/A	N/A	N/A	0
MWD1	0.0	2.8	0.0	0.0	0.0	2.8
MWD2	0.0	3.3	0.0	0.0	0.0	3.3
MWD3	0.0	2.1	0.0	0.0	0.0	2.1
MWD4	0.2	1.67	0.0	0.0	0.0	1.8
MWD5	0.0	2.5	0.0	0.0	0	2.5
Jupiter Pit	0.0	0.4	39.0	0.0	15.1	54.5

Table 6.6 - Water storage catchment areas (Stage 2)

Dam	Landuse area (ha)					Total
	Natural	Disturbed/ Industrial	In Pit spoil	Out of pit spoil	Pit	
SD1	1.1	2.2	0.0	15.4	0.0	18.7
SD2	0.0	0.9	0.0	5.4	0.0	6.3
SD3	0.0	1.0	9.5	0.0	0.0	10.5
SD4	0.0	1.3	3.2	0.0	0.0	4.5
SD5	0.0	1.7	15.0	0.0	0.0	16.7
SD6	1.8	9.4	1.7	0.0	0.0	12.9
DD1	48.5	8.13	0	0.0	0.0	56.6
MWD1	0.0	2.8	0.0	0.0	0.0	2.8
MWD2	0.0	3.3	0.0	0.0	0.0	3.3
MWD3	0.0	2.1	0.0	0.0	0.0	2.1
MWD4	0.2	1.67	0.0	0.0	0.0	1.8
MWD5	0.0	2.5	0.0	0.0	0.0	2.5
Jupiter Pit	17.2	2.4	71.4	0.0	9.3	100.3

6.5 SITE WATER DEMANDS

6.5.1 Haul road dust suppression

Water for haul road dust suppression is primarily sourced from the mine dams (with the priorities outlined in Table 6.4). Haul road designs were provided by Vitrinite.

Haul road dust suppression demands are estimated using supplied haul road design plans and historical climate data as follows:

- Daily pan evaporation and rainfall rates are sourced from the SILO database;
- For a dry day (zero rainfall), the haul road watering rate is equal to the daily evaporation rate;
- For a rainy day when rainfall is less than the daily evaporation rate, the watering rate is reduced and is only required to make up the remaining depth to the daily evaporation rate; and
- For a rainy day when rainfall exceeds the daily evaporation rate, no haul road watering is required.

Assuming a haul road width of 30 m, an in-pit haul road length of 3 km and 1 km of haulage above surface (i.e. a total haul road length of 4 km), the estimated demand rates averaged over each month are summarised in Table 6.7. These rates were adopted for Stages 1 and 2.

Table 6.7 - Forecast Haul Road Dust Suppression usage

Month	Haul road demand (kL/d)
January	691.2
February	608.1
March	636.7
April	548.9
May	417.9
June	340.5
July	376.0
August	486.5
September	667.6
October	775.4
November	789.5
December	761.3
Annual	591.6

6.5.2 Potable water demand

Potable water demand is supplied by trucked water delivered onsite. Potable water demand was assumed at 50 ML/annum (137 kL/d).

6.6 WATER SOURCES

6.6.1 Groundwater

Groundwater inflow estimates to the open cut pit were provided by Hydrogeologist.com.au and have been provided as a daily rate for six-monthly periods over the mine life. A summary of the predicted groundwater inflows provided by Hydrogeologist.com.au are provided in Table 6.8. Also shown in Table 6.8 is the assumed modelled groundwater inflow for each stage of operations. The estimated groundwater inflow rates are small and will likley have a negligible impact on the Mine water balance. Notwithstanding this, groundwater inflows have been included in the water balance model for completeness.

Table 6.8 - Estimated groundwater inflows

Stage	Period start/end	Groundwater inflow (m^3/day)	Modelled groundwater inflow per stage (m^3/day)
1	1/01/2021	0	4.31
	1/07/2021	10.41	
	1/01/2022	5.91	
	1/07/2022	0.91	
2	1/01/2023	8.9	26.22
	1/07/2023	34.75	
	1/01/2024	39.79	
	1/07/2024	21.42	

6.6.2 External water

A key objective of the mine site water management system is to reuse surface water runoff captured within the mine affected water system. Recycling mine water will minimise the volume of water from external sources that is required to satisfy site demands. However, the volume of water captured on site is highly variable and dependent upon climatic conditions. Hence, under dry conditions there is a requirement to source water from external sources.

For the purposes of the assessment, it has been assumed that Vitrinite will source external mine water (likely from BMA's Peak Downs operation) to provide water as required via a pipeline for the life of the Project. Vitrinite are currently investigating other possible sources of water for the Project. The assessment of other sources of water, if utilised, will be undertaken if required.

The pipeline will transfer mine affected water to be stored in MWD1 when mine affected water inventories are low.

6.7 WATERCOURSE FLOW MODELLING

As outlined in Section 4.4 and 4.5, Boomerang Creek streamflow and water quality data was not available for this assessment.

Flows in the surrounding natural watercourses have therefore been simulated using the calibrated AWBM parameter set previously derived for Philips Creek (WRM, 2012) (as shown in Table 6.9). Phillips Creek is a tributary of the Isaac River and is located approximately 25 km south of the Project area. Phillips Creek drains primarily undisturbed land to the west of the Norwich Park Branch Railway through Saraji Mine to the Isaac River. Phillips Creek drains into the Isaac River approximately 4 km downstream of Boomerang Creek. The undisturbed catchment which drains to Phillips Creek is similar in nature to the undisturbed catchment to the west of the Project which drains to Boomerang Creek.

The catchment area of Boomerang Creek directly downstream of the Project (i.e. approximately where Drainage Line 1 meets Drainage Line 2) is approximately 4,300 ha. This catchment area has been adopted for assessing the potential mixing within the downstream receiving waters.

Table 6.9 - Phillips Creek AWBM parameters

Parameter	Phillips Creek Value
A1	0.013
A2	0.444
A3	0.543
BFI	0.21
C1	15.0
C2	100.0
C3	651.0
C_{av}	398.1
Kbase	0.914
Ksurf	0.502
Average annual runoff co-efficient (C_v)	4.5%

6.8 WATER QUALITY MODELLING

RGS Environmental have undertaken an assessment of the overburden and potential coal reject materials at the Vulcan Complex. RGS (2019) presented initial results from the Jupiter Pit area. A series of geochemical tests were completed on samples from the Jupiter pit to assess the risk of potential oxidation of sulphides, acid and metalliferous drainage, potential presence and potential leaching of soluble metals/metalloids and other salinity/erosion issues. RGS (2019) made the following findings regarding the geochemical characterisation of the potential spoil:

- all samples tested had a high factor of safety and negligible risk of generating acid mine drainage;
- assay of the multi-element concentration present in selected representative samples indicates that there are no elements (metals/metalloids) enriched in the sample materials compared to median crustal abundance in unmineralised soils;
- the initial static and kinetic test results indicate that surface runoff and seepage from the sample materials are likely to be pH neutral with moderate excess alkalinity, and low levels of salinity;
- the initial geochemistry results are consistent with the larger data set of results obtained from geochemical characterisation of 139 samples from 21 drill holes across the broader Jupiter and Vulcan prospect areas in the VCP; and
- the results represent an 'assumed worst case' scenario as the samples are pulverised (to minus 75 micrometres) prior to testing. Therefore, samples have a very high surface area compared to materials in the field. This process provides a greater potential for dissolution and reaction and represents an assumed initial 'worst case' scenario for geochemical testing of these materials.

In consideration of the RGS (2019) findings from the preliminary geochemical characterisation, salinity is considered the key contaminant for assessment purposes. Assessment of other contaminants has not been undertaken as part of this surface water assessment. If subsequent monitoring data indicates that there are other contaminants of concern, the assessment can be updated to include additional water quality parameters.

6.8.1 Adopted salinity parameters

The water balance model is configured to use salinity as an indicator of water quality using electrical conductivity (EC) values of runoff for each landuse type and other sources of water.

The proposed EC values are shown in Table 6.10. EC values have been sourced from previous water balance models for mines in similar areas of the Bowen Basin.

Table 6.10 - Adopted salinity concentrations

Water source/land use	EC (µS/cm)	Comment
Natural/ undisturbed	300	Value adopted for Olive Downs SWA and Lake Vermont Northern Extension SWA.
Disturbed	500	Runoff value typical for cleared/stripped areas.
Mining pit	4,500	Value adopted for Lake Vermont Northern Extension SWA.
In pit spoil/out of pit spoil	350	Value adopted for Olive Downs SWA.
External water (pipelines from BMA Peak Downs)	10,000	Salinity of mine water unknown, conservatively high value adopted.
Industrial area	900	Salinity of ROM coal unknown, conservatively high value adopted.
Groundwater	9,520	Average groundwater salinity reading from historical groundwater monitoring undertaken at site (Hydrogeologist.com.au, 2020).

7 Water management system assessment

7.1 OVERVIEW

The Project OPSIM model was used to assess the performance of the water management system, using the following key performance indicators:

- overall water balance – the average inflows and outflows of the water management system based on all model realisations (Section 7.3.1);
- mine water inventory – the risk of accumulation (or reduction) of the overall mine water inventory (Section 7.3.2);
- in-pit storage – the risk of accumulation of water in the mining pits, and the associated water volumes (Section 7.3.3);
- external water demand – the volumes of imported external water required to supplement site mine water supplies (Section 7.3.4);
- uncontrolled spillway discharges – the risk and associated volumes of uncontrolled discharge from the mine affected water storages and sediment dams to the receiving environment (Section 7.3.5);
- overall salt balance – the average salt loads in and out of the water management system based on all model realisations (Section 7.3.6);
- potential receiving water impacts - predicted water quality in the receiving environment during predicted 'worst case' release scenarios (Section 7.3.7 and 7.3.8); and
- sensitivity analysis - varying the assumed haul road dust suppression over the mine life and the potential impacts of climate change (Section 7.4).

The use of a large number of climate sequences reflecting the full range of historical climatic conditions provides an indication of the system performance under very wet, very dry and average climatic conditions. It is important to note that the results of the water balance modelling are dependent on the accuracy of input assumptions. There is inherent uncertainty with respect to some key site characteristics (e.g. catchment yield/runoff, groundwater inflows etc.).

7.2 INTERPRETATION OF MODEL RESULTS

In interpreting the results of the water balance assessment, it should be noted that the results provide a statistical analysis of the water management system's performance over the 4 years of mine life, based on 125 stochastically generated climatic rainfall sequences and historical average monthly evaporation. The model results are presented as a probability of exceedance. For example, the 10%ile represents 10% probability of exceedance and the 90%ile represents 90% probability of exceedance. There is an 80% chance that the result will lie between the 10%ile and 90%ile 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%ile storage volume will be exceeded, which would correspond to very wet climatic conditions. For off-site 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%ile water supply volume would be required. This would correspond to very 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 50%ile trace does not represent the model time series for median climatic conditions.

7.3 WATER BALANCE MODEL RESULTS

7.3.1 Overall water balance

Water balance results for all of the 125 model realisations are presented in Table 7.1.The results presented in Table 7.1 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 7.1 provides an indication of the long-term average annual inflows and outflows. Key outcomes from the overall water balance are as follows:

- Average annual inflows from rainfall runoff for mine affected and surface water dams increase from Stage 1 to Stage 2, as the pit progresses, and more catchment runoff is collected in mine affected water dams and sediment dams.
- The proposed water management system is in negative balance under 'average' climate conditions. This indicates that the Project will require significant volumes of external water to meet mine water demands.
- External water requirements are greater in Stage 1 when compared to Stage 2.

It should be recognised that the following items are subject to climatic variability:

- Rainfall runoff;
- Evaporation;
- External water requirement;
- Dust suppression demand; and
- Dam overflows.

Whilst it provides an indication of the long-term average annual inflows and outflows, application of the nominated values for other purposes should only be undertaken with due consideration of the suitability of the nominated value and any potential implications.

In particular, the "average" sediment dam overflows do not necessarily mean that discharges occur under median climatic conditions. It means that there was a discharge in at least one of the 125 model realisations. A more detailed analysis of the performance of the various components of the water management system is provided in the following sections.

Table 7.1 - Average annual water balance - all realisations

Description	Stage 1	Stage 2
Inflows (ML/year)		
Rainfall Runoff		
Mine affected water	77.0	110.1
Surface water	69.6	71.4
Diverted water	0.0	62.8
Groundwater inflow	1.6	9.6
External water	124.7	95.6
Trucked potable water (external water)	50.0	50.0
Total Inflows	322.8	399.5
Outflows (ML/year)		
Evaporation	20.3	30.1
Dam overflows		
Mine affected water	0.0	0.0
Surface water	29.3	35.3
Diverted water	0.0	60.7
Haul road dust suppression	216.1	216.0
Potable water demand	50.0	50.0
Total Outflows	315.7	392.1
Change in volume (ML/year)		
Change in stored volume	7.2	7.4

7.3.2 Mine affected water inventory

7.3.2.1 MWD1 inventory

Figure 7.1 shows the forecast inventory for MWD1 which is the key out-of-pit mine affected water storage, controlling the dewatering of the pit. Figure 7.2 shows the annual maximum forecast inventory for MWD1 over the mine life.

These results show the 1%ile (wettest climatic conditions), 5%ile, 10%ile, 25%ile and 50%ile traces.

As outlined in Section 5.6.1, to prevent uncontrolled discharges from MWD1 a MOV is required. If the MOV is exceeded, all transfers to the storage cease (i.e. pit dewatering and mine water dam dewatering). The MWD1 MOV, in addition to the FSV are shown in Figure 7.1 and Figure 7.2.

The model results show the following:

- The MWD1 inventory is maintained below the FSV for all climatic conditions assessed and therefore is not predicted to spill under any modelled climate sequence;
- The MWD1 inventory is maintained below its MOV for 5%ile and drier conditions in Stage 1 and 25%ile and drier conditions in Stage 2. This means pit and mine

dam dewatering is restricted under 1%ile in Stage 1 and 10%ile and wetter conditions in Stage 2;

- Under the 50%ile trace, the MWD1 inventory is maintained below 40 ML for the entire mine life;
- Under very wet (1%ile) conditions, MWD1 has an inventory of up to 140 ML during both Stage 1 and Stage 2; and
- Under wet (10%ile conditions), MWD1 has a maximum inventory of approximately:
  - up to 100 ML during Stage 1; and
  - up to 140 ML during Stage 2.

7.3.2.2 Mine water dam inventories

Mine water dams MWD2, MWD3, MWD4 and MWD5 collect mine water draining from the mine infrastructure areas and the ROM pad. They have been grouped together for the purpose of this assessment as they are operated in a similar way. Figure 7.3 shows the annual maximum forecast combined inventory for MWD2, MWD3, MWD4 and MWD5.

The model results show that:

- The combined water inventories in MWD1, MWD2, MWD3, MWD4 and MWD5 remain below the combined FSV under all climatic conditions assessed and therefore are not predicted to spill under any modelled climate sequence;
- Under the 50%ile trace, the maximum mine water inventory is maintained at the combined OV for all years; and
- MWD2, MWD3, MWD4 and MWD5 are predicted to require dewatering every year to MWD1 to maintain water levels at or below their respective OVs.

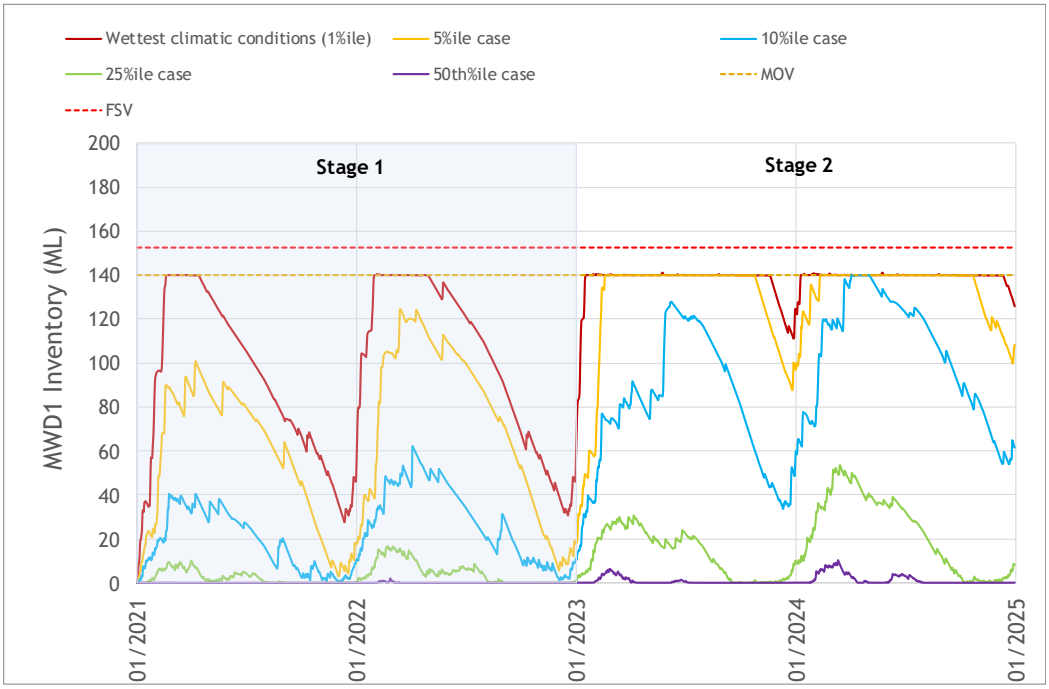


Figure 7.1 - Forecast MWD1 inventory

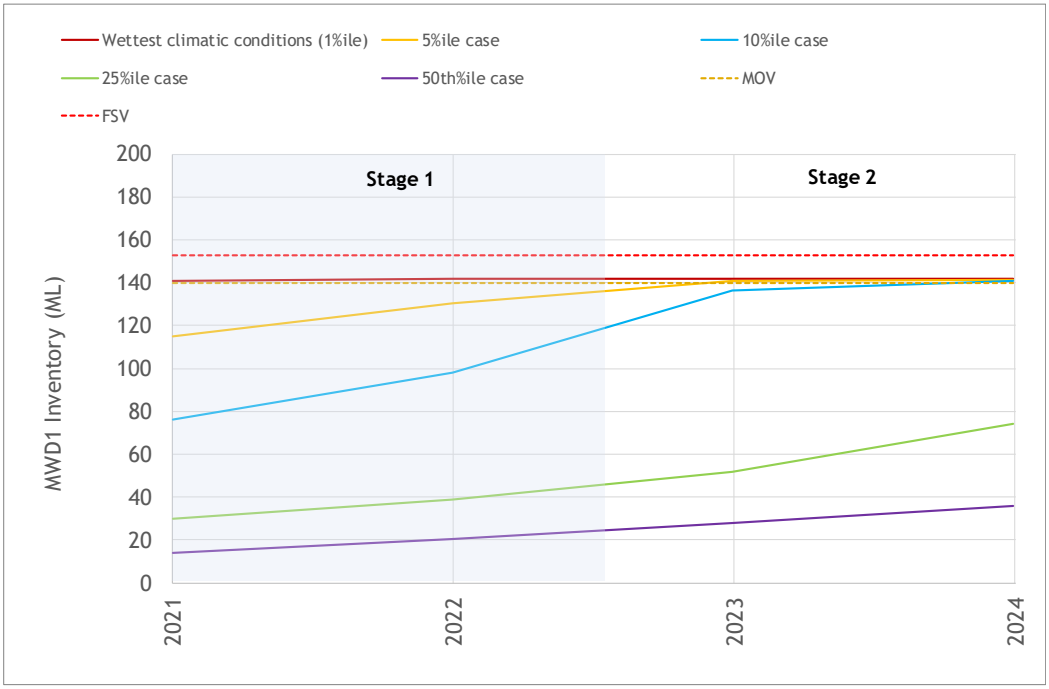


Figure 7.2 - Forecast annual maximum MWD1 inventory

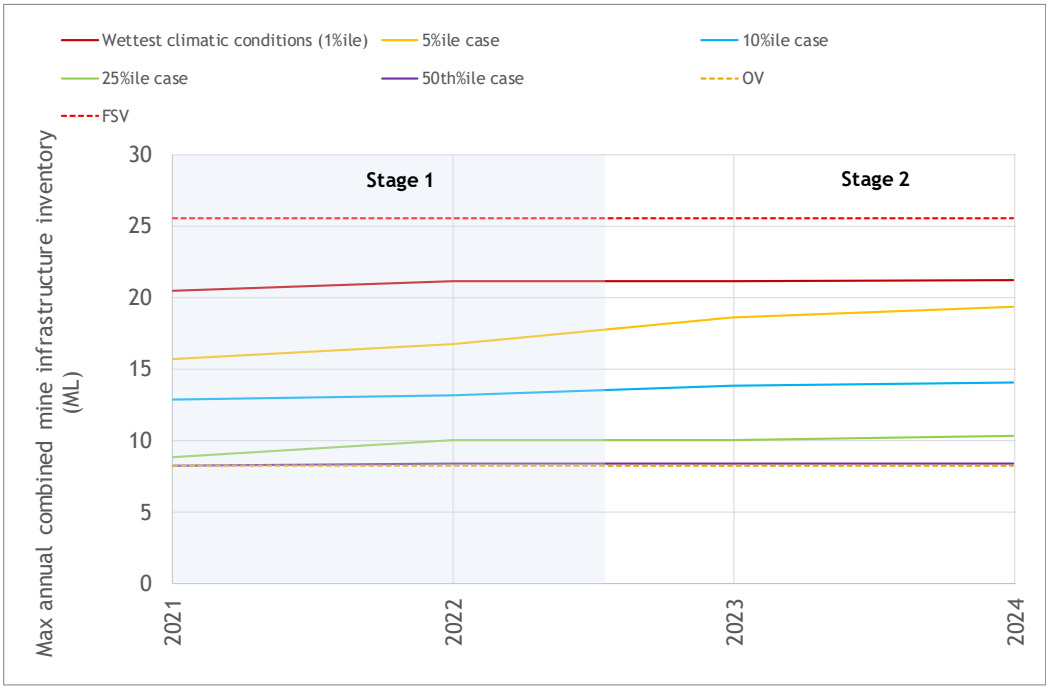


Figure 7.3 - Forecast annual combined maximum water inventory in MWD2, MWD3, MWD4 and MWD5

7.3.3 Jupiter pit water inventory

7.3.3.1 In pit storage

Figure 7.4 shows the forecast inventory of the Jupiter mine pit and Figure 7.5 shows the forecast annual maximum Jupiter pit inventory during the 4-year operational period.

The 1%ile (wettest climatic conditions), 5%ile, 10%ile, 25%ile and 50%ile percentile traces are shown. As outlined in Section 5.6.1, the pit is continuously dewatered into MWD1 as long as MWD1 is maintained below its MOV. MWD1 has been sized to keep the pit dewatered as long as practical given sizing constraints.

The model results show the following:

- Under very wet (1%ile) conditions, the Jupiter pit will have a forecast inventory of approximately:
  - up to 40 ML during Stage 1; and
  - up to 190 ML during Stage 2.
- Under wet (10%ile conditions), the Jupiter pit will have an inventory of approximately:
  - up to 15 ML during Stage 1; and
  - up to 60 ML during Stage 2.
- Under 50%ile conditions, the maximum pit inventory is less than 1 ML during Stage 1 and Stage 2.

The results suggest that the Jupiter pit may begin to accumulate water during Stage 2 during very wet climate conditions due to insufficient storage capacity in MWDs (rather than dewatering capacity). If there is a 5%ile or wetter climatic condition then the on-site water storages would be filled to capacity and the Jupiter pit would have to store excess water for many months potentially disrupting mining activities for extended periods. To prevent this happening, additional water storage and/or water disposal methods such as controlled discharges would be required to recover the Jupiter pit sooner.

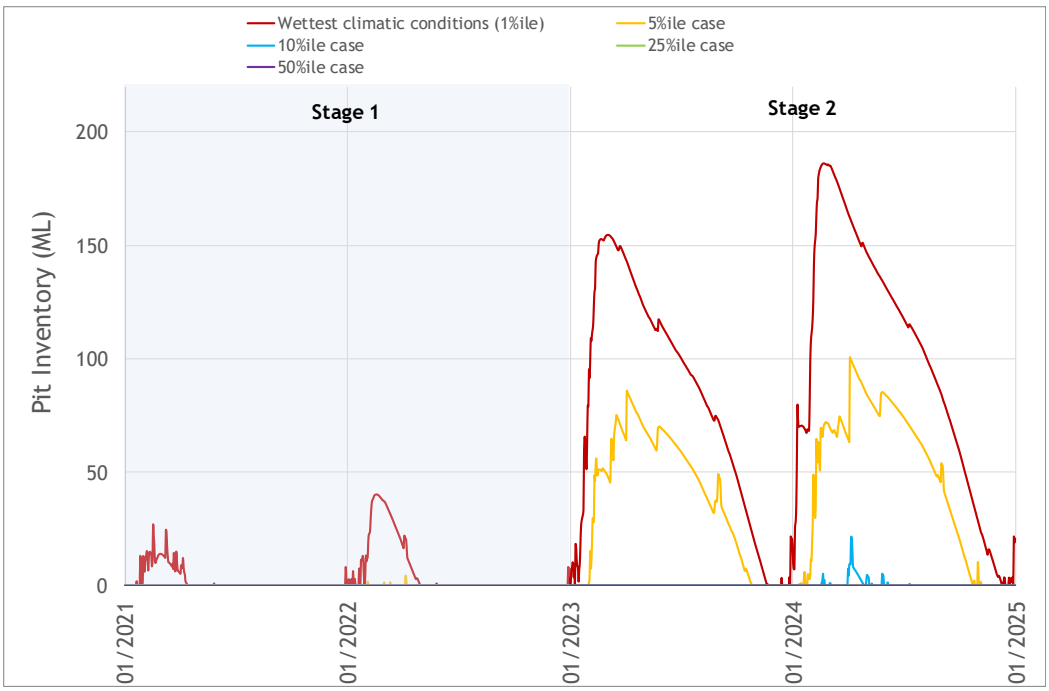


Figure 7.4 - Jupiter forecast mine pit inventory

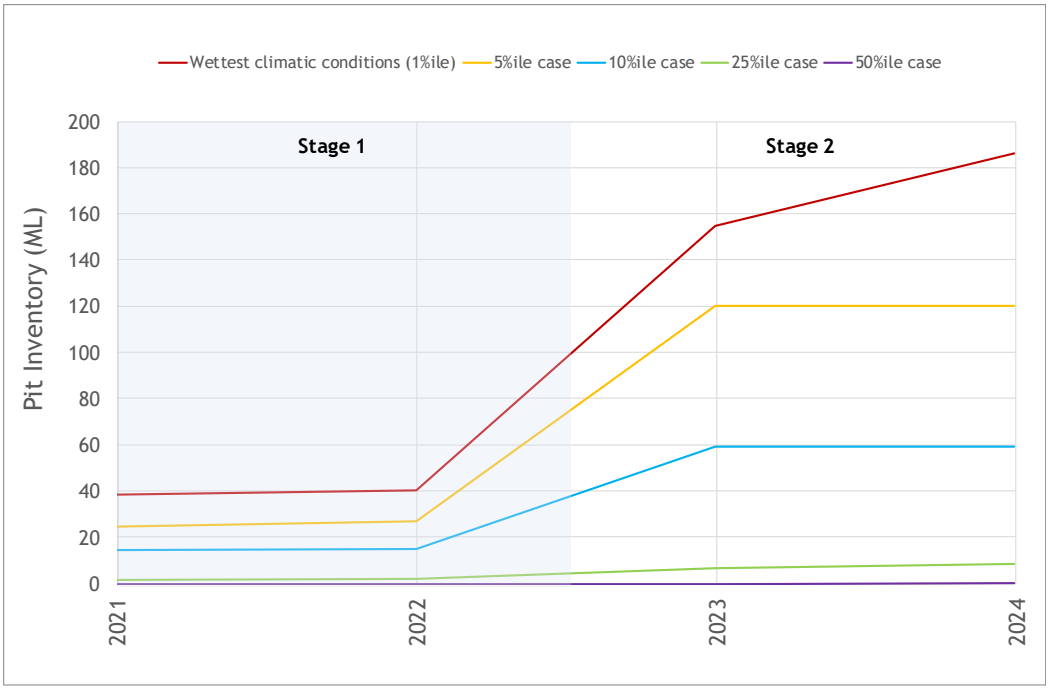


Figure 7.5 – Jupiter forecast annual maximum pit inventory

7.3.4 Dust suppression makeup requirements from external water sources

Figure 7.6 shows the total annual modelled external water required to meet predicted dust suppression demands. The 1%ile (driest climatic conditions), 5%ile, 10%ile, 25%ile and 50%ile percentile traces are shown.

The modelling results show the following:

- Stage 1 requires more external water than Stage 2 due to less yield from catchment runoff inflows to the water management system;
- During the driest (1%ile) climatic conditions, the predicted external water requirement for dust suppression is:
  - up to approximately 200 ML/annum during Stage 1; and
  - up to 190 ML/annum during Stage 2.
- During 50%ile conditions, the predicted external water requirements for dust suppression is:
  - up to approximately 140 ML/annum during Stage 1; and
  - up to approximately 110 ML/annum during Stage 2.

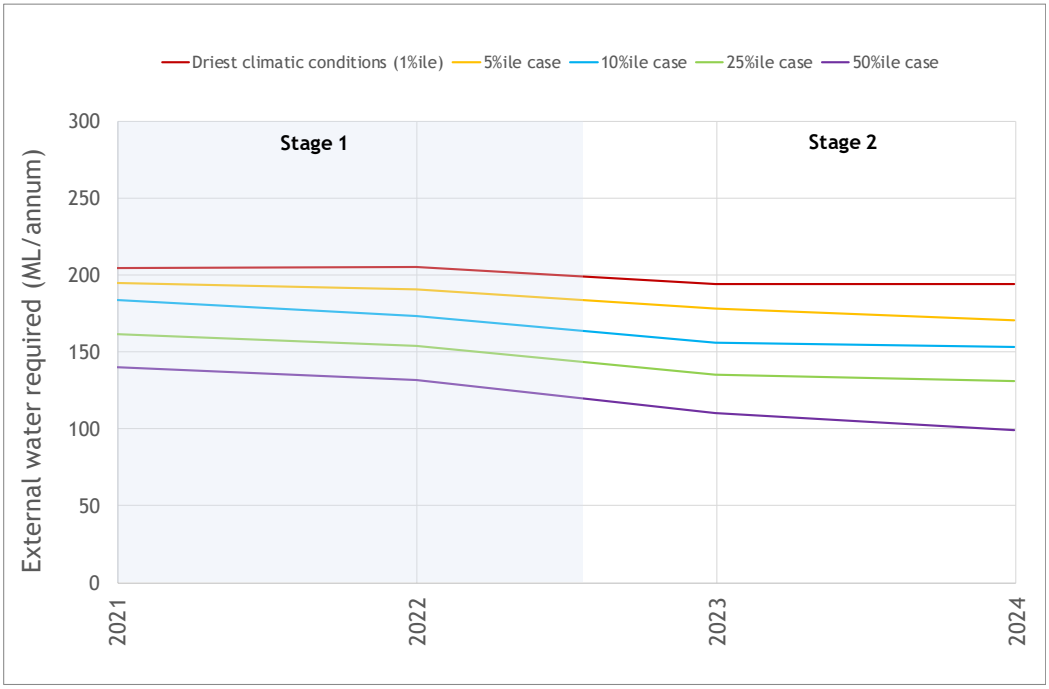


Figure 7.6 – Forecast external water requirement for dust suppression

7.3.5 Spillway water discharges

7.3.5.1 Mine Affected Water Dams

As outlined in Section 7.3.2, no spills are predicted from any of the mine affected water dams (i.e. MWD1, MWD2, MWD3, MWD4 and MWD5) under any of the climate sequences modelled.

7.3.5.2 Sediment Dams

Consistent with the IECA guidelines (2008), sediment dams do not provide 100% containment for captured runoff. Hence overflows will occur from sediment dams when rainfall exceeds the design standard.

The potential for overflows from the proposed sediment dam has been modelled using a passive overflow rather than active release (to regain storage capacity within 5 days). SD6 is pumped to the existing drainage diversion at 2.7 ML/d following rainfall events.

Figure 7.7 shows the forecast annual sediment dam releases to the receiving waters (including the pumped flows from SD6) which indicates that:

- Under wet (10%ile) conditions, the annual volume of sediment dam releases to the receiving waters are approximately:
  - up to 100 ML/yr during Stage 1; and
  - up to 120 ML/yr during Stage 2.
- Under 50%ile conditions, the annual volume of sediment dam releases to the receiving waters are approximately:
  - up to 9 ML/yr during Stage 1; and
  - up to 15 ML/yr during Stage 2.

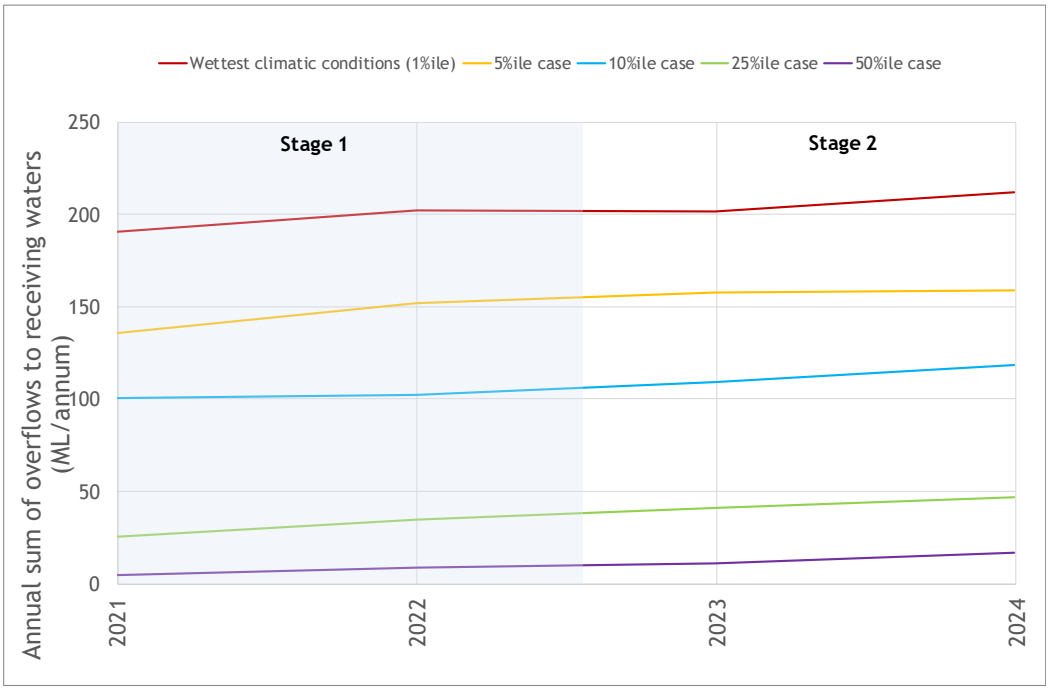


Figure 7.7 – Forecast annual sediment dam overflows to the receiving waters

SD6 will spill to DD1 during Stage 2 via a constructed surface water drain. Figure 7.9 shows the forecast total annual SD6 spills to DD1. SD6 has a predicted risk of spilling up to 3 ML/annum to DD1 over Stage 2 under 1%ile conditions. Further, SD6 has an overall spill risk of 3% AEP to DD1 during Stage 2.



Figure 7.8 – Forecast total annual overflows from SD6 to DD1

7.3.5.3 DD1

DD1 will be constructed in Stage 2 and will collect water from an undisturbed catchment to the northwest of the Project as well as overflows from SD6. All water stored in DD1 will be dewatered to the existing drainage diversion at 100 L/s. If the capacity of DD1 is exceeded, water will spill to the Jupiter Pit.

Figure 7.9 shows the annual total pumped flows from DD1 to the existing drainage diversion and Figure 7.10 shows the annual sum of overflows from DD1 to the Jupiter Pit. The 1%ile (wettest climatic conditions), 5%ile, 10%ile, 25%ile and 50%ile percentile traces are shown.

The model results predict the following:

- Under 10%ile conditions:
  - DD1 dewaters up to approximately 150 ML/year to the existing drainage diversion in Stage 2; and
  - Does not spill to the Jupiter Pit.
- Under 1%ile conditions (wettest climatic conditions):
  - DD1 dewaters up to approximately 210 ML/year to the existing drainage diversion; and
  - Spills (overflows) up to approximately 35 ML/year in Stage 2 to the Jupiter Pit.
- The results in Figure 7.10 indicate that DD1 has a spill risk of between a 5% and 10% AEP.



Figure 7.9 - Forecast total annual pumped transfers from DD1 to the existing drainage diversion



Figure 7.10 – Forecast total annual overflow volumes from DD1 to the Jupiter pit

7.3.6 Overall salt balance

Table 7.2 shows the average annual salt balance for the Project for each stage.

Salt inputs to the Project include salts in the groundwater inflow, catchment runoff and external water. Salt inputs from direct rainfall was assumed to be zero.

Salt outputs from the Project include site demands and offsite (spillway) discharges from the water management system.

The results indicate the following:

- The largest contributor to the Project salt load is due to external water assuming it is sourced from BMA's operations. This is due to the high assumed salinity of the BMA water (Section 6.8.1);
- The largest outflow in the salt balance from the Project is haul road dust suppression demands; and
- The change in stored salt load is generally low in comparison to the total inputs and outputs, which suggests that salt will not accumulate within the site water management system.

Note that the salt balance is reported in annual tonnes of total dissolved solids (TDS) based on an EC to TDS conversion factor of 0.7.

Table 7.2 - Average annual salt balance (based on TDS)

Description	Stage 1	Stage 2
Inputs (t/year)		
Rainfall Runoff		
Mine affected water	92.5	73.3
Surface water	19.7	20.0
Diverted water	0.0	15.5
Groundwater inflow	10.5	63.8
External water	872.7	669.2
Trucked potable water	0.0	0.0
Total Input	995.4	841.8
Outputs (t/year)		
Evaporation	0.0	0.0
Dam overflows		
Mine affected water	0.0	0.0
Surface water	8.5	10.5
Diverted water	0.0	15.0
Haul road dust suppression	979.3	810.7
Potable water demand	0.0	0.0
Total Output	987.8	836.2
Change in salt (t/year)		
Change in stored salt	7.7	5.6

7.3.7 Receiving waters water quality

The three potential sources of receiving waters contamination from the water management system are releases from the sediment dams, releases from the mine affected dams and pumped releases from DD1. As outlined in Section 7.3.2, the mine affected dams are not predicted to spill under any of the modelled climate sequences. Releases from DD1 are expected to be of a water quality that is similar to the default WQO trigger values as it primarily collects water from a rural catchment and overflows from SD6 following sediment removal.

Potential impacts to EC in the receiving environment were assessed at a point directly downstream of the Project (where Drainage Line 1 meets Drainage Line 2, approximately 1 km downstream of the Project boundary). The default WQO trigger levels for EC outlined in Section 3 have been used for this assessment.

Figure 7.11 shows the predicted annual maximum EC in the receiving waters over the mine life. Note that most of the time, EC concentrations will be lower due to dilution with natural flows. The 1%ile, 5%ile, 10%ile, 25%ile and 50%ile (median climatic conditions) traces are shown. The results predict that:

- Under 1%ile conditions the maximum EC in the receiving waters is approximately 440 µS/cm in Stage 1 and 500 µS/cm in Stage 2; and
- Under 50%ile conditions the maximum EC in the receiving waters is approximately 340 µS/cm in Stage 1 and 455 µS/cm in Stage 2.

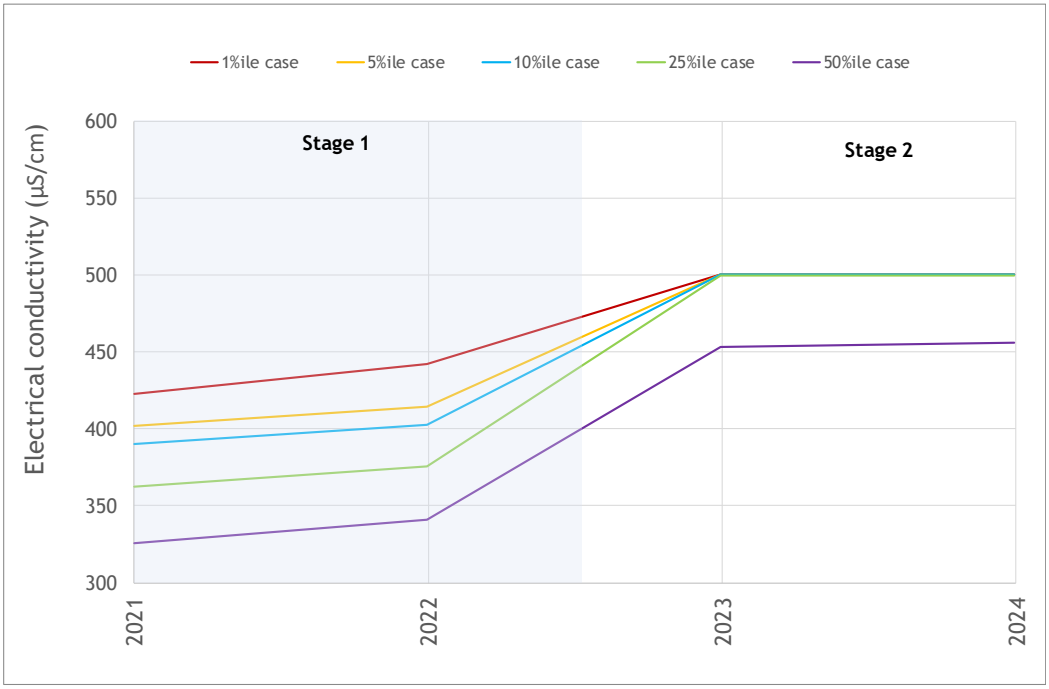


Figure 7.11 – Predicted Boomerang Creek annual maximum EC variation downstream of the Project

7.3.8 Release scenarios

The OPSIM model was used to assess the release (spill or transfer) from sediment dams and DD1. No other dams or storages are predicted to release to the receiving waters. The release scenarios that were investigated include:

- Scenario 1 – The highest EC release from the sediment dams; and
- Scenario 2 – The highest flow rate release from the sediment dams.

The release events were compared to the WQO levels outlined in Section 3.

7.3.8.1 Scenario 1 – Sediment dams highest EC release

The cumulative release with the highest EC from the Project occurs during Stage 2 at approximately 646 µS/cm with a flow rate of approximately 0.54 ML/d. Figure 7.12 and Figure 7.13 show the release rate and EC compared to the rates in the receiving waters. The WQO levels outlined in Section 3 are also shown.

The OPSIM model predicts that during the Scenario 1 release, the release causes a minor increase to EC levels in the receiving waters. This is due to the low flow rate of the release in comparison to the high flows within the receiving waters. The model predicts that during the event both the EC levels of the release, and receiving waters remain above the high flow WQO but below the baseflow WQO. It is noted that for this assessment, the assumed receiving waters EC level (300 µS/cm) is greater than the high flow WQO of 250 µS/cm.

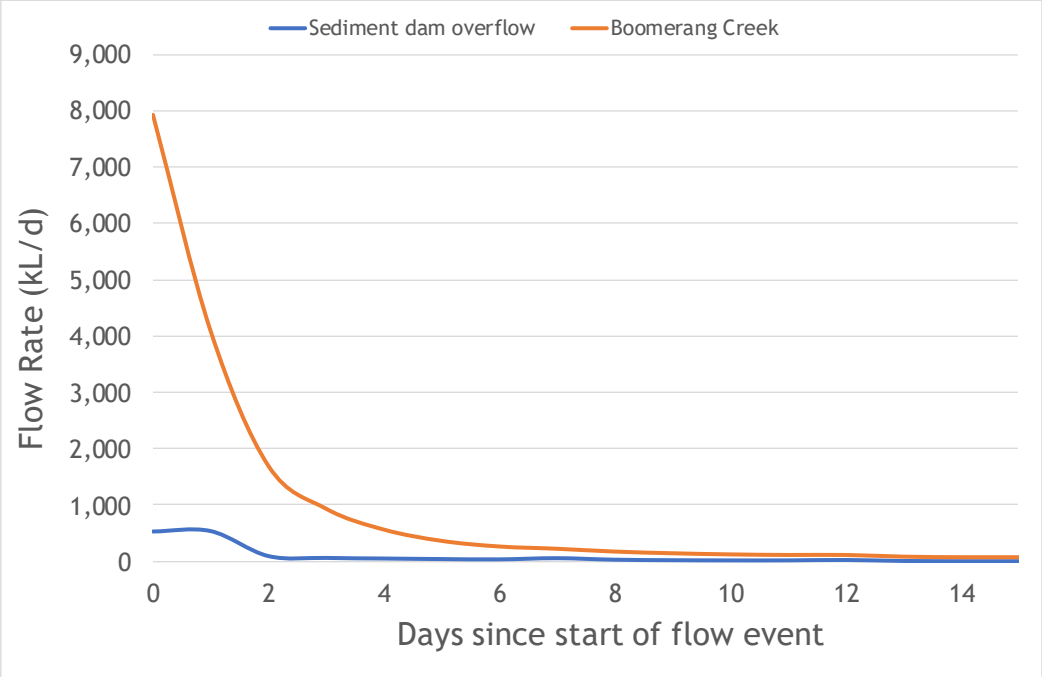


Figure 7.12 - Project release rate compared to flow rate in the receiving waters - Scenario 1

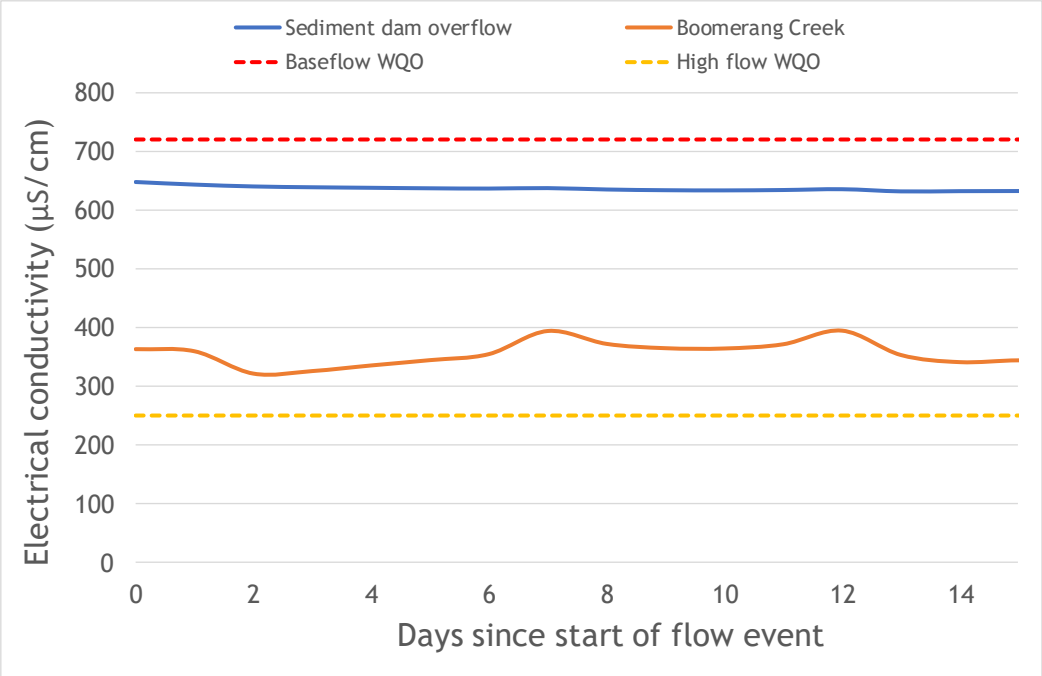


Figure 7.13 - Project release EC levels compared to EC levels in the receiving waters and corresponding water quality criteria - Scenario 1

7.3.8.2 Scenario 2 – Sediment dam highest flow rate

The Scenario 2 highest release rate occurs during Stage 1 with a cumulative release of approximately 39 ML/d. Figure 7.14 and Figure 7.15 shows the Scenario 2 release rate and EC from the cumulative release compared to the flow rate and EC in Boomerang Creek during and following the release event.

The OPSIM model predicts that during the Scenario 2 release, Boomerang Creek will already have a very large flow. The cumulative release has a negligible effect on the Boomerang Creek EC levels due to the already high flows present. The model predicts that during the event both the EC levels of the release, and within Boomerang Creek remain above the high flow WQO but below the baseflow WQO. It is noted that for this assessment, the assumed Boomerang Creek EC is greater than the high flow WQO of 250 µS/cm.

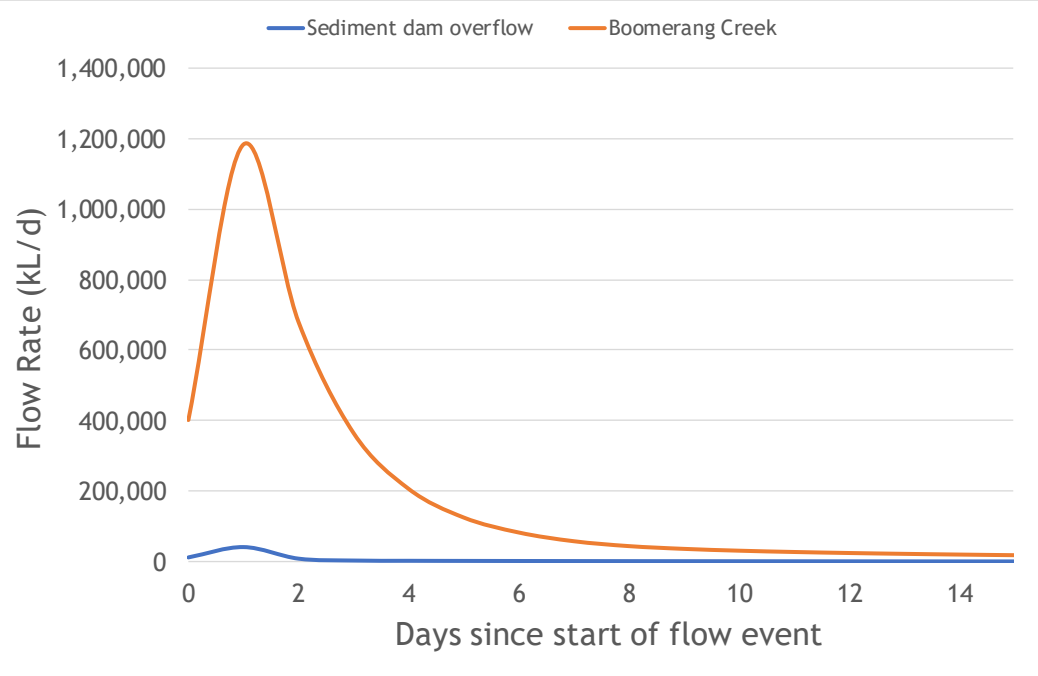


Figure 7.14 – Project release rates compared to flow rates in the receiving waters- Scenario 2

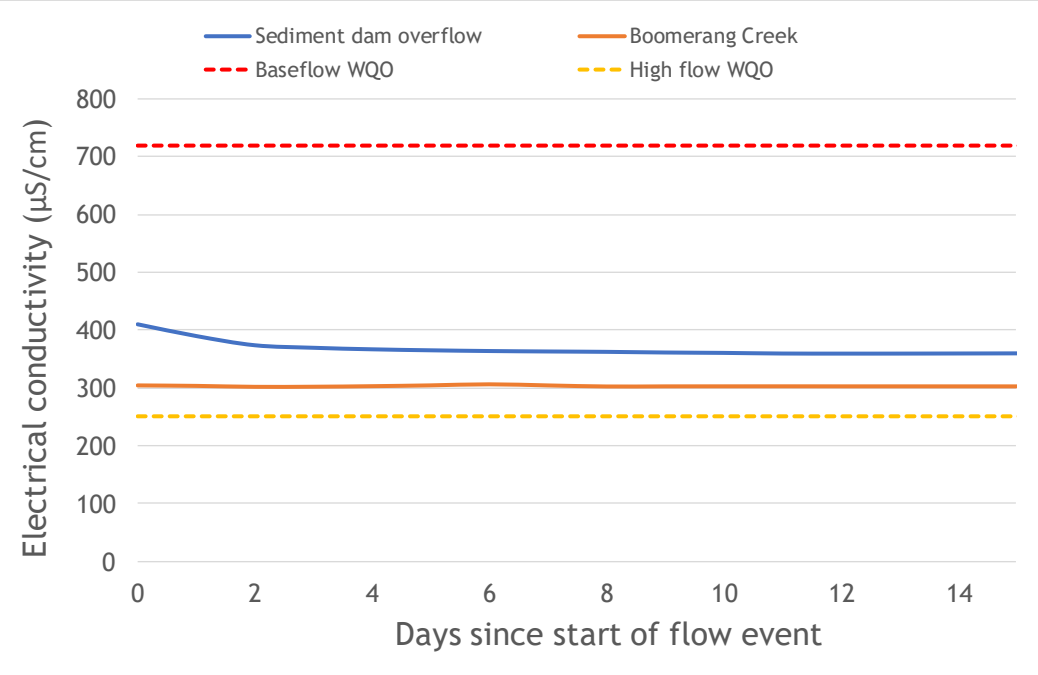


Figure 7.15 – Project release EC levels compared to EC levels in the receiving waters as well as the corresponding water quality criteria – Scenario 2

7.4 SENSITIVITY ANALYSIS

7.4.1 Haul road dust suppression

A sensitivity analysis was undertaken by varying the haul road dust suppression demand to assess the potential impacts on the overall water balance and MWD spill risk.

As outlined in Section 7.3, haul road dust suppression has the biggest influence on the Project water and salt balance. The haul road dust suppression demand has been estimated using the methodology outlined in Section 6.5.1. It is likely that the dust suppression demand will vary over the mine life as operations progress, as well as climatic and seasonal conditions. The haul road dust suppression is therefore likely the largest uncertainty for the water balance model and will have the greatest effect on the overall water balance.

A preliminary haul road dust suppression demand estimate of 1.33 ML/d was adopted for the sensitivity assessment based on preliminary rates adopted for the bulk sample project.

Figure 7.16 shows the annual maximum MWD1 inventory, Figure 7.17 shows the annual maximum Jupiter mine pit inventory and Figure 7.18 shows the forecast annual total external water requirement for the sensitivity assessment.

The results of the sensitivity analysis indicate that:

- Less water would accumulate in onsite water storages and the Jupiter Pit when compared to the base case:
  - Under 10%ile conditions, MWD1 would store up to 70 ML in Stage 1 and 130 ML in Stage 2 when compared with 100 and 140 ML respectively in the base case;
  - During Stage 1, MWD1 would only be filled to capacity in wettest (1%ile) conditions when compared with the 5%ile condition in the base case; and
  - During Stage 2, under 1%ile conditions the Jupiter pit would store up to 140 ML compared to 190 ML in the base case.

- More external water would be required to meet site water demands. During the driest climatic conditions (1%ile), external water demand would be up to 480 ML/annum in Stage 1 and 460 ML/annum in Stage 2. The maximum predicted base case external water demand is up to 200 ML/annum during Stage 1 and 190 ML/annum during Stage 2; and
- No mine affected water dam spills to the environment occur for this sensitivity assessment and the base case.

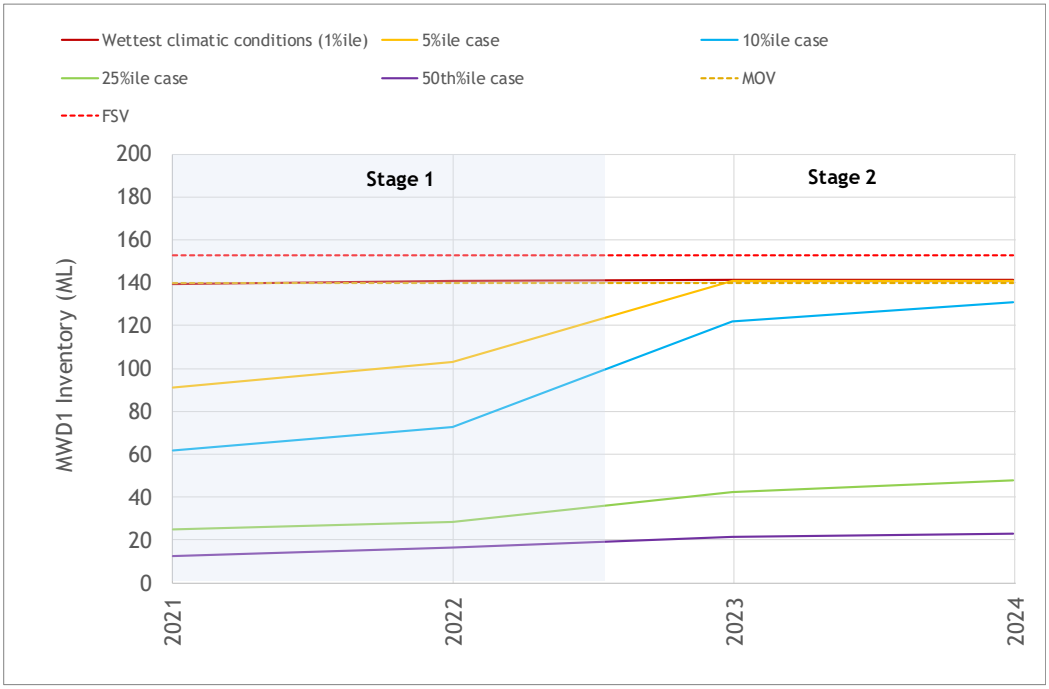


Figure 7.16 - Forecast annual maximum MWD1 inventory - dust suppression sensitivity analysis

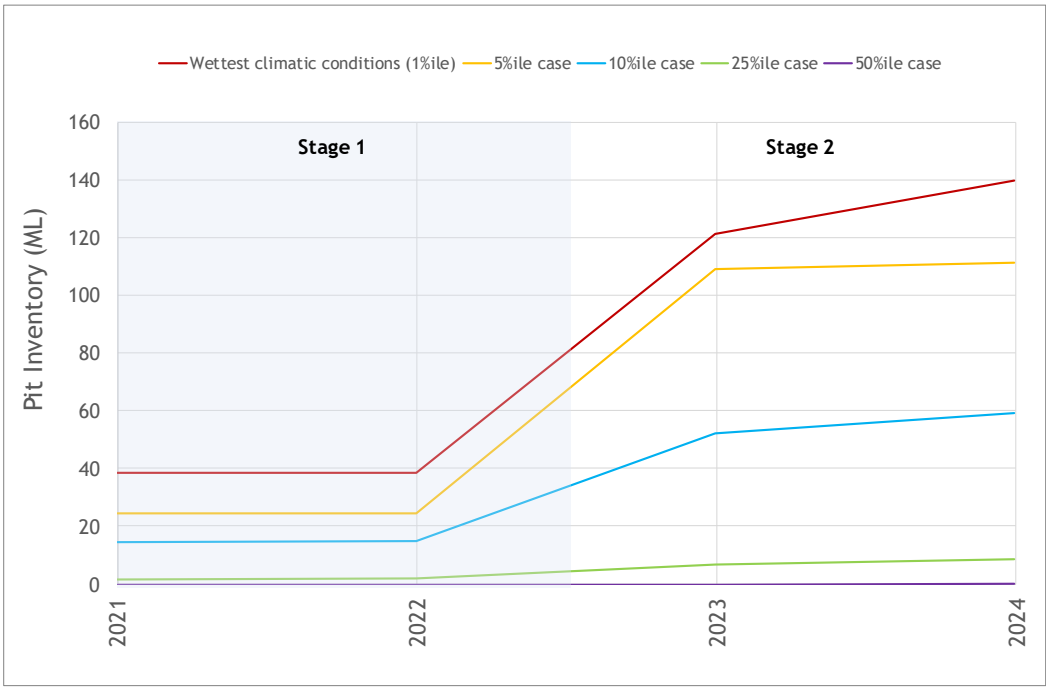


Figure 7.17 - Jupiter forecast annual maximum mine pit inventory - dust suppression sensitivity analysis

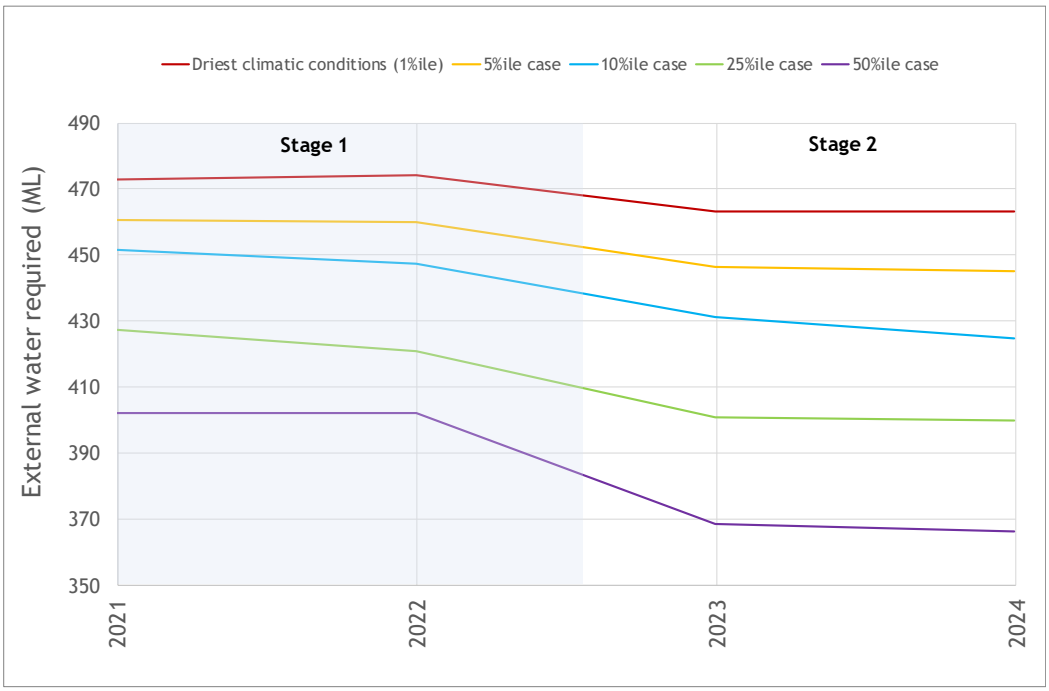


Figure 7.18 - Forecast annual total external water requirement - dust suppression sensitivity analysis

7.4.2 Climate change

The potential changes to climate within the operational life of the Project 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. 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 7.3.

Temperatures are expected to increase by approximately 1°C, rainfall is expected to decline by between 3% and 10% and evapotranspiration is expected to increase by between 3% and 4%.

The climate variable inputs (rainfall and evaporation) to the Project water balance model were adjusted to undertake the climate change impact assessment. Table 7.3 shows the adopted climate projections for the 'best case' and 'worst case' RCP4.5 climate change scenarios. The 'maximum consensus' scenario has not been run as it falls between 'best case' and 'worst case' scenarios.

Table 7.3 – Projections of changes to climate

Scenario	Climate model	Mean surface temperature	Rainfall	Evapotranspiration
		Annual change	Annual change	Annual change
Best case	MIROC5	1.02°C	-3.1%	3.2%
Maximum consensus	MIROC5	1.02°C	-3.1%	3.2%
Worst case	GFDL-ESM2M	1.07°C	-10.4%	3.9%

Figure 7.19 and Figure 7.20 show the forecast annual modelled demand for water from external sources for the 'best' and 'worst' case climate scenarios in comparison to the base case results.

The model results are summarised as follows:

- 'Best' case climate scenario (Figure 7.19):
  - For the 1%ile results (very dry climatic conditions), the 'best' case modelled annual external water demands are up to 3 ML/a higher than the base case results; and
  - For the 50%ile results the 'best' case modelled annual external water requirement be up to 10 ML/a higher than the base case results.
- 'Worst' case climate scenario (Figure 7.20):

- For the 1%ile results (very dry climatic conditions), the 'worst' case modelled annual external water demands are up to 6 ML/a higher than the base case results; and
- For the 50%ile conditions, the 'worst' case modelled annual external water requirements are up to 25 ML/a higher than the base case.

There is an increase in external water demand requirements under both the 'best' and 'worst' climate scenarios, when compared with the base case results. This is due to the increase in evaporation and decrease in rainfall under both scenarios.

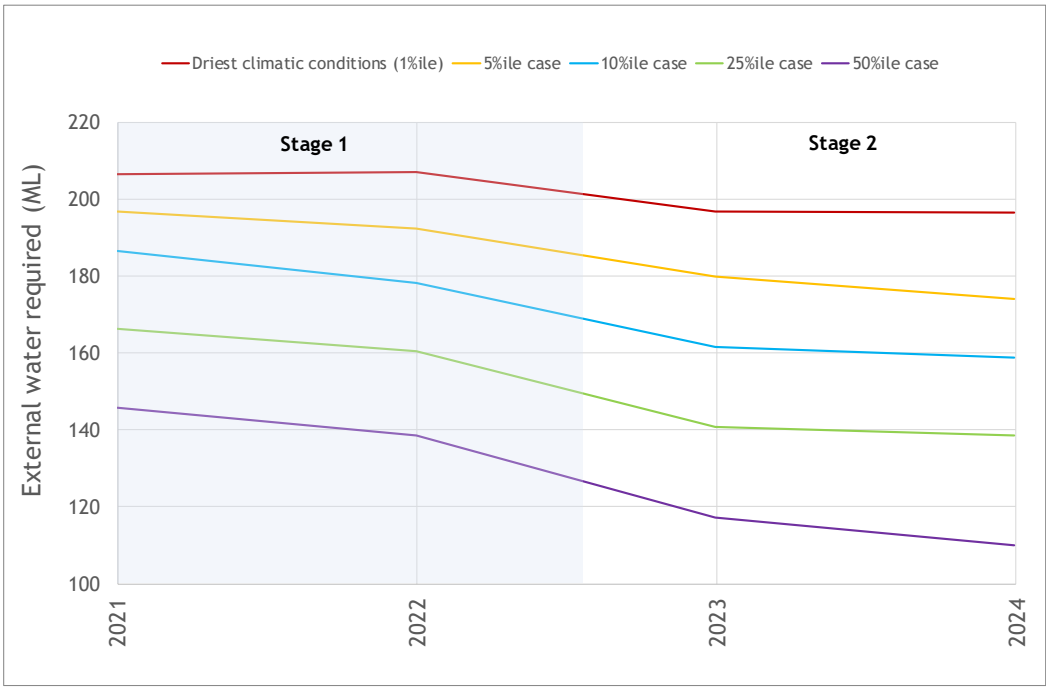


Figure 7.19 - Forecast annual total external water requirement - climate change 'best case' sensitivity analysis

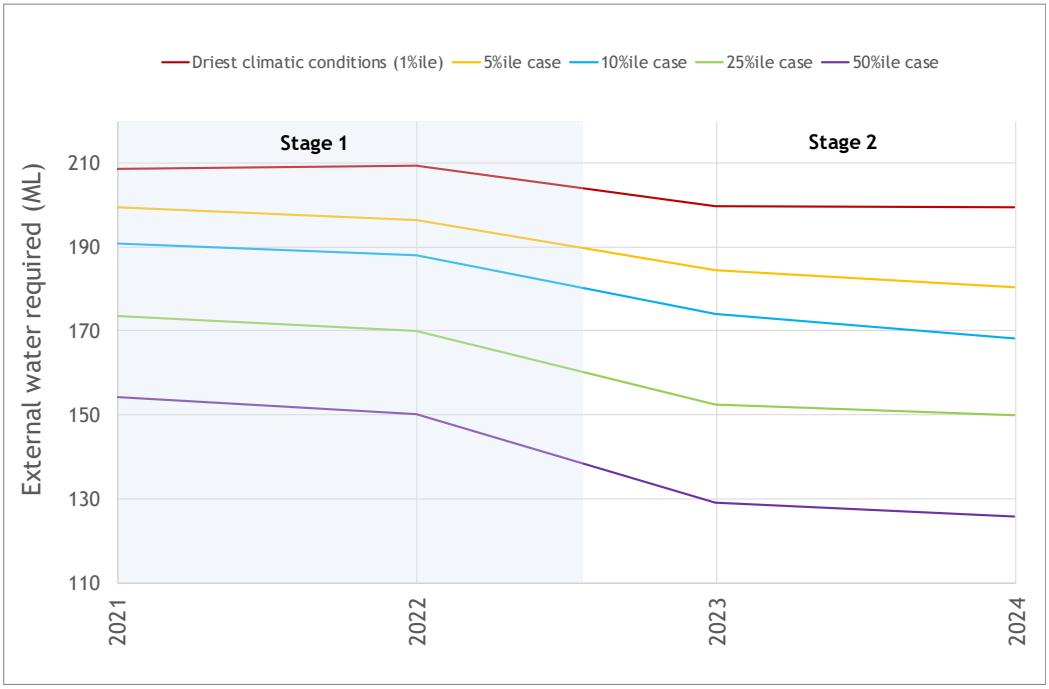


Figure 7.20 – Forecast annual total external water requirement – climate change 'worst case' sensitivity analysis

7.5 ADAPTIVE MANAGEMENT OF THE WATER MANAGEMENT SYSTEM

The model results presented above represent the application of the proposed water management system rules over the mine life, regardless of climatic conditions. There are numerous options for adaptive management of the mine water system to respond to climatic conditions and the current site water inventory in a way that will reduce the risks of impacts to surface water resources.

A site water balance model will be developed once the mine is operational and will be updated regularly (annually or biennially) using site monitoring data.

8 Flood modelling and impact assessment

8.1 OVERVIEW

The drainage features that cross the Project have been assessed to determine the potential impact of the Project on flood behaviour including:

- The potential to impact on flood levels;
- The potential to increase the extent of flooding;
- The potential to increase erosion and/or sedimentation of the impacted waterways;
- The potential to impact on the morphology of the adjacent floodplains; and
- The potential loss of flow from the catchment.

8.2 ADOPTED METHODOLOGY

8.2.1 Hydrological model

A hydrological model was developed for the Boomerang Creek and Hughes Creek catchments, including the features that cross the Project area, using the XP-RAFTS runoff-routing software (Innovyze, 2019). Section 8.2 describes the development, configuration and calibration of the hydrological model.

There was no publicly available recorded streamflow data in the drainage lines that cross the proposed Project area to calibrate the model. As a result, the XP-RAFTS design discharges estimated for Boomerang Creek and Hughes Creek catchments were validated against the Rational Method for the 10% and 1% AEP design flood event.

The Phillips Creek catchment was also included in the hydrologic model because of the availability of recorded water levels and flows. The peak 10% and 1% AEP design discharges estimated for Phillips Creek by the XP-RAFTS model were validated against a Flood Frequency Analysis (FFA) of the annual series peak discharges recorded at the (now closed) Phillips Creek at Tayglen streamflow gauge.

Design flood hydrographs estimated using the calibrated XP-RAFTS model were adopted as inflows in the hydraulic model.

8.2.2 Hydraulic model

The TUFLOW model was used to estimate design flood levels, velocities and extents in Boomerang Creek and its tributaries across the Project area for the 10% (1 in 10) AEP, 1% (1 in 100) AEP and 0.1% (1 in 1000) AEP design flood events for the Existing Conditions and the proposed Final Landform Conditions. The model results were used to assess the potential impacts on flood levels, velocities and extents along Boomerang Creek for the Final Landform Conditions. Section 8.3 and Section 8.4 describe the development and configuration of the hydraulic model and Section 8.5 and Section 8.6 provide the flood modelling results and impact assessment.

8.3 CONDITIONS ASSESSED

8.3.1 General

The potential flood impacts of the Project were assessed for the following two conditions:

- Existing Conditions; and
- Post-closure Conditions.

For each condition, two possible levee scenarios were considered for the existing drainage diversion and levee to ensure that the Project could cater for future modification/removal of this structure by others. Note that no changes to the existing structure is proposed as part of the Project. The two scenarios assessed for the flood impact assessment were:

- The existing drainage diversion and levee remains operational after the completion of the Project; and
- The existing drainage diversion and levee is removed by others at some time in the future after the completion of the Project.

8.4 EXISTING CONDITIONS HYDROLOGIC MODEL CONFIGURATION

8.4.1 General

Figure 8.1 shows the configuration of the XP-RAFTS model of the Boomerang, Hughes and Phillips Creek catchments. The model consists of a total of 73 sub-catchments, ranging in size from 0.2 km^2 to 59.8 km^2. This includes 37 sub-catchments for Boomerang Creek, 22 sub-catchments for Hughes Creek, 3 sub-catchments for Barrett Creek and 11 sub-catchments for Phillips Creek.

The XP-RAFTS model uses a single sub-catchment approach to determine runoff hydrographs, based on the overall sub-catchment parameters (fraction impervious, slope and roughness). All sub-catchments were assigned a fraction impervious of 0%, catchment slope based on the available topographic data and a Manning's n (roughness) of 0.04. Channel routing was modelled using the Muskingum-Cunge method, based on the channel length and average channel slope for each "link" between catchment nodes.

8.4.2 Design rainfall depths, intensities and temporal patterns

Design rainfall depths and intensities for the design events were derived using intensity-frequency duration (IFD) data obtained from the Bureau of Meteorology's (BOM's) 2019 Rainfall IFD Data System.

The East Coast North temporal patterns were adopted for events up to the 1% AEP as per recommendations in Australian Rainfall and Runoff (AR&R) Data Hub (Geoscience Australia, 2019). For the 0.1% AEP event, one temporal pattern was applied to each storm duration. The 0.1% AEP temporal patterns were adopted from the Generalised Short Duration Method (GSDM) (BOM, 2003) for storm durations of 6 hours and less.

8.4.3 Design rainfall losses

The initial (IL) and continuing loss (CL) method of accounting for rainfall losses was adopted for this assessment. The recommended regional IL and CL values for the Boomerang Creek and Hughes Creek catchments from the AR&R Data Hub (Geoscience Australia, 2019), were 45 mm (prior to adjustment for preburst rainfall) and 1.9 mm/hr respectively. The IL and CL adopted for the 0.1% AEP was 0.0 mm and 1.9 mm/h respectively.

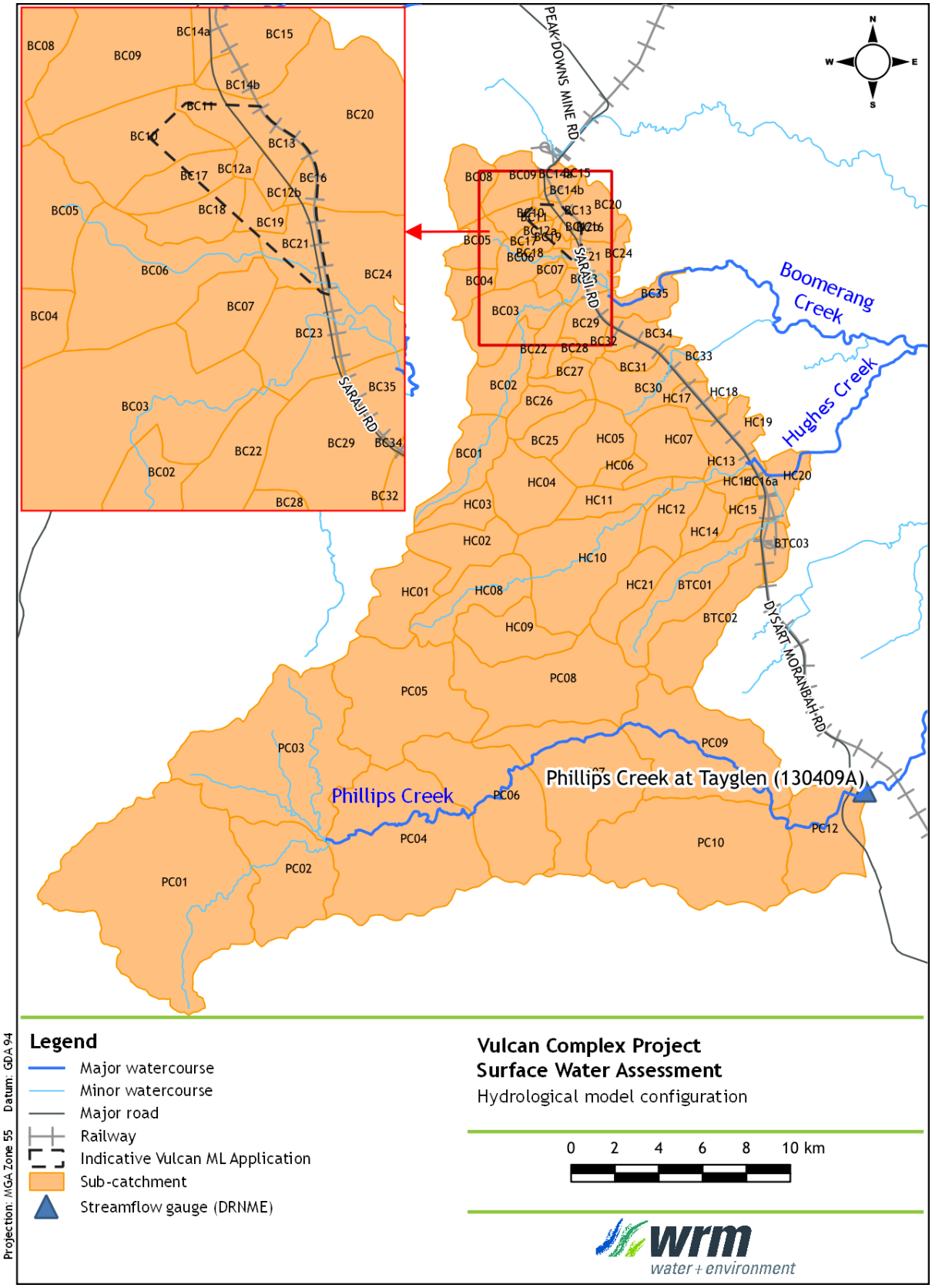


Figure 8.1 - XP-RAFTS model configuration

8.4.4 Peak flow validation

8.4.4.1 Boomerang Creek catchment

The Rational Method was used to validate the 10% and 1% AEP design flood discharges in Boomerang Creek estimated by XP-RAFTS. Table 8.1 compares the XP-RAFTS design discharge estimates for Boomerang Creek at BC11 and BC17 against the Rational Method estimates. The table shows that the design discharges derived by the XP-RAFTS model are generally within 15% of the Rational Method estimates.

Table 8.1 - Peak design discharge comparison between XP-RAFTS and Rational Method

Sub-catchment ID (see Figure 8.1)	Sub-catchment area (ha)	AEP event (%)	Design Discharge (m^3/s)		
			Rational Method	XP-RAFTS	Difference
BC11	61	10%	3.8	3.3	-0.5
		1%	6.7	7.2	0.5
BC17	107	10%	8.1	7.2	-0.9
		1%	14.0	15.5	1.5

8.4.4.2 Phillips Creek catchment

The results of the XP-RAFTS model for Phillips Creek were validated by comparing the peak design discharges from XP-RAFTS to the results of a FFA undertaken to the annual flood peak series from DNRME's Tayglen gauge (gauge no. 130409A), which operated between 1968 and 1988. The catchment to the gauge is approximately 344 km^2.

The results compared in Table 8.2 show that the XP-RAFTS 1% AEP peak discharge compares reasonably well with the FFA expected result. The 10% AEP XP-RAFTS peak discharge overestimates the FFA peak discharge, however it is within the 90th percentile confidence limits.

Table 8.2 - FFA at Tayglen gauge compared to XP-RAFTS peak discharge

Design event	XP-RAFTS design peak discharge (m^3/s)	FFA design peak discharges (m^3/s)			% Difference
		Expected result	Lower confidence limit	Upper confidence limit	
10%	490	376	227	622	23%
1%	1,109	1,083	402	2,922	2%

8.4.4.3 Summary

Overall, the XP-RAFTS hydrological model is considered satisfactorily validated and acceptable for estimating design hydrographs for input into the hydraulic model.

8.4.5 Adopted design discharges

Table 8.3 shows the adopted peak design discharges estimated by the XP-RAFTS model at key locations in the vicinity of the Project area for the 10%, 1% and 0.1% AEP design flood events. Table 8.3 also shows the critical storm durations and representative temporal patterns producing the peak discharge at each location.

Table 8.3 - Adopted design discharges, critical storm durations and temporal pattern

Key location	AEP event (%)	XP-RAFTS Ensemble mean peak discharge (m^3/s)	XP-RAFTS adopted design peak discharge (m^3/s)[1]	Critical storm duration (hours)	Temporal pattern number
Boomerang Creek at Peak Downs (BC35)	10%	236.1	236.8	6	7*
	1%	520.5	520.9	6	6
	0.1%	NA	1,037.1	3	NA
Drainage Line 2 upstream of Saraji Road (BC06)	10%	50.9	51.5	3	4*
	1%	102.4	102.8	2	8*
	0.1%	NA	233.4	2	NA
Drainage Line 3 at Saraji Road (BC23)	10%	69.4	71.0	6	7
	1%	164.7	166.8	6	2*
	0.1%	NA	323.9	3	NA
Drainage Line 4 at Saraji Road (BC29)	10%	68.5	70.2	6	4
	1%	143.1	145.2	4.5	2
	0.1%	NA	342.4	2	NA

NA – not applicable; Note that the 1 hour to 6 hour storm durations were all run in the hydraulic model for the 0.1% AEP event.

[1]Adopted design peak discharge calculated from the temporal pattern which generated a peak discharge closest to, but higher than, the ensemble mean.

*Indicates the selected temporal pattern run in the hydraulic model.

8.5 HYDRAULIC MODEL DEVELOPMENT

The two-dimensional TUFLOW hydraulic model (BMT, 2018a) was used to simulate the flow behaviour of Boomerang Creek and its tributaries in the vicinity of (and through) the proposed Project area.

TUFLOW represents hydraulic behaviour on a fixed grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow (BMT, 2018b). The model automatically calculates breakout points and flow directions within the study area. A 2 m grid cell size was adopted to obtain the best representation of flow distributions between the drainage channels, drainage diversions, hydraulic structures (e.g., culverts) and floodplains.

8.5.1 Topographic data

The TUFLOW model used topographic aerial survey data (LiDAR) supplied by Aerometrex Pty Ltd via Vitrinite. The ground surface data was obtained by LiDAR capture on 7, 8 and 27 May 2019. Aerometrex Pty Ltd quote that the LiDAR data has a vertical root mean squared error of 0.0755 m.

8.5.2 Inflow and outflow boundaries

Figure 8.2 shows the locations of the 2D inflow and outflow boundaries used in the TUFLOW model. The discharge hydrographs estimated using the XP-RAFTS runoff-routing model were adopted as inflows to the TUFLOW model.

Normal depth outflow boundaries were adopted at Peak Downs's Boomerang Creek diversion, located 3.5 km downstream of the Project area to ensure that the boundary assumptions have no material impact on peak flood levels in the study area. The adopted tailwater slope for the Boomerang Creek diversion was set at 0.0025 m/m.

8.5.3 Manning's 'n' values

The TUFLOW model uses Manning's 'n' values to represent hydraulic resistance. Manning's 'n' values were adopted based on typical published values (e.g. Chow (1959)) and consistent with Manning's 'n' value adopted in nearby flood studies. Manning's 'n' values were mapped within the study area based on aerial photography taken on 27 May 2019. The following Manning's 'n' values were adopted:

- Vegetated channels: 'n' = 0.060;
- Rocky channels: 'n' = 0.045;
- Light vegetation: 'n' = 0.050;
- Dense vegetation: 'n' = 0.080;
- Exposed soil / unsealed roads: 'n' = 0.025;
- Water bodies / dams: 'n' = 0.015;
- Sealed roads: 'n' = 0.020; and
- Buildings: 'n' = 0.300.

8.5.4 Hydraulic structures

There are 22 culvert structures modelled as 1d structures in the 2d domain. The culvert locations are shown in Figure 8.2 and include the culverts beneath Saraji Road and the Norwich Park Branch Railway.

The culvert structures within the Peak Downs and Saraji mining leases were modelled as gaps or openings to represent the culverts as information on these structures was not available for this study.

8.6 POST-CLOSURE CONDITIONS CHANGES TO THE EXISTING CONDITIONS

The Existing Conditions TUFLOW model developed for the Project was modified (for both levee scenarios) to include the proposed final landform including drainage channels and the realignment of Saraji Road. The model updates shown in Figure 8.3 include:

- The proposed drainage corridor through backfilled spoil;
- Out-of-pit spoil emplacement;
- Modified inflow boundary locations to represent Post-closure Conditions catchment areas;
- Realignment of Saraji Road; and
- Proposed Saraji Road culverts.

8.6.1 Proposed drainage corridor

The proposed drainage corridor was designed to divert runoff from Post-closure Conditions catchments around the proposed Jupiter Final Landform to the existing Drainage Line 1 rail culverts. Figure 8.4 shows a cross-section of the proposed drainage corridor approximately 500 m upstream of the existing Norwich Park Branch Railway culverts under Post-closure Conditions (see Figure 8.3 for cross-section location). Figure 8.4 and Table 8.4 show the modelled flood levels and velocities within the proposed drainage corridor.

The preliminary sizing of the proposed drainage corridor was 40 m wide with 17% batter slopes that grade up to existing ground levels. The results show that the drainage corridor has sufficient capacity under both levee scenarios to convey flood events up to the 0.1% AEP. Refinements to the design will be required to incorporate a meandering low flow channel within the drainage corridor and will be undertaken prior to undertaking detail design. Also, careful consideration of scour protection will be required at the upstream and downstream ends of the drainage corridor as well as at tributary inflow locations.

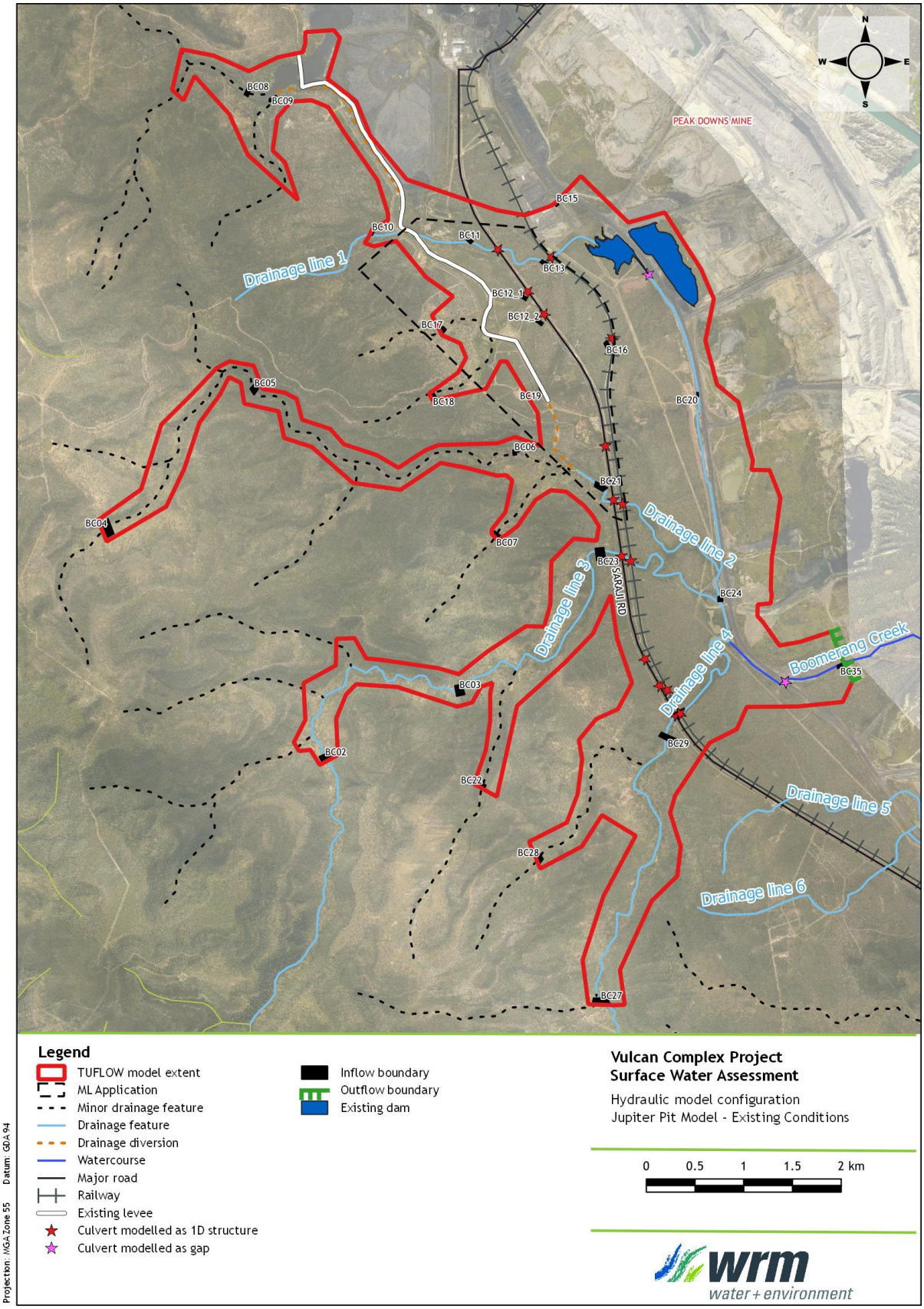


Figure 8.2 – Jupiter Pit Existing Conditions hydraulic model configuration

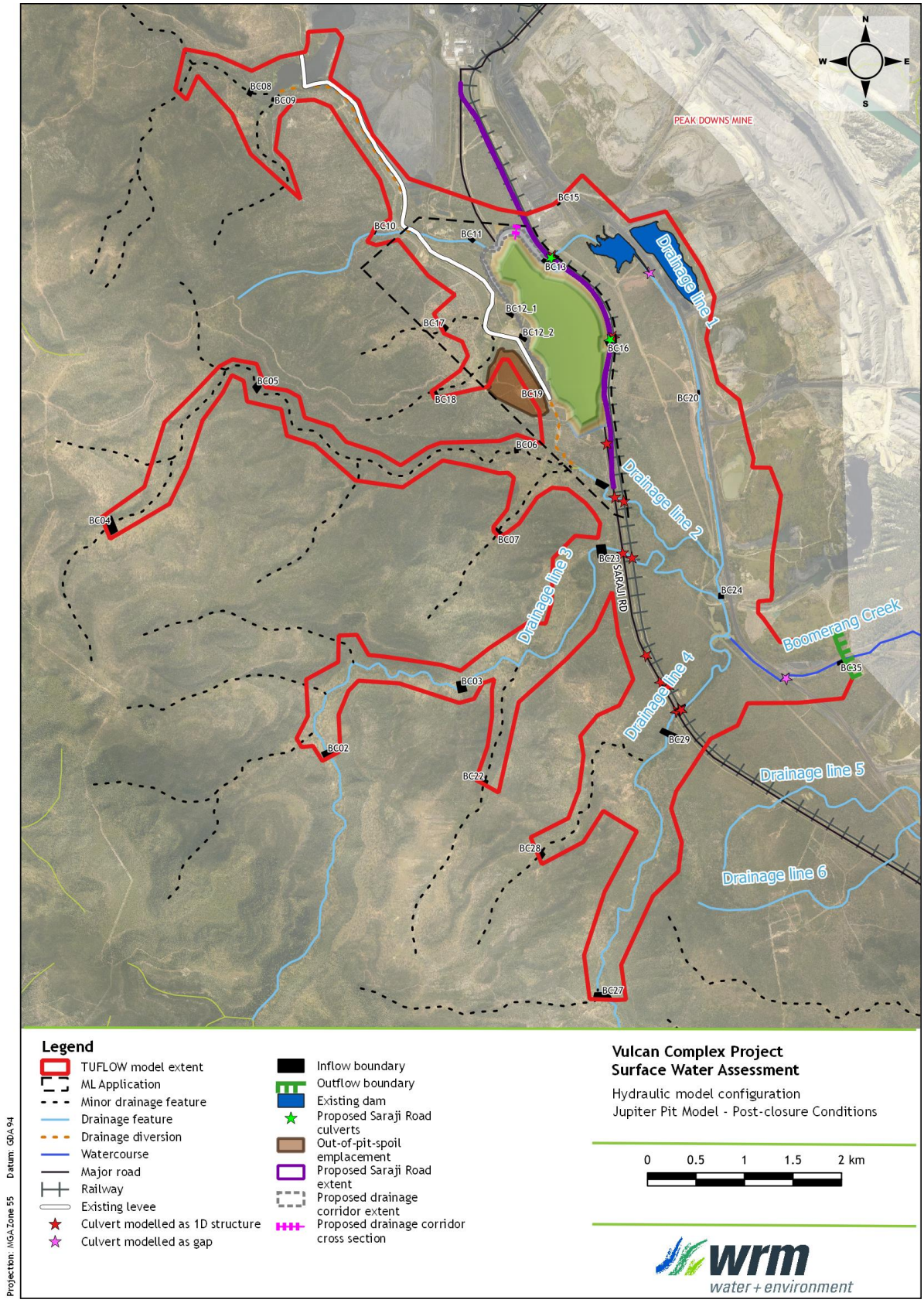


Figure 8.3 - Jupiter Pit Final Landform (Post-closure Conditions) hydraulic model configuration

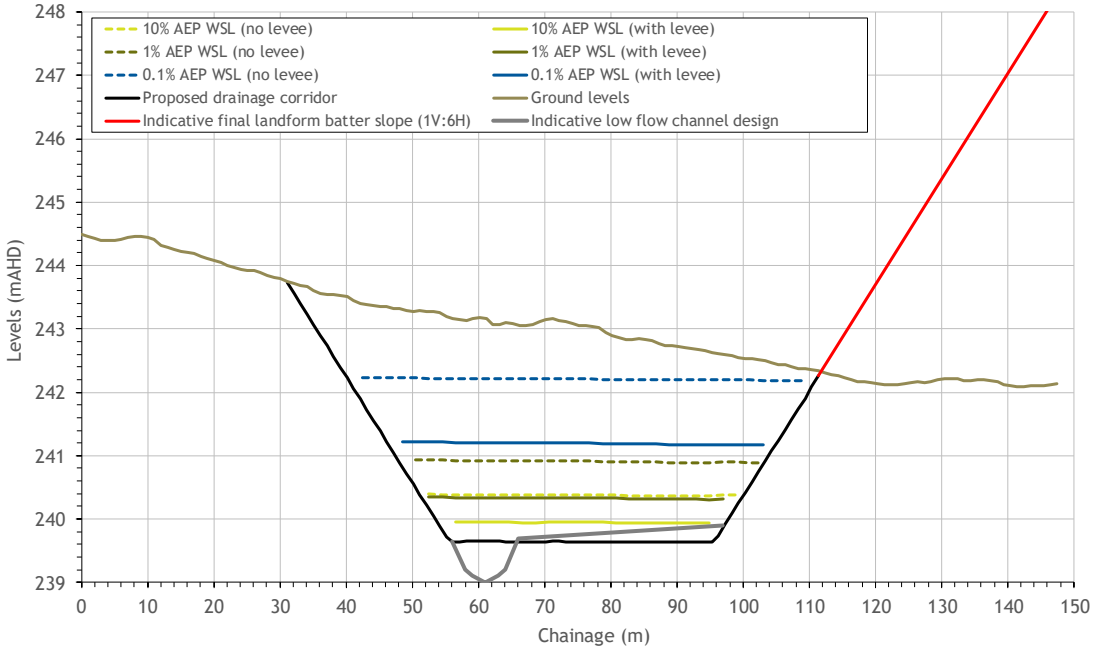


Figure 8.4 - Conceptual cross section of the proposed drainage corridor and the 10%, 1% and 0.1% AEP event water surface elevations for both levee scenarios

Table 8.4 - Indicative drainage corridor depths and velocities during Post-closure Conditions

AEP event (%)	Scenario 1 (with levee)		Scenario 2 (no levee)	
	Depth (m)	Velocity (m/s)	Depth (m)	Velocity (m/s)
10%	0.3	0.7	0.75	1.2
1%	0.7	1.1	1.3	1.6
0.1%	1.6	1.7	2.6	1.9

8.6.2 Proposed Saraji Road culverts

The proposed Saraji Road culverts were sized based on the existing Saraji Road culverts to replicate the flow conveyance at the realigned road design. The culverts included in the Post-closure TUFLOW model were ten (10) 2.1 m high by 2.1 m wide reinforced concrete box culverts (RCBC) along Drainage Line 1 and three (3) 0.9 m diameter reinforced concrete pipes (RCP) were duplicated along the proposed Saraji Road upstream of the railway culverts approximately 1 km south east of Drainage Line 1.

The culvert size requirements will be confirmed as part of the Saraji Road design.

8.6.3 Proposed flood protection levee

Table 8.5 shows the preliminary 0.1% AEP event flood levels during Post-closure Conditions along the western side of the proposed pit flood protection levee (see Figure 8.5). Table 8.5 also provides the existing ground levels along the proposed flood protection levee alignment. The proposed flood protection levee will be required during operations to protect the mining pit from ingress of clean water. The 0.1% AEP flood levels shown in Table 8.5 are based on the two Post-closure Conditions levee scenarios (with and without the existing drainage diversion and levee). Figure 8.5 shows the reported chainage along the proposed flood protection levee.

It is recommended that Scenario 1 (with levee) peak 0.1% AEP peak flood levels are adopted for the basis of the flood levee requirements during operations and the freeboard for determining the required levee crest level is the maximum of:

- 0.3 m above the Scenario 1 (with levee) flood level ; and
- 0.1 m above the Scenario 2 (no levee) flood level.

During post-closure conditions, Scenario 2 (no levee) should be considered for determining suitable lining and erosion protection works along the toe of the final landform.

The results show that the proposed flood protection levee will be between 0.3 m high and 3.9 m (at chainage 800 m). The average height is 1.7 m.

The proposed flood protection levee configuration is preliminary only. The final horizontal and vertical alignment will be confirmed in conjunction with the proposed drainage requirements and potential existing drainage diversion failure assessments during the design phase.

Table 8.5 – 0.1% AEP flood levels adjacent to the proposed flood protection levee required for operations

Chainage (m)	Ground level (mAHD)	0.1% AEP flood level (mAHD)		Required minimum levee crest level (m AHD)
		Scenario 1 (with levee)	Scenario 2 (no levee)	
0	252.5	-	-	252.5
100	250.5	250.6	-	250.9
200	248.6	249.4	-	249.7
300	249.2	249.4	247.7	249.7
400	248.3	248.6	247.7	248.9
500	246.2	247.3	247.7	247.8
600	245.1	247.3	247.7	247.8
700	245.3	247.3	247.7	247.8
800	243.9	247.3	247.7	247.8
900	245.0	247.3	247.7	247.8
1000	245.5	247.3	247.7	247.8
1100	247.0	247.3	247.7	247.8
1125	247.8	-	-	247.8

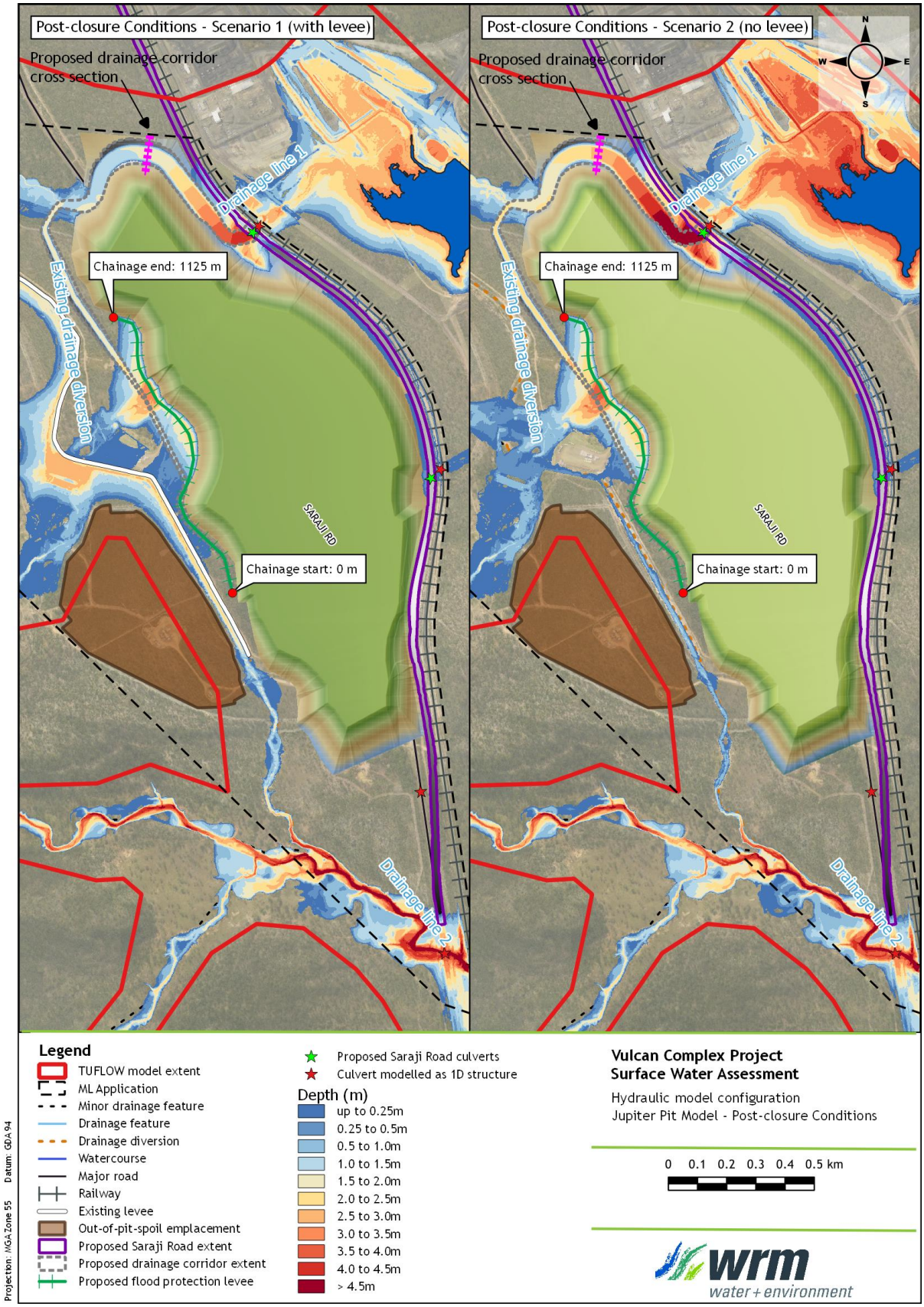


Figure 8.5 - Proposed flood protection levee alignment

8.7 EXISTING CONDITIONS DESIGN FLOOD LEVELS AND EXTENTS

8.7.1 Existing Conditions modelling results

The TUFLOW model was used to determine the Existing Conditions 10%, 1% and 0.1% AEP design flood levels, depth, extents and velocities in the vicinity of the Project for the two levee scenarios. Figure A.1 to Figure A.6 in Appendix A show the predicted flood depth and flood velocity profiles under Existing Conditions (with levee) for the 10%, 1% and 0.1% AEP events. Figure A.7 to Figure A.12 show the predicted flood depth and flood velocity profiles under Existing Conditions (no levee) for the 10%, 1% and 0.1% AEP events.

8.7.2 Scenario 1 – Existing Conditions (with levee)

Key findings on flooding within the Boomerang Creek catchment and its tributaries are summarised below:

- For the 10% AEP event (see Figure A.1 and Figure A.4):
    - floodwaters through the Project area are generally conveyed within the channel banks of natural drainage lines. Saraji Road is overtopped at some crossing locations. The Norwich Park Branch Railway culverts have sufficient flow capacity to convey the 10% AEP event;
    - peak flood velocities along natural drainage channels are typically elevated in the vicinity of the Project area (greater than 2.0 m/s in localised areas);
    - overbank flood depths adjacent to natural drainage lines are generally shallow (less than 0.5 m); and
    - the existing drainage diversion and levee to the west of the Jupiter Pit diverts all upstream flows to Drainage Line 2. Flood depths within the existing drainage diversion are up to 2.2 m.
- For the 1% AEP event (see Figure A.2 and Figure A.5):
    - floodwaters through the Project area are generally conveyed within the channel banks of natural drainage lines with limited overbank flooding. Saraji Road is overtopped at most crossing locations. The Norwich Park Branch Railway culverts have sufficient flow capacity to convey the 1% AEP event;
    - peak flood velocities in natural drainage channels are typically elevated (greater than 2.0 m/s in localised areas). Overbank velocities are generally up to 1 m/s;
    - flood widths and depths adjacent to natural drainage lines are greatest upstream of Saraji Road and Norwich Park Branch Railway where floodwaters are impounded behind the constructed embankments; and
    - floodwaters overtop the existing drainage diversion and levee to the west of the Jupiter Pit at several locations and drain east across the proposed Jupiter Pit footprint before flowing towards the rail culverts. Flood depths within the existing drainage diversion are up to 2.7 m.
- For the 0.1% AEP event (see Figure A.3 and Figure A.6):
    - floodwaters through the Project area are generally conveyed within the channel banks of natural drainage lines with confined overbank flooding;
    - flood velocities along natural drainage channels are typically elevated (greater than 2.5 m/s in localised areas). Overbank velocities are generally up to 1 m/s;
    - peak flood widths and depths along the eastern side of the Project area increase as natural drainage lines drain towards Saraji Road and Norwich Park Branch Railway where floodwaters are impounded behind the constructed embankments. Overbank flood depths range from about 2 m at the western boundary of the Project area to greater than 4 m at the eastern boundary; and

- floodwaters overtop the existing drainage diversion at a number of locations.

8.7.3 Scenario 2 – Existing Conditions (no levee)

- For the 10% AEP event (see Figure A.7 and Figure A.10):
  - floodwaters previously diverted by the existing drainage diversion and levee drain east to the existing Saraji Road crossings. Floodplain depths are generally less than 1 m upstream of Saraji Road. The existing crossings at Saraji Road and the Norwich Park Branch Railway culverts have sufficient flow capacity to convey the 10% AEP event; and
  - floodwaters draining east towards Saraji Road have peak flood velocities which are typically less than 1.5 m/s.
- For the 1% AEP event (see Figure A.8 and Figure A.11):
  - floodwaters previously diverted by the existing drainage diversion and levee drain to the existing Saraji Road crossings. The northernmost Saraji Road crossing is overtopped by 0.1 m during the 1% AEP event, however, all other existing crossings at Saraji Road and the Norwich Park Branch Railway culverts have sufficient flow capacity to convey the 1% AEP event; and
  - floodwaters draining east towards Saraji Road have peak flood velocities which are typically less than 2 m/s upstream of Saraji Road.
- For the 0.1% AEP event (see Figure A.9 and Figure A.12):
  - floodwaters previously diverted by the existing drainage diversion and levee drain to the existing Saraji Road crossings, where the existing road is overtopped by up to 0.25 m. Floodwaters are impounded behind the constructed Norwich Park Branch Railway embankment, with flood extents up to 500 m; and
  - floodwaters draining east have peak flood velocities which reach up to 2.5 m/s upstream of Saraji Road within the Project area.

8.8 POST-CLOSURE CONDITIONS POTENTIAL FLOOD IMPACTS

8.8.1 General

Figure 8.3 shows the proposed Post-closure Conditions configuration used in the TUFLOW model. The TUFLOW model results show that the proposed Post-closure Conditions configuration may cause potential flow constraints and flood impacts within the Project area. These include:

- Changed flow conditions between the Norwich Park Branch Railway and the realigned Saraji Road realignment;
- Changed catchment areas due to the final landform configuration; and
- Diversion of Drainage Line 1 around the proposed pit.

Figure B.1 to Figure B.6 show the change in peak water levels and the change in peak velocities for the 10%, 1% and 0.1% AEP events for Post-closure Conditions compared to Existing Conditions (with levee) across the Project.

Figure B.7 to Figure B.12 show the change in peak water levels and the change in peak velocities for the 10%, 1% and 0.1% AEP events for Post-closure Conditions compared to Existing Conditions (no levee) across the Project.

Table 8.6 and Table 8.7 summarise the changes in peak water levels and peak velocities respectively for the 10%, 1% and 0.1% AEP events at the reporting location points shown in Figure B.1 to Figure B.12.

In general, the results show that there are negligible impacts along Drainage Line 1 with the levee for the 10% and 1% AEP events and small impacts for the 0.1% AEP event.

Drainage Line 1 impacts without the levee are greater and may require additional erosion protection to cater for the increase flooding potential. The Post-closure Conditions configuration will not impact on peak water levels or velocities along Drainage Line 2, Drainage Line 3, Drainage Line 4 or Boomerang Creek under both levee scenarios for the 10% to 0.1% AEP events.

There will be some minor areas that will require erosion control measures such as where existing natural drainage paths enter constructed drains and at the upstream and downstream ends of constructed drains.

Hence, the proposed surface water drainage infrastructure for the Project will result in a very low risk of changes to the existing erosion and sedimentation process in the receiving environment.

8.8.2 Scenario 1 – Post-closure Conditions impacts (with levee)

Key findings on potential Post-closure Conditions (with levee) flooding impacts in the vicinity of the project include:

- For the 10% AEP event (see Figure B.1 and Figure B.4):
    - there are no increases in peak water levels and peak velocities within the Norwich Park Branch Railway corridor;
    - downstream of the railway corridor, there are no modelled increases in peak water levels and peak velocities; and
    - within the Project MLA area, peak water levels and peak velocities generally do not change significantly.
- For the 1% AEP event (see Figure B.2 and Figure B.5):
    - there are negligible increases in peak water levels and peak velocities within the Norwich Park Branch Railway corridor;
    - downstream of the railway corridor, there are no increases in peak water levels;
    - within the Project area, peak water levels generally do not increase. Peak velocities at the upstream end of the proposed drainage corridor are up to 1.4 m/s. This highlights the need to construct and revegetate the drainage corridor prior to removing DD1 and allowing upstream inflows into the drainage corridor. If vegetation is not allowed to establish, additional erosion protection may be required to limit scour and erosion within the drainage corridor.
- For the 0.1% AEP event (see Figure B.3 and Figure B.6):
    - similar to the existing Saraji Road, the realigned Saraji Road is inundated as the culverts have insufficient capacity to convey the 0.1% AEP event flows and floodwaters are impounded behind the constructed Norwich Park Branch Railway embankment;
    - there are increases in peak water levels and peak velocities within the Norwich Park Branch Railway corridor of up to 0.25 m and 0.4 m/s;
    - downstream of the Norwich Park Branch Railway there are minor increases in peak water levels of 0.08 m; and
    - within the Project MLA area, there are generally no increases in peak water levels and peak velocities along Drainage Line 1, except where it connects with the proposed drainage corridor, where maximum velocities are up to 1.9 m/s.

8.8.3 Scenario 2 – Post-closure Conditions impacts (no levee)

Key findings on potential Post-closure Conditions (no levee) flooding impacts in the vicinity of the project include:

- For the 10% AEP event (see Figure B.7 and Figure B.10):

- within the Norwich Park Branch Railway corridor, there are minor increases in peak water levels of 0.08 m and increases in peak velocities of up to 0.3 m/s;
- downstream of the railway corridor, there are localised increases in peak water levels and peak velocities of 0.2 m and 0.5 m/s, respectively;
- within the Project area, there are generally no increases in peak water levels and peak velocities. Typical peak velocities along the proposed drainage corridor are 1.2 m/s. Maximum velocities of up to 1.8 m/s occur at the inlet to the drainage corridor.

- For the 1% AEP event (see Figure B.8 and Figure B.11):
  - the proposed Saraji Road is overtopped during the 1% AEP event under the no levee scenario;
  - within the Norwich Park Branch Railway corridor, there are minor increases in peak water levels of up to 0.09 m and there are increases in peak velocities of up to 0.45 m/s;
  - downstream of the railway corridor, there are negligible increases in peak water levels and increases in peak velocities are 0.3 m/s along the existing dirt road downstream of the railway culverts; and
  - Typical peak velocities along the proposed drainage corridor are 1.6 m/s. Maximum velocities of up to 2.6 m/s occur at the inlet to the drainage corridor.
- For the 0.1% AEP event (see Figure B.9 and Figure B.12):
  - floodwaters are impounded behind the constructed embankment of the Norwich Park Branch Railway with extents spanning 600 m upstream of the railway;
  - within the Norwich Park Branch Railway corridor, there are increases in peak water levels and peak velocities of 0.35 m and 0.35 m/s, respectively;
  - downstream of the railway corridor, there are increases in peak water levels of 0.15 m and increases in peak velocities of 0.75 m/s; and
  - Typical peak velocities along the proposed drainage corridor are 1.9 m/s. Maximum velocities of up to 2.8 m/s occur at the inlet to the drainage corridor.

Table 8.6 – Changes in peak water levels under Post-closure Conditions

Location ID	Modelled change in peak water level (m)					
	Scenario 1 (with levee)			Scenario 2 (no levee)		
	10%	1%	0.1%	10%	1%	0.1%
1	NA	0.06	0.24	0.10	0.11	0.34
2	-0.22	0.01	0.20	0.04	0.02	0.32
3	-0.22	0.03	0.03	0.04	0.01	0.01
4	-0.50	-0.39	-0.11	0.42	-0.23	-0.04
5	NA	-0.26	0.22	NA	-0.10	0.64
6	-0.02	-0.02	-0.034	0.02	-0.02	-0.04
7	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	-0.00	0.00

Table 8.7 – Changes in peak velocities under Post-closure Conditions

Location ID	Modelled change in peak velocity (m/s)					
	Scenario 1 (with levee)			Scenario 2 (no levee)		
	10%	1%	0.1%	10%	1%	0.1%
1	NA	0.18	0.14	0.20	0.17	0.23
2	-0.01	0.06	0.07	0.08	0.08	0.08
3	-0.18	-0.15	0.16	0.07	0.02	0.32
4	-0.09	0.08	0.16	0.04	0.14	0.06
5	NA	0.63	0.59	NA	0.83	0.72
6	-0.09	-0.09	-0.16	-0.09	-0.09	-0.16
7	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00
9	0.000	0.000	0.000	-0.006	0.001	0.000

9 Surface water monitoring

9.1 OVERVIEW

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

The surface water monitoring protocols will:

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

Details of the receiving water quality monitoring, mine affected water quality monitoring and sediment dam water monitoring program are outlined in Sections 0, 0 and 0 respectively. Locations of the proposed surface water monitoring locations and mine affected dam monitoring locations are shown in Figure 9.1 and summarised in Table 9.1. Note that the mine water release points are the same as the mine water monitoring locations (i.e. at the spillway).

Table 9.1 – Proposed surface water and mine water dam quality monitoring locations

Station ID	Catchment Area	Easting*	Northing*	Description
Receiving water monitoring sites				
Upstream sites				
VSW1	Boomerang Ck	621,003	7,536,086	Diversion bund approximately 3.1 km upstream of Drainage Line 2. Used as an upstream monitoring site for all site dams.
Downstream sites				
VSW2[1]	Boomerang Ck	623,117	7,533,362	Drainage Line 2 upstream of the railway. Used as a downstream monitoring site for MWD1 and SD6.
VSW8	Boomerang Ck	622,370	7,535,855	Drainage Line 1 upstream of the railway. Used as a downstream site for MWD2, MWD3, MWD4 and MWD5, as well as SD1, SD2 and SD5
Mine water dam monitoring locations/release points				
MWD1	-	621,839	7,535,246	MWD1 spillway
MWD2	-	622,016	7,534,275	MWD2 spillway
MWD3	-	621,715	7,534,539	MWD3 spillway
MWD4	-	622,703	7,533,983	MWD4 spillway
MWD5	-	622,471	7,533,952	MWD5 spillway

* Projection – MGA94 (Zone 55)
[1] Remote logger location

9.2 RECEIVING WATER QUALITY MONITORING

The proponent has undertaken a round of baseline monitoring at a number of surface water locations in the Project vicinity (as detailed in Section 4.5.2). The Surface Water Monitoring Program will include the continued monitoring of a number of these sites to monitor surface water flows and quality upstream and downstream of the Project. Locations of the proposed receiving water monitoring locations are shown in Figure 9.1 and summarised in Table 9.1.

Sampling for the receiving water monitoring locations will be undertaken monthly and following any rainfall event greater than 50 mm in a 24-hour period. Monitoring will be also be undertaken downstream of any spill following a release event. Field and laboratory sampling will be undertaken. Note that sampling may only be possible during brief periods of runoff immediately following rainfall due to the ephemeral nature of the natural surface water system.

The receiving water quality monitoring points have been designated as upstream and downstream monitoring points in Table 9.1. Upstream monitoring points, which are not influenced by releases from the Project, will be used to analyse the background surface water quality in the vicinity of the Project. This information can be used to develop site specific trigger levels for contaminant releases when sufficient data is available.

Downstream monitoring points will be used to assess the water quality of the receiving waters in the context of the Project. In addition to routine monitoring, these sites will be monitored directly after release events to assess the effect of Project releases.

Electrical Conductivity and pH can vary between the time of sampling and analysis in the laboratory. Therefore, field testing of samples will be undertaken for the following parameters:

- Electrical Conductivity;
- pH;
- Dissolved Oxygen; and
- Temperature.

In lieu of field testing of turbidity, the laboratory result for total suspended sediment should be used to inform on turbidity. In addition, the suite of laboratory analyses shown in Table 9.2 will be collected for the receiving water monitoring locations.

The receiving water locations will be monitored against the WQOs for the Project (outlined in Table 3.1). In addition, preliminary release contaminant trigger investigation levels have been proposed for downstream monitoring sites.

9.2.1 Release contaminant trigger investigation levels

A set of initial proposed receiving water contaminant triggers levels have been developed, based on conditions at nearby operating coal mines, preliminary baseline results and the WQOs for the Project vicinity. These trigger levels are presented in Table 9.3 and are proposed to be measured against at the downstream water monitoring locations (i.e. VSW2 and VSW8). Monitoring at these locations will allow for an accurate evaluation of the impact of any releases from the Project.

It is noted that only limited baseline water monitoring has been undertaken and therefore the receiving water contamination water levels may need to be refined following further monitoring. Total suspended solids (TSS) levels will be updated once sufficient baseline monitoring has been collected. These levels will be updated progressively as part of the Water Management Plan for the Project.

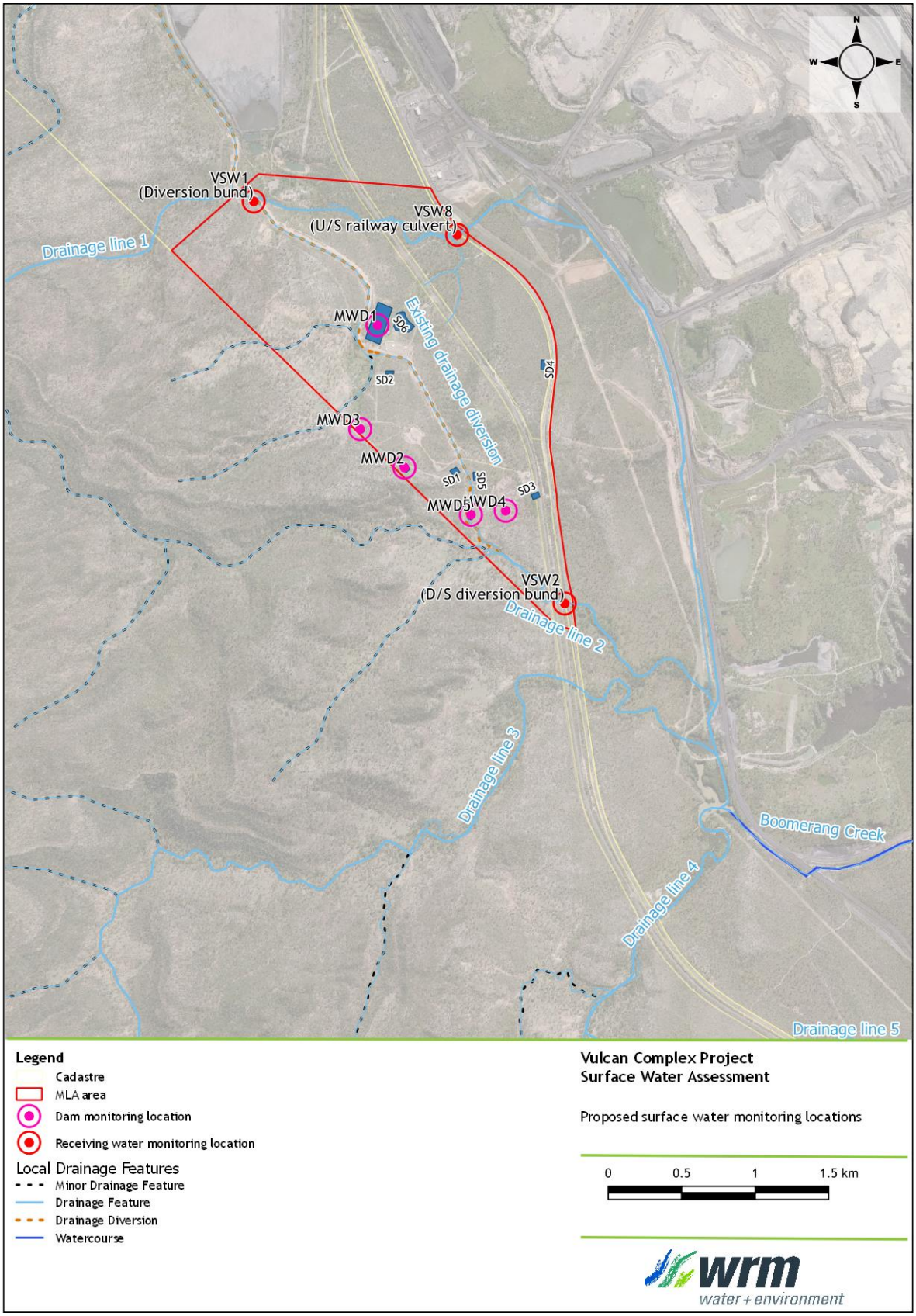


Figure 9.1 – Proposed surface water monitoring locations

Table 9.2 – Receiving waters water quality laboratory analysis parameters

Analyte		Analyte	
Physico-chemical		*Metals and metalloids (total and filtered)*	
1	Electrical conductivity	17	Aluminium
2	pH	18	Arsenic
3	Turbidity	19	Cadmium
4	Total Suspended Solids	20	Chromium
5	Dissolved Oxygen	21	Copper
Major cations and anions		22	Iron
6	Sulfate	23	Lead
7	Calcium	24	Mercury
8	Fluoride	25	Nickel
9	Chloride	26	Zinc
10	Sodium	27	Boron
Nutrients		28	Cobalt
11	Total Phosphorus	29	Manganese
12	Filterable Reactive Phosphorus	30	Molybdenum
13	Total Nitrogen	31	Selenium
14	Oxidised Nitrogen	32	Silver
15	Total Kjeldahl Nitrogen	33	Uranium
16	Ammonium	34	Vanadium
		Hydrocarbons	
		35	Total Petroleum Hydrocarbon (C6-C36)
		Biological	
		36	Chlorophyll-a

Table 9.3 – Receiving water contaminant trigger levels

Quality characteristic	Units	Trigger level	Monitoring locations	Monitoring frequency
pH	-	6.5 – 8.0	VSW2 & VSW8	Monthly, following any rainfall event greater than 50 mm in a 24-hour period and following a release event
Electrical conductivity	(µS/cm)	1,500		
TSS or TDS	(mg/L)	*TBC*		
Sulfate (SO_4^{2-})	(mg/L)	1,000		

9.3 MINE AFFECTED WATER QUALITY MONITORING

The water quality monitoring program will also include monitoring at all dams which contain mine affected water with the potential to discharge to the receiving waters. This includes the following dams:

- MWD1;
- MWD2;
- MWD3;
- MWD4; and
- MWD5.

Locations of the proposed mine water monitoring locations are shown in Figure 9.1 and summarised in Table 9.1.

Sampling for the mine water dam monitoring locations will be undertaken quarterly, as well as daily during a release event.

Water quality parameters which will be collected for the mine water dams are outlined in . Note that the metals listed in will be analysed for both total and dissolved concentrations.

Table 9.4 – Dam laboratory analysis parameters

Location	Parameter	Monitoring frequency
MWD1, MWD2, MWD3, MWD4 & MWD5	pH, EC, sulfate, fluoride, aluminium, arsenic, cadmium, cobalt, copper, lead, nickel and zinc	Quarterly and daily during a release event

Preliminary mine affected water release limits have been proposed based upon similar surrounding mines for the mine affected water releases, as outlined in Table 9.5. Note that maximum EC, TSS and Sulphate water release limits will be outlined once sufficient baseline monitoring data has been collected. These release limits will be generated progressively as part of the Water Management Plan for the Project. Mine affected water releases would occur only during times of sufficient natural flow in the receiving waters to provide adequate dilution so that the receiving waters triggers given in are not exceeded.

Table 9.5 – Mine affected water release limits

Quality Characteristic	Units	Minimum	Maximum
Electrical Conductivity (EC)	µs/cm	n/a	TBC
pH	pH units	6.5	9.0
Total Suspended Solids (TSS)	mg/L	n/a	TBC
Sulphate (SO_4^{2-})	mg/L	n/a	TBC

9.4 SEDIMENT DAM MONITORING

Surface runoff and seepage from spoil piles, including any rehabilitated areas, would be monitored for 'standard' water quality parameters including, but not limited to pH, EC, major anions (sulfate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), TDS and a broad suite of soluble metals/metalloids. This monitoring would be undertaken at all Project sediment dams (as listed in Table 5.2 and shown in Figure 1.2, Figure 1.3 and Figure 1.4).

The sediment dam monitoring would be used to validate the anticipated quality of water runoff reporting to sediment dams and haul road runoff dams. Initially, the sediment dam monitoring would occur on a regular (e.g. monthly) basis to demonstrate the water quality of stored waters is consistent with the relevant operating parameters to allow releases from sediment dams to occur when required. Subject to demonstrating the water quality objectives can be met, the frequency of monitoring and suite of parameters for the sediment dam monitoring would be reviewed and updated accordingly (e.g. to occur only when releases occur).

9.5 RECEIVING ENVIRONMENT MONITORING PROGRAM (REMP)

A REMP document will be developed which describes in detail the proposed monitoring program for the local receiving waters. The REMP will incorporate the historical and proposed monitoring as described in Section 4.5.2 and in the sections above.

The main objective of the REMP will be to report against WQOs for local waterways potentially affected by discharge from the Project and will assist in assessing general aquatic ecosystem health.

10 Cumulative impacts

10.1 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 two levels at which cumulative impacts have been assessed:

- 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 Isaac River catchment have been included; and
- 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.

10.2 EXISTING PROJECTS

Projects which are currently operating within the Isaac River catchment upstream of the Deverill gauging station and have been included in the cumulative impacts assessment for the project are listed in Table 10.1.

10.3 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, Manufacturing, Infrastructure and Planning (DSDMIP) website that are undergoing assessment under the State Development and Public Works Organisation Act 1971 (SDPWO Act) for which an Initial Advice Statement (IAS) or an EIS are available;
- Projects within the predicted sphere of influence of the Project, which are listed on the website of the Department of Environment and Science (DES) that are undergoing assessment under the Environmental Protection Act 1994 (EP Act) for which an IAS or an EIS are available; and
- Projects within the predicted sphere of influence of the Project, which are listed on the website of the Department of Infrastructure, Local Government and Planning (DILGP) that are undergoing assessment under the Regional Planning Interests Act 2014 (RPI Act) for which an Assessment Application is available.

Projects currently undergoing assessment or having recently completed assessment under these processes and included in the cumulative impact assessment for the Project are listed in Table 10.2.

10.4 CUMULATIVE IMPACTS – SURFACE WATER RESOURCES

10.4.1 Water quality

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

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

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

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

- Water quality objectives were developed for the Fitzroy Basin and added to Schedule 1 of the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (WWB)) in October 2011;
- Model water conditions were developed for coal mines in the Fitzroy basin (DERM February 2012). These model water conditions are designed to manage water discharges to meet the water quality objectives set out in the EPP (WWB) and to provide consistency between mining operations in the Fitzroy basin;
- Environmental authorities for a number of mining operations were amended to introduce conditions consistent with the model water conditions; and
- A number of mining operations entered into Transitional Environmental Programs (TEP) under the EP Act. These TEPs were focussed on actions that would allow mines to achieve compliance with new environmental authority conditions and upgrade operating conditions.

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

Mine affected water from the proposed Project will be managed through a mine water management system which is designed to operate in accordance with proposed EA conditions that are based on Model Mining Conditions, and incorporated into the release criteria used in modelling the mine water management system in this report.

It is noted that the Project is located within the Boomerang Creek catchment, which has already been significantly disturbed by existing mining operations in the Project vicinity.

In addition, given that the Project water releases will be managed within an existing overarching strategic framework for management of cumulative impacts of mining activities, the proposed management approach for mine water from the project is expected to have negligible cumulative impact on surface water quality and associated environmental values.

Table 10.1 – Existing projects considered in the cumulative impact assessment

Project - Proponent	Description	Operational status	Relationship to the Project Mining Lease	
			Timing	Location
Burton Mine – Peabody Energy Australia	Open cut coal mine	Ceased production indefinitely	May have overlapping operational phases with the construction and operations of the project, although unlikely given the current operational status.	Located 75 km to the north of the Project area. Located within the Isaac River catchment (upstream).
North Goonyella Mine - Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 75 km to the northwest of the Project area. Located within the Isaac River catchment (upstream).
Goonyella Riverside Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 60 km to the northwest of the Project area. Located within the Isaac River catchment (upstream).
Moranbah North Mine – Anglo American	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 50 km to the northwest of the Project area. Located within the Isaac River catchment (upstream).
Grosvenor Mine – Anglo American	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 40 km to the north of the Project area. Located within the Isaac River catchment (upstream).
Broadlea Mine – Fitzroy Australia Resources	Open cut coal mine	Care and maintenance	May have overlapping operational phases with the construction and operations of the project.	Located 40 km to the north of the Project area. Located within the headwaters of Smoky Creek, within the Isaac River catchment.
Carborough Downs Mine – Fitzroy Australia Resources	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 35 km to the northeast of the Project area. Located within the headwaters of Billy's Gully, within the Isaac River catchment.
Isaac Plains Mine - Stanmore Coal	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 35 km to the north of the Project area. Located within the headwaters of Billy's Gully, within the Isaac River catchment.
Millennium Mine – Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 30 km to the northeast of the Project area. Located within the headwaters of Southern Gully, within the Isaac River catchment.

Daunia Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 25 km to the northeast of the Project area. Located within the Isaac River catchment (upstream).
Poitrel Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 20 km to the northeast of the Project area. Located within the Isaac River catchment (upstream).
Caval Ridge Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 10 km to the north of the Project area. Located within the Isaac River catchment (upstream).
Peak Downs Mine - BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located directly adjacent (i.e. less than 1 km to the north and east of the Project area. Located within the Isaac River catchment.
Moorvale Mine – Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 35 km to the northeast of the Project area. Located within the headwaters of North Creek, within the Isaac River catchment.
Saraji Mine – BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 10 km to the southeast of the Project area. Located within the Isaac River catchment.
Norwich Park Mine – BMA	Open cut coal mine	Ceased production indefinitely	May have overlapping operational phases with the construction and operations of the project, although unlikely given the current operational status.	Located 45 km to the southeast of the Project area. Located within the Isaac River catchment (downstream).
Lake Vermont Mine – Jellinbah Group	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	Located 30 km to the southeast of the Project area. Located within the Isaac River catchment (downstream).

Table 10.2 – Proposed projects considered in the cumulative impact assessment

Project - Proponent	Description	Project status	Relationship to the Project Mining Lease	
			Timing	Location
Moranbah South Project – Anglo American	Underground coal mine	Approved project	May have overlapping operational phases with the construction and operations of the project.	Located 30 km to the northwest of the Project area. Located within the Isaac River catchment (upstream).
Moorvale South Project – Peabody Energy Australia	Open cut coal mine	Approved project	May have overlapping operational phases with the construction and operations of the project.	Located 25 km to the northeast of the Project area. Located within the Isaac River catchment (upstream).
Eagle Downs Mine – Bowen Central Coal Joint Venture	Underground coal mine	Construction on hold – site on care and maintenance	May have overlapping operational phases with the construction and operations of the project.	Located 10 km to the north of the Project area. Located within the Isaac River catchment upstream).
Winchester South Project – Whitehaven Coal	Open cut coal mine	EIS active	May have overlapping operational phases with the construction and operations of the project.	Located 15 km to the northwest of the Project area. Located within the Isaac River catchment (upstream).
Olive Downs Coking Coal Project – Pembroke Olive Downs Pty Ltd	Open cut coal mine	Approved with conditions	May have overlapping operational phases with the construction and operations of the project.	Located 10 km to the west of the Project area. Located within the Isaac River catchment (downstream).
Saraji East Mine - BMA	Open cut coal mine	EIS active	May have overlapping operational phases with the construction and operations of the project.	Located 15 km to the southwest of the Project area. Located within the Isaac River catchment (downstream).
Dysart East Coal Mine – Bengal Coal	Underground coal mine	ML granted	May have overlapping operational phases with the construction and operations of the project.	Located 35 km to the southwest of the Project area. Located within the Isaac River catchment (downstream).
Red Hill - BMA	Underground coal mine	Approved with conditions	May have overlapping operational phases with the construction and operations of the project.	Located 60 km to the northeast of the Project area. Located within the Isaac River catchment (upstream).
Isaac Downs Project	Open cut coal mine	EIS active	May have overlapping operational phases with the construction and operations of the project.	Located 30 km to the north of the Project area. Located within the Isaac River catchment (upstream).

10.4.2 Loss of catchment and stream flows in the Isaac River

The Project will result in a loss of catchment to the Isaac River during operations, which will be reinstated after closure. The surface runoff volume lost from the catchment will generally be in proportion to the loss of catchment area. The Project area is less than 0.03% of the catchment area of the Isaac River to the confluence of Phillips Creek. Of this, around 60% of this area is managed through the ESCP and then released to the downstream environment.

There are approximately 18 existing coal mines in the vicinity of the Project that also capture runoff from the Isaac River catchment, as shown in Figure 10.1. The total estimated captured area of all these projects (including the Project) combined represents around 7.1% of the Isaac River catchment to the Phillips Creek confluence.

A comparison of the captured catchment areas of the existing mining projects considered in the cumulative impact assessment with the Isaac River catchment to the Phillips Creek confluence is provided in Table 10.3, which indicates the following:

- The combined total catchment area of the existing mines (including the Project) represents around 7.1% of the total catchment area of the Isaac River to the Phillips Creek confluence; and
- The combined mine affected catchment area (estimated) represents less than 2.4% of the total Isaac River catchment area to the Philips Creek confluence.

When taking into account potential discharges from the operating mines in accordance with their current approved release rules, the overall loss of catchment area and associated stream flow is relatively small. In practical terms, impacts on the volume of water flow in the Isaac River would be negligible.

Table 10.3 - Catchment area of existing projects considered in the cumulative impact assessment

Catchment	Total catchment area (km^2)	Estimated mine affected catchment area (km^2)
Vulcan Complex Project (the Project)	2.64	1.1
Other mines	551	182
Combined	554	183
Isaac River (to the Phillips Creek confluence)	7,731	-

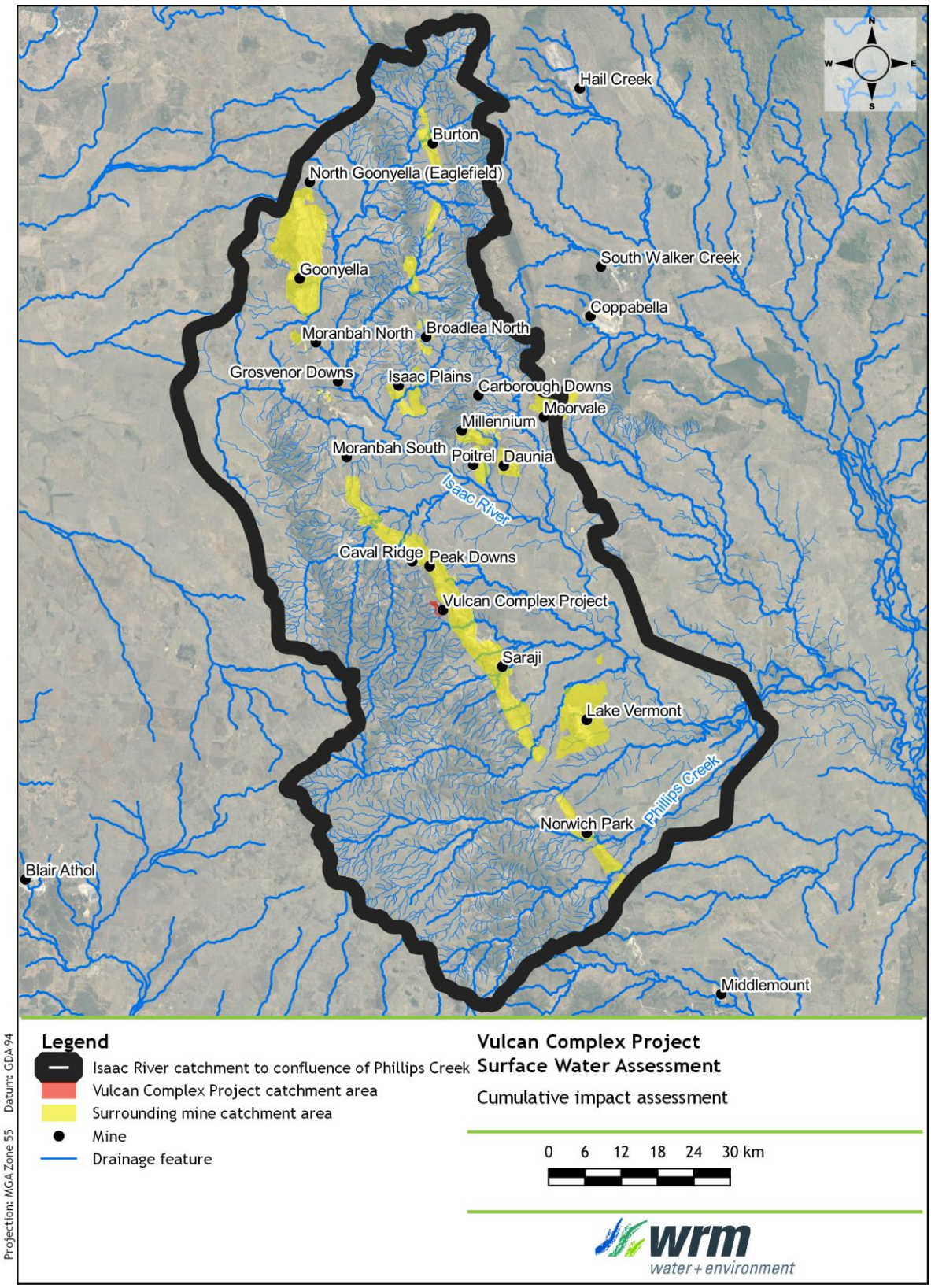


Figure 10.1 - Cumulative impact assessment

11 Summary of findings

11.1 OVERVIEW

The potential impacts of the Project on surface water resources will be mitigated through the implementation of a mine site water management system to control the flow and storage of water of different qualities across the site. A surface water monitoring program will be implemented to monitor potential environmental impacts and ensure that the site water management system is meeting its objectives.

11.2 WATER MANAGEMENT SYSTEM PERFORMANCE

The performance of the mine water management system has been investigated using a detailed site water balance model. The model simulated water inflows and outflows through the various stages of mine development, based on 125 realisations with different climatic sequences.

Water collected on the site will be used as first priority to satisfy site demands. Mine affected water from the infrastructure areas and open cut pit will be collected in MWD1 and reused to meet operational needs.

External water will be supplied to MWD1 when the site water inventory is at a low level, in order to meet site water demands.

The water balance results show that although water collected on site will be used as a first priority to meet mine demands, the Project will frequently require external water to operate. Under 50%ile conditions, the Project is predicted to require up to 140 ML/annum in external water under 50%ile conditions.

The water balance model was used to assess the risk of uncontrolled offsite spills from the mine affected water dams that can potentially overflow directly to the receiving environment (MWD1, MWD2, MWD3, MWD4 and MWD5). There were no modelled overflows from the mine affected water dams to the receiving environment during any of the model realisations over the life of the Project.

11.3 FLOODING

The flood impact assessment undertaken for the Project showed that post-closure conditions compared with existing conditions results in changes to flood levels and velocities, however, impacts are generally confined within the Project MLA area. For the modelled scenario with the existing drainage diversion and levee, the changes in peak water levels and peak velocities were relatively small under the 10% and 1% AEP events. The modelled scenario with no existing drainage diversion and levee resulted in increased flows draining east through the site and showed that the potential impacts under the 10% and 1% AEP events are slightly higher than the scenario with the levee.

For rare events (0.1% AEP), the predicted change in flood level and velocity in the vicinity of the Project MLA area extends downstream of the proposed Saraji Road realignment and the Norwich Park Branch Railway corridor. The predicted increase in water level and velocity is less than 0.35 m and 0.4 m/s respectively for both levee scenarios. It is recommended that erosion and scour protection options are considered along the proposed drainage corridor and existing channels where these increases occur as required to mitigate the risk of rapid geomorphic change.

Overall, the impact of the Project on the hydraulic characteristics of Boomerang Creek and its tributaries do not affect the existing conditions significantly. It is expected that the channel and floodplain will undergo little, if any, adjustment to the altered hydraulic

conditions upstream or downstream of the Project as a result of the Project. It is critical that suitable erosion protection and revegetation is implemented along permanent drainage structures as soon as possible to mitigate the risk of any rapid geomorphic change.

11.4 IMPACTS ON DOWNSTREAM WATER QUALITY

Preliminary baseline monitoring indicates that water quality in the surrounding environment is of poor quality. Notwithstanding, the water balance modelling indicates that no mine affected spills are predicted from mine operations. In addition, modelling predicts that spills from the sediment dams will be below the 720 µS/cm WQO for low flows. Baseline salinity exceeds the WQO for high flows.

In consideration of the already heavily disturbed nature of the surrounding catchment, it is unlikely that Project releases will have a measurable impact on receiving water quality or environmental values.

11.5 CUMULATIVE IMPACTS

The Project will reduce the catchment area draining to receiving waters due to capture of runoff from disturbed catchment areas within the water management system. The Project catchment area represents approximately 0.03% of the total catchment area of the Isaac River to its confluence with Phillips Creek. Of this, approximately 60% will be managed through the Project ESC and released back to receiving waters. The combined total catchment area of the existing mines (including the Project) represents around 7.1% of the total catchment area of the Isaac River to the Phillips Creek confluence.

The site water management system has been designed such that the risk of offsite release of mine affected water is very low (with no modelled mine affected dam uncontrolled releases under any climatic conditions).

11.6 FINAL LANDFORM

A conceptual final landform water management plan for the Project under post-closure conditions has been developed. The key features of the final landform are:

- No final voids are proposed. All open cut pits will be backfilled with overburden material.
- Drainage structures will be implemented on and around the final landform to ensure that the landform is free draining.
- When sediment dam catchments are completely rehabilitated, and water quality monitoring of the runoff has established that it is consistent with natural background conditions, the sediment dam and associated drainage infrastructure will be decommissioned.

In summary, the conceptual final landform is not considered likely to have a long-term significant impact on the receiving waters.

12 References

AARC, 2019	*Vulcan Project Soil and Land Suitability Assessment*. October 2019
ANZECC & ARMCANZ, 2000	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality.
ANZG, 2018	Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines
Ball et al, 2019	*'Australian Rainfall and Runoff: A Guide to Flood Estimation'*, Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), © Commonwealth of Australia (Geoscience Australia), 2019.
BMT, 2018a	TUFLOW (software), BMT, version 2018-03-AD, 2018.
BMT, 2018b	*'TUFLOW Classic/HPC User Manual – Build 2018-03-AD'*, BMT WBM, 2018a.
BOM, 2003	*'The Estimation of Probable Maximum Precipitation in Australia, Generalised Short Duration Method'*, Hydrometeorological Advisory Service, Commonwealth Bureau of Meteorology, June 2003.
Boughton, 2003	Cooperative Research Centre for Catchment Hydrology (2003). Technical Report 03/15, Calibrations of the AWBM for the use on ungauged catchments.
Chow, 1959	*Open-Channel Hydraulics,* McGraw-Hill Inc., Singapore, 1959.
CSIRO and Bureau of Meteorology, 2015	*Climate change in Australia Information for Australia's Natural resource Management Regions: Technical Report*, CSIRO and Bureau of Meteorology, Australia.
DEHP, 2011	*Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part)*
DES, 2016	*Manual for assessing consequence categories and hydraulic performance of structures.* Version 5.02.
DES, 2017	*Guideline Model Mining Conditions*. ESR/2016/1936. Version 6.02. Effective 07 March 2017.
DNRME, 2017	Department of Natural Resources, Mines and Energy (DNRME) (2017). Water Information Portal (https://water-monitoring.information.qld.gov.au/).
Geoscience Australia, 2019	AR&R Data Hub (software), Geoscience Australia, Version 2019_v1, April 2019, <http://data.arr-software.org/>.
Hydrogeologist.com.au, 2020	*Vulcan Mining Complex Groundwater Assessment*
IECA, 2008	International Erosion Control Association (IECA) (2008). *Best Practice Erosion and Sediment Control Guideline*.
Innovyze, 2019	XP-RAFTS (software), Innoyvze, Version 2018.1.2, 2019

McKenzie NJ, Grundy MJ, Webster R and Ringrose-Voase, 2008	*Guidelines for Surveying Soil and Land Resources.* Australian Soil and Land Survey Handbook Series. CSIRO Publishing, Melbourne
Queensland Government, 2019	*Queensland Globe service.* Accessed February 2020
RGS Environmental Pty Ltd, 2019	*Preliminary Geochemistry Results – Jupiter and Vulcan Target Prospects. Vulcan Complex.*
WRM, 2012	*Lake Vermont Coal Mine Site Water Balance Model Report.* Lake Vermont Resources

Appendix A – Existing Conditions flood maps and results

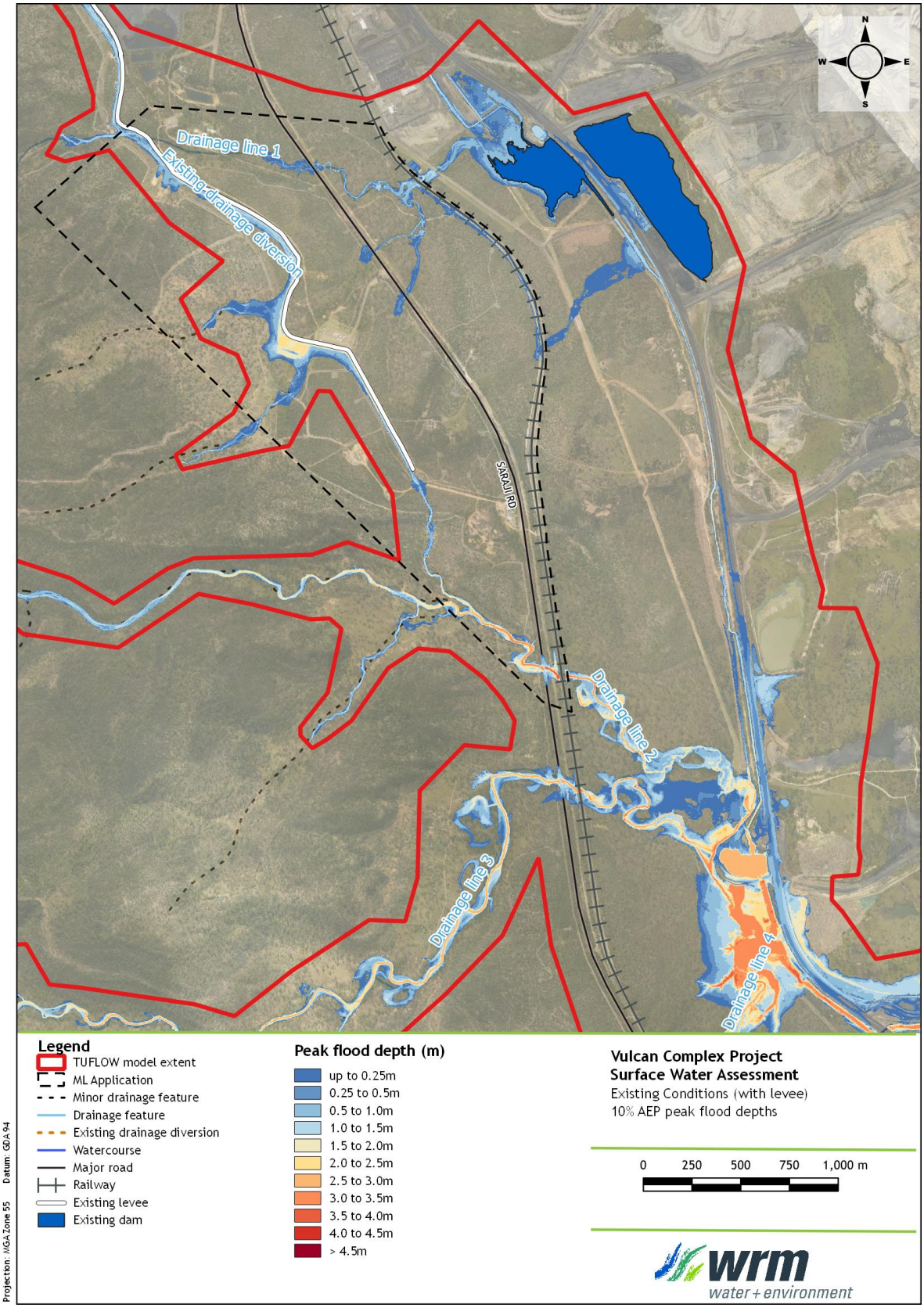


Figure A.1 - 10% AEP peak flood depths - Existing Conditions (with levee)

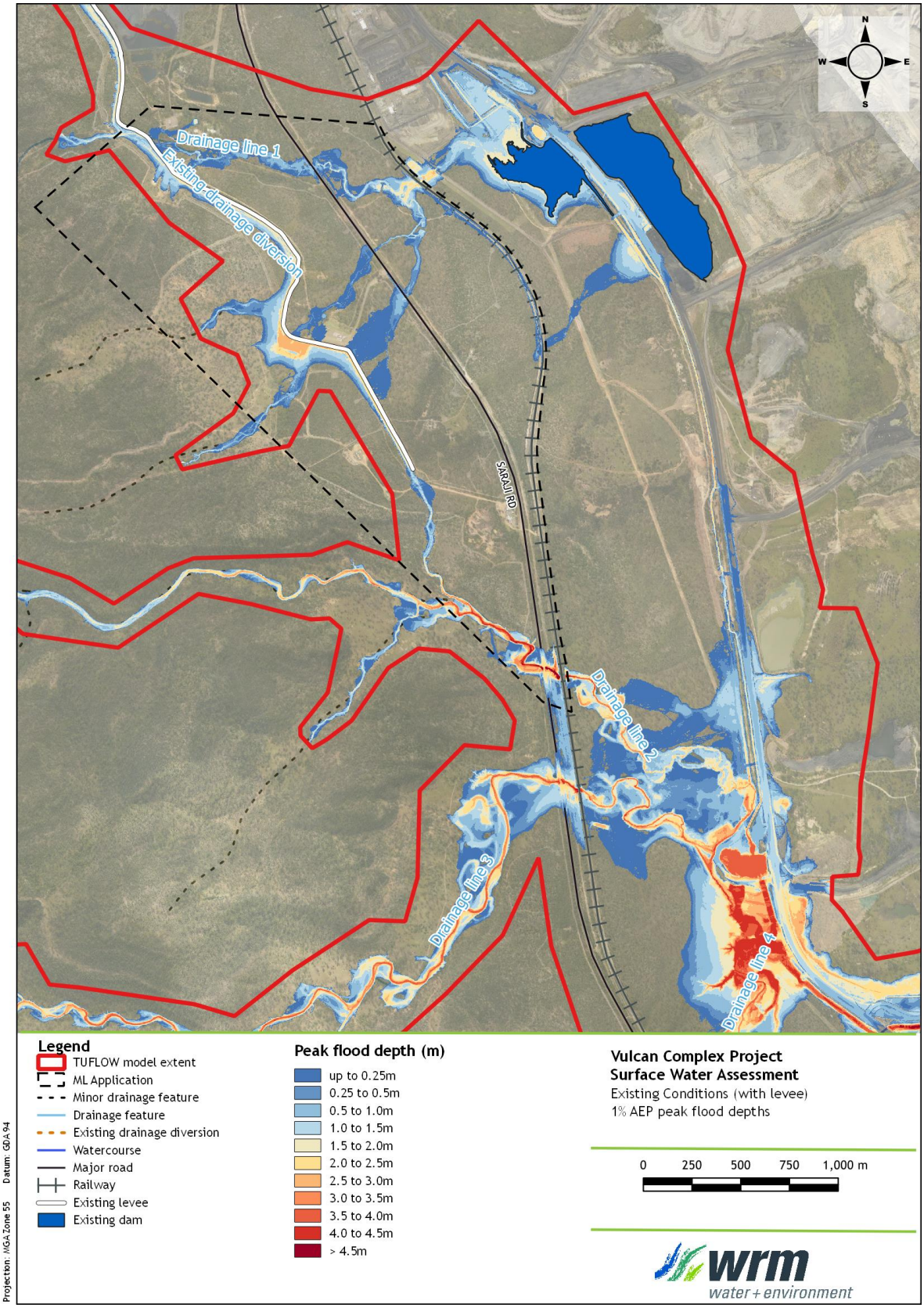


Figure A.2 - 1% AEP peak flood depths - Existing Conditions (with levee)

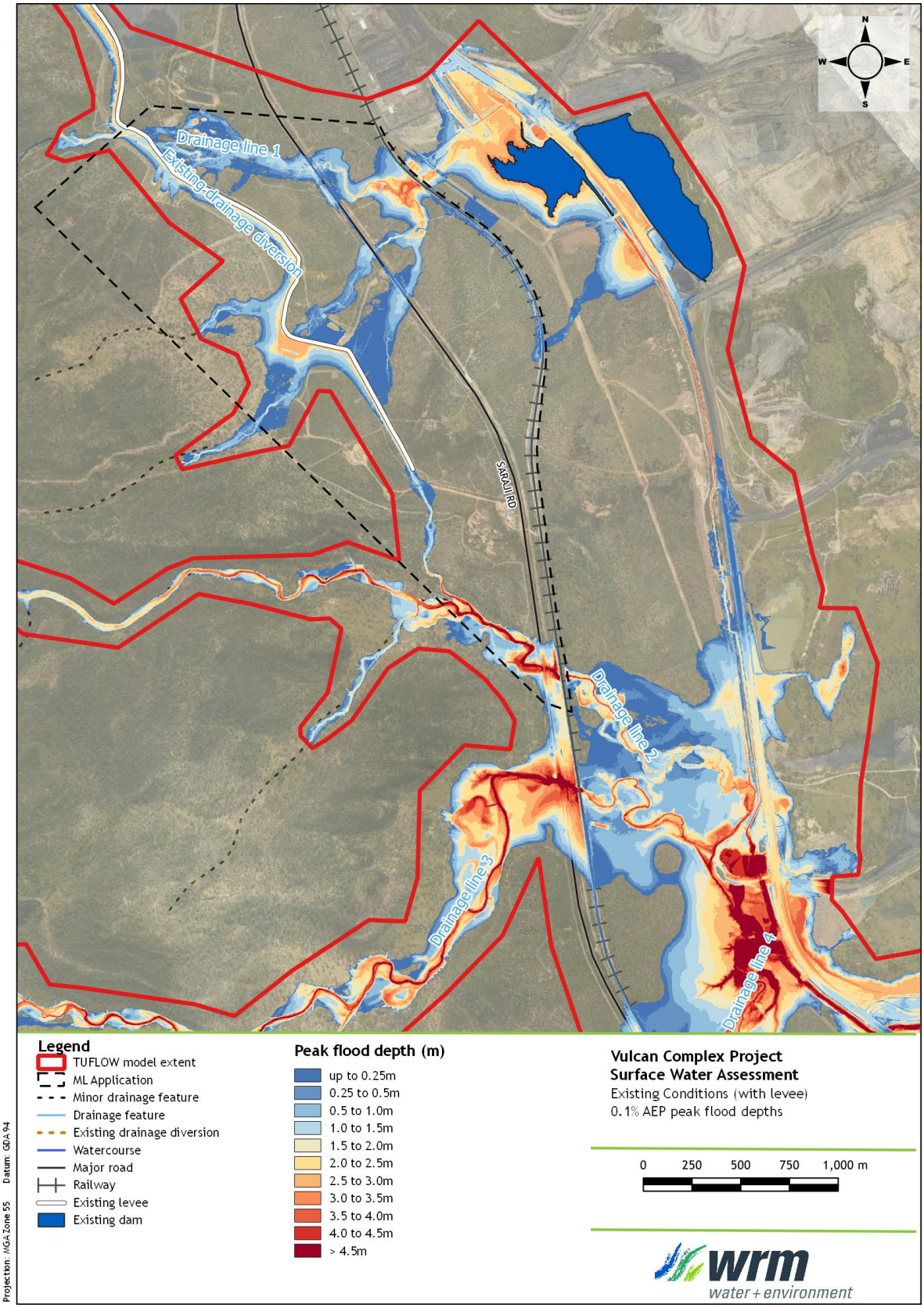


Figure A.3 - 0.1% AEP peak flood depths - Existing Conditions (with levee)

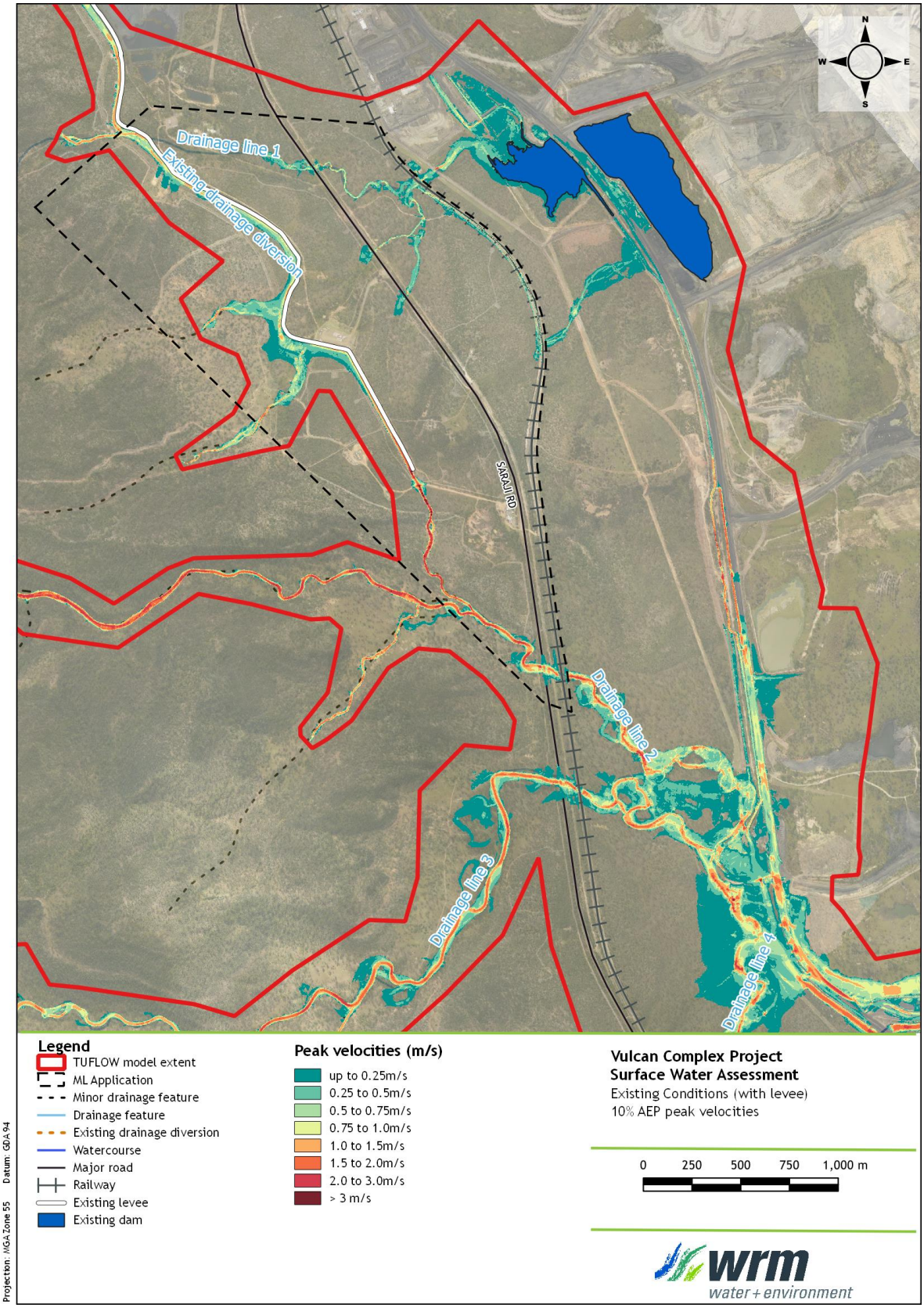


Figure A.4 - 10% AEP peak velocities - Existing Conditions (with levee)

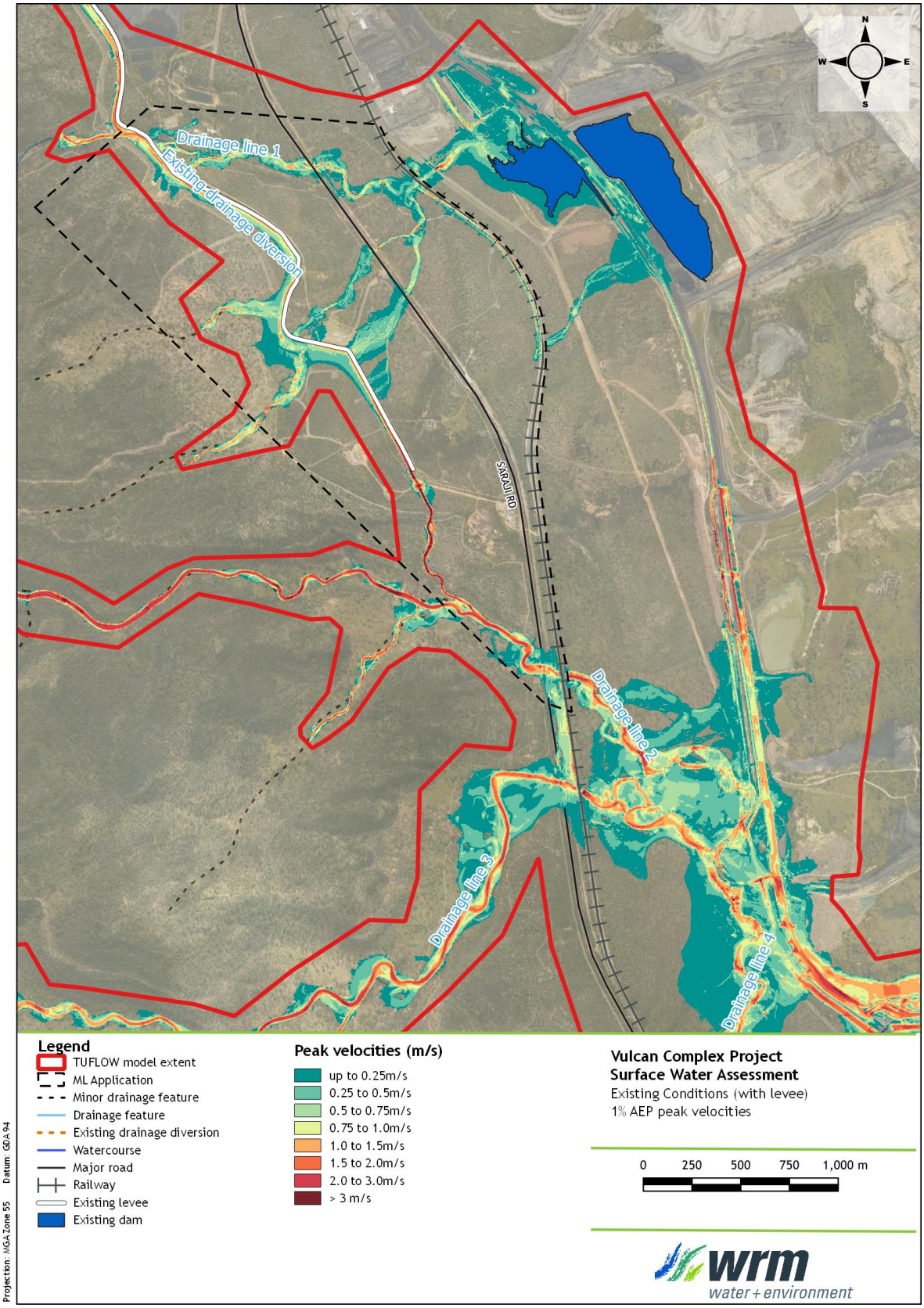


Figure A.5 - 1% AEP peak velocities - Existing Conditions (with levee)

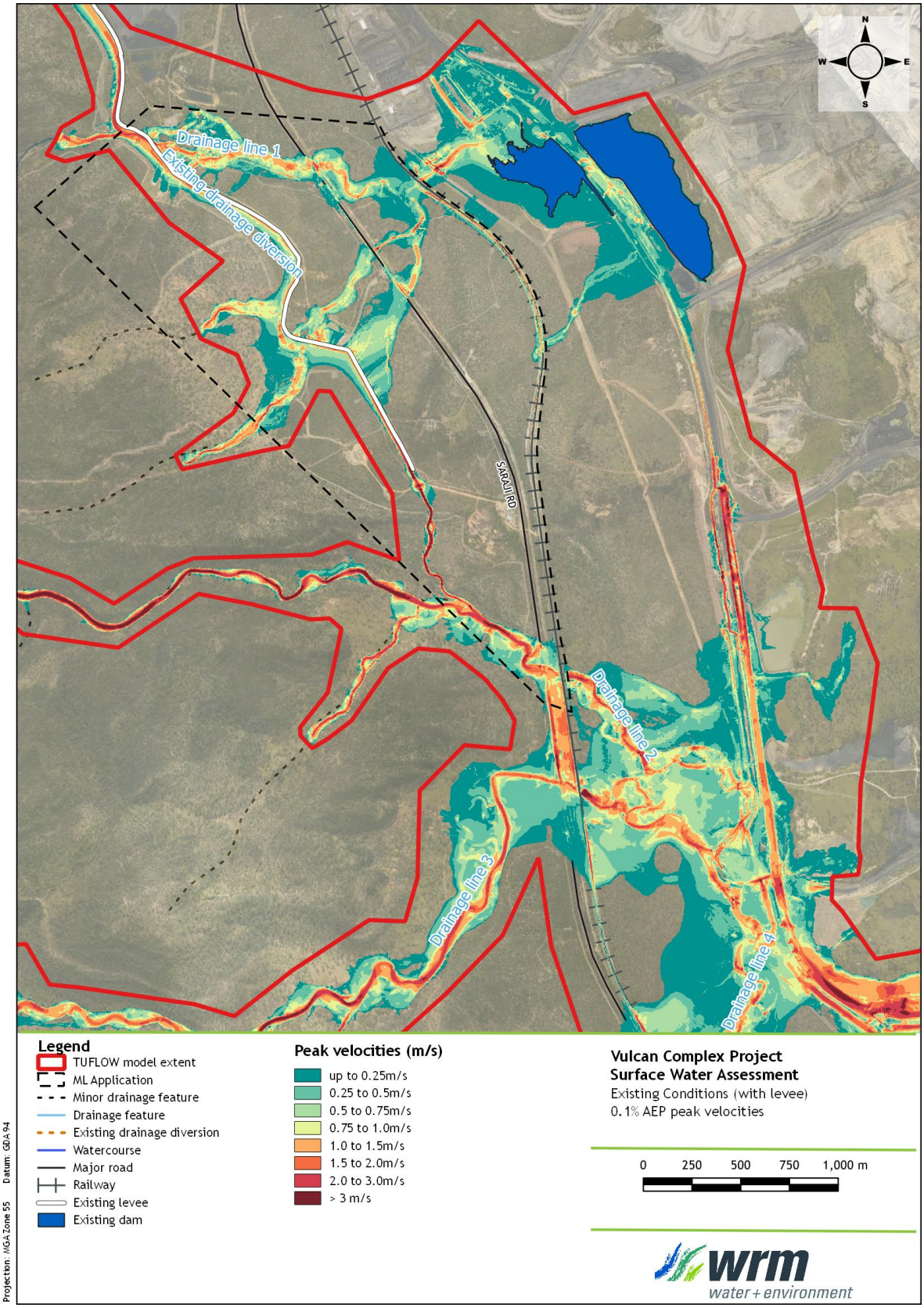


Figure A.6 - 0.1% AEP peak velocities - Existing Conditions (with levee)

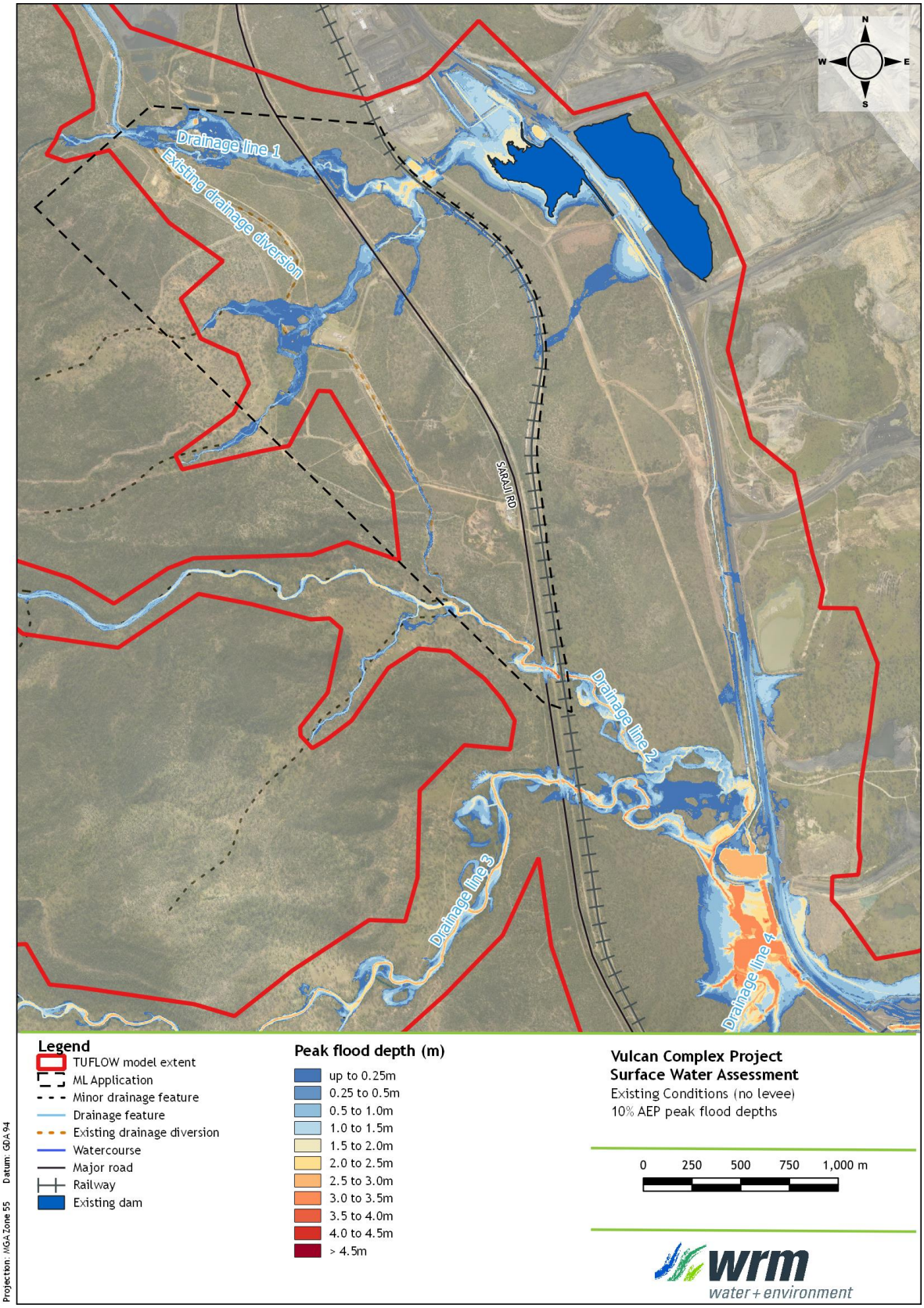


Figure A.7 - 10% AEP peak flood depths - Existing Conditions (no levee)

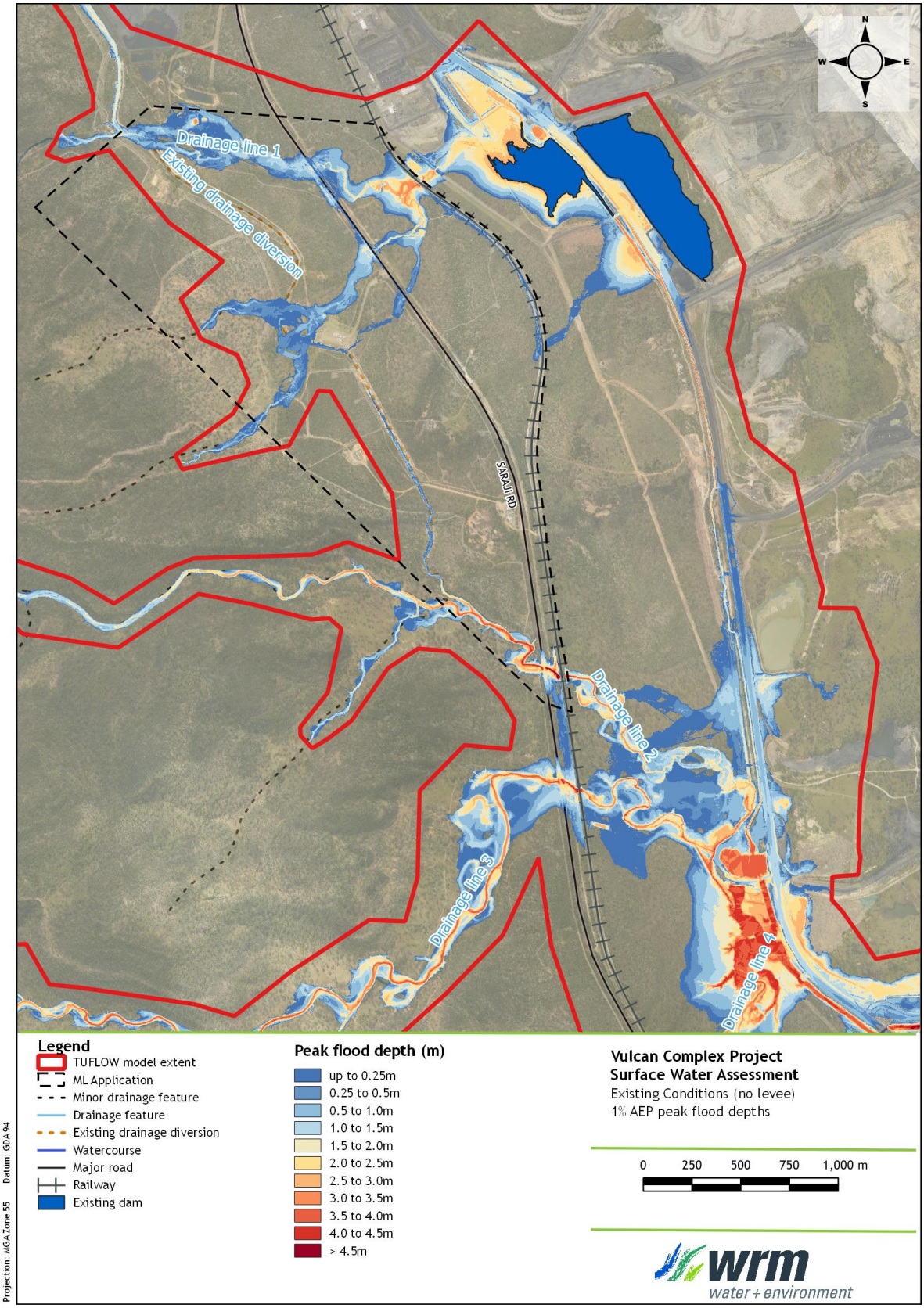


Figure A.8 - 1% AEP peak flood depths - Existing Conditions (no levee)

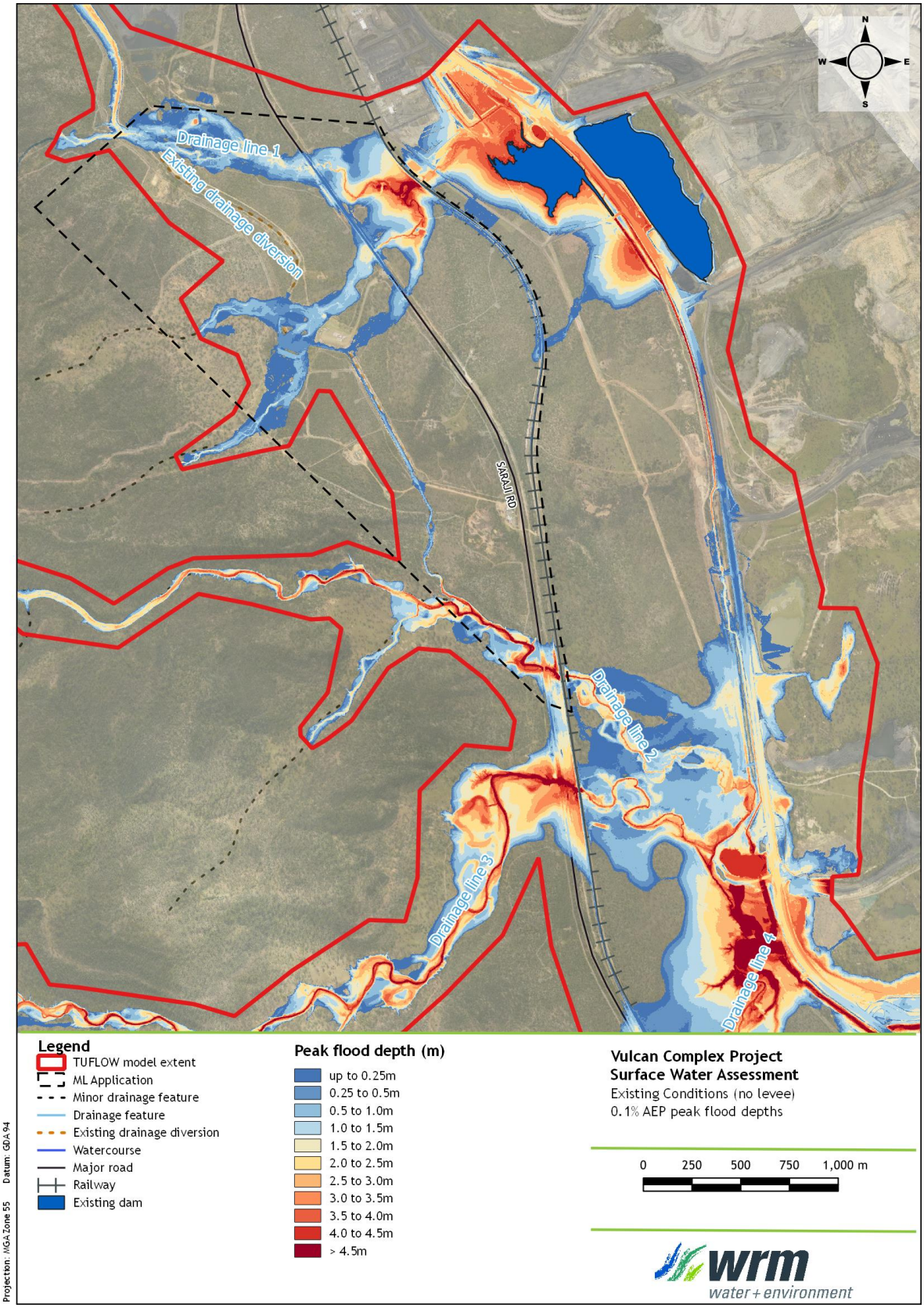


Figure A.9 - 0.1% AEP peak flood depths - Existing Conditions (no levee)

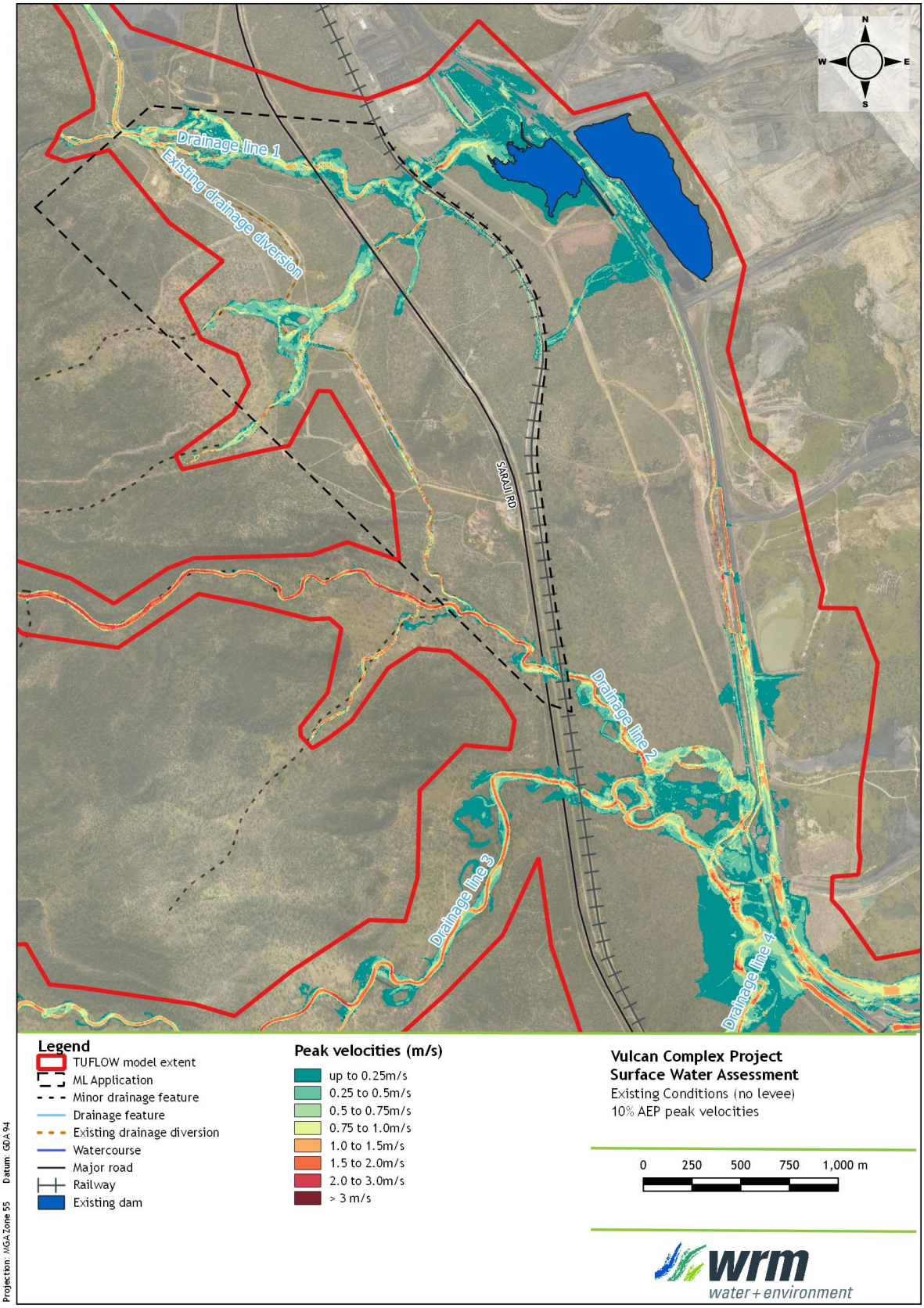


Figure A.10 - 10% AEP peak velocities - Existing Conditions (no levee)

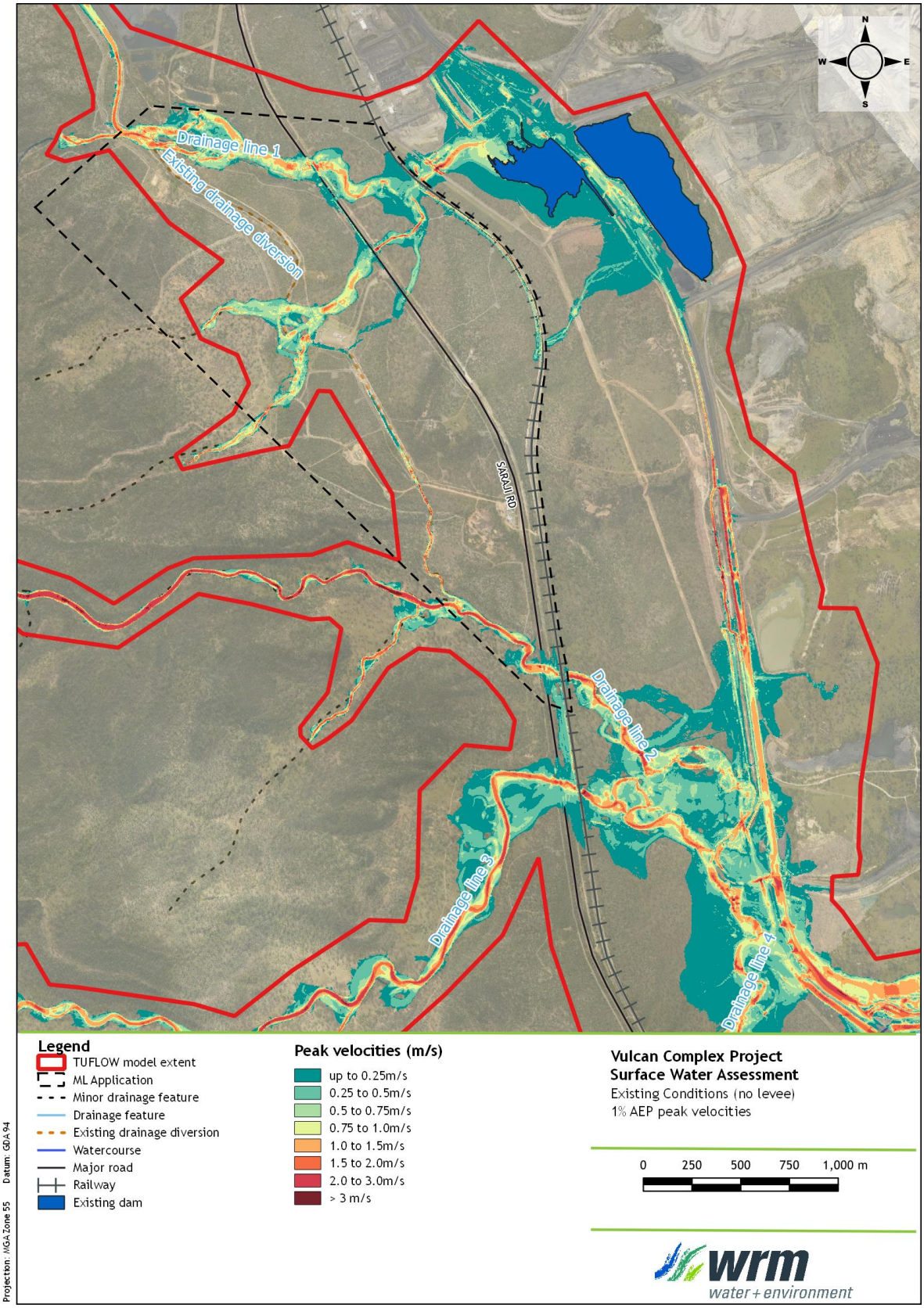


Figure A.11 - 1% AEP peak velocities - Existing Conditions (no levee)

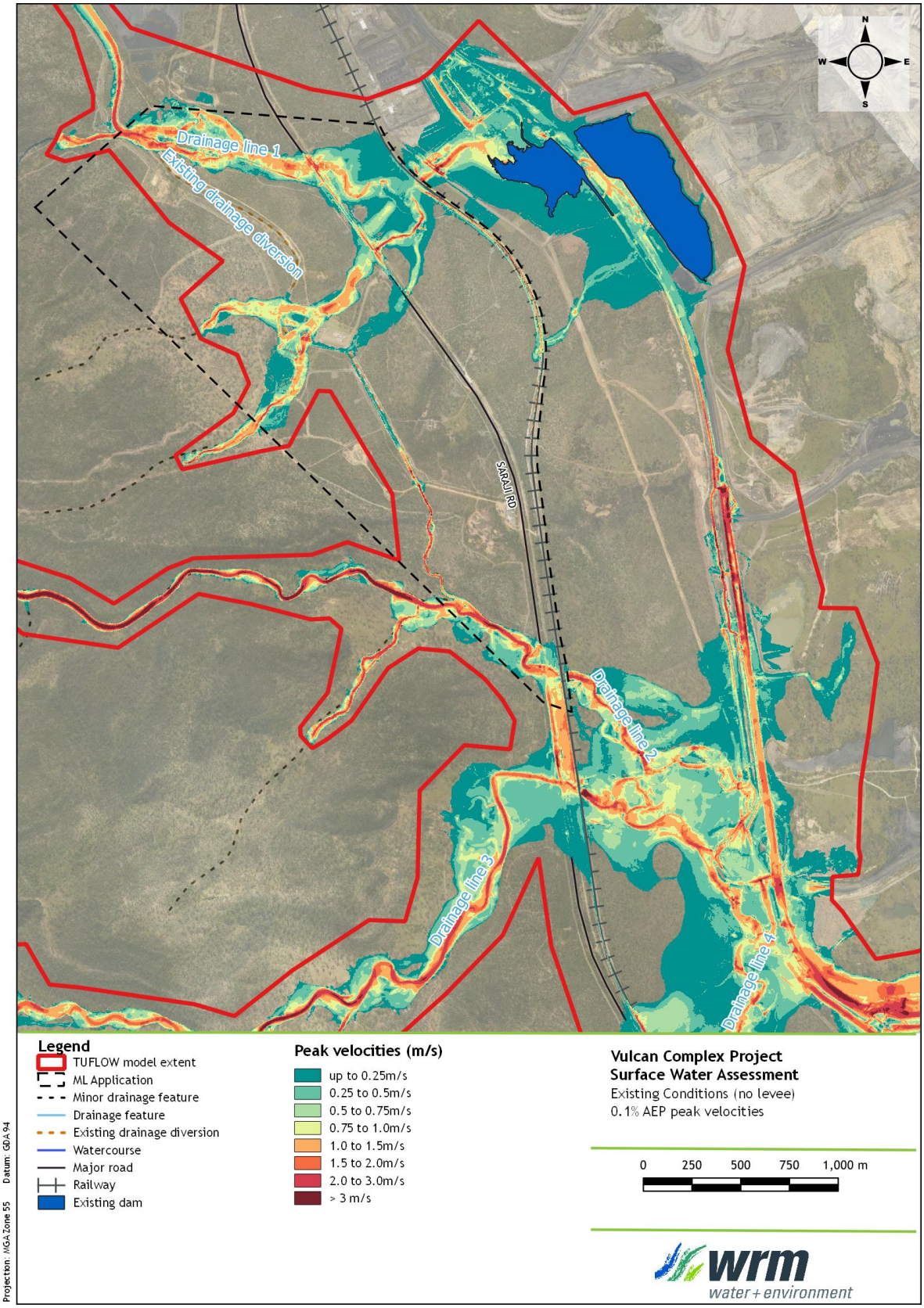


Figure A.12 - 0.1% AEP peak velocities - Existing Conditions (no levee)

Appendix B – Post-closure Conditions flood impact maps

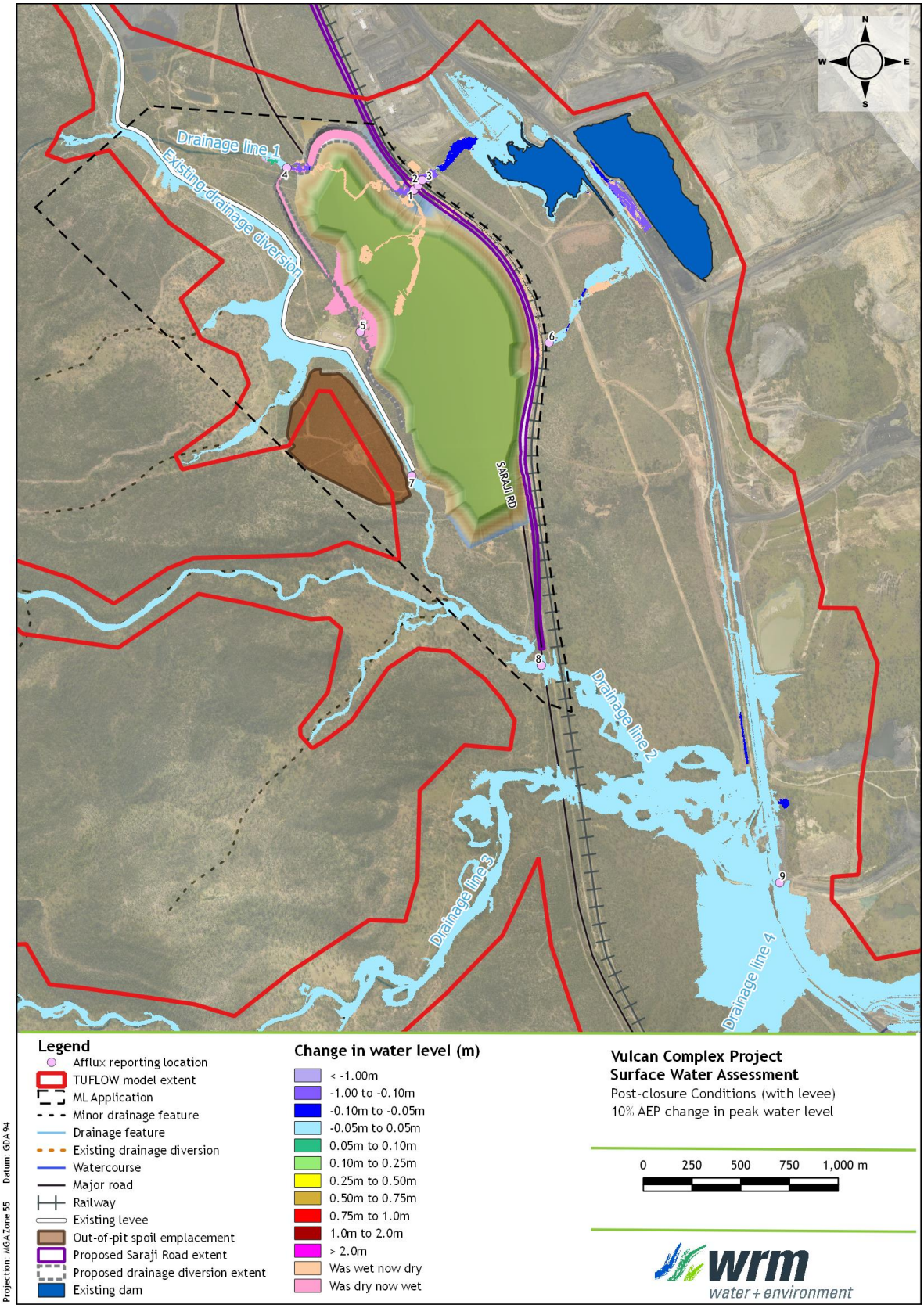


Figure B.1 - 10% AEP change in peak water levels - Post-closure Conditions (with levee) impacts

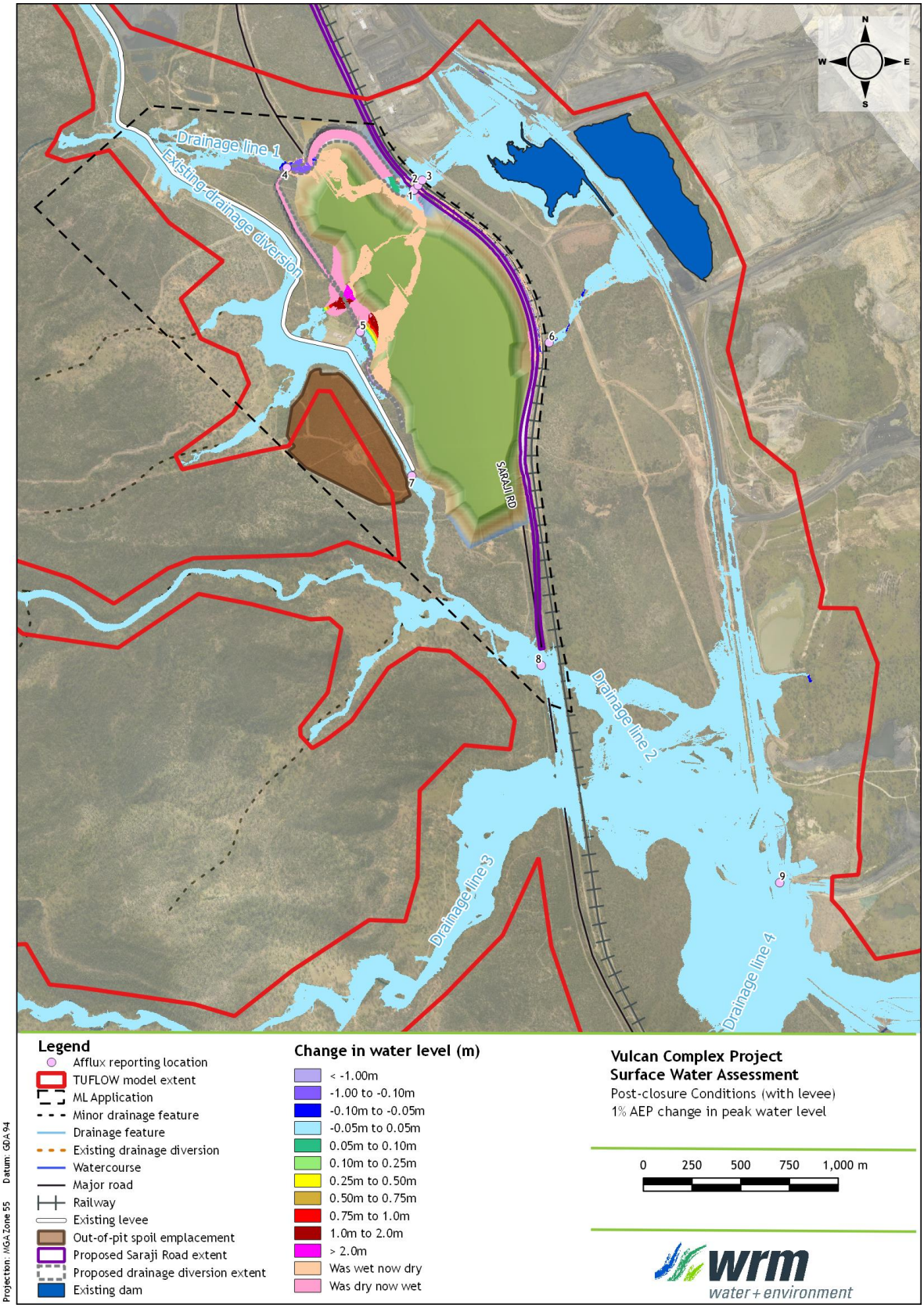


Figure B.2 - 1% AEP change in peak water levels - Post-closure Conditions (with levee) impacts

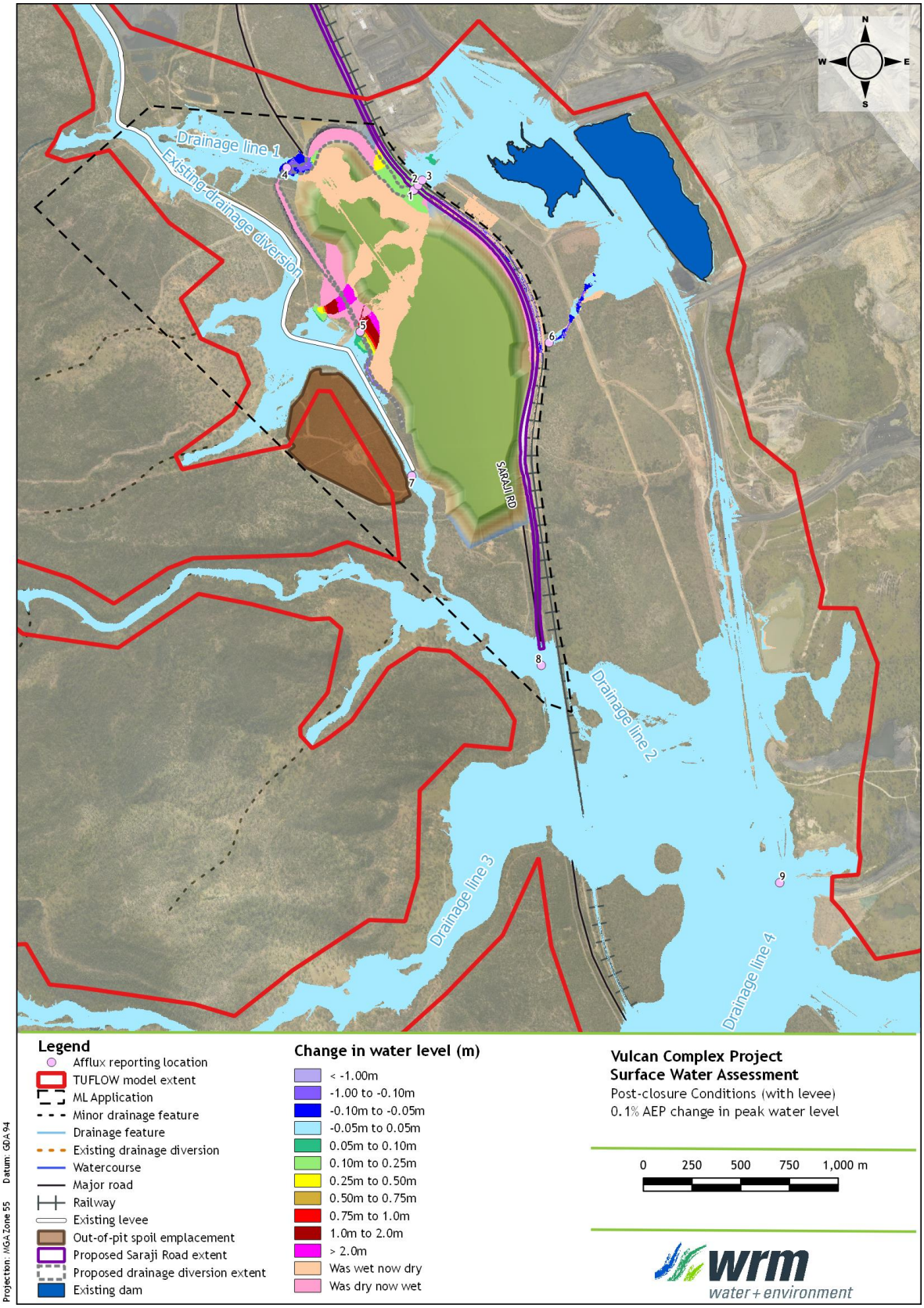


Figure B.3 - 0.1% AEP change in peak water levels - Post-closure Conditions (with levee) impacts

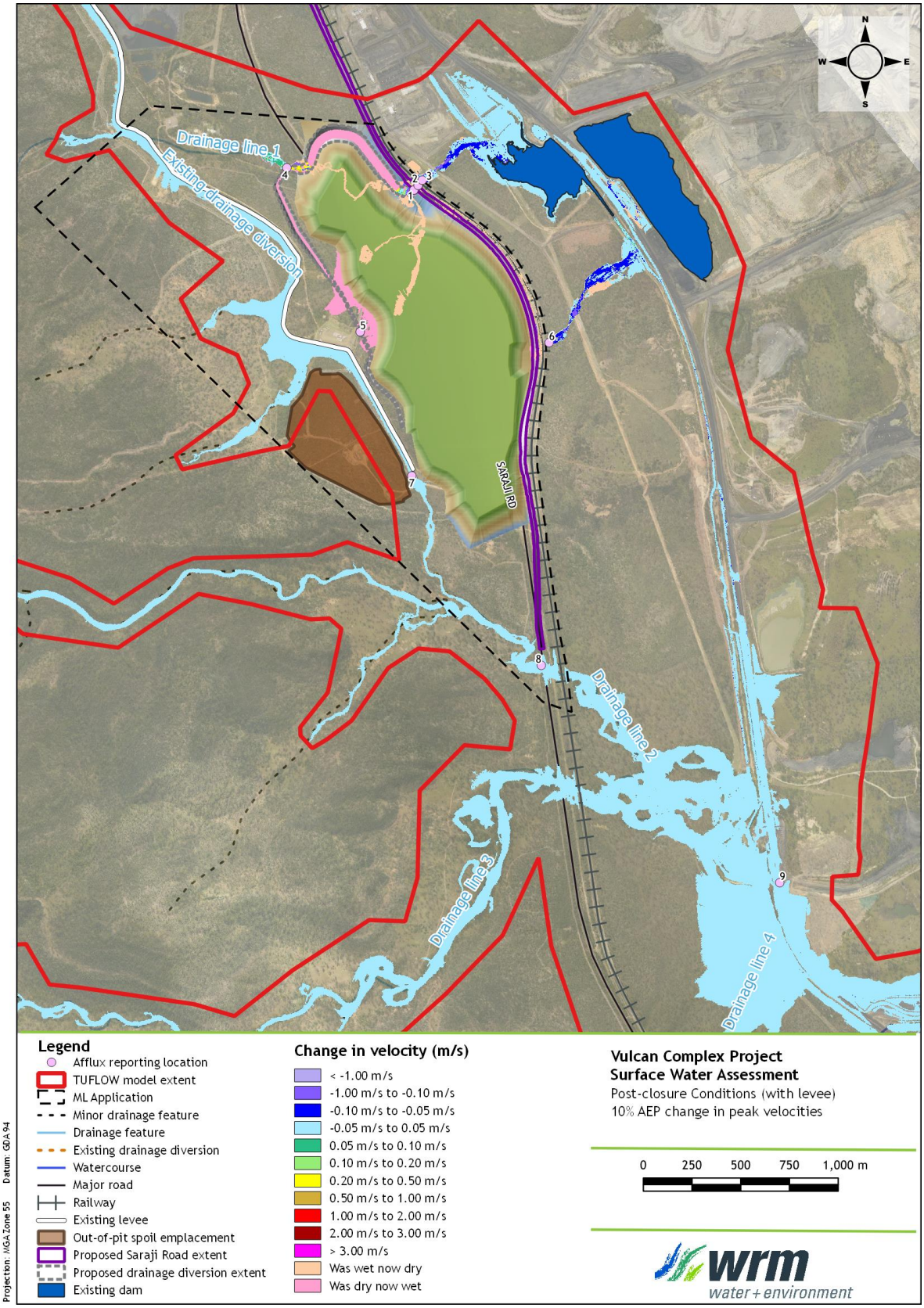


Figure B.4 - 10% AEP change in peak velocities - Post-closure Conditions (with levee) impacts

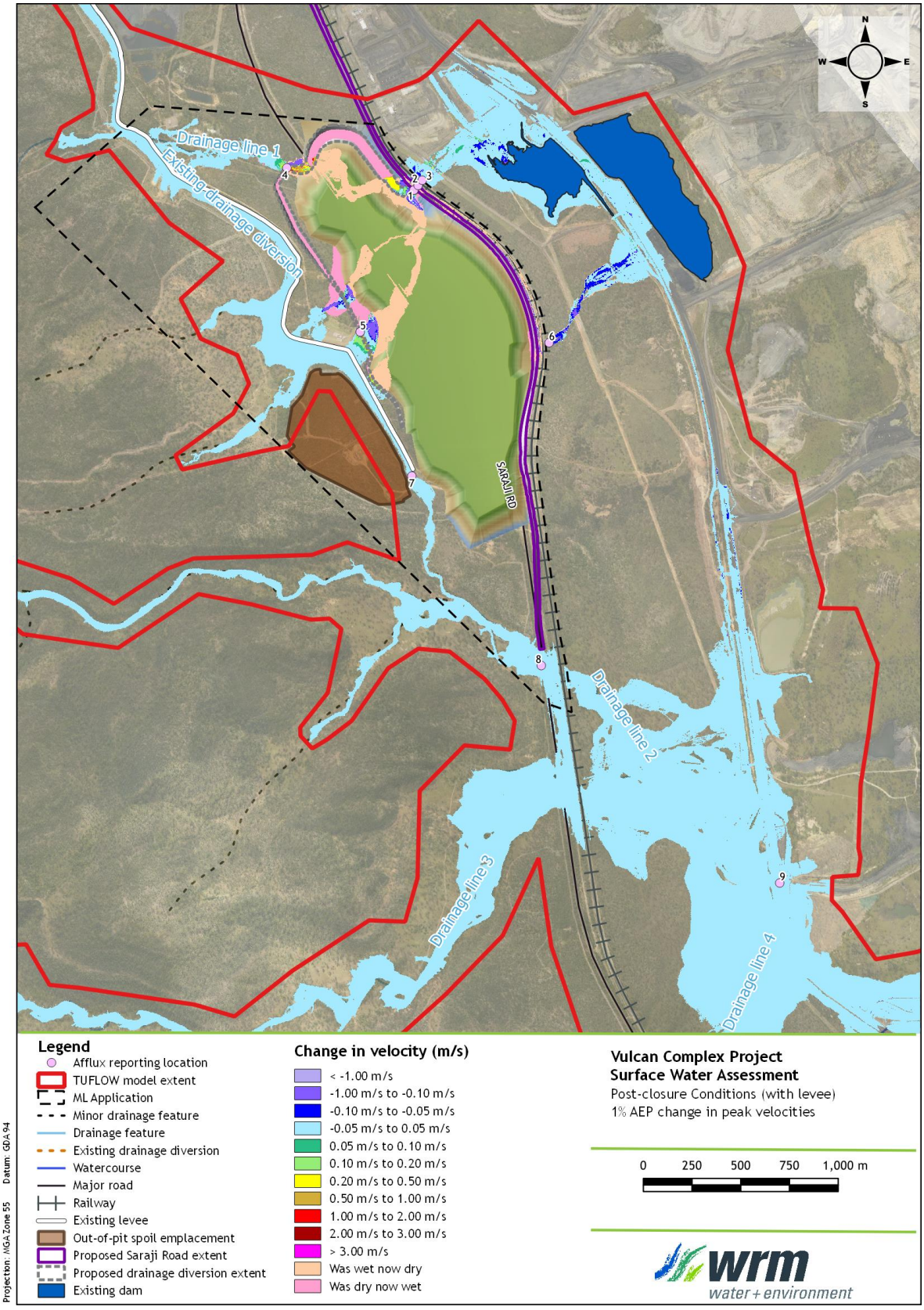


Figure B.5 - 1% AEP change in peak velocities - Post-closure Conditions (with levee) impacts

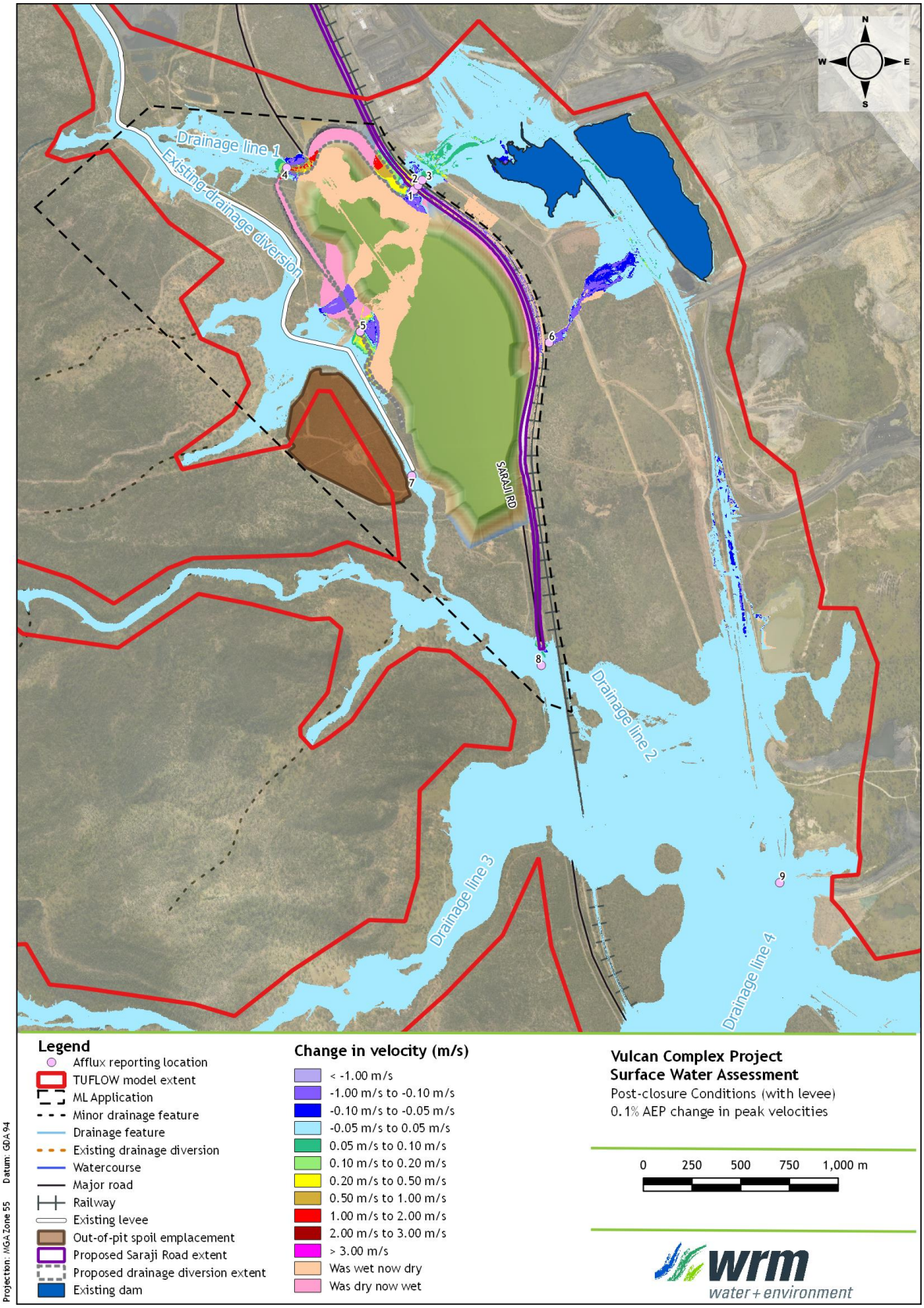


Figure B.6 - 0.1% AEP change in peak velocities - Post-closure Conditions (with levee) impacts

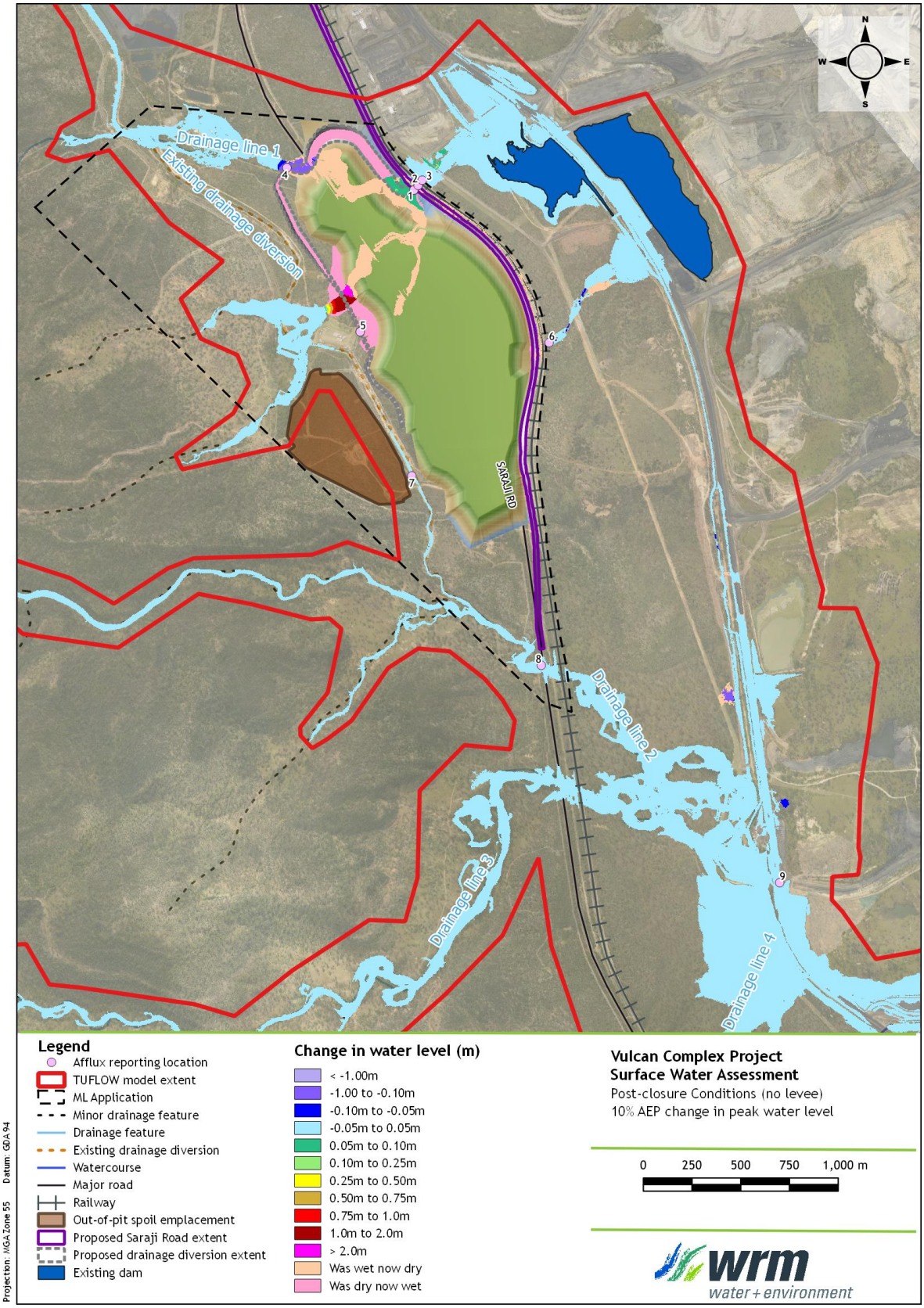


Figure B.7 - 10% AEP change in peak water levels - Post-closure Conditions (no levee) impacts

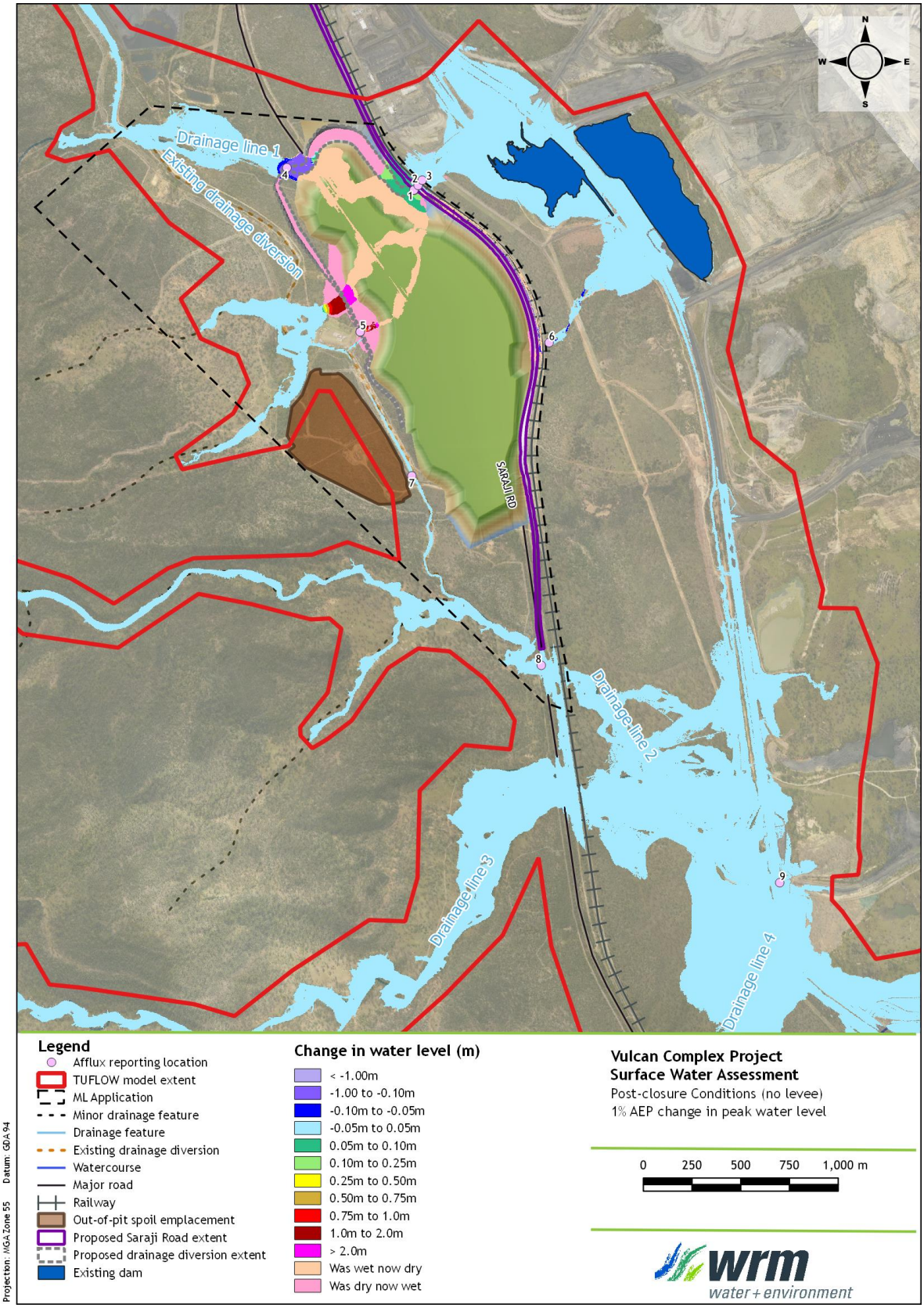


Figure B.8 - 1% AEP change in peak water levels - Post-closure Conditions (no levee) impacts

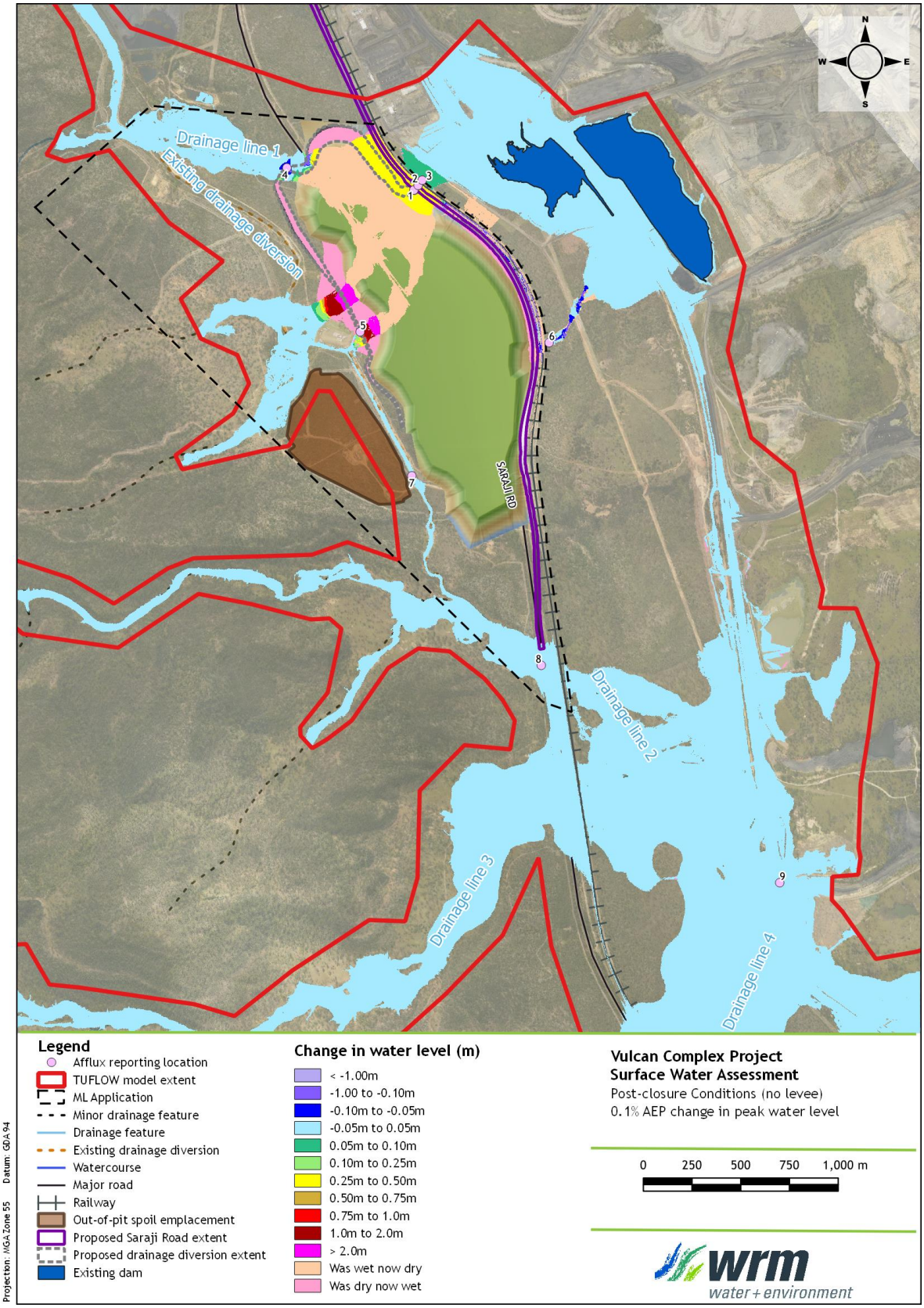


Figure B.9 - 0.1% AEP change in peak water levels - Post-closure Conditions (no levee) impacts

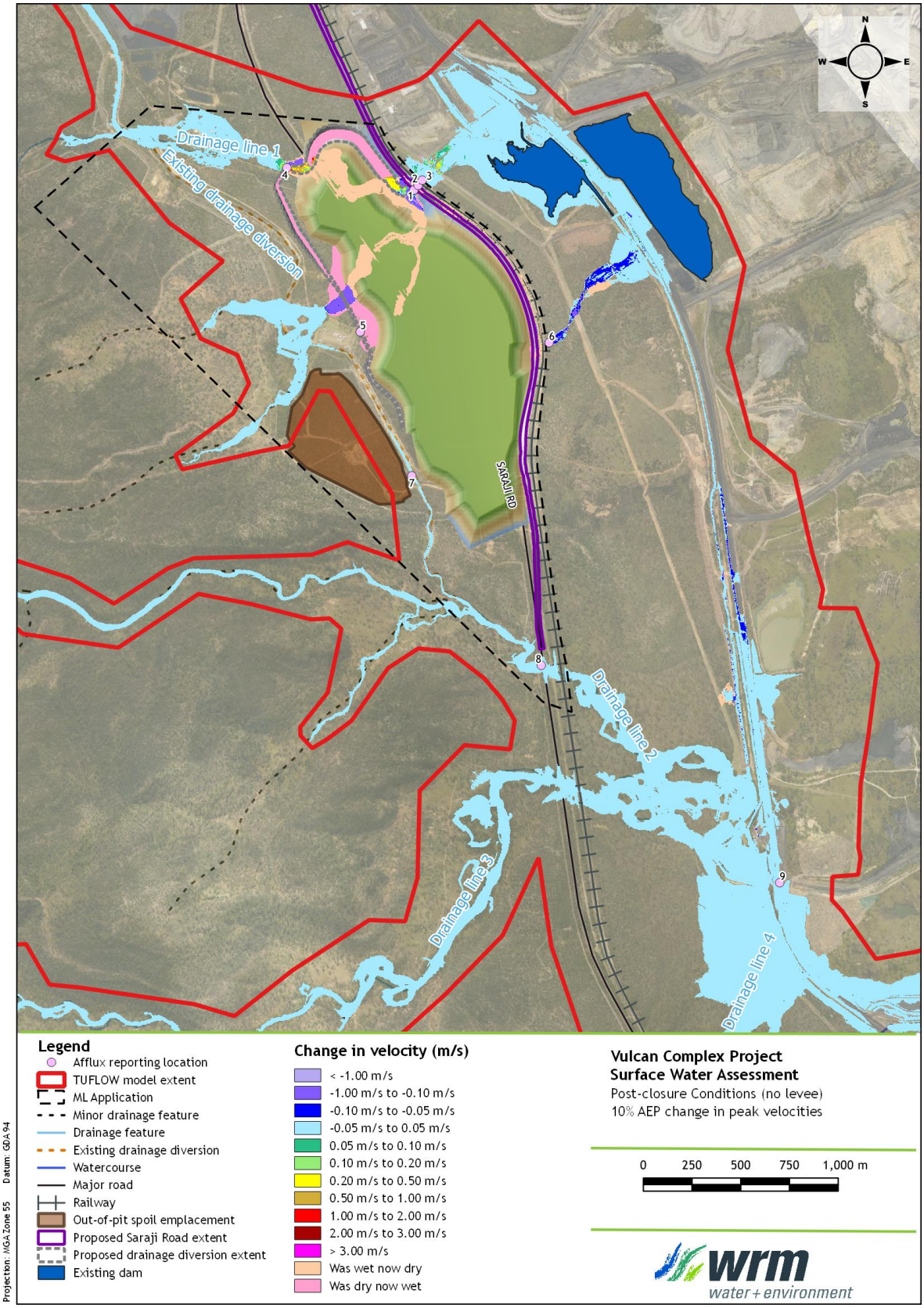


Figure B.10 - 10% AEP change in peak velocities - Post-closure Conditions (no levee) impacts

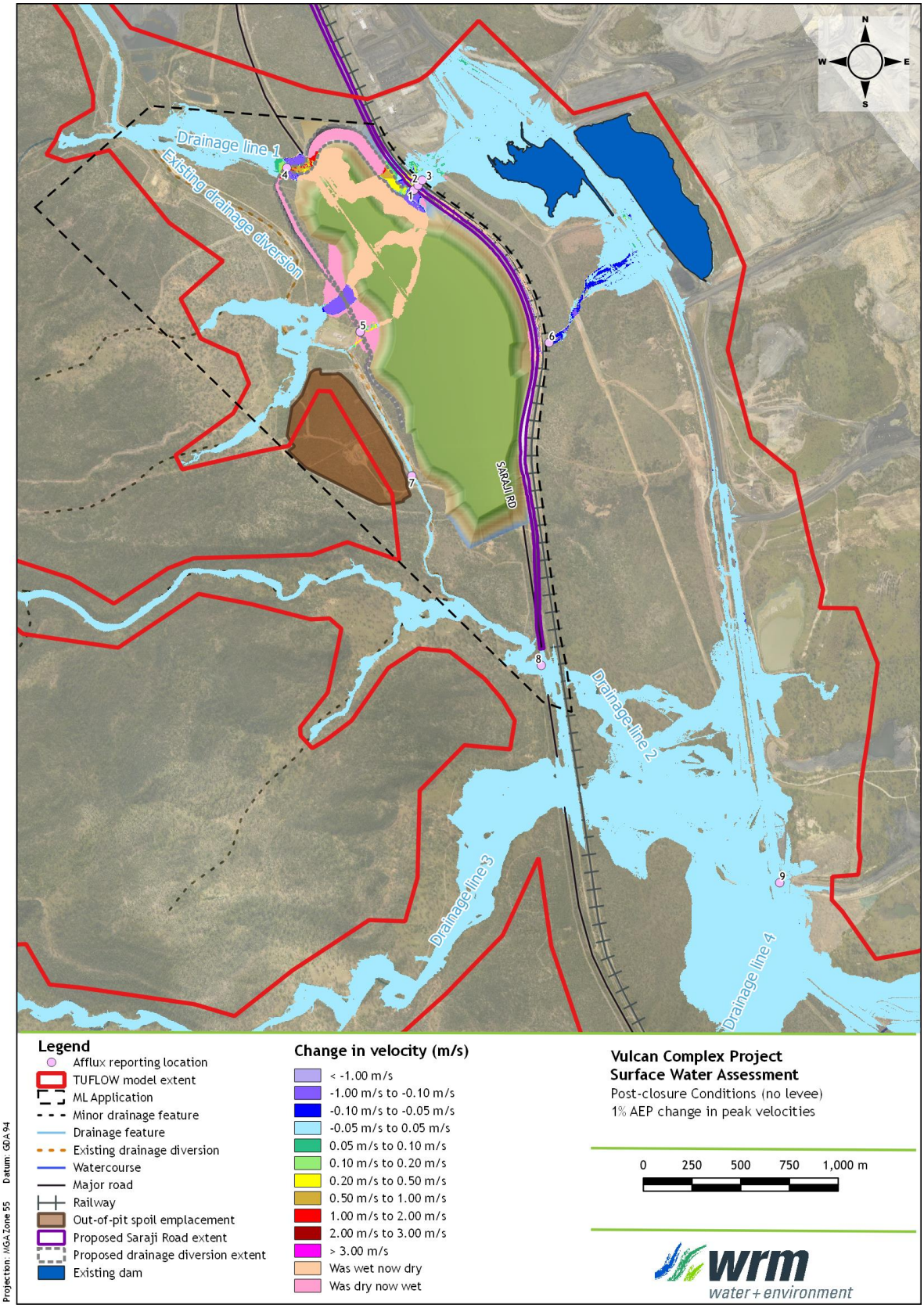


Figure B.11 - 1% AEP change in peak velocities - Post-closure Conditions (no levee) impacts

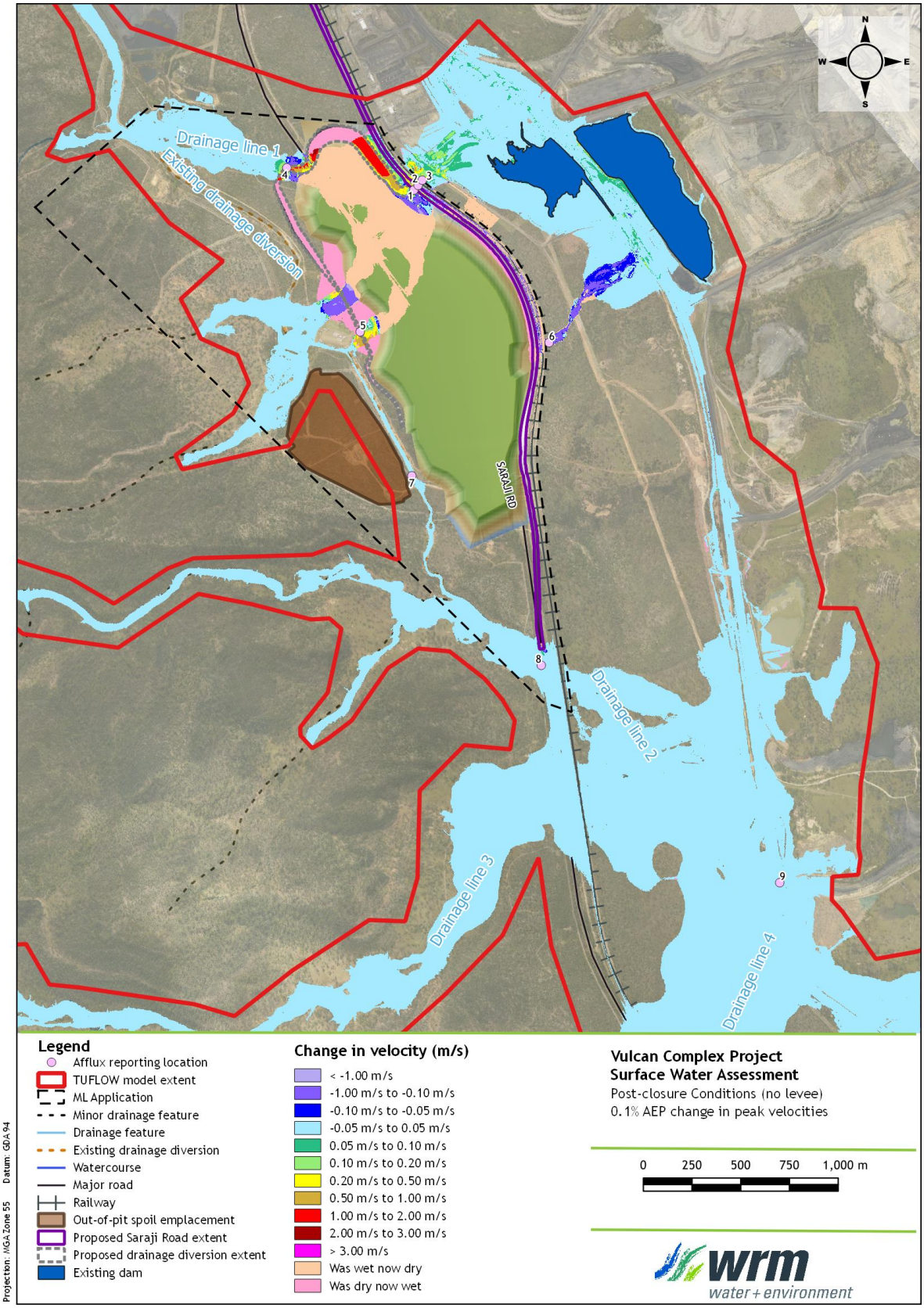


Figure B.12 - 0.1% AEP change in peak velocities - Post-closure Conditions (no levee) impacts